

Draft

Ecma/TC39/2013/0xx

Standard ECMA-262

6th Edition / Draft May 14, 2013

Draft

**ECMAScript Language
Specification**

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Product: Draft for 6th Edition
Component: choose an appropriate one
Version: Rev 15, May 14, 2013 Draft

Standard

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Introduction

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 introduced 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 third edition of the ECMAScript standard was adopted by the Ecma General Assembly of December 1999 and published as ISO/IEC 16262:2002 in June 2002.

Since publication of the third edition, ECMAScript has achieved massive adoption in conjunction with the World Wide Web where it has become the programming language that is supported by essentially all web browsers. Significant work was done to develop a fourth edition of ECMAScript. Although that work was not completed and not published¹ as the fourth edition of ECMAScript, it informs continuing evolution of the language. The fifth edition of ECMAScript (published as ECMA-262 5th edition) codifies de facto interpretations of the language specification that have become common among browser implementations and adds support for new features that have emerged since the publication of the third edition. Such features include accessor properties, reflective creation and inspection of objects, program control of property attributes, additional array manipulation functions, support for the JSON object encoding format, and a strict mode that provides enhanced error checking and program security.

The edition 5.1 of the ECMAScript Standard has been fully aligned with the third edition of the international standard ISO/IEC 16262:2011.

This present sixth edition of the Standard.....

ECMAScript is a vibrant language and the evolution of the language is not complete. Significant technical enhancement will continue with future editions of this specification.

This Ecma Standard has been adopted by the General Assembly of <month> <year>.

¹ Note: Please note that for ECMAScript Edition 4 the Ecma standard number "ECMA-262 Edition 4" was reserved but not used in the Ecma publication process. Therefore "ECMA-262 Edition 4" as an Ecma International publication does not exist.

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ECMAScript Language Specification

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 Standard shall interpret characters in conformance with the Unicode Standard, Version 5.1.0 or later and ISO/IEC 10646. If the adopted ISO/IEC 10646-1 subset is not otherwise specified, it is presumed to be the Unicode set, collection 10646.

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 7.6.1.2 of this specification.

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Deleted: BMP subset

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Deleted: If the adopted encoding form is not otherwise specified, it is presumed to be the UTF-16 encoding form.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 9899:1996, *Programming Languages – C, including amendment 1 and technical corrigenda 1 and 2*

ISO/IEC 10646:2003: Information Technology – Universal Multiple-Octet Coded Character Set (UCS) plus Amendment 1:2005, Amendment 2:2006, Amendment 3:2008, and Amendment 4:2008, plus additional amendments and corrigenda, or successor

The Unicode Standard, Version 5.0, as amended by Unicode 5.1.0, or successor

Unicode Standard Annex #15, Unicode Normalization Forms, version Unicode 5.1.0, or successor

Unicode Standard Annex #31, Unicode Identifiers and Pattern Syntax, version Unicode 5.1.0, or successor

Deleted: ISO/IEC 10646-1:1993, *Information Technology – Universal Multiple-Octet Coded Character Set (UCS) plus its amendments and corrigenda*

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 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.

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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. ECMAScript was originally designed to be used as a scripting language, but has become widely used as a general purpose programming language.

ECMAScript was originally designed to be a **Web scripting language**, providing a mechanism to enliven Web pages in browsers and to perform server computation as part of a Web-based client-server architecture. ECMAScript is now used both as a general purpose programming language and to provide core scripting capabilities for a variety of host environments. Therefore the core 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:

Gosling, James, Bill Joy and Guy Steele. The Java™ Language Specification. Addison Wesley Publishing Co., 1996.

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

IEEE Standard for the Scheme Programming Language. IEEE Std 1178-1990.

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 a 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 **functions**. A primitive value is a member of one of the following built-in types: **Undefined**, **Null**, **Symbol**, **Boolean**, **Number**, and **String**; an object is a member of the remaining built-in type **Object**; and a function is a callable object. A function that is associated with an object via a property is a **method**.

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**

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object, the **Boolean** object, the **Number** object, the **Math** object, the **Date** object, the **RegExp** object, the **JSON** 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 use classes such as those in C++, Smalltalk, or Java. Instead objects may be created in various ways including via a literal notation or via **constructors** which create objects and then execute code that initialises all or part of them by assigning initial values to their properties. Each constructor is a function that 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 Date(2009, 11)** creates a new Date object. Invoking a constructor without using **new** has consequences that depend on the constructor. For example, **Date()** produces a string representation of the current date and time rather than an object.

Comment [AWB101]: This description probably need to be tweaked in light of new features such as class declarations and explicit exposure of the [[Prototype]] property

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.

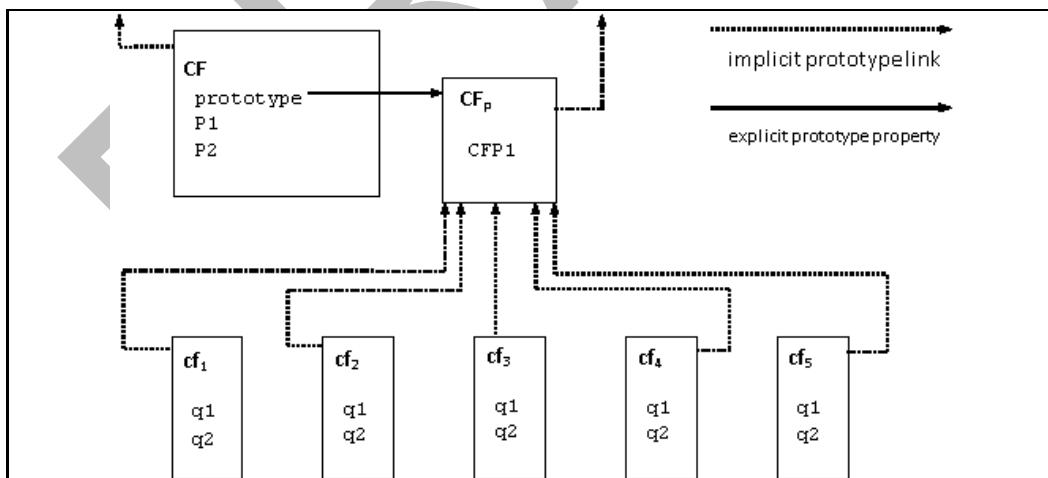


Figure 1 — Object/Prototype Relationships

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, while structure, behaviour, and state are all inherited.

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All objects that do not directly contain a particular property that their prototype contains share that property and its value. Figure 1 illustrates this:

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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 **CF_p**. The constructor, **CF**, has two properties itself, named **P₁** and **P₂**, which are not visible to **CF_p**, **cf₁**, **cf₂**, **cf₃**, **cf₄**, or **cf₅**. The property named **CFP₁** in **CF_p** is shared by **cf₁**, **cf₂**, **cf₃**, **cf₄**, and **cf₅** (but not by **CF**), as are any properties found in **CF_p**'s implicit prototype chain that are not named **q₁**, **q₂**, or **CFP₁**. Notice that there is no implicit prototype link between **CF** and **CF_p**.

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 **CF_p**.

4.2.2 The Strict Variant of ECMAScript

The ECMAScript Language recognises 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 enhanced error checking, or for other reasons of their choosing. In support of this possibility, ECMAScript defines a strict variant of the language. The strict variant of the language excludes some specific syntactic and semantic features of the regular 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 code unit, strict mode only imposes restrictions that have local effect within such a code unit. Strict mode does not restrict or modify any aspect of the ECMAScript semantics that must operate consistently across multiple code units. A complete ECMAScript program may be composed for both strict mode and non-strict mode ECMAScript code units. In this case, strict mode only applies when actually executing code that is defined within a strict mode code 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 code units into a single composite program.

4.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.3.1 type

set of data values as defined in Clause 8 of this specification

4.3.2 primitive value

member of one of the types Undefined, Null, Symbol, Boolean, Number, or String as defined in Clause 8

NOTE A primitive value is a datum that is represented directly at the lowest level of the language implementation.

4.3.3 object

member of the type Object

NOTE An object is a collection of properties and has a single prototype object. The prototype may be the null value.

4.3.4

constructor

function object that creates and initialises objects

NOTE 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

object that provides shared properties for other objects

NOTE 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. Alternatively, a new object may be created with an explicitly specified prototype by using the `Object.create` built-in function.

4.3.6

ordinary object

object that has the default behaviour for the internal methods that must be supported by all ECMAScript objects.

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4.3.7

exotic object

object that has some alternative behaviour for one or more of the internal methods that must be supported by all ECMAScript objects.

NOTE Any object that is not an ordinary object is an exotic object.

4.3.8

standard object

object whose semantics are defined by this specification.

Deleted: NOTE 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.||

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4.3.9

built-in object

object supplied by an ECMAScript implementation, independent of the host environment, that is present at the start of the execution of an ECMAScript program

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host exotic object||
object that has some alternative behaviour for one or more of the internal methods that must be supported by all ECMAScript objects supplied by the host environment to complete the execution environment of ECMAScript||
NOTE Any object that is not a native ordinary object is a host exotic object.||

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4.3.10

undefined value

primitive value used when a variable has not been assigned a value

4.3.11

Undefined type

type whose sole value is the **undefined** value

4.3.12

null value

primitive value that represents the intentional absence of any object value

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4.3.13

Null type

type whose sole value is the null value

4.3.14

Boolean value

member of the Boolean type

NOTE There are only two Boolean values, **true** and **false**.

4.3.15

Boolean type

type consisting of the primitive values **true** and **false**

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4.3.16

Boolean object

member of the Object type that is an instance of the standard built-in **Boolean** constructor

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4.3.17

String value

primitive value that is a finite ordered sequence of zero or more 16-bit unsigned integer

4.3.18

String type

set of all possible String values

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4.3.19

String object

member of the Object type that is an instance of the standard built-in **String** constructor

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4.3.20

Number type

primitive value corresponding to a double-precision 64-bit binary format IEEE 754 value

4.3.21

Number type

set of all possible Number values including the special “Not-a-Number” (NaN) value, positive infinity, and negative infinity

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4.3.22

Number object

member of the Object type that is an instance of the standard built-in **Number** constructor

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4.3.23

Infinity

number value that is the positive infinite Number value

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4.3.24

NaN

number value that is a IEEE 754 “Not-a-Number” value

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4.3.25**function**

member of the Object type that may be invoked as a subroutine

NOTE In addition to its 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.

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4.3.26**built-in function**

built-in object that is a function

NOTE Examples of built-in functions include `parseInt` and `Math.exp`. An implementation may provide implementation-dependent built-in functions that are not described in this specification.

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4.3.27**property**

association between a name and a value that is a part of an object

NOTE 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 object) or indirectly by a pair of accessor functions.

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4.3.28**method**

function that is the value of a property

NOTE When a function is called as a method of an object, the object is passed to the function as its `this` value.

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4.3.29**built-in method**

method that is a built-in function

NOTE Standard built-in methods are defined in this specification, and an ECMAScript implementation may specify and provide other additional built-in methods.

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4.3.30**attribute**

internal value that defines some characteristic of a property

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4.3.31**own property**

property that is directly contained by its object

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4.3.32**inherited property**

property of an object that is not an own property but is a property (either own or inherited) of the object's prototype

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5 Notational Conventions

5.1 Syntactic and Lexical Grammars

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.

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A chain production is a production that has exactly one nonterminal symbol on its right-hand side along with zero or more terminal symbols.

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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 characters (Unicode code units) that conform to the rules for *SourceCharacter* defined in Clause 6. It defines a set of productions, starting from the goal symbol *InputElementDiv* or *InputElementRegExp*, that describe how sequences of such 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 as defined by *SourceCharacter*. It defines a set of productions, starting from the goal symbol *Pattern*, that describe how sequences of 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

Another 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 *SourceCharacter*. 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 *Script*, that describe how sequences of tokens can form syntactically correct independent components of an ECMAScript programs.

When a stream of characters is to be parsed as an ECMAScript *script*, 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 syntactic grammar. The *script* is syntactically in error if the tokens in the stream of input elements cannot be parsed as a single instance of the goal nonterminal *Script*, 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 clauses 11, 12, 13 and 14 is actually not a complete account of which token sequences are accepted as correct ECMAScript *scripts*. 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.

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In certain cases in order to avoid ambiguities the syntactic grammar uses generalise productions that permit token sequences that are not valid ECMAScript scripts. For example, this technique is used in with object literals and object destructuring patterns. In such cases a more restrictive *supplemental grammar* is provided that further restricts the acceptable token sequences. In certain contexts, when explicitly specific, the input elements corresponding to such a production are parsed again using a goal symbol of a supplemental grammar. The script is syntactically in error if the tokens in the stream of input elements cannot be parsed as a single instance of the supplemental goal symbol, with no tokens left over.

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5.1.5 The JSON Grammar

The JSON grammar is used to translate a String describing a set of ECMAScript objects into actual objects. The JSON grammar is given in 15.12.1.

The JSON grammar consists of the JSON lexical grammar and the JSON syntactic grammar. The JSON lexical grammar is used to translate character sequences into tokens and is similar to parts of the ECMAScript lexical grammar. The JSON syntactic grammar describes how sequences of tokens from the JSON lexical grammar can form syntactically correct JSON object descriptions.

Productions of the JSON lexical grammar are distinguished by having two colons “::” as separating punctuation. The JSON lexical grammar uses some productions from the ECMAScript lexical grammar. The JSON syntactic grammar is similar to parts of the ECMAScript syntactic grammar. Productions of the JSON syntactic grammar are distinguished by using one colon “:” as separating punctuation.

5.1.6 Grammar Notation

Terminal symbols of the lexical, RegExp, and numeric string grammars, and some of the terminal symbols of the other grammars, 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 *script* either exactly as written or using equivalent Unicode escape sequences (see clause 6). All terminal symbol 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.

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Nonterminal symbols are shown in *italic* type. The definition of a nonterminal (also called a “production”) 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
  ArgumentList , AssignmentExpression
```

states that an *ArgumentList* may represent either a single *AssignmentExpression* or an *ArgumentList*, followed by a comma, followed by an *AssignmentExpression*. This definition of *ArgumentList* is recursive, that is, 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 Initialiser_{opt}

is a convenient abbreviation for:

VariableDeclaration :
Identifier
Identifier Initialiser

and that:

IterationStatement :
for (*ExpressionNoIn_{opt}* ; *Expression_{opt}* ; *Expression_{opt}*) *Statement*

is a convenient abbreviation for:

IterationStatement :
for (; *Expression_{opt}* ; *Expression_{opt}*) *Statement*
for (*ExpressionNoIn* ; *Expression_{opt}* ; *Expression_{opt}*) *Statement*

which in turn is an abbreviation for:

IterationStatement :
for (; ; *Expression_{opt}*) *Statement*
for (; *Expression* ; *Expression_{opt}*) *Statement*
for (*ExpressionNoIn* ; ; *Expression_{opt}*) *Statement*
for (*ExpressionNoIn* ; *Expression* ; *Expression_{opt}*) *Statement*

which in turn is an abbreviation for:

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

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

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

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 \notin set]” appears in the right-hand side of a production, it indicates that the production may not be used if the immediately following input token 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 ::
n [lookahead \notin {1, 3, 5, 7, 9}] *DecimalDigits*
DecimalDigit [lookahead \notin *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:

ThrowStatement :
throw [no LineTerminator here] *Expression* ;

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

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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 script.

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The lexical grammar has multiple goal symbols and the appropriate goal symbol to use depends upon the syntactic grammar context. If a phrase of the form “[Lexical goal LexicalGoalSymbol]” appears on the right-hand-side of a syntactic production then the next token must be lexically recognised using the indicated goal symbol. In the absence of such a phrase the default lexical goal symbol is used.

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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 sans-serif type in cases where it would be impractical to list all the alternatives:

SourceCharacter ::
any Unicode character

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5.2 Algorithm Conventions

The specification often uses a numbered list to specify steps in an algorithm. These algorithms are used to precisely specify the required semantics of ECMAScript language constructs. The algorithms are not intended to imply the use of any specific implementation technique. In practice, there may be more efficient algorithms available to implement a given feature.

Algorithms may be explicitly parameterised, in which case the names and usage of the parameters must be provided as part of the algorithm's definition. In order to facilitate their use in multiple parts of this specification, some algorithms, called *abstract operations*, are named and written in parameterised functional form so that they may be referenced by name from within other algorithms.

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Algorithms may be associated with productions of one of the ECMAScript grammars. A production that has multiple alternative definitions will typically have a distinct algorithm for each alternative. When an algorithm is associated with a grammar production, it may reference the terminal and non-terminal symbols of the production alternative as if they were parameters of the algorithm. When used in this manner, non-terminal symbols refer to the actual alternative definition that is matched when parsing the script source code.

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Unless explicitly specified otherwise, all chain productions have an implicit associated definition for every algorithm that might be applied to that production's left-hand side nonterminal. The implicit simply reapplies the same algorithm name with the same parameters, if any, to the chain production's sole right-hand side nonterminal and then result. For example, assume there is a production

Block :
{ *StatementList* }

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but there is no evaluation algorithm that is explicitly specified for that production. If in some algorithm there is a statement of the form: “Return the result of evaluating *Block*” it is implicit that the algorithm has an evaluation algorithm of the form:

Runtime Semantics: Evaluation

Block : { *StatementList* }

1. Return the result of evaluating *StatementList*

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 labelled 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.

Deleted: 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*”. ¶

- b. Substep
 - i. Subsubstep.
 - ii. Subsubstep.
 - 1. Subsubsubstep
 - a Subsubsubsubstep

A step or substep may be written as an "if" 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 "if" predicate step at the same level.

A step may specify the iterative application of its substeps.

A step may assert an invariant condition of its algorithm. Such assertions are used to make explicit algorithmic invariants that would otherwise be implicit. Such assertions add no additional semantic requirements and hence need not be checked by an implementation. They are used simply to clarify algorithms.

Mathematical operations such as addition, subtraction, negation, multiplication, division, and the mathematical functions defined later in this clause 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 $\text{abs}(x)$ yields the absolute value of x , which is $-x$ if x is negative (less than zero) and otherwise is x itself.

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

The mathematical function $\text{min}(x_1, x_2, \dots, x_n)$ yields the mathematically smallest of x_1 through x_n .

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 $\text{abs}(k) < \text{abs}(y)$ and $x-k = q \times y$ for some integer q .

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

NOTE $\text{floor}(x) = x - (x \text{ modulo } 1)$.

5.3 Static Semantic Rules

Context-free grammars are not sufficiently powerful to express all the rules that define whether a stream of input elements make up a valid ECMAScript script that may be evaluated. In some situations additional rules are needed that may be expressed using either ECMAScript algorithm conventions or prose requirements. Such rules are always associated with a production of a grammar and are called the static semantics of the production.

Static Semantic Rules have names and typically are defined using an algorithm. Named Static Semantic Rules are associated with grammar productions and a production that has multiple alternative definitions will typically have for each alternative a distinct algorithm for each applicable named static semantic rule.

Unless otherwise specified every grammar production alternative in this specification implicitly has a definition for a static semantic rule named `Contains` which takes an argument named `symbol` whose value is a terminal or non-terminal of the grammar that includes the associated production. The default definition of `Contains` is:

1. For each terminal and non-terminal grammar symbol `sym`, in the definition of this production do
 - a. If `sym` is the same grammar symbol as `symbol`, return `true`.
 - b. If `sym` is a non-terminal, then

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

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Deleted: grammar

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- i. Let *contained* be the result of Contains for *sym* with argument *symbol*.
- ii. If *contained* is true, return true.

2. Return false.

The above definition is explicitly over-ridden for specific productions.

A special kind of static semantic rule is an Early Error Rule. Early error rules define early error conditions (see clause 16) that are associate with specific grammar productions. Evaluation of most early error rules are not explicitly invoked within the algorithms of this specification. A conforming implementation must, prior to the first evaluation of a Script, validate all of the early error rules of the productions used to parse that Script. If any of the early error rules are violated the Script is invalid and cannot be evaluated.

6 Source Text

Syntax

SourceCharacter ::
any Unicode character

The ECMAScript code is expressed using Unicode, version 5.1 or later. ECMAScript source text is a sequence of Unicode characters. The phrase "Unicode character" refers to the abstract linguistic or typographical unit represented by a single Unicode scalar value. The actual encodings used to store and interchange ECMAScript source text is not relevant to this specification. Any well-defined encoding such as UTF-32 or UTF-16 may be used. Source text might even be externally represented using a non-Unicode character encoding. Regardless of the external source text encoding, a conforming ECMAScript implementation processes the source text as if it was an equivalent sequence of *SourceCharacter* values. Each *SourceCharacter*, being an abstract Unicode character, with a corresponding Unicode scalar value. Conforming ECMAScript implementations are not required to perform any normalisation of text, or behave as though they were performing normalisation of text.

The phrase "code point" refers to such a Unicode scalar value. "Unicode character" 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, template literals and identifiers, any Unicode characters may also be expressed as a Unicode escape sequence that explicitly express a code point's numeric value. Within a comment, such an escape sequence is effectively ignored as part of the comment. Within other contexts, such an escape sequence contextually contributes one Unicode character.

NOTE 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 Unicode 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 Unicode character to the literal and is never interpreted as a line terminator or as a quote mark that might terminate the string literal.

ECMAScript String values (8.4) are computational sequences of 16-bit integer values called "code units". ECMAScript language constructs that generate string values from *SourceCharacter* sequences use UTF-16 encoding to generate the code unit values.

Static Semantics: UTF-16 Encoding

The UTF-16 Encoding of a numeric code point value, *cp*, is determined as follows:

1. Assert: $0 \leq cp \leq 0x1FFFFF$
2. If *cp* < 65535, then return *cp*.
3. Let *cu1* be floor((*cp* - 65536) / 1024) + 55296. NOTE 55296 is 0xD800.

Deleted: I

Deleted: An

Deleted: Program

Deleted: static semantic

Deleted: used to

Deleted: a

Deleted: Program

Deleted: prior to the first evaluation of that Program

Comment [AW2]: Perhaps this should be somewhere else. Currently we don't have a section that enumerates all the steps in loading and evaluating a program.

Deleted: static semantic

Deleted: Program

Deleted:

Deleted: Static semantic rule violations are early errors (see clause 16) and reported in the same manner as syntax errors.

Deleted: ECMAScript source text is represented as a sequence of characters in the Unicode character encoding, version 3.0 or later. The text is expected to have been normalised to Unicode Normalization Form (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. ECMAScript source text is assumed to be a sequence 16-bit code units for the purposes of this specification. Such a source text may include sequences of 16-bit code units that are not valid UTF-16 character encodings. If actual source text is encoded in a form other than 16-bit code units it must be processed as if it was first converted to UTF-16.¶

Deleted: code unit

Deleted: well defined

Deleted: source character

Deleted: s

Deleted: Throughout the rest of this document, the phrase "code unit" and the word "character" will be used to refer to a 16-bit unsigned value used to represent a single 16-bit unit of text. The phrase "Unicode character" will be used to refer to the abstract linguistic or typographical unit represented by a single Unicode scalar value.

Deleted: quasi

Deleted: (code unit)

Deleted: consisting

Deleted: of six characters, namely \u plus four

Deleted: Within a string literal or regular expression

Deleted: the

Deleted: to the identifier

Deleted: ¶

Formatted: Note

Deleted: NOTE Although this document sometimes

Deleted: String value of the

Deleted: determined

4. Let cu_2 be $((cp - 65536) \text{ modulo } 1024) + 56320$. NOTE 56320 is $0xDC00$.
5. Return the code unit sequence consisting of cu_1 followed by cu_2 .

7 Lexical Conventions

The source text of an ECMAScript script is first converted into a sequence of input elements, which are 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.

Deleted: program

There are several situations where the identification of lexical input elements is sensitive to the syntactic grammar context that is consuming the input elements. This requires multiple goal symbols for the lexical grammar. The *InputElementDiv* goal symbol is the default goal symbol and is used in those syntactic grammar contexts where a leading division (/) or division-assignment (/=) operator is permitted. The *InputElementRegExp* goal symbol is used in all syntactic grammar contexts where a *RegularExpressionLiteral* is permitted. The *InputElementTemplateTail* goal is used in syntactic grammar contexts where a *TemplateLiteral* logically continues after a substitution element.

Deleted: o

Deleted: There

Deleted: are two

Deleted: other

Deleted: Quasi

Deleted: Quasi

Comment [AWB93]: May need to also say something about *TemplateSubstitution tail*. Also need to consider with there are any ASI issues concerning it.

NOTE There are no syntactic grammar contexts where both a leading division or division-assignment, and a leading *RegularExpressionLiteral* are permitted. This is not affected by semicolon insertion (see 7.9); in examples such as the following:

```
a = b
/hi/g.exec(c).map(d);
```

where the first non-whitespace, non-comment character after a *LineTerminator* is slash (/) and the syntactic context allows division or division-assignment, no semicolon is inserted at the *LineTerminator*. That is, the above example is interpreted in the same way as:

```
a = b / hi / g.exec(c).map(d);
```

Syntax

InputElementDiv ::
WhiteSpace
LineTerminator
Comment
Token
DivPunctuator
RightBracePunctuator

Deleted: Quasi

InputElementRegExp ::
WhiteSpace
LineTerminator
Comment
Token
RightBracePunctuator
RegularExpressionLiteral

Deleted: Quasi

InputElementTemplateTail ::
WhiteSpace
LineTerminator
Comment
Token
DivPunctuator
TemplateSubstitutionTail

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 format-control characters in source text to facilitate editing and display. All format control characters may be used within comments, and within string literals, template literals, and regular expression literals.

<ZWNJ> and <ZWJ> are format-control characters that are used to make necessary distinctions when forming words or phrases in certain languages. In ECMAScript source text, <ZWNJ> and <ZWJ> may also be used in an identifier after the first character.

<BOM> is a format-control character used primarily at the start of a text to mark it as Unicode and to allow detection of the text's encoding and byte order. <BOM> characters intended for this purpose can sometimes also appear after the start of a text, for example as a result of concatenating files. <BOM> characters are treated as white space characters (see 7.2).

The special treatment of certain format-control characters outside of comments, string literals, and regular expression literals is summarised in [Table 1](#).

Table 1 — Format-Control Character Usage

Code Point	Name	Formal Name	Usage
U+200C	Zero width non-joiner	<ZWNJ>	<i>IdentifierPart</i>
U+200D	Zero width joiner	<ZWJ>	<i>IdentifierPart</i>
U+FEFF	Byte Order Mark	<BOM>	<i>Whitespace</i>

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 characters may occur between any two tokens and at the start or end of input. White space characters may occur within a StringLiteral, a RegularExpressionLiteral, a Template, or a TemplateSubstitutionTail where they are considered significant characters forming part of a literal value. They may also occur within a Comment, but cannot appear within any other kind of token.

The ECMAScript white space characters are listed in [Table 2](#).

Table 2 — Whitespace Characters

Code Point	Name	Formal Name
U+0009	Tab	<TAB>
U+000B	Vertical Tab	<VT>
U+000C	Form Feed	<FF>
U+0020	Space	<SP>
U+00A0	No-break space	<NBSP>
U+FEFF	Byte Order Mark	<BOM>
Other category “Zs”	Any other Unicode “space separator”	<USP>

ECMAScript implementations must recognise all of the white space characters defined in Unicode 5.1. Later editions of the Unicode Standard may define other white space characters. ECMAScript implementations may recognise white space characters from later editions of the Unicode Standard.

Deleted: , quasis

Deleted: *Unit*

Deleted: *Value*

Deleted: \u

Deleted: \u

Deleted: \u

Deleted: also

Deleted: or

Deleted:

Deleted: *Quasi*

Deleted: *Quasi*

Deleted: (

Deleted: the

Deleted:)

Deleted: or

Deleted: *Unit*

Deleted: *Value*

Deleted: \u

Deleted: \u

Deleted: \u

Deleted: \u

Deleted: \u

Deleted: 3

Deleted: 0

Syntax

```
WhiteSpace ::  
    <TAB>  
    <VT>  
    <FF>  
    <SP>  
    <NBSP>  
    <BOM>  
    <USP>
```

7.3 Line Terminators

Comment [AWB94]: Need to talk about line terminators in Templates

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. Line terminators also affect the process of automatic semicolon insertion (7.9). A line terminator cannot occur within any token except a *StringLiteral*, *Template*, or *TemplateSubstitutionTail*. Line terminators may only occur within a *StringLiteral* token as part of a *LineContinuation*.

Deleted: Quasi
Deleted: Quasi

A line terminator can occur within a *MultiLineComment* (7.4) but cannot occur within a *SingleLineComment*.

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

The ECMAScript line terminator characters are listed in Table 3.

Table 3 — Line Terminator Characters

Code Point	Name	Formal Name
U+000A	Line Feed	<LF>
U+000D	Carriage Return	<CR>
U+2028	Line separator	<LS>
U+2029	Paragraph separator	<PS>

Deleted: Unit
Deleted: Value
Deleted: \u
Deleted: \u
Deleted: \u
Deleted: character
Deleted: character

Only the Unicode characters in Table 3 are treated as line terminators. Other new line or line breaking Unicode characters are treated as white space but not as line terminators. The sequence <CR><LF> is commonly used as a line terminator. It should be considered a single SourceCharacter for the purpose of reporting line numbers.

Syntax

```
LineTerminator ::  
    <LF>  
    <CR>  
    <LS>  
    <PS>
```

```
LineTerminatorSequence ::  
    <LF>  
    <CR> [lookahead ≠ <LF>]  
    <LS>  
    <PS>  
    <CR> <LF>
```

7.4 Comments

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

Because a single-line comment can contain any Unicode 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 (see 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 ::

`/* MultiLineCommentCharsopt */`

MultiLineCommentChars ::

MultiLineNotAsteriskChar *MultiLineCommentChars_{opt}*
 `* PostAsteriskCommentCharsopt`

PostAsteriskCommentChars ::

MultiLineNotForwardSlashOrAsteriskChar *MultiLineCommentChars_{opt}*
 `* PostAsteriskCommentCharsopt`

MultiLineNotAsteriskChar ::

SourceCharacter **but not** `*`

MultiLineNotForwardSlashOrAsteriskChar ::

SourceCharacter **but not one of** `/` `*`

SingleLineComment ::

`// SingleLineCommentCharsopt`

SingleLineCommentChars ::

SingleLineCommentChar *SingleLineCommentChars_{opt}*

SingleLineCommentChar ::

SourceCharacter **but not** *LineTerminator*

7.5 Tokens

Syntax

Token ::

IdentifierName
 Punctuator
 NumericLiteral
 StringLiteral
 Template

Deleted: *Quasi*

NOTE The *DivPunctuator*, *RegularExpressionLiteral*, *RightBracePunctuator*, and *TemplateSubstitutionTail* productions define tokens, but are not included in the *Token* production.

Deleted: *and*

Deleted: *Quasi*

7.6 Identifier Names and Identifiers

IdentifierName, Identifier, and ReservedWord are tokens that are interpreted according to the Default Identifier Syntax given in Unicode Standard Annex #31, Identifier and Pattern Syntax, with some small modifications. ReservedWord is an enumerated subset of IdentifierName and Identifier is an IdentifierName that is not a ReservedWord (see 7.6.1). The Unicode identifier grammar is based on character properties specified by the Unicode Standard. The Unicode characters in the specified categories in version 5.1.0 of the Unicode standard must be treated as in those categories by all conforming ECMAScript implementations. ECMAScript implementations may recognise identifier characters defined in later editions of the Unicode Standard.

NOTE 1 This standard specifies specific character additions: The dollar sign (u+0024) and the underscore (u+005f) are permitted anywhere in an IdentifierName, and the characters zero width non-joiner (U+200C) and zero width joiner (U+200D) are permitted anywhere after the first character of an IdentifierName.

Unicode escape sequences are permitted in an IdentifierName, where they contribute a single Unicode character to the IdentifierName. The code point of the contributed character is expressed by the HexDigits of the UnicodeEscapeSequence (see 7.8.6). The \ preceding the UnicodeEscapeSequence and the u and \ characters, if they appear, do not contribute characters to the IdentifierName. A UnicodeEscapeSequence cannot be used to put a character into an IdentifierName that would otherwise be illegal. In other words, if a \ UnicodeEscapeSequence sequence were replaced by the Unicode character it contributes, the result must still be a valid IdentifierName that has the exact same sequence of characters as the original IdentifierName. All interpretations of IdentifierName within this specification are based upon their actual characters regardless of whether or not an escape sequence was used to contribute any particular characters.

Two IdentifierName that are canonically equivalent according to the Unicode standard are *not* equal unless they are represented by the exact same sequence of code units (in other words, conforming ECMAScript implementations are only required to do bitwise comparison on IdentifierName values).

NOTE 2 If maximal portability is a concern, programmers should only employ the identifier characters that were defined in Unicode 3.0.

Syntax

Identifier ::
 IdentifierName **but not** ReservedWord

IdentifierName ::
 IdentifierStart
 IdentifierName IdentifierPart

IdentifierStart ::
 UnicodeIDStart
 \$
 \ UnicodeEscapeSequence

IdentifierPart ::
 UnicodeIDContinue
 \$
 \ UnicodeEscapeSequence
 <ZWNJ>
 <ZWJ>

UnicodeIDStart ::
 any Unicode character **with the Unicode property "ID_Start"**

UnicodeIDContinue ::
 any Unicode character **with the Unicode property "ID_Continue"**

Deleted: Identifier,
Deleted: Identifier Names
Deleted: grammar given in the "Identifiers" section of chapter 5 of the Unicode standard
Deleted: An
Deleted: both normative and informative
Deleted: categories
Deleted: 3
Formatted: Note
Deleted: (\$)
Deleted: ()
Deleted: also
Deleted: ,
Deleted: as computed by the CV of the
Deleted: 4
Deleted: es
Deleted: a
Deleted: its
Deleted: <u>UnicodeEscapeSequence's CV</u>
Deleted: identifiers
Deleted: The intent is that the incoming source text has been converted to normalised form C before it reaches the compiler.
Formatted: Note
Deleted: ECMAScript implementations may recognise identifier characters defined in later editions of the Unicode Standard.
Comment [AWB95]: Norbert suggests changing this to 5.1.0. Would be really be better for "portability"?
Deleted: <u>UnicodeLetter</u>
Deleted: <u>IdentifierStart</u>
Deleted: <u>Identifier</u>
Deleted: <u>UnicodeCombiningMark</u> . <u>UnicodeDigit</u> <u>UnicodeConnectorPunctuation</u>
Deleted: <u>UnicodeLetter</u>
Deleted: in
Deleted: categories
Deleted: Uppercase letter (Lu)
Deleted: , "Lowercase letter (Ll)", "Titlecase letter (Lt)", "Modifier letter (Lm)", "Other letter (Lo)", or "Letter number (Ni)"
Deleted: Start
Deleted: <u>UnicodeCombiningMark</u>
Deleted: in
Deleted: categories
Deleted: Non-spacing mark (Mn)
Deleted: or "Combining spacing mark (Mc)"

The definitions of the nonterminal *UnicodeEscapeSequence* is given in 7.8.6

Static Semantics: StringValue

Identifier :: *IdentifierName* but not *ReservedWord*

1. Return the StringValue of *IdentifierName*.

IdentifierName ::

IdentifierStart
IdentifierName IdentifierPart

1. Return the String value consisting of the sequence of code units corresponding to *IdentifierName*. In determining the sequence any occurrences of \ *UnicodeEscapeSequence* are first replaced with the code point represented by the *UnicodeEscapeSequence* and then the code points of the entire *IdentifierName* are converted to code units by UTF-16 Encoding (clause 6) each code point.

7.6.1 Reserved Words

A reserved word is an *IdentifierName* that cannot be used as an *Identifier*.

Syntax

ReservedWord ::
 Keyword
 FutureReservedWord
 NullLiteral
 BooleanLiteral

The *ReservedWord* definitions are specified as literal sequences of Unicode characters. However, any Unicode character in a *ReservedWord* can also be expressed by a \ *UnicodeEscapeSequence* that expresses that same Unicode character's code point. Use of such escape sequences does not change the meaning of the *ReservedWord*.

7.6.1.1 Keywords

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

Syntax

<i>Keyword</i> :: one of			
break	delete	import	this
case	do	in	throw
catch	else	instanceof	try
<u>class</u>	<u>export</u>	<u>let</u>	<u>typeof</u>
<u>continue</u>	<u>finally</u>	<u>new</u>	<u>var</u>
<u>const</u>	for	return	<u>void</u>
debugger	function	<u>super</u>	while
default	if	switch	with

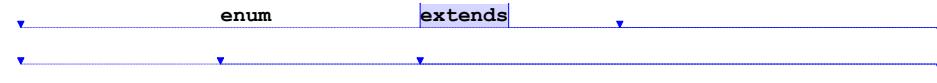
7.6.1.2 Future Reserved Words

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.

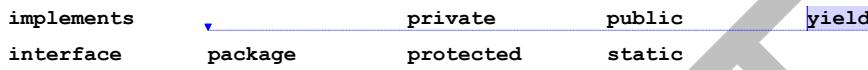
Deleted: *UnicodeDigit* :: any character in the Unicode category "Decimal number (Nd)"
UnicodeConnectorPunctuation :: any character in the Unicode category "Connector punctuation (Pc)"
Deleted: 4
Deleted:
Deleted: *Semantics*
 The String value of the production
Deleted: is determined as follows:
Deleted:
Deleted: v
Deleted: consisting
Deleted: The String value of *IdentifierName* is determined follows:
Deleted: characters
Deleted: a
Deleted: and

Syntax

FutureReservedWord :: **one of**



The following tokens are also considered to be *FutureReservedWords* when they occur within strict mode code (see 10.1.1). The occurrence of any of these tokens within strict mode code in any context where the occurrence of a *FutureReservedWord* would produce an error must also produce an equivalent error:



Comment [AWB86]: It isn't clear that external actually needs to be reserved. It's only usage is highly contextual.

Deleted: class

Deleted: super

Deleted: const

Deleted: export

Deleted: import

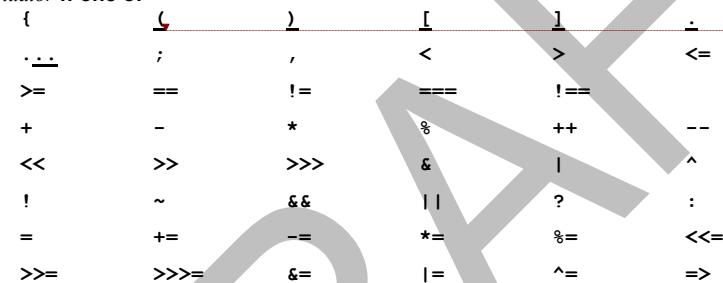
Comment [AWB87]: Move to keywords

Deleted: 1st

7.7 Punctuators

Syntax

Punctuator :: one of



Deleted: 3

DivPunctuator :: **one of**

7.8 Literals

7.8.1 Null Literals

Syntax

NullLiteral ::

7.8.2 Boolean Literals

Syntax

BooleanLiteral ::=
 true
 false

```
Deleted: Syntax¶
Literal ::= ¶
NullLiteral
ValueLiteral
¶
ValueLiteral ::= ¶
BooleanLiteral
NumericLiteral
StringLiteral
RegularExpressionLiteral¶
```

Deleted: Semantics¶
The value of the null literal `null` is the sole value of the Null type, namely `null`.¶

7.8.3 Numeric Literals

Syntax

NumericLiteral ::
DecimalLiteral
BinaryIntegerLiteral
OctalIntegerLiteral
HexIntegerLiteral

DecimalLiteral ::
DecimalIntegerLiteral . *DecimalDigits*_{opt} *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

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

ExponentPart ::
ExponentIndicator *SignedInteger*

ExponentIndicator :: one of
e E

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

BinaryIntegerLiteral ::
0b *BinaryDigit*
0B *BinaryDigit*
BinaryIntegerLiteral *BinaryDigit*

BinaryDigit :: one of
0 1

OctalIntegerLiteral ::
0o *OctalDigit*
0O *OctalDigit*
OctalIntegerLiteral *OctalDigit*

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

HexIntegerLiteral ::
0x *HexDigits*
0X *HexDigits*

Deleted: 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.

Comment [AWB78]: From March 29 meeting notes:
Hex floating point literals:
Waldemar: Other languages include these things.
They're rarely used but when you want one, you really want one. Use cases are similar to that of hex literals.
Will explore adding them.
MarkM: `0x3.p1` currently evaluates to undefined. This would be a breaking change.
Waldemar: Not clear anyone would notice. How did other languages deal with this?

Comment [AWB79]: The various Digit productions could be refactored to have less redundancy

HexDigits ::

HexDigit

~~HexDigits HexDigit~~

Deleted:

Deleted: *IntegerLiteral*

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

The SourceCharacter, immediately following a NumericLiteral must not be an IdentifierStart or DecimalDigit.

Deleted: *source character*

NOTE For example:

3in

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

A conforming implementation, when processing strict mode code (see 10.1.1), must not extend the syntax of NumericLiteral to include OctalIntegerLiteral as described in B.1.1.

Static Semantics: MV's

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 NumericLiteral :: DecimalLiteral is the MV of DecimalLiteral.
- The MV of NumericLiteral :: BinaryIntegerLiteral is the MV of BinaryIntegerLiteral.
- The MV of NumericLiteral :: OctalIntegerLiteral is the MV of OctalIntegerLiteral.
- 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 is the MV of DecimalDigits times 10^{-n} , where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: . DecimalDigits ExponentPart is the MV of DecimalDigits times 10^{e-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 :: NonZeroDigit is the MV of NonZeroDigit.
- The MV of DecimalIntegerLiteral :: NonZeroDigit DecimalDigits is (the MV of NonZeroDigit times 10^n) plus the MV of DecimalDigits, where n is the number of characters in DecimalDigits.
- The MV of DecimalDigits :: DecimalDigit is the MV of DecimalDigit.
- The MV of DecimalDigits :: DecimalDigits DecimalDigit is (the MV of DecimalDigits times 10) plus the MV of DecimalDigit.
- The MV of ExponentPart :: ExponentIndicator SignedInteger is the MV of SignedInteger.
- The MV of SignedInteger :: DecimalDigits is the MV of DecimalDigits.
- The MV of SignedInteger :: + DecimalDigits is the MV of DecimalDigits.
- The MV of SignedInteger :: - DecimalDigits is the negative of the MV of DecimalDigits.
- The MV of DecimalDigit :: 0 or of HexDigit :: 0 or of OctalDigit :: 0 or of BinaryDigit :: 0 is 0.
- The MV of DecimalDigit :: 1 or of NonZeroDigit :: 1 or of HexDigit :: 1 or of OctalDigit :: 1 or of BinaryDigit :: 1 is 1.

Deleted:

- The MV of *DecimalDigit* :: 2 or of *NonZeroDigit* :: 2 or of *HexDigit* :: 2 or of *OctalDigit* :: 2 is 2.
- The MV of *DecimalDigit* :: 3 or of *NonZeroDigit* :: 3 or of *HexDigit* :: 3 or of *OctalDigit* :: 3 is 3.
- The MV of *DecimalDigit* :: 4 or of *NonZeroDigit* :: 4 or of *HexDigit* :: 4 or of *OctalDigit* :: 4 is 4.
- The MV of *DecimalDigit* :: 5 or of *NonZeroDigit* :: 5 or of *HexDigit* :: 5 or of *OctalDigit* :: 5 is 5.
- The MV of *DecimalDigit* :: 6 or of *NonZeroDigit* :: 6 or of *HexDigit* :: 6 or of *OctalDigit* :: 6 is 6.
- The MV of *DecimalDigit* :: 7 or of *NonZeroDigit* :: 7 or of *HexDigit* :: 7 or of *OctalDigit* :: 7 is 7.
- The MV of *DecimalDigit* :: 8 or of *NonZeroDigit* :: 8 or of *HexDigit* :: 8 is 8.
- The MV of *DecimalDigit* :: 9 or of *NonZeroDigit* :: 9 or of *HexDigit* :: 9 is 9.
- The MV of *HexDigit* :: a or of *HexDigit* :: A is 10.
- The MV of *HexDigit* :: b or of *HexDigit* :: B is 11.
- The MV of *HexDigit* :: c or of *HexDigit* :: C is 12.
- The MV of *HexDigit* :: d or of *HexDigit* :: D is 13.
- The MV of *HexDigit* :: e or of *HexDigit* :: E is 14.
- The MV of *HexDigit* :: f or of *HexDigit* :: F is 15.
- The MV of *BinaryIntegerLiteral* :: 0b *BinaryDigit* is the MV of *BinaryDigit*.
- The MV of *BinaryIntegerLiteral* :: 0B *BinaryDigit* is the MV of *BinaryDigit*.
- The MV of *BinaryIntegerLiteral* :: *BinaryIntegerLiteral* *BinaryDigit* is (the MV of *BinaryIntegerLiteral* times 2) plus the MV of *BinaryDigit*.
- The MV of *OctalIntegerLiteral* :: 0o *OctalDigit* is the MV of *OctalDigit*.
- The MV of *OctalIntegerLiteral* :: 0O *OctalDigit* is the MV of *OctalDigit*.
- The MV of *OctalIntegerLiteral* :: *OctalIntegerLiteral* *OctalDigit* is (the MV of *OctalIntegerLiteral* times 8) plus the MV of *OctalDigit*.
- The MV of *HexIntegerLiteral* :: 0x *HexDigits* is the MV of *HexDigits*.
- The MV of *HexIntegerLiteral* :: 0X *HexDigits* is the MV of *HexDigits*.
- The MV of *HexDigits* :: *HexDigit* is the MV of *HexDigit*.
- The MV of *HexDigits* :: *HexDigits* *HexDigit* is (the MV of *HexDigits* 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 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 (as specified 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 Regular Expression Literals

NOTE A regular expression literal is an input element that is converted to a *RegExp* object (see 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` (see 15.10.4) or calling the *RegExp* constructor as a function (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 source code comprising the *RegularExpressionBody* and the *RegularExpressionFlags* are subsequently parsed using the more stringent ECMAScript Regular Expression grammar (15.10.1).

An implementation may extend the ECMAScript Regular Expression grammar defined in 15.10.1, but it must not extend the *RegularExpressionBody* and *RegularExpressionFlags* productions defined below or the productions used by these productions.

Deleted: <#>The MV of *NumericLiteral* :: *BinaryIntegerLiteral* is the MV of *BinaryIntegerLiteral*.
 <#>The MV of *BinaryDigit* :: 0 is 0.
 <#>The MV of *BinaryDigit* :: 1 is 1.
 <#>The MV of *BinaryIntegerLiteral* :: 0ob *BinaryDigit* is the MV of *BinaryDigit*.
 <#>The MV of *BinaryIntegerLiteral* :: 0OB *BinaryDigit* is the MV of *BinaryDigit*.
 <#>The MV of *BinaryIntegerLiteral* :: *BinaryIntegerLiteral* *BinaryDigit* is (the MV of *BinaryIntegerLiteral* times 2) plus the MV of *BinaryDigit*.
 <#>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* :: 0o *OctalDigit* is the MV of *OctalDigit*.
 <#>The MV of *OctalIntegerLiteral* :: 0O *OctalDigit* is the MV of *OctalDigit*.
 <#>The MV of *OctalIntegerLiteral* :: *OctalIntegerLiteral* *OctalDigit* is (the MV of *OctalIntegerLiteral* times 8) plus the MV of *OctalDigit*.

Deleted: *HexIntegerLiteral*

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Deleted: *HexIntegerLiteral*

Deleted: A conforming implementation, when processing strict mode code (see 10.1.1), must not extend the syntax of *NumericLiteral* to include *OctalIntegerLiteral* as described in B.1.1.

Deleted: 7.8.4 String Literals

NOTE A string literal is zero or more Unicode character code points enclosed in single or double quotes. Unicode character code points may also be represented by an escape sequence. All characters may appear literally in a string literal except for the closing quote character, backslash, carriage return, line separator, paragraph separator, and line feed. Any character may appear in the form of an escape sequence. String literals evaluate to ECAMScript String values. When generating these string values Unicode character code points are UTF-16 encoded as defined in clause 6. Code points belonging to Basic Multilingual Plane are encoded as single code unit element of the string. All other Unicode character code points are encoded using UTF-16 as two code unit elements of the string.

Syntax

StringLiteral ::
 " *DoubleStringCharacters*_{opt} "
 ' *SingleStringCharacters*_{opt} '

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Formatted: Note

Deleted: Strings of characters

Deleted: passed uninterpreted to the regular expression constructor, which interprets them according to its own grammar.

Deleted: regular expression constructor's grammar

Syntax

RegularExpressionLiteral ::
 / *RegularExpressionBody* / *RegularExpressionFlags*

RegularExpressionBody ::
 RegularExpressionFirstChar *RegularExpressionChars*

RegularExpressionChars ::
 [empty]
 RegularExpressionChars *RegularExpressionChar*

RegularExpressionFirstChar ::
 RegularExpressionNonTerminator **but not one of * or \ or / or [**
 RegularExpressionBackslashSequence
 RegularExpressionClass

RegularExpressionChar ::
 RegularExpressionNonTerminator **but not one of \ or / or [**
 RegularExpressionBackslashSequence
 RegularExpressionClass

RegularExpressionBackslashSequence ::
 \ *RegularExpressionNonTerminator*

RegularExpressionNonTerminator ::
 SourceCharacter **but not** *LineTerminator*

RegularExpressionClass ::
 [*RegularExpressionClassChars*]

RegularExpressionClassChars ::
 [empty]
 RegularExpressionClassChars *RegularExpressionClassChar*

RegularExpressionClassChar ::
 RegularExpressionNonTerminator **but not one of] or **
 RegularExpressionBackslashSequence

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: /(?:)/.

Static Semantics: Early Errors

RegularExpressionFlags:: *RegularExpressionFlags IdentifierPart*

- It is a Syntax Error if *IdentifierPart* contains a Unicode escape sequence.

Static Semantics: BodyText

RegularExpressionLiteral :: / *RegularExpressionBody* / *RegularExpressionFlags*

1. Return the source code that was recognised as *RegularExpressionBody*.

Deleted: z

Static Semantics: FlagText

RegularExpressionLiteral :: / *RegularExpressionBody* / *RegularExpressionFlags*

1. Return the source code that was recognised as *RegularExpressionFlags*.

7.8.5 Template Literal Lexical Components

Syntax

Template ::

NoSubstitutionTemplate
TemplateHead

NoSubstitutionTemplate ::

` TemplateCharacters_{opt} `

TemplateHead ::

` TemplateCharacters_{opt} \${

TemplateSubstitutionTail ::

TemplateMiddle
TemplateTail

TemplateMiddle ::

} TemplateCharacters_{opt} \${

TemplateTail ::

} TemplateCharacters_{opt} `

TemplateCharacters ::

TemplateCharacter TemplateCharacters_{opt}

TemplateCharacter ::

SourceCharacter but not one of ` or \ or \$
\$ lookahead ∈ {`}
\ EscapeSequence
LineContinuation

Static Semantics: TV's and TRV's

A template literal component is interpreted as a sequence of Unicode characters. The Template Value (TV) of a literal component is described in terms of code unit values (CV, 7.8.4) contributed by the various parts of the template literal component. As part of this process, some Unicode characters within the template component are interpreted as having a mathematical value (MV, 7.8.3). In determining a TV, escape sequences are replaced by the code unit of the Unicode characters represented by the escape sequence. The Template Raw Value (TRV) is similar to a Template Value with the difference that in TRVs escape sequences are interpreted literally.

- The TV and TRV of NoSubstitutionTemplate :: `` is the empty code unit sequence.
- The TV and TRV of TemplateHead :: `\${ is the empty code unit sequence.
- The TV and TRV of TemplateMiddle :: \${ is the empty code unit sequence.
- The TV and TRV of TemplateTail :: ` is the empty code unit sequence.
- The TV of NoSubstitutionTemplate :: ` TemplateCharacters ` is the TV of TemplateCharacters.
- The TV of TemplateHead :: ` TemplateCharacters \${ is the TV of TemplateCharacters.
- The TV of TemplateMiddle :: } TemplateCharacters \${ is the TV of TemplateCharacters.
- The TV of TemplateTail :: } TemplateCharacters ` is the TV of TemplateCharacters.
- The TV of TemplateCharacters :: TemplateCharacter is the TV of TemplateCharacter.
- The TV of TemplateCharacters :: TemplateCharacter TemplateCharacters is a sequence consisting of the code units in the TV of TemplateCharacter followed by all the code units in the TV of TemplateCharacters in order.

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A regular expression literal evaluates to a value of Object type that is an instance of the standard built-in constructor RegExp. 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 the name. The newly constructed object becomes the value of the *RegularExpressionLiteral*. If the call to `new RegExp` would generate an error as specified in 15.10.4.1, the error must be treated as an early error (Clause 16).¶

Deleted: 6

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Deleted: 7.9

Deleted: Quasi

Deleted: FullQuasi...oSubstitutionTemplate .

Deleted: FullQuasi

Deleted: Quasi

Deleted: Quasi

Deleted: Quasi

Deleted: Quasi...emplateMiddle

Deleted: Quasi

Deleted: Quasi

Deleted: Quasi

Deleted: Quasi...emplateCharacter Quasi

Deleted: Quasi

Comment [AWB910]: Note that the original proposal allowed \$IdentifierName to be used as a substitution without {} around the name.

Deleted: QV...V's and RQV

Deleted: quasi...emplate literal component is interpreted

Deleted: QV...V and QRV...RV of FullQuasi

Deleted: QV...V and QRV...RV of Quasi

Deleted: QV...V and QRV...RV of Quasi

Deleted: r

Deleted: QV...V and QRV...RV of Quasi

Deleted: QV...V of FullQuasi...oSubstitutionTemplate ::

Deleted: QV...V of Quasi...emplateHead :: `

Deleted: QV...V of Quasi...emplateMiddle :: }

Deleted: QV...V of Quasi...emplateTail :: }

Deleted: QV...V of Quasi...emplateCharacters ::

Deleted: QV...V of Quasi...emplateCharacters ::

7.8.6 String Literals

NOTE A string literal is zero or more Unicode code points enclosed in single or double quotes. Unicode code points may also be represented by an escape sequence. All characters may appear literally in a string literal except for the closing quote character, backslash, carriage return, line separator, paragraph separator, and line feed. Any character may appear in the form of an escape sequence. String literals evaluate to ECAMScript String values. When generating these string values Unicode code points are UTF-16 encoded as defined in clause 6. Code points belonging to Basic Multilingual Plane are encoded as a single code unit element of the string. All other code points are encoded as two code unit elements of the string.

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Syntax

StringLiteral ::
 " DoubleStringCharacters_{opt} "
 ' SingleStringCharacters_{opt} '

DoubleStringCharacters ::
DoubleStringCharacter DoubleStringCharacters_{opt}

SingleStringCharacters ::
SingleStringCharacter SingleStringCharacters_{opt}

DoubleStringCharacter ::
SourceCharacter but not one of " or \ or LineTerminator
\ EscapeSequence
LineContinuation

SingleStringCharacter ::
SourceCharacter but not one of ' or \ or LineTerminator
\ EscapeSequence
LineContinuation

LineContinuation ::
\ LineTerminatorSequence

EscapeSequence ::
CharacterEscapeSequence
0 [lookahead ≠ DecimalDigit]
HexEscapeSequence
UnicodeEscapeSequence

A conforming implementation, when processing strict mode code (see 10.1.1), must not extend the syntax of EscapeSequence to include OctalEscapeSequence as described in B.1.2.

CharacterEscapeSequence ::
SingleEscapeCharacter
NonEscapeCharacter

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

NonEscapeCharacter ::
SourceCharacter but not one of EscapeCharacter or LineTerminator

EscapeCharacter ::
SingleEscapeCharacter
DecimalDigit
x
u

HexEscapeSequence ::
 x HexDigit HexDigit

UnicodeEscapeSequence ::
 u HexDigit HexDigit HexDigit HexDigit
 u{ HexDigits }

The definition of the nonterminal *HexDigit* is given in 7.8.3. *SourceCharacter* is defined in clause 6.

NOTE A line terminator character cannot appear in a string literal, except as part of 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`.

Static Semantics

Static Semantics: Early Errors

UnicodeEscapeSequence :: u{ HexDigits }

- It is a Syntax Error if the MV of *HexDigits* > 1114111.

Static Semantics: SV's and CV's

A string literal stands for a value of the String type. The String value (SV) of the literal is described in terms of code unit values (CV) contributed by the various parts of the string literal. As part of this process, some Unicode characters within the string literal are interpreted as having a mathematical value (MV), as described below or in 7.8.3.

- The SV of *StringLiteral* :: "" is the empty code unit sequence.
- The SV of *StringLiteral* :: ' ' is the empty code unit sequence.
- The SV of *StringLiteral* :: " DoubleStringCharacters " is the SV of *DoubleStringCharacters*.
- The SV of *StringLiteral* :: ' SingleStringCharacters ' is the SV of *SingleStringCharacters*.
- The SV of *DoubleStringCharacters* :: *DoubleStringCharacter* is a sequence of one or two code units that is the CV of *DoubleStringCharacter*.
- The SV of *DoubleStringCharacters* :: *DoubleStringCharacter DoubleStringCharacters* is a sequence of one or two code units that is the CV of *DoubleStringCharacter* followed by all the code units in the SV of *DoubleStringCharacters* in order.
- The SV of *SingleStringCharacters* :: *SingleStringCharacter* is a sequence of one or two code units that is the CV of *SingleStringCharacter*.
- The SV of *SingleStringCharacters* :: *SingleStringCharacter SingleStringCharacters* is a sequence of one or two code units that is the CV of *SingleStringCharacter* followed by all the code units in the SV of *SingleStringCharacters* in order.
- The SV of *LineContinuation* :: \ *LineTerminatorSequence* is the empty code unit sequence.
- The CV of *DoubleStringCharacter* :: *SourceCharacter* but not one of " or \ or *LineTerminator* is the UTF-16 Encoding (clause 6) of the code point value of *SourceCharacter*.
- The CV of *DoubleStringCharacter* :: \ *EscapeSequence* is the CV of the *EscapeSequence*.
- The CV of *DoubleStringCharacter* :: *LineContinuation* is the empty character sequence.
- The CV of *SingleStringCharacter* :: *SourceCharacter* but not one of ' or \ or *LineTerminator* is the UTF-16 Encoding (clause 6) of the code point value of *SourceCharacter*.
- The CV of *SingleStringCharacter* :: \ *EscapeSequence* is the CV of the *EscapeSequence*.
- The CV of *SingleStringCharacter* :: *LineContinuation* is the empty character sequence.
- The CV of *EscapeSequence* :: *CharacterEscapeSequence* is the CV of the *CharacterEscapeSequence*.
- The CV of *EscapeSequence* :: 0 [lookahead \notin *DecimalDigit*] is the code unit value 0.
- 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 unit value is determined by the *SingleEscapeCharacter* according to:

Field Code Changed

Table 4 — String Single Character Escape Sequences

Escape Sequence	Code Unit Value	Name	Symbol
\b	0x0008	backspace	<BS>
\t	0x0009	horizontal tab	<HT>
\n	0x000A	line feed (new line)	<LF>
\v	0x000B	vertical tab	<VT>
\f	0x000C	form feed	<FF>
\r	0x000D	carriage return	<CR>
\"	0x0022	double quote	"
\'	0x0027	single quote	'
\\\	0x005C	backslash	\

- The CV of *CharacterEscapeSequence :: NonEscapeCharacter* is the CV of the *NonEscapeCharacter*.
- The CV of *NonEscapeCharacter :: SourceCharacter but not one of EscapeCharacter or LineTerminator* is the UTF-16 Encoding (clause 6) of the code point value of *SourceCharacter*.
- The CV of *HexEscapeSequence :: x HexDigit HexDigit* is the code unit value that 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* is the code unit value that is (4096 times the MV of the first *HexDigit*) plus (256 times the MV of the second *HexDigit*) plus (16 times the MV of the third *HexDigit*) plus the MV of the fourth *HexDigit*.
- The CV of *UnicodeEscapeSequence :: u{ HexDigits }* is the UTF-16 Encoding (clause 6) of the MV of *HexDigits*.

7.9 Automatic Semicolon Insertion

Deleted:

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

There are three basic rules of semicolon insertion:

- When, as the *script* 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:
 - The offending token is separated from the previous token by at least one *LineTerminator*.
 - The offending token is `}`.
- When, as the *script* 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 *script*, then a semicolon is automatically inserted at the end of the input stream.
- When, as the *script* 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

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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 (see 12.6.3).

NOTE The following are the only restricted productions in the grammar:

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

ContinueStatement :
 `continue` [no *LineTerminator* here] *Identifier* ;

BreakStatement :
 `break` [no *LineTerminator* here] *Identifier* ;

ReturnStatement :
 `return` [no *LineTerminator* here] *Expression* ;

ThrowStatement :
 `throw` [no *LineTerminator* here] *Expression* ;

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.

An *Identifier* 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

```
{ 1 2 } 3
```

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

```
{ 1  
2 } 3
```

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

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

which is a valid ECMAScript sentence.

The source

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

is not a valid ECMAScript sentence and is not altered by automatic semicolon insertion because the 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

```
return
a + b
```

is transformed by automatic semicolon insertion into the following:

```
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

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

is transformed by automatic semicolon insertion into the following:

```
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

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

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

The source

```
a = b + c
(d + e).print()
```

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:

```
a = b + c(d + e).print()
```

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

Algorithms within this specification manipulate values each of which has an associated type. The possible value types are exactly those defined in this clause. Types are further subclassified into ECMAScript language types and specification types.

Within this specification, the notation “`Type(x)`” is used as shorthand for “the type of `x`” where “type” refers to the ECMAScript language and specification types defined in this clause.

8.1 ECMAScript Language Types

An ECMAScript language type corresponds to values that are directly manipulated by an ECMAScript programmer using the ECMAScript language. The ECMAScript language types are `Undefined`, `Null`, `Boolean`,

Deleted: An ECMAScript language type corresponds to values that are directly manipulated by an ECMAScript programmer using the ECMAScript language. The ECMAScript language types are `Undefined`, `Null`, `Boolean`, `String`, `Number`, and `Object`.¹¹ A specification type corresponds to meta-values that are used within algorithms to describe the semantics of ECMAScript language constructs and ECMAScript language types. The specification types are `Reference`, `List`, `Completion`, `Property Descriptor`, `Property Identifier`, `Lexical Environment`, and `Environment Record`, and `Declarative Block`. Specification type values are specification artefacts that do not necessarily correspond to any specific entity within an ECMAScript implementation. Specification type values may be used to describe intermediate results of ECMAScript expression evaluation but such values cannot be stored as properties of objects or values of ECMAScript language variables.¹²

String, Number, Symbol, and Object. An ECMAScript language value is a value that is characterized by an ECMAScript language type.

8.1.1 The Undefined Type

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

8.1.2 The Null Type

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

8.1.3 The Boolean Type

The Boolean type represents a logical entity having two values, called **true** and **false**.

8.1.4 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 case each element in the String is treated as a UTF-16 code unit value. 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 index 0, the next element (if any) at index 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.

Deleted: Unicode
Deleted: (see Clause 6)
Deleted: position
Deleted: position

Where ECMAScript operations interpret String values, each element is interpreted as a single UTF-16 code unit. However, ECMAScript does not place any restrictions or requirements on the sequence of code units in a String value, so they may be ill-formed when interpreted as UTF-16 code unit sequences. Operations that do not interpret String contents treat them as sequences of undifferentiated 16-bit unsigned integers. No operations ensure that Strings are in a normalized form. Only operations that are explicitly specified to be language or locale sensitive produce language-sensitive results

NOTE The rationale behind this design was to keep the implementation of Strings as simple and high-performing as possible. If ECMAScript source code is in Normalised Form C, string literals are guaranteed to also be normalised, as long as they do not contain any Unicode escape sequences.

Deleted: <#>When a String contains actual textual data, each element is considered to be a single UTF-16 code unit. Whether or not this is the actual storage format of a String, the characters within a String are numbered by their initial code unit element position 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 normalized form, nor do they ensure language-sensitive results.¶

Some operations interpret String contents as UTF-16 encoded Unicode code points. In that case the interpretation is:

- A code unit in the range 0 to 0xD7FF or in the range 0xE000 to 0xFFFF is interpreted as a code point with the same value.
- A sequence of two code units, where the first code unit *c₁* is in the range 0xD800 to 0xDBFF and the second code unit *c₂* is in the range 0xDC00 to 0xFFFF, is a surrogate pair and is interpreted as a code point with the value $(c_1 - 0xD800) \times 0x400 + (c_2 - 0xDC00) + 0x10000$.
- A code unit that is in the range 0xD800 to 0xFFFF, but is not part of a surrogate pair, is interpreted as a code point with the same value.

Deleted: 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

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8.1.5 The Number Type

The Number type has exactly 18437736874454810627 (that is, $2^{64}-2^{53}+3$) values, representing the double-precision 64-bit format IEEE 754 values as specified in the IEEE Standard for Binary Floating-Point Arithmetic, except that the 9007199254740990 (that is, $2^{53}-2$) distinct "Not-a-Number" values of the IEEE Standard are represented in ECMAScript as a single special **NaN** value. (Note that the **NaN** value is produced by the program expression **NaN**.) In some implementations, external code might be able to detect a difference between various Not-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 $+\infty$ and $-\infty$, respectively. (Note that these two

infinite Number values are produced by the program expressions `+Infinity` (or simply `Infinity`) and `-Infinity`.)

The other 18437736874454810624 (that is, $2^{64}-2^{53}$) values are called the finite numbers. Half of these are positive numbers and half are negative numbers; for every finite positive Number value there is a corresponding negative value having the same magnitude.

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

The 18437736874454810622 (that is, $2^{64}-2^{53}-2$) finite nonzero values are of two kinds:

18428729675200069632 (that is, $2^{64}-2^{54}$) of them are normalised, having the form

$$s \times m \times 2^e$$

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

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

$$s \times m \times 2^e$$

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

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

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 π) means a Number value chosen in the following manner. Consider the set of all finite values of the Number type, with `-0` removed and with two additional values added to it that are not representable in the Number type, namely 2^{1024} (which is $+1 \times 2^{53} \times 2^{971}$) and -2^{1024} (which is $-1 \times 2^{53} \times 2^{971}$). Choose the member of this set that is closest in value to x . If two values of the set are equally close, then the one with an even significand is chosen; for this purpose, the two extra values 2^{1024} and -2^{1024} are considered to have even significands. Finally, if 2^{1024} was chosen, replace it with `+0`; if -2^{1024} was chosen, replace it with `-0`; 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 `ToInt32` operators in 9.5 and 9.6, respectively.

8.1.6 The Symbol Type

The Symbol type is the set of all non-String values that may be used as the key of an Object property (8.1.7).

Each possible Symbol values is unique and immutable.

Symbol values have a single observable attribute called `[[Private]]` whose immutable value is either `true` or `false`. A private symbol is a Symbol value whose `[[Private]]` attribute has the value `true`.

8.1.7 The Object Type

An Object is logically a collection of properties. Each property is either a ~~data property~~, or an ~~accessor property~~:

- A ~~data property~~ associates a ~~key value~~ with an ECMAScript language value and a set of Boolean attributes.
- A ~~accessor property~~ associates a ~~key value~~ with one or two accessor functions, and a set of Boolean attributes. The accessor functions are used to store or retrieve an ECMAScript language value that is associated with the property.

Properties are identified using key values. A key value is either an ECMAScript String value or a ~~Symbol value~~.

Property keys are used to access properties and their values. There are two kinds of access for properties: get and set, corresponding to value retrieval and assignment, respectively. The properties accessible via get and set access includes both own properties that are a direct part of an object and inherited properties which are provided by another associated object via a property inheritance relationship. Inherited properties may be either own or inherited properties of the associated object.

All objects are logically collections of properties, but there are multiple forms of objects that differ in their semantics for accessing and manipulating their properties. Ordinary objects are the most common form of objects and have the default object semantics. An exotic object is any form of object whose property semantics differ in any way from the default semantics.

8.1.7.1 Property Attributes

Attributes are used in this specification to define and explain the state of Object properties. A ~~data property~~ associates a ~~key value~~ with the attributes listed in Table 5.

Table 5 — Attributes of a Data Property

Attribute Name	Value Domain	Description
<code>[[Value]]</code>	Any ECMAScript language type	The value retrieved by a <u>get</u> access of the property.
<code>[[Writable]]</code>	Boolean	If <code>false</code> , attempts by ECMAScript code to change the property's <code>[[Value]]</code> attribute using <code>[[Set]]</code> will not succeed.
<code>[[Enumerable]]</code>	Boolean	If <code>true</code> , the property will be enumerated by a <u>for-in</u> enumeration (see 12.6.4). Otherwise, the property is said to be non-enumerable.
<code>[[Configurable]]</code>	Boolean	If <code>false</code> , attempts to delete the property, change the property to be an accessor property, or change its attributes (other than <code>[[Value]]</code> , or changing <code>[[Writable]]</code> to <code>false</code>) will fail.

An ~~accessor property~~ associates a ~~key value~~ with the attributes listed in Table 6.

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Table 6 — Attributes of an Accessor Property

Attribute Name	Value Domain	Description
[[Get]]	Object or Undefined	If the value is an Object it must be a function Object. The function's [[Call]] internal method (8.6.2) is called with an empty arguments list to retrieve the property value each time a get access of the property is performed.
[[Set]]	Object or Undefined	If the value is an Object it must be a function Object. The function's [[Call]] internal method (8.6.2) is called with an arguments list containing the assigned value as its sole argument each time a set access of the property is performed. The effect of a property's [[Set]] internal method may, but is not required to, have an effect on the value returned by subsequent calls to the property's [[Get]] internal method.
[[Enumerable]]	Boolean	If true, the property is to be enumerated by a for-in enumeration (see 12.6.4). Otherwise, the property is said to be non-enumerable.
[[Configurable]]	Boolean	If false, attempts to delete the property, change the property to be a data property, or change its attributes will fail.

If the initial values of a property's attributes are not explicitly specified by this specification, the default value defined in Table 7 is used.

Table 7 — Default Attribute Values

Attribute Name	Default Value
[[Value]]	undefined
[[Get]]	undefined
[[Set]]	undefined
[[Writable]]	false
[[Enumerable]]	false
[[Configurable]]	false

8.1.7.2 Object Internal Methods and Internal Data Properties

The actual semantics of ECMAScript objects are specified via algorithms called *internal methods*. Each object in an ECMAScript engine is associated with a set of internal methods that defines its runtime behaviour. These internal methods are not part of the ECMAScript language. They are defined by this specification purely for expository purposes. However, each object within an implementation of ECMAScript must behave as specified by the internal methods associated with it. The exact manner in which this is accomplished is determined by the implementation.

Internal methods are identified within this specification using names enclosed in double square brackets [[]]. Internal method names are polymorphic. This means that different ECMAScript object values may perform different algorithms when a common internal method name is invoked upon them. If, at runtime, the implementation of an algorithm attempts to use an internal method of an object that the object does not support, a **TypeError** exception is thrown.

Internal data properties correspond to internal state that is associated with objects and used by various ECMAScript specification algorithms. Depending upon the specific internal data property such state may consist of values of any ECMAScript language type or of specific ECMA specification type values. Unless explicitly specified otherwise, internal data properties are allocated as part of the process of creating an ECMAScript object and may not be dynamically added to ECMAScript objects. Unless specified otherwise, the initial value of an internal data property is the value **undefined**.

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Table 8 summarises the essential internal methods used by this specification that are applicable to all ECMAScript objects. Every object must have algorithms for all of the essential internal methods. However, all objects do not necessarily use the same algorithms for those methods.

The “Signature” column of Table 8 and other similar tables describes the invocation pattern for each internal method. The invocation pattern always includes a parenthesised list of descriptive parameter names. If a parameter name is the same as an ECMAScript type name then the name describes the required type of the parameter value. If an internal method explicitly returns a value, its parameter list is followed by the symbol “→” and the type name of the returned value. The type names used in signatures refer to the types defined in Clause 8 augmented by the following additional names. “any” means the value may be any ECMAScript language type. An internal method implicitly returns a Completion Record as described in 8.8. In addition to its parameters, an internal method always has access to the object upon which it is invoked as a method.

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- Deleted:** “SpecOp”
- Deleted:** “primitive” means Undefined, Null, Boolean, String, or Number.

Table 8 — Essential Internal Methods

Internal Method	Signature	Description
<code>[[GetInheritance]]</code>	<code>()→Object or Null</code>	Determine the object that provides inherited properties for this object. A <code>null</code> value indicates that there are no inherited properties. an object.
<code>[[SetInheritance]]</code>	<code>(Object or Null)→Boolean</code>	Associate with an object another object that provides inherited properties. Passing <code>null</code> indicates that there are no inherited properties. Returns <code>true</code> indicating that the operation was completed successfully or <code>false</code> indicating that the operation was not successful.
<code>[[HasIntegrity]]</code>	<code>(String)→Boolean</code>	Determine whether the property structure of an object is fixed to at least the specified level. The argument is one of the values <code>"nonextensible"</code> , <code>"sealed"</code> , or <code>"frozen"</code> .
<code>[[SetIntegrity]]</code>	<code>(String)→Boolean</code>	Restrict the mutability of an object's properties to that which is allowed for the specified integrity level. The argument is one of the values <code>"nonextensible"</code> , <code>"sealed"</code> , or <code>"frozen"</code> . Returns <code>true</code> indicating that the operation was completed successfully or <code>false</code> indicating that the operation was not successful. The integrity level of an object may be raised but may not be lowered.
<code>[[HasOwnProperty]]</code>	<code>(propertyKey) → Boolean</code>	Returns a Boolean value indicating whether the object already has an own property whose key is <code>propertyKey</code> .
<code>[[GetProperty]]</code>	<code>(propertyKey) → Undefined or Property Descriptor</code>	Returns a Property Descriptor for the own property of this object whose key is <code>propertyKey</code> , or <code>undefined</code> if no such property exists.
<code>[[HasProperty]]</code>	<code>(propertyKey) → Boolean</code>	Returns a Boolean value indicating whether the object already has either an own or inherited property whose key is <code>propertyKey</code> .
<code>[[Get]]</code>	<code>(propertyKey, Receiver) → any</code>	Retrieve the value of an object's property using the <code>propertyKey</code> parameter. If any ECMAScript code must be executed to retrieve the property value, <code>Receiver</code> is used as the <code>this</code> value when evaluating the code.
<code>[[Set]]</code>	<code>(propertyKey, value, Receiver) → Boolean</code>	Try to set the value of an object's property identified by <code>propertyKey</code> to <code>value</code> . If any ECMAScript code must be executed to set the property value, <code>Receiver</code> is used as the <code>this</code> value when evaluating the code. Returns <code>true</code> indicating that the property value was set or <code>false</code> indicating that it could not be set.
<code>[[Delete]]</code>	<code>(propertyKey) → Boolean</code>	Removes the own property identified by the <code>propertyKey</code> parameter from the object. Return <code>false</code> if the property was not deleted and is still present. Return <code>true</code> if the property was deleted or was not present.
<code>[[DefineOwnProperty]]</code>	<code>(propertyKey,PropertyDescriptor) → Boolean</code>	Creates or alters the named own property to have the state described by a Property Descriptor. Returns <code>true</code> indicating that the property was successfully created/updated or <code>false</code> indicating that the property could not be created or updated.
<code>[[Enumerate]]</code>	<code>()→Object</code>	Returns an iterator object over the string values of the keys of the enumerable properties of the

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Deleted: Retrieve the value of an object's property using the `propertyKey` parameter. If any ECMAScript code must be executed to retrieve the property value, `Receiver` is used as the `this` value when evaluating the code.

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<u>[[OwnPropertyKeys]]</u>	<u>(\rightarrowObject)</u>	object. Returns an Iterator object that produces all of the own property keys for the object except those that are private Symbols.
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Table 9 summarises additional essential internal methods that are supported by objects that may be called as functions.

Table 9 — Additional Essential Internal Methods of Function Objects

Internal Method	Signature	Description
<u>[[Call]]</u>	<u>(any, a List of any) \rightarrow any</u>	Executes code associated with the object. Invoked via a function call expression. The arguments to the internal method are a this value and a list containing the arguments passed to the function by a call expression. Objects that implement this internal method are <i>callable</i> .
<u>[[Construct]]</u>	<u>(a List of any) \rightarrow Object</u>	Creates an object. Invoked via the new operator. The arguments to the internal method are the arguments passed to the new operator. Objects that implement this internal method are called <i>constructors</i> . A Function object is not necessarily a constructor and such non-constructor Function object do not have a [[Construct]] internal method.

8.1.7.3 Invariants of the Essential Internal Methods

Current this section is just a bunch of material merged together from the ES5 spec. and from the wiki Proxy pages. It need to be completely reworked.

The intent is that it lists all invariants of the Essential Internal Methods. This includes both invariants that are enforced for Proxy objects and other invariants that may not be enforced.

Definitions:

- The *target* of an internal method is the object the internal method is called upon.
- A *sealed property* is a non-configurable own property of a target.
- A *frozen property* is a non-configurable non-writable own property of a target.
- A *new property* is a property that does not exist on a non-extensible target.
- Two property descriptors *desc1* and *desc2* for a property key value are incompatible if:
 1. *desc1* is produced by calling [[GetOwnPropertyDescriptor]] of *target* with *key*, and
 2. Calling [[DefineOwnProperty]] of *target* with arguments *key* and *desc2* would throw a *TypeError* exception.

Exotic objects may define additional constraints upon their [[Set]] internal method behaviour. If possible, exotic objects should not allow [[Set]] operations in situations where this definition of [[CanPut]] returns **false**.

[[GetInheritance]]

Every [[Prototype]] chain must have finite length (that is, starting from any object, recursively accessing the [[Prototype]] internal data property must eventually lead to a **null** value).

getOwnPropertyDescriptor

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Non-configurability invariant: cannot return incompatible descriptors for sealed properties

Non-extensibility invariant: must return **undefined** for new properties

Invariant checks:

if trap returns **undefined**, check if the property is configurable

if property exists on target, check if the returned descriptor is compatible

if returned descriptor is non-configurable, check if the property exists on the target and is also non-configurable

defineProperty

Non-configurability invariant: cannot succeed (return true) for incompatible changes to sealed properties

Non-extensibility invariant: must reject (return **false**) for new properties

Invariant checks:

on success, if property exists on target, check if existing descriptor is compatible with argument descriptor

on success, if argument descriptor is non-configurable, check if the property exists on the target and is also non-configurable

getOwnPropertyNames

Non-configurability invariant: must report all sealed properties

Non-extensibility invariant: must not list new property names

Invariant checks:

check whether all sealed target properties are present in the trap result

If the target is non-extensible, check that no new properties are listed in the trap result

deleteProperty

Non-configurability invariant: cannot succeed (return true) for sealed properties

Invariant checks:

on success, check if the target property is configurable

getPrototypeOf

Invariant check: check whether the target's prototype and the trap result are identical (according to the `egal` operator)

freeze | seal | preventExtensions

Invariant checks:

on success, check if `isFrozen(target)`, `isSealed(target)` or `!isExtensible(target)`

isFrozen | isSealed | isExtensible

Invariant check: check whether the boolean trap result is equal to `isFrozen(target)`, `isSealed(target)` or `isExtensible(target)`

hasOwn

Non-configurability invariant: cannot return **false** for sealed properties

Non-extensibility invariant: must return **false** for new properties

Invariant checks:

if **false** is returned, check if the target property is configurable

if **false** is returned, the property does not exist on target, and the target is non-extensible, throw a **TypeError**

has

Non-configurability invariant: cannot return **false** for sealed properties

Invariant checks:

if **false** is returned, check if the target property is configurable

get

Non-configurability invariant: cannot return inconsistent values for frozen data properties, and must return **undefined** for sealed accessors with an **undefined** getter

Invariant checks:

if property exists on target as a data property, check whether the target property's value and the trap result are identical (according to the **egal** operator)

if property exists on target as an accessor, and the accessor's get attribute is **undefined**, check whether the trap result is also **undefined**.

set

Non-configurability invariant: cannot succeed (return true) for frozen data properties or sealed accessors with an **undefined** setter

Invariant checks:

on success, if property exists on target as a data property, check whether the target property's value and the update value are identical (according to the **egal** operator)

on success, if property exists on target as an accessor, check whether the accessor's set attribute is not **undefined**

keys

Non-configurability invariant: must report all enumerable sealed properties

Non-extensibility invariant: must not list new property names

Invariant checks:

Check whether all enumerable sealed target properties are listed in the trap result

If the target is non-extensible, check that no new properties are listed in the trap result

enumerate

Non-configurability invariant: must report all enumerable sealed properties

Invariant checks:

Check whether all enumerable sealed target properties are listed in the trap result

NOTE This specification defines no ECMAScript language operators or built-in functions that permit a program to modify an object's **[[Prototype]]** internal property or to change the value of **[[Extensible]]** from **false** to **true**. Implementation specific extensions that modify **[[Prototype]]** or **[[Extensible]]** must not violate the invariants defined in the preceding paragraph.

Unless otherwise specified, the standard ECMAScript objects are ordinary objects and behave as described in 8.3. Some standard objects are exotic objects and have behaviour defined in 8.4.

Comment [AWB1213]: These are placeholders based upon the proxy trap invariants. We need to provide new versions all the essential internal methods.

Deleted: Clause 8.12 provides the algorithm that defined the default behaviour for the internal methods in Table 8. An *ordinary object* is an object that uses all of these default algorithms. An *exotic object* is an object that uses some other algorithm to provide alternative behaviour for one or more of these internal methods. The descriptions in these tables indicate their behaviour for native ECMAScript objects, unless stated otherwise in this document for particular kinds of native ECMAScript objects. ¶

Deleted: Host objects may support these internal properties with any implementation-dependent behaviour as long as it is consistent with the specific host object restrictions stated in this document.¶

Deleted: The "Value Type Domain" column in the following tables define the types of values associated with internal properties. The type names refer to the types defined in Clause 8 augmented by the following additional names: "any" means the value may be any ECMAScript language type. "primitive" means Undefined, Null, Boolean, String, or Number. "SpecOp" means the internal property is an internal method, an implementation provided procedure defined by an abstract operation specification. "SpecOp" is followed by a list of descriptive parameter names. If a parameter name is the same as a type name then the name describes the type of the parameter. If a "SpecOp" returns a value, its parameter list is followed by the symbol "...", and the type of the returned value.

Table — Internal Properties Common to All Objects¶

Internal Property

Comment [AWB1214]: No longer true because of Proxies.

Deleted: Every object (including host objects) must implement all of the internal properties listed in Table 8. However, the **[[DefaultValue]]** internal method may, for some objects, simply throw a **TypeError** exception.¶

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Exotic objects may implement internal methods in any manner unless specified otherwise; for example, one possibility is that [[Get]] and [[Set]] for a particular exotic object indeed fetch and store property values but [[HasOwnProperty]] always generates **false**. However, if any specified manipulation of an exotic object's internal properties is not supported by an implementation, that manipulation must throw a **TypeError** exception when attempted.

The [[GetOwnProperty]] internal method of all objects must conform to the following invariants for each property of the object:

- If a property is described as a data property and it may return different values over time, then either or both of the [[Writable]] and [[Configurable]] attributes must be **true** even if no mechanism to change the value is exposed via the other internal methods.
- If a property is described as a data property and its [[Writable]] and [[Configurable]] are both **false**, then the SameValue (according to 9.12) must be returned for the [[Value]] attribute of the property on all calls to [[GetOwnProperty]].
- If the attributes other than [[Writable]] may change over time or if the property might disappear, then the [[Configurable]] attribute must be **true**.
- If the [[Writable]] attribute may change from **false** to **true**, then the [[Configurable]] attribute must be **true**.
- If the result of calling an object's [[IsExtensible]] internal method has been observed by ECMAScript code to be false, then if a call to [[GetOwnProperty]] describes a property as non-existent all subsequent calls must also describe that property as non-existent.

The [[DefineOwnProperty]] internal method of all objects must not permit the addition of a new property to an object if the [[Extensible]] internal method of that object has been observed by ECMAScript code to be **false**.

If the result of calling the [[IsExtensible]] internal method of an object has been observed by ECMAScript code to be false then it must not subsequently become **true**.

8.1.7.4 Well-Known Symbols and Intrinsics

Well-known symbols are built-in Symbol values (8.4.4) that are explicitly referenced by algorithms of this specification. They are typically used as the keys of properties whose values serve as extension points of a specification algorithm. Unless otherwise specified, well-known symbols values are shared by all Code Realms (10.3) and the value of their [[Private]] attribute is **false**.

Within this specification a well-known symbol is referred to by using a notation of the form @@name, where "name" is one of the values listed in Table 10.

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Table 10--Well-known Symbols

<u>Specification Name</u>	<u>Value and Purpose</u>
<u><code>@@create</code></u>	A method used to allocate an object. Called from the <u><code>[[Construct]]</code></u> internal method.
<u><code>@@hasInstance</code></u>	A method that determines if a constructor object recognizes an object as one of the constructor's instances. Called by the semantics of the <u><code>instanceof</code></u> operator.
<u><code>@@isRegExp</code></u>	A Boolean value that if true indicates that an object may be used as a regular expression.
<u><code>@@iterator</code></u>	A method that returns the default iterator for an object. Called by the semantics of the <code>for-of</code> statement.
<u><code>@@ToPrimitive</code></u>	A method that converts an object to a corresponding primitive value. Called by the <code>ToPrimitive</code> abstract operation.
<u><code>@@toStringTag</code></u>	A string value that is used in the creation of the default string description of an object. Called by the built-in method <code>Object.prototype.toString</code> .

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Well-known intrinsics are built-in objects that are explicitly referenced by the algorithms of this specification and which usually have Realm specific identities. Unless otherwise specified each intrinsic object actually corresponds to a set of similar objects, one per Realm.

Within this specification a reference such as %name% means the intrinsic object, associated with the current Realm, corresponding to the name. Determination of the current Realm and its intrinsics is described in 10.4. The well-known intrinsics are listed in Table 11.

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Table 11.— Well-known Intrinsic Objects

<i>Intrinsic Name</i>	<i>ECMAScript Language Association</i>
<u>%Object%</u>	The initial value of the global object property named " <u>Object</u> ".
<u>%ObjectPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %Object%.
<u>%ObjProto_toString%</u>	The initial value of the " <u>toString</u> " data property of the intrinsic %ObjectPrototype%.
<u>%Function%</u>	The initial value of the global object property named " <u>Function</u> ".
<u>%FunctionPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %Function%.
<u>%Array%</u>	The initial value of the global object property named " <u>Array</u> ".
<u>%ArrayPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %Array%.
<u>%ArrayIteratorPrototype%</u>	The prototype object used for iterator objects created by the CreateArrayIterator abstract operation.
<u>%Map%</u>	The initial value of the global object property named " <u>Map</u> ".
<u>%MapPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %Map%.
<u>%MapIteratorPrototype%</u>	The prototype object used for iterator objects created by the CreateMapIterator abstract operation
<u>%WeakMap%</u>	The initial value of the global object property named " <u>WeakMap</u> ".
<u>%WeakMapPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %WeakMap%.
<u>%Set%</u>	The initial value of the global object property named " <u>Set</u> ".
<u>%SetPrototype%</u>	The initial value of the " <u>prototype</u> " data property of the intrinsic %Set%.
<u>%SetIteratorPrototype%</u>	The prototype object used for iterator objects created by the CreateSetIterator abstract operation
<u>%GeneratorFunction%</u>	The initial value of the name "GeneratorFunction" exported from the built-in module "std:iteration".
<u>%Generator%</u>	The initial value of the name "Generator" exported from the built-in module "std:iteration"
<u>%ErrorPrototype%</u>	
<u>%EvalErrorPrototype%</u>	
<u>%RangeErrorPrototype%</u>	

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%ReferenceErrorPrototype%	
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%ArrayBuffer%	
%DateViewPrototype%	
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8.2 ECMAScript Specification Types

A specification type corresponds to meta-values that are used within algorithms to describe the semantics of ECMAScript language constructs and ECMAScript language types. The specification types are Reference, List, Completion, Property Descriptor, Lexical Environment, Environment Record, and Data Block. Specification type values are specification artefacts that do not necessarily correspond to any specific entity within an ECMAScript implementation. Specification type values may be used to describe intermediate results of ECMAScript expression evaluation but such values cannot be stored as properties of objects or values of ECMAScript language variables.

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Internal Property

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8.2.1 Data Blocks

This section is a placeholder for describing the Data Block internal type. The following material is verbatim from the the Binary Data ES wiki proposal. The material has not yet been reviewed or integrated with the rest of this spec.

This spec introduces a new, spec-internal block datatype, intuitively representing a contiguously allocated block of binary data. Blocks are not ECMAScript language values and appear only in the program store (aka heap).

A block is one of:

- a number-block
- an array-block[t, n]
- a struct-block[t1, ..., tn]

A number-block is one of:

- an unsigned-integer; i.e., one of uint8, uint16, uint32, or uint64
- a signed-integer; i.e., one of int8, int16, int32, or int64
- a floating-point; i.e., one of float32 or float64

A uintk is an integer in the range [0, 2^k). An intk is an integer in the range [-2^{k-1}, 2^{k-1}). A floatk is a floating-point number representable as a k-bit IEE754 value.

An array-block[t, n] is an ordered sequence of n blocks of homogeneous block type t. Each element of the array is stored at an independently addressable location in the program store, and multiple Data objects may contain references to the element.

A struct-block[t1, ..., tn] is an ordered sequence of n blocks of heterogeneous types t1 to tn, respectively. Each field of the struct is stored at an independently addressable location in the program store, and multiple Data objects may contain references to the field.

The spec also introduces a datatype of Data objects, which are ECMAScript objects that encapsulate references to block data in the program store. Every Data object has the following properties:

[[Class]] = "Data"

[[Value]] : reference[block] – a reference to a block in the program store

[[DataType]] : reference[Type] – a reference to a Type object describing this object's data block

8.2.2 The List and Record Specification Type

The List type is used to explain the evaluation of argument lists (see 11.2.4) in `new` expressions, in function calls, and in other algorithms where a simple list of values is needed. Values of the List type are simply ordered sequences of values. These sequences may be of any length.

The Record type is used to describe data aggregations within the algorithms of this specification. A Record type value consists of one or more named fields. The value of each field is either an ECMAScript value or an abstract value represented by a name associated with the Record type. Field names are always enclosed in double brackets, for example `[[value]]`.

For notational convenience within this specification, an object literal-like syntax can be used to express a Record value. For example, `{[[field1]]: 42, [[field2]]: false, [[field3]]: empty}` defines a Record value that has three fields each of which is initialized to a specific value. Field name order 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 Record value. For example, if `R` is the record shown in the previous paragraph then `R.[[field2]]` is shorthand for "the field of `R` named `[[field2]]`".

Schema for commonly used Record field combinations may be named, and that name may be used as a prefix to a literal Record value to identify the specific kind of aggregations that is being described. For example: Property Descriptor `{[[Value]]: 42, [[Writable]]: false, [[Configurable]]: true}`.

8.2.3 The Completion Record Specification Type

The Completion type is a Record used to explain the runtime propagation of values and control flow such as the behaviour of statements (`break`, `continue`, `return` and `throw`) that perform nonlocal transfers of control.

Values of the Completion type are Record values whose fields are defined as by Table 12.

Table 12 — Completion Record Fields

Field Name	Value	Meaning
<code>[[type]]</code>	One of <code>normal</code> , <code>break</code> , <code>continue</code> , <code>return</code> , or <code>throw</code>	The type of completion that occurred.
<code>[[value]]</code>	any ECMAScript language value or <code>empty</code>	The value that was produced.
<code>[[target]]</code>	any ECMAScript identifier or <code>empty</code>	The target label for directed control transfers.

The term "abrupt completion" refers to any completion with a `[[type]]` value other than `normal`.

8.2.3.1 NormalCompletion

The abstract operation `NormalCompletion` with a single *argument*, such as:

1. `Return NormalCompletion(argument).`

Is a short hand that is defined as follows:

1. `Return Completion {[[type]]: normal, [[value]]: argument, [[target]]:empty}.`

8.2.3.2 Implicit Completion Values

The algorithms of this specification often implicitly return Completion Records whose `[[type]]` is `normal`. Unless it is otherwise obvious from the context, an algorithm statement that returns a value that is not a Completion Record, such as:

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1. Return **"Infinity"**.

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Generally means the same thing as:

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1. Return NormalCompletion(**"Infinity"**).

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A "return" statement without a value in an algorithm step means the same thing as:

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1. Return NormalCompletion(**undefined**).

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Similarly, any reference to a Completion Record value that is in a context that does not explicitly require a complete Completion Record value is equivalent to an explicit reference to the [[value]] field of the Completion Record value unless the Completion Record is an abrupt completion.

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8.2.3.3 Throw an Exception

Algorithms steps that say to throw an exception, such as

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The abstract operation NormalCompletion with a single argument, such as:¶
The abstraction operation NormalValue with a single argument is a short hand that is defined as follows:¶
<#>If argument is not a Completion Record, return argument.¶
<#>If argument is an abrupt completion, return argument.¶
<#>Return argument.[value].¶

1. Throw a **TypeError** exception.

The abstraction operation abstract operation NormalCompletion with a single argument, such as:¶
<#>Return NormalCompletion(argument).¶
Is a short hand that is defined as follows:¶
<#>Return Completion {[type]]: normal, [[value]]: argument, [[target]]:empty}.¶

8.2.3.4 ReturnIfAbrupt

Algorithms steps that say

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1. ReturnIfAbrupt(**argument**).

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mean the same things as:

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1. If **argument** is an abrupt completion, then return **argument**.

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2. Else if **argument** is a Completion Record, then let **argument** be **argument.[[value]]**.

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8.2.4 The Reference Specification Type

NOTE The Reference type is used to explain the behaviour of such operators as **delete**, **typeof**, the assignment operators, the **super** keyword and other language features. For example, the left-hand operand of an assignment is expected to produce a reference.

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A **Reference** is a resolved name or property 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 **undefined**, an Object, a Boolean, a String, a Number, or an environment record (10.2.1). A **base** value of **undefined** indicates that the **Reference** could not be resolved to a binding. The referenced name is a String or Symbol.

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A Super Reference is a Reference that is used to represents a name binding that was expressed using the **super** keyword. A Super Reference has an additional **thisValue** component and its **base** value will never be an environment record.

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The following abstract operations are used in this specification to access the components of references:

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- **GetBase(V)**. Returns the **base** value component of the reference V.
- **GetReferencedName(V)**. Returns the referenced name component of the reference V.
- **IsStrictReference(V)**. Returns the strict reference flag component of the reference V.
- **HasPrimitiveBase(V)**. Returns **true** if the **base** value is a Boolean, String, or Number.
- **IsPropertyReference(V)**. Returns **true** if either the **base** value is an object or HasPrimitiveBase(V) is **true**; otherwise returns **false**.
- **IsUnresolvableReference(V)**. Returns **true** if the **base** value is **undefined** and **false** otherwise.

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Deleted: The behaviour of assignment could, instead, 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 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.)

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Deleted: <#>**GetThisValue(V)**. Returns the **thisValue** component of the reference V.¶

- IsSuperReference(V). Returns **true** if this reference has a *thisValue* component.

The following abstract operations are used in this specification to operate on references:

8.2.4.1 GetValue (V)

1. ReturnIfAbrupt(V).
2. If Type(V) is not Reference, return V.
3. Let *base* be the result of calling GetBase(V).
4. If IsUnresolvableReference(V), throw a **ReferenceError** exception.
5. If IsPropertyReference(V), then
 - a. If HasPrimitiveBase(V) is **true**, then
 - i. Assert: In this case, *base* will never be a Symbol, **null** or **undefined**.
 - ii. Let *base* be ToObject(*base*).
 - b. Return the result of calling the **[[Get]]** internal method of *base* passing GetReferencedName(V) and GetThisValue(V) as the arguments.
6. Else *base* must be an environment record.
 - a. Return the result of calling the GetBindingValue (see 10.2.1) concrete method of *base* passing GetReferencedName(V) and IsStrictReference(V) as arguments.

NOTE The object that may be created in step 5.a.ii is not accessible outside of the above abstract operation and the ordinary object **[[Get]]** internal method. An implementation might choose to avoid the actual creation of the object.

8.2.4.2 PutValue (V, W)

1. ReturnIfAbrupt(V).
2. ReturnIfAbrupt(W).
3. If Type(V) is not Reference, throw a **ReferenceError** exception.
4. Let *base* be the result of calling GetBase(V).
5. If IsUnresolvableReference(V), then
 - a. If IsStrictReference(V) is **true**, then
 - i. Throw **ReferenceError** exception.
 - b. Let *globalObj* be the result of the abstract operation **GetGlobalObject**.
 - c. Return the result of calling **Put(globalObj, GetReferencedName(V), W, false)**.
6. Else if IsPropertyReference(V), then
 - a. If HasPrimitiveBase(V) is **true**, then
 - i. Assert: In this case, *base* will never be a Symbol, **null** or **undefined**.
 - ii. Set *base* to ToObject(*base*).
 - b. Let *succeeded* be the result of calling the **[[Set]]** internal method of *base* passing GetReferencedName(V), W, and GetThisValue(V) as arguments.
 - c. ReturnIfAbrupt(succeeded).
 - d. If *succeeded* is **false** and IsStrictReference(V) is **true**, then throw a **TypeError** exception.
 - e. Return.
7. Else *base* must be a reference whose base is an environment record. So,
 - a. Return the result of calling the **SetMutableBinding** (10.2.1) concrete method of *base*, passing GetReferencedName(V), W, and IsStrictReference(V) as arguments.
8. Return.

NOTE The object that may be created in step 6.a.ii is not accessible outside of the above algorithm and the ordinary object **[[Set]]** internal method. An implementation might choose to avoid the actual creation of that object.

8.2.4.3 GetThisValue (V)

1. ReturnIfAbrupt(V).
2. If Type(V) is not Reference, return V.
3. If IsUnresolvableReference(V), throw a **ReferenceError** exception.
4. If IsSuperReference(V), then
 - a. Return the value of the *thisValue* component of the reference V.
5. Return GetBase(V).

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Deleted: <#>If IsSuperReference(<i>V</i>) is false , then <#>Return the result of calling the <i>get</i> as an internal method using of <i>base</i> as its this value, and passing GetReferencedName(<i>V</i>) for the argument.¶ <#>Else,¶
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Deleted: The following [[Get]](P, accessorThisValue) internal method is used when <i>V</i> is a property reference with primitive base value. It is called using <i>base</i> as the value the internal method is called upon as this value and with property name <i>P</i> as its argument. The following steps are taken:¶ <#>Let <i>O</i> be ToObject(<i>base</i>).¶
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8.2.5 The Property Descriptor Specification Type

The Property Descriptor type is used to explain the manipulation and reification of Object 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 as specified in 8.1.6.1. 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 [[Get]] or [[Set]]. Any property descriptor may have fields named [[Enumerable]] and [[Configurable]]. A Property Descriptor value may not be both a data property descriptor and an accessor property descriptor; however, it may be neither. A generic property descriptor is a Property Descriptor value that is neither a data property descriptor nor an accessor property descriptor. A fully populated property descriptor is one that is either an accessor property descriptor or a data property descriptor and that has all of the fields that correspond to the property attributes defined in either 8.1.6.1 Table 5 or Table 6.

A Property Descriptor may be derived from an ECMAScript object that has properties that directly correspond to the fields of a Property Descriptor. Such a derived Property Descriptor has an additional field named [[Origin]] whose value is the object from which the Property Descriptor was derived.

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

8.2.5.1 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.[[Get]] and Desc.[[Set]] are absent, then return **false**.
3. Return **true**.

8.2.5.2 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**.

8.2.5.3 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**.

8.2.5.4 FromPropertyDescriptor (Desc)

When the abstract operation FromPropertyDescriptor is called with property descriptor Desc, the following steps are taken:

The following algorithm assumes that Desc is a fully populated Property Descriptor, such as that returned from [[GetOwnProperty]] (see 8.12.1).

1. If Desc is **undefined**, then return **undefined**.
2. If Desc has an [[Origin]] field, then return Desc.[[Origin]].

Deleted: 8.8 The List Specification Type
 The List type is used to explain the evaluation of argument lists (see 11.2.4) in new expressions, in function calls, and in other algorithms where a simple list of values is needed. Values of the List type are simply ordered sequences of values. These sequences may be of any length.
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The Completion type is used to explain the behavior 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 language value or empty, and target is any ECMAScript identifier or empty. If cv is a completion value then cv.type, cv.value, and cv.target may be used to directly refer to its constituent values.
 The term "abrupt completion" refers to any completion with a type other than normal.

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 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 shorthand 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.

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3. Let obj be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
 4. Assert: obj is an extensible ordinary object with no own properties.
 5. If $Desc$ has a `[[Value]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"value"`, and Property Descriptor `[[Value]]: Desc.[[Value]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
 6. If $Desc$ has a `[[Writable]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"writable"`, and Property Descriptor `[[Value]]: Desc.[[Writable]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
 7. If $Desc$ has a `[[Get]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"get"`, and Property Descriptor `[[Value]]: Desc.[[Set]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
 8. If $Desc$ has a `[[Set]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"set"`, and Property Descriptor `[[Value]]: Desc.[[Set]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
 9. If $Desc$ has a `[[Enumerable]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"enumerable"`, and Property Descriptor `[[Value]]: Desc.[[Enumerable]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
 10. If $Desc$ has a `[[Configurable]]` field, then
 - a. Call `OrdinaryDefineOwnProperty` with arguments obj , `"configurable"`, and Property Descriptor `[[Value]]: Desc.[[Configurable]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.

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8.2.5.5 ToPropertyDescriptor (Obj)

When the abstract operation `ToPropertyDescriptor` is called with object *Obj*, the following steps are taken:

1. ReturnIfAbrupt(*Obj*).
 2. If Type(*Obj*) is not Object throw a **TypeError** exception.
 3. Let *desc* be the result of creating a new Property Descriptor that initially has no fields.
 4. If the result of HasProperty(*Obj*, "enumerable") is true, then
 - a. Let *enum* be the result of Get(*Obj*, "enumerable").
 - b. ReturnIfAbrupt(*enum*).
 - c. Set the [[Enumerable]] field of *desc* to ToBoolean(*enum*).
 5. If the result of HasProperty(*Obj*, "configurable") is true, then
 - a. Let *conf* be the result of Get(*Obj*, "configurable").
 - b. ReturnIfAbrupt(*conf*).
 - c. Set the [[Configurable]] field of *desc* to ToBoolean(*conf*).
 6. If the result of HasProperty(*Obj*, "value") is true, then
 - a. Let *value* be the result of Get(*Obj*, "value").
 - b. ReturnIfAbrupt(*value*).
 - c. Set the [[Value]] field of *desc* to *value*.
 7. If the result of HasProperty(*Obj*, "writable") is true, then
 - a. Let *writable* be the result of Get(*Obj*, "writable").
 - b. ReturnIfAbrupt(*writable*).
 - c. Set the [[Writable]] field of *desc* to ToBoolean(*writable*).
 8. If the result of HasProperty(*Obj*, "get") is true, then
 - a. Let *getter* be the result of Get(*Obj*, "get").
 - b. ReturnIfAbrupt(*getter*).
 - c. If IsCallable(*getter*) is false and *getter* is not undefined, then throw a **TypeError** exception.
 - d. Set the [[Get]] field of *desc* to *getter*.
 9. If the result of HasProperty(*Obj*, "set") is true, then
 - a. Let *setter* be the result of Get(*Obj*, "set").
 - b. ReturnIfAbrupt(*setter*).
 - c. If IsCallable(*setter*) is false and *setter* is not undefined, then throw a **TypeError** exception.
 - d. Set the [[Set]] field of *desc* to *setter*.
 10. If either *desc*.[[Get]] or *desc*.[[Set]] are present, then
 - a. If either *desc*.[[Value]] or *desc*.[[Writable]] are present, then throw a **TypeError** exception.
 11. Set the [[Origin]] field of *desc* to *Obj*.

12. Return *desc*.

8.2.5.6 CompletePropertyDescriptor (Desc, LikeDesc)

When the abstract operation *CompletePropertyDescriptor* is called with Property Descriptor *Desc*, the following steps are taken:

1. Assert: *LikeDesc* is either a Property Descriptor or **undefined**.
2. *ReturnIfAbrupt(Desc)*.
3. Assert: *Desc* is a Property Descriptor.
4. If *LikeDesc* is **undefined**, then set *LikeDesc* to Record{[[Value]]: **undefined**, [[Writable]]: **false**, [[Get]]: **undefined**, [[Set]]: **undefined**, [[Enumerable]]: **false**, [[Configurable]]: **false**}.
5. If either *IsGenericDescriptor(Desc)* or *IsDataDescriptor(Desc)* is **true**, then
 - a. If *Desc* does not have a [[Value]] field, then set *Desc*.[[Value]] to *LikeDesc*.[[Value]].
 - b. If *Desc* does not have a [[Writable]] field, then set *Desc*.[[Writable]] to *LikeDesc*.[[Writable]].
6. Else,
 - a. If *Desc* does not have a [[Get]] field, then set *Desc*.[[Get]] to *LikeDesc*.[[Get]].
 - b. If *Desc* does not have a [[Set]] field, then set *Desc*.[[Set]] to *LikeDesc*.[[Set]].
7. If *Desc* does not have a [[Enumerable]] field, then set *Desc*.[[Enumerable]] to *LikeDesc*.[[Enumerable]].
8. If *Desc* does not have a [[Configurable]] field, then set *Desc*.[[Configurable]] to *LikeDesc*.[[Configurable]].
9. *Return Desc*.

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8.2.6 The Lexical Environment and Environment Record Specification Types

The Lexical Environment and Environment Record types are used to explain the behaviour of name resolution in nested functions and blocks. These types and the operations upon them are defined in Clause 10.

8.3 Ordinary Object Internal Methods and Internal Data Properties

Sections 8.3-8.5 will eventually be subsections of a new toplevel section that follow the current section 10

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Deleted: 8.112.6 The Lexical Environment and Environment Record Specification Types
The Lexical Environment and Environment Record types are used to explain the behaviour of name resolution in nested functions and blocks. These types and the operations upon them are defined in Clause 10.¶

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Comment [AWB1217]: TODO

All *ordinary objects* have an internal *data* property called [[Prototype]]. The value of this property is either **null** or an object and is used for implementing inheritance. 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 *set* access. Accessor properties are inherited for both get access and *set* access.

Every *ordinary ECMAScript object* has a Boolean-valued [[Extensible]] internal *data* property that controls whether or not properties may be added to the object. If the value of the [[Extensible]] internal *data* property is **false** then additional properties may not be added to the object. In addition, if [[Extensible]] is **false** the value of [[Prototype]] internal *data* properties of the object may not be modified. Once the value of an *object's* [[Extensible]] internal *data* property has been set to **false** it may not be subsequently changed to **true**.

In the following algorithm descriptions, assume *O* is an *ordinary ECMAScript object*, *P* is a *property key value*, *V* is any *ECMAScript language value*, *Desc* is a *Property Description record*, and *B* is a *Boolean flag*.

8.3.1 [[GetInheritance]] ()

When the [[GetInheritance]] internal method of *O* is called the following steps are taken:

1. *Return the value of the [[Prototype]] internal data property of O*.

Deleted: Whether or not an object can have an object its [[Prototype]] depends on the implementation. Every [[Prototype]] chain must have finite length (that is, starting from any object, recursively accessing the [[Prototype]] internal property must eventually lead to a **null** value).

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When the [[SetInheritance]] internal method of *O* is called with argument *V* the following steps are taken:

1. Assert: Either Type(*V*) is Object or Type(*V*) is Null.
2. Let *extensible* be the value of the [[Extensible]] internal data property of *O*.
3. Let *current* be the value of the [[Prototype]] internal data property of *O*.

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4. If SameValue(V , $current$), then return **true**.
5. If $extensible$ is **false**, then return **false**.
6. If V is not **null**, then
 - a. Let p be V .
 - b. Repeat, while p is not **null**
 - i. If SameValue(p , O) is **true**, then return **false**.
 - ii. Let $nextp$ be the result of calling the **[[GetInheritance]]** internal method of p with no arguments.
 - iii. ReturnIfAbrupt($nextp$).
 - iv. Let p be $nextp$.
7. Set the value of the **[[Prototype]]** internal data property of O to V .
8. Return **true**.

8.3.3 **[[HasIntegrity]] (Level)**

When the **[[HasIntegrity]]** internal method of O is called the following steps are taken:

1. Assert: $Level$ is one of "**nonextensible**", "**sealed**", or "**frozen**".
2. If $Level$ is "**nonextensible**", then
 - a. Return Boolean negation of the value of the **[[Extensible]]** internal data property of O .
3. Return the result of **TestIntegrityLevel**(O , $Level$).

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8.3.4 **[[SetIntegrity]] (Level)**

When the **[[SetIntegrity]]** internal method of O is called the following steps are taken:

1. Assert: $Level$ is one of "**nonextensible**", "**sealed**", or "**frozen**".
2. Set the value of the **[[Extensible]]** internal data property of O to **false**.
3. If $Level$ is not "**nonextensible**", then
 - a. Return the result of **SetIntegrityLevel**(O , $Level$).
4. Return **true**.

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8.3.5 **[[HasOwnProperty]] (P)**

When the **[[HasOwnProperty]]** internal method of O is called with property key P , the following steps are taken:

1. Assert: **IsPropertyKey**(P) is **true**.
2. If O does not have an own property with key P , return **false**.
3. Return **true**.

Deleted: P is a valid property key, either a String or a Symbol Object

8.3.6 **[[GetOwnProperty]] (P)**

When the **[[GetOwnProperty]]** internal method of O is called with property key P , the following steps are taken:

1. Return the result of **OrdinaryGetOwnProperty** with arguments O and P .

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8.3.6.1 OrdinaryGetOwnProperty (O, P)

When the abstract operation **OrdinaryGetOwnProperty** is called with Object O and with property key P , the following steps are taken:

1. Assert: **IsPropertyKey**(P) is **true**.
2. If O does not have an own property with key P , return **undefined**.
3. Let D be a newly created Property Descriptor with no fields.
4. Let X be O 's own property whose key is P .
5. 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
6. Else X is an accessor property, so

Deleted: P is a valid property key, either a String or a Symbol Object

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- a. Set $D.[[Get]]$ to the value of X 's $[[\text{Get}]]$ attribute.
 - b. Set $D.[[Set]]$ to the value of X 's $[[\text{Set}]]$ attribute.
7. Set $D.[[\text{Enumerable}]]$ to the value of X 's $[[\text{Enumerable}]]$ attribute.
8. Set $D.[[\text{Configurable}]]$ to the value of X 's $[[\text{Configurable}]]$ attribute.
9. Return D .

8.3.7 $[[\text{DefineOwnProperty}]]$ (P, Desc)

When the $[[\text{DefineOwnProperty}]]$ internal method of O is called with property key P and property descriptor Desc , the following steps are taken:

1. Return the result of $\text{OrdinaryDefineOwnProperty}$ with arguments O , P , and Desc .

8.3.7.1 OrdinaryDefineOwnProperty (O, P, Desc)

When the abstract operation $\text{OrdinaryDefineOwnProperty}$ is called with Object O , property key P , and property descriptors Desc the following steps are taken:

1. Let current be the result of calling $\text{OrdinaryGetOwnProperty}$ with arguments O and P .
2. Let extensible be the value of the $[[\text{Extensible}]]$ internal data property of O .
3. Return the result of $\text{ValidateAndApplyPropertyDescriptor}$ with arguments O , P , extensible , Desc , and current .

8.3.7.2 IsCompatiblePropertyDescriptor (Extensible, Desc, Current)

When the abstract operation $\text{IsCompatiblePropertyDescriptor}$ is called with Boolean value Extensible , and property descriptors Desc , and Current the following steps are taken:

1. Return the result of $\text{ValidateAndApplyPropertyDescriptor}$ with arguments **undefined, undefined, Extensible, Desc, and Current**.

8.3.7.3 ValidateAndApplyPropertyDescriptor (O, P, extensible, Desc, current)

When the abstract operation $\text{ValidateAndApplyPropertyDescriptor}$ is called with Object O , property key P , Boolean value extensible , and property descriptors Desc , and current the following steps are taken:

This algorithm contains steps that test various fields of the Property Descriptor Desc for specific values. The fields that are tested in this manner need not actually exist in Desc . If a field is absent then its value is considered to be **false**.

NOTE If **undefined** is passed as the O argument only validation is performed and no object updates are preformed.

Deleted: However, if O is a String object it has a more elaborate $[[\text{GetOwnProperty}]]$ internal method defined in 15.5.5.2.¶

1. **Assert:** If O is not **undefined** then P is a valid property key.
2. If current is **undefined**, then
 - a. If extensible is **false**, then return **false**.
 - b. **Assert:** extensible is **true**.
 - c. If $\text{IsGenericDescriptor}(\text{Desc})$ or $\text{IsDataDescriptor}(\text{Desc})$ is **true**, then
 - i. If O is not **undefined**, then create an own data property named P of object O whose $[[\text{Value}]]$, $[[\text{Writable}]]$, $[[\text{Enumerable}]]$ and $[[\text{Configurable}]]$ 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.
 - d. Else Desc must be an accessor Property Descriptor.
 - i. If O is not **undefined**, then create an own accessor property named P of object O whose $[[\text{Get}]]$, $[[\text{Set}]]$, $[[\text{Enumerable}]]$ and $[[\text{Configurable}]]$ 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.
 - e. Return **true**.
 3. Return **true**, if every field in Desc is absent.
 4. Return **true**, if every field in Desc also occurs in current and the value of every field in Desc is the same value as the corresponding field in current when compared using the SameValue algorithm (9.12).
 5. If the $[[\text{Configurable}]]$ field of current is **false** then

- a. Return **false**, if the **[[Configurable]]** field of *Desc* is **true**.
- b. Return **false**, if the **[[Enumerable]]** field of *Desc* is present and the **[[Enumerable]]** fields of *current* and *Desc* are the Boolean negation of each other.
6. If **IsGenericDescriptor(*Desc*)** is **true**, then no further validation is required.
7. Else if **IsDataDescriptor(*current*)** and **IsDataDescriptor(*Desc*)** have different results, then
 - a. Return **false**, if the **[[Configurable]]** field of *current* is **false**.
 - b. If **IsDataDescriptor(*current*)** is **true**, then
 - i. If *O* is not **undefined**, then 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 rest of the property's attributes to their default values.
 - c. Else,
 - i. If *O* is not **undefined**, then 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 rest of the property's attributes to their default values.
 8. Else if **IsDataDescriptor(*current*)** and **IsDataDescriptor(*Desc*)** are both **true**, then
 - a. If the **[[Configurable]]** field of *current* is **false**, then
 - i. Return **false**, if the **[[Writable]]** field of *current* is **false** and the **[[Writable]]** field of *Desc* is **true**.
 - ii. If the **[[Writable]]** field of *current* is **false**, then
 1. Return **false**, if the **[[Value]]** field of *Desc* is present and **SameValue(*Desc*.**[[Value]]**, *current*.**[[Value]]**)** is **false**.
 - b. else the **[[Configurable]]** field of *current* is **true**, so any change is acceptable.
 9. Else **IsAccessorDescriptor(*current*)** and **IsAccessorDescriptor(*Desc*)** are both **true**.
 - a. If the **[[Configurable]]** field of *current* is **false**, then
 - i. Return **false**, if the **[[Set]]** field of *Desc* is present and **SameValue(*Desc*.**[[Set]]**, *current*.**[[Set]]**)** is **false**.
 - ii. Return **false**, if the **[[Get]]** field of *Desc* is present and **SameValue(*Desc*.**[[Get]]**, *current*.**[[Get]]**)** is **false**.
 10. If *O* is not **undefined**, then
 - a. 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.
 11. Return **true**.

NOTE Step 8.b allows any field of *Desc* to be different from the corresponding field of *current* if *current*'s **[[Configurable]]** field is **true**. This even permits changing the **[[Value]]** of a property whose **[[Writable]]** attribute is **false**. This is allowed because a **true** **[[Configurable]]** attribute would permit an equivalent sequence of calls where **[[Writable]]** is first set to **true**, a new **[[Value]]** is set, and then **[[Writable]]** is set to **false**.

8.3.8 **[[HasProperty]](*P*)**

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

1. Assert: **IsPropertyKey(*P*)** is **true**.
2. Let *hasOwn* be the result of calling the **[[HasOwnProperty]]** internal method of *O* with argument *P*.
3. ReturnIfAbrupt(*hasOwn*).
4. If *hasOwn* is **false**, then
 - a. Let *parent* be the result of calling the **[[GetInheritance]]** internal method of *O*.
 - b. ReturnIfAbrupt(*parent*).
 - c. If *parent* is not **null**, then
 - i. Return the result of calling the **[[HasProperty]]** internal method of *parent* with argument *P*.
5. Return *hasOwn*.

8.3.9 **[[Get]](*P*, *Receiver*)**

When the **[[Get]]** internal method of *O* is called with property key *P* and ECMAScript language value *Receiver*, the following steps are taken:

1. Assert: **IsPropertyKey(*P*)** is **true**.
2. Let *desc* be the result of calling the **[[GetOwnProperty]]** internal method of *O* with argument *P*.

Deleted: However, if *O* has an **[[BuiltInBrand]]** internal data property whose value is **BuiltinArray** *O* also has a more elaborate **[[DefineOwnProperty]]** internal method defined in 15.4.5.1.1

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Comment [AWB1218]: Replaced with ToPrimitive changes and possible call to @@ToPrimitive method

Deleted: 8.3.11 **[[DefaultValue]](*hint*)**
 When the **[[DefaultValue]]** internal method of *O* is called with hint **String**, the following steps are taken:
 ↪ Let *ToString* be the result of Get(*O*, **"toString"**).
 ↪ ReturnIfAbrupt(*ToString*).
 ↪ If *IsCallable(*ToString*)* is **true** then
 ↪ Let *str* be the result of calling the **[[Call]]** internal method of *ToString*, with *O* as **thisArgument** and an empty **List** as **argumentsList**.
 ↪ ReturnIfAbrupt(*str*).
 ↪ If *str* is a primitive value, return *str*.
 ↪ Let *valueOf* be the result of Get(*O*, **"valueOf"**).
 ↪ ReturnIfAbrupt(*valueOf*).
 ↪ If *IsCallable(*valueOf*)* is **true** then
 ↪ Let *val* be the result of calling the **[[Call]]** internal method of *valueOf*, with *O* as **thisArgument** and an empty **argumentList**.
 ↪ ReturnIfAbrupt(*val*).
 ↪ If *val* is a primitive value, return *val*.
 ↪ Throw a **TypeError** exception.
 When the **[[DefaultValue]]** internal method of *O* is called with hint **Number**, the following steps are taken:
 ↪ Let *valueOf* be the result of Get(*O*, **"valueOf"**).

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3. ReturnIfAbrupt(*desc*).
4. If *desc* is **undefined**, then
 - a. Let *parent* be the result of calling the **[[GetInheritance]]** internal method of *O*.
 - b. ReturnIfAbrupt(*parent*).
 - c. If *parent* is **null**, then return **undefined**.
 - d. Return the result of calling the **[[Get]]** internal method of *parent* with arguments *P* and *Receiver*.
5. If *IsDataDescriptor(*desc*)* is **true**, return *desc.[[Value]]*.
6. Otherwise, *IsAccessorDescriptor(*desc*)* must be **true** so, let *getter* be *desc.[[Get]]*.
7. If *getter* is **undefined**, return **undefined**.
8. Return the result of calling the **[[Call]]** internal method of *getter* with *Receiver* as the *thisArgument* and an empty List as *argumentsList*.

8.3.10 [[Set]] (*P, V, Receiver*)

When the **[[Set]]** internal method of *O* is called with property key *P*, value *V*, and ECMAScript language value *Receiver*, the following steps are taken:

1. Assert: *IsPropertyKey(*P*)* is **true**.
2. Let *ownDesc* be the result of calling the **[[GetOwnProperty]]** internal method of *O* with argument *P*.
3. ReturnIfAbrupt(*ownDesc*).
4. If *ownDesc* is **undefined**, then
 - a. Let *parent* be the result of calling the **[[GetInheritance]]** internal method of *O*.
 - b. ReturnIfAbrupt(*parent*).
 - c. If *parent* is not **null**, then
 - i. Return the result of calling the **[[Set]]** internal method of *parent* with arguments *P, V*, and *Receiver*.
 - d. Else,
 - i. If *Type(*Receiver*)* is not *Object*, return **false**.
 - ii. Return the result of performing *CreateOwnDataProperty(*Receiver, P, V*)*.
5. If *IsDataDescriptor(*ownDesc*)* is **true**, then
 - a. If *ownDesc.[[Writable]]* is **false**, return **false**.
 - b. If *Type(*Receiver*)* is not *Object*, return **false**.
 - c. Let *existingDescriptor* be the result of calling the **[[GetOwnProperty]]** internal method of *Receiver* with argument *P*.
 - d. ReturnIfAbrupt(*existingDescriptor*).
 - e. If *existingDescriptor* is not **undefined**, then
 - i. Let *valueDesc* be the Property Descriptor **{[[Value]]: V}**.
 - ii. Return the result of calling the **[[DefineOwnProperty]]** internal method of *Receiver* with arguments *P* and *valueDesc*.
 - f. Else *Receiver* does not currently have a property *P*.
 - i. Return the result of performing *CreateOwnDataProperty(*Receiver, P, V*)*.
6. If *IsAccessorDescriptor(*ownDesc*)* is **true**, then
 - a. Let *setter* be *ownDesc.[[Set]]*.
 - b. If *setter* is **undefined**, return **false**.
 - c. Let *setterResult* be the result of calling the **[[Call]]** internal method of *setter* providing *Receiver* as *thisArgument* and a new List containing *V* as *argumentsList*.
 - d. ReturnIfAbrupt(*setterResult*).
 - e. Return **true**.

8.3.11 [[Delete]] (*P*)

When the **[[Delete]]** internal method of *O* is called with property key *P* the following steps are taken:

1. Assert: *IsPropertyKey(*P*)* is **true**.
2. Let *desc* be the result of calling the **[[GetOwnProperty]]** internal method of *O* with argument *P*.
3. If *desc* is **undefined**, then return **true**.
4. If *desc.[[Configurable]]* is **true**, then
 - a. Remove the own property with name *P* from *O*.
 - b. Return **true**.
5. Return **false**.

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Deleted: <u>and Boolean flag Throw</u>
Deleted: <u>P</u> is a valid property key, either a String or a
Deleted: <#>If the result of calling the <u>[[CanPut]]</u> internal
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Comment [AWB1219]: Need to decide what replace
Comment [AWB1220]: TODO replace with <u>[[SetP]]</u>
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Deleted: <#>Else if <i>Throw</i> , then throw a <u>TypeError</u>

8.3.12 [[Enumerate]] ()

When the `[[Enumerate]]` internal method of O is called the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method iterates over all the String valued keys of enumerable property keys of O . The mechanics and order of enumerating the properties is not specified but must conform to the rules specified below.

Enumerated properties do not include properties whose property key is a Symbol. Properties of the object being enumerated may be deleted during enumeration. If a property that has not yet been visited during enumeration is deleted, then it will not be visited. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be visited in the active enumeration. A property name must not be visited more than once in any 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. The values of `[[Enumerable]]` attributes are not considered when determining if a property of a prototype object is shadowed by a previous object on the prototype chain.

The following is an informative algorithm that conforms to these rules

1. Let obj be O .
2. Let $proto$ be the result of calling the `[[GetInheritance]]` internal method of O with no arguments.
3. ReturnIfAbrupt($proto$).
4. If $proto$ is the value `null`, then
 - a. Let $propList$ be a new empty List.
5. Else
 - a. Let $propList$ be the result of calling the `[[Enumerate]]` internal method of $proto$.
6. ReturnIfAbrupt($propList$).
7. For each $name$ that is the property key of an own property of O
 - a. If `Type(name)` is String, then
 - i. Let $desc$ be the result of calling `OrdinaryGetOwnProperty` with arguments O and $name$.
 - ii. If $name$ is an element of $propList$, then remove $name$ as an element of $propList$.
 - iii. If $desc.[[Enumerable]]$ is true, then add $name$ as an element of $propList$.
8. Order the elements of $propList$ in an implementation defined order.
9. Return $propList$.

8.3.13 [[OwnPropertyKeys]] ()

When the `[[OwnPropertyKeys]]` internal method of O is called the following steps are taken:

1. Let $keys$ be a new empty List.
2. For each own property key P of O
 - a. If P is not a private Symbol, then
 - i. Add P as the last element of $keys$.
3. Return `MakeListIterator(keys)`.

8.3.14 ObjectCreate(proto, internalDataList) Abstract Operation

The abstract operation `ObjectCreate` with argument $proto$ (an object or null) is used to specify the runtime creation of new ordinary objects. The optional argument $internalDataList$ is a List of the names of internal data property names that should be defined as part of the object. If the list is not provided, an empty List is used. It performs the following steps:

1. If $proto$ was not provided, let $proto$ be the intrinsic `%ObjectPrototype%`.
2. Let obj be a newly created ECMAScript object with an internal data property for each name in $internalDataList$.
3. Set obj 's essential internal methods to the default ordinary object definitions specified in 8.3.
4. Set the `[[Prototype]]` internal data property of obj to $proto$.

Comment [AWB621]: TODO

Comment [AWB622]: TODO: Finish this up and turn it into iterator definition include a next method

Deleted: 8.3.910 [[DefineOwnProperty]] (Desc, Throw)

When the `[[DefineOwnProperty]]` internal method of O is called with property key P and property descriptor $Desc$, the following steps are taken:
 $\langle\#>$ Return the result of `OrdinaryDefineOwnProperty` with arguments O , P , and $Desc$.

8.3.10.1 OrdinaryDefineOwnProperty (O, P, Desc)

When the abstract operation `OrdinaryDefineOwnProperty` is called with Object O , property key P , and property descriptors $Desc$, the following steps are taken:
 $\langle\#>$ Let $current$ be the result of calling `OrdinaryGetOwnProperty` with arguments O and P .

$\langle\#>$ Let $extensible$ be the value of the `[[Extensible]]` internal data property of O .
 $\langle\#>$ Return the result of `ValidateAndApplyPropertyDescriptor` with arguments O , P , $extensible$, $Desc$, and $current$.

8.3.10.2 IsCompatableDescriptor (Extensible, Desc, Current)

When the abstract operation `IsCompatablePropertyDescriptor` is called with Boolean value $Extensible$, and property descriptors $Desc$, and $Current$ the following steps are taken:
 $\langle\#>$ Return the result of `ValidateAndApplyPropertyDescriptor` with arguments `undefined`, `undefined`, $Extensible$, $Desc$, and $Current$.

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Comment [AWB623]: TODO

Comment [AWB624]: TODO: Finish this up and turn it into iterator definition include a next method

Deleted: 8.123.112 [[IterateKeys]] ()

When the `[[IterateKeys]]` internal method of O is called the following steps are taken:
 $\langle\#>$ If `Type(O)` is not Object, return $result$.

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Deleted: <\#>If `Type(O)` is not Object, return $result$.

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Comment [AWB1325]: TODO: need to define, returns an iterator object over the elements of an internal list.

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Deleted: 8.3.14 [[Freeze]] ()

When the `[[Freeze]]` internal method of O is called the following steps are taken:
 $\langle\#>$ If `Type(O)` is not Object, return $result$.

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5. Set the `[[Extensible]]` internal data property of `obj` to `true`.
6. Return `obj`.

8.3.15 Ordinary Function Objects

Ordinary function objects encapsulate parameterised ECMAScript code closed over a lexical environment and support the dynamic evaluation of that code. An ordinary function object is an ordinary object and has the same internal data properties and (except as noted below) the same internal methods as other ordinary objects.

Ordinary function objects have the additional internal data properties listed in Table 13.

Ordinary function objects provide alternative definitions for the `[[Get]]` and `[[GetOwnProperty]]` internal methods. These alternatives prevent the value of strict mode function from being revealed as the value of a function object property named `"caller"`. These alternative definitions exist sole to preclude a non-standard legacy feature of some ECMAScript implementations from revealing information about strict mode callers. If an implementation does not provide such a feature, it need not implement these alternative internal methods for ordinary function objects.

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Table 13 -- Internal Data Properties of Ordinary Function Objects

Internal Data Property	Type	Description
<code>[[Scope]]</code>	<code>Lexical Environment</code>	The Lexical Environment that the function was closed over. Is used as the outer environment when evaluating the code of the function.
<code>[[FormalParameters]]</code>	<code>Parse Node</code>	The root parse node of the source code that defines the function's formal parameter list.
<code>[[FunctionKind]]</code>	<code>String</code>	Either <code>"normal"</code> or <code>"generator"</code> .
<code>[[Code]]</code>	<code>Parse Node</code>	The root parse node of the source code that defines the function's body.
<code>[[Realm]]</code>	<code>Realm Record</code>	The Code Realm in which the function was created and which provides any intrinsic objects that are accessed when evaluating the function.
<code>[[ThisMode]]</code>	<code>(lexical, strict, global)</code>	Defines how <code>this</code> references are interpreted within the formal parameters and code body of the function. <code>lexical</code> means that <code>this</code> refers to the <code>this</code> value of a lexically enclosing function. <code>strict</code> means that the <code>this</code> value is used exactly as provided by an invocation of the function. <code>global</code> means that a <code>this</code> value of <code>undefined</code> is interpreted as a reference to the global object.
<code>[[Strict]]</code>	<code>Boolean</code>	<code>true</code> if this is a strict mode function, <code>false</code> this is not a strict mode function.
<code>[[Home]]</code>	<code>Object</code>	If the function uses <code>super</code> , this is the object whose <code>[[GetInheritance]]</code> provides the object where <code>super</code> property lookups begin. Not present for functions that don't reference <code>super</code> .
<code>[[MethodName]]</code>	<code>String or Symbol</code>	If the function uses <code>super</code> , this is the property keys that is used for unqualified references to <code>super</code> . Not present for functions that don't reference <code>super</code> .

Ordinary function objects all have the `[[Call]]`, `[[Get]]` and `[[GetOwnProperty]]` internal methods defined here. Ordinary functions that are also constructors in addition have the `[[Construct]]` internal method.

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8.3.15.1 `[[Call]]` (`thisArgument, argumentsList`)

The `[[Call]]` internal method for an ordinary Function object `F` is called with parameters `thisArgument` and `argumentsList`, a List of ECMAScript language values. The following steps are taken:

1. Let *callerContext* be the running execution context.
2. If *callerContext* is not already suspended, then Suspend *callerContext*.
3. Let *calleeContext* be a new ECMAScript Code execution context.
4. Let *calleeRealm* be the value of *F*'s *[[Realm]]* internal data property.
5. Set *calleeContext*'s Realm to *calleeRealm*.
6. Let *thisMode* be the value of *F*'s *[[ThisMode]]* internal data property.
7. If *thisMode* is lexical, then
 - a. Let *localEnv* be the result of calling *NewDeclarativeEnvironment* passing the value of the *[[Scope]]* internal data property of *F* as the argument.
8. Else,
 - a. If *thisMode* is strict, set *thisValue* to *thisArgument*.
 - b. Else
 - i. if *thisArgument* is null or undefined, then
 1. Set *thisValue* to *calleeRealm*.*[[globalThis]]*.
 - ii. Else if Type(*thisArgument*) is not Object, set the *thisValue* to *ToObject(thisArgument)*.
 - iii. Else set the *thisValue* to *thisArgument*.
 - c. Let *localEnv* be the result of calling *NewFunctionEnvironment* passing *F* and *thisValue* as the arguments.
 9. Set the LexicalEnvironment of *calleeContext* to *localEnv*.
 10. Set the VariableEnvironment of *calleeContext* to *localEnv*.
 11. Push *calleeContext* onto the execution context stack; *calleeContext* is now the running execution context.
 12. Let *status* be the result of performing Function Declaration Instantiation using the function *F*, *argumentsList* and *localEnv* as described in 10.5.3.
 13. If *status* is an abrupt completion, then
 - a. Remove *calleeContext* from the execution context stack and restore *callerContext* as the running execution context.
 - b. Return *status*.
 14. Let *result* be the result of EvaluateBody of the production that is the value of *F*'s *[[Code]]* internal data property passing *F* as the argument.
 15. Remove *calleeContext* from the execution context stack and restore *callerContext* as the running execution context.
 16. Return *result*.

NOTE 1 Most ordinary functions use a Function Environment Record as their LexicalEnvironment. Ordinary functions that are arrow functions use a Declarative Environment Record as their LexicalEnvironment.

NOTE 2 When *calleeContext* is removed from the execution context stack it must not be destroyed because it may have been suspended and retained by a generator object for later resumption.

8.3.15.2 *[[Construct]]* (*argumentsList*)

The *[[Construct]]* internal method for an ordinary Function object *F* is called with a single parameter *argumentsList* which is a possibly empty List of ECMAScript language values. The following steps are taken:

1. Return the result of OrdinaryConstruct(*F*, *argumentsList*).

8.3.15.2.1 OrdinaryConstruct (*F*, *argumentsList*)

When the abstract operation OrdinaryConstruct is called with Object *F* and List *argumentsList* the following steps are taken:

1. Let *creator* be the result of Get(*F*, *@@create*).
2. ReturnIfAbrupt(*creator*).
3. If *creator* is not undefined, then
 - a. If IsCallable(*creator*) is false, then throw a **TypeError** exception.
 - b. Let *obj* be the result of calling the *[[Call]]* internal method of *creator* with arguments *F* and an empty List.
4. Else *creator* is undefined so fall back to object creation defaults
 - a. Let *obj* be the result of calling OrdinaryCreateFromConstructor(*F*, "%ObjectPrototype%").
5. ReturnIfAbrupt(*obj*).
6. If Type(*obj*) is not Object, then throw a **TypeError** exception.
7. Let *result* be the result of calling the *[[Call]]* internal method of *F*, providing *obj* and *argumentsList* as the arguments.

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Comment [AWB 326]: May need to update section number

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Comment [AWB1427]: At Jan 29, 2012 TC several people suggest that this fall back was unnecessary complexity and that it should thus be thrown. However, that means that a ordinary function whose *__proto__* is set to undefined will throw if newed. I'm not sure that is desirable. It's a breaking change for the realit web.

Deleted: <#>Let *proto* be the result of Get(*F*, "prototype").¶

<#>ReturnIfAbrupt(*proto*).¶

<#>If Type(*proto*) is Object, let *obj* be the result of the abstract operation ObjectCreate with argument *proto*.¶

<#>Else, let *obj* be the result of the abstract operation ObjectCreate.¶

8. ReturnIfAbrupt(result).
9. If Type(result) is Object then return result.
10. Return obj.

8.3.15.3 [[Get]] (P, Receiver)

When the `[[Get]]` internal method of ordinary function object F is called with property key P and ECMAScript language value $Receiver$ the following steps are taken:

1. Let v be the result of calling the default ordinary object `[[Get]]` internal method (8.3.7) on F passing P and $Receiver$ as arguments.
2. ReturnIfAbrupt(v).
3. If P is `"caller"` and v is a strict mode Function object, return `null`.
4. Return v .

If an implementation does not provide such a built-in `caller` method for `Function.prototype` then it must not use this definition. Instead the ordinary object `[[Get]]` internal method is used.

8.3.15.4 [[GetOwnProperty]] (P)

When the `[[GetOwnProperty]]` internal method of ordinary function object F is called with property key P , the following steps are taken:

1. Let v be the result of calling the default ordinary object `[[GetOwnProperty]]` internal method (8.3.6) on F passing P as the argument.
2. ReturnIfAbrupt(v).
3. If `IsDataDescriptor(v)` is `true`, then
 - a. If P is `"caller"` and $v.[[Value]]$ is a strict mode Function object, then
 - i. Set $v.[[Value]]$ to `null`.
4. Return v .

If an implementation does not provide such a built-in `caller` method for `Function.prototype` then it must not use this definition. Instead the ordinary object `[[GetOwnProperty]]` internal method is used.

8.3.15.5 FunctionAllocate Abstract Operation

The abstract operation `FunctionAllocate` requires the one arguments, `functionPrototype` and accepts one optional argument, `functionKind`. `FunctionAllocate` performs the following steps:

1. Assert: `Type(functionPrototype)` is `Object`.
2. Assert: If `functionKind` is present, its value is either `"normal"` or `"generator"`.
3. If `functionKind` is not present, then let `functionKind` be `"normal"`.
4. Let F be a newly created ordinary function object with the internal data properties listed in Table 13.
5. Set F 's essential internal methods except for `[[Get]]` and `[[GetOwnProperty]]` to the default ordinary object definitions specified in 8.3.
6. Set F 's essential internal methods for `[[Call]]`, `[[Get]]` and `[[GetOwnProperty]]` to the default ordinary object definitions specified in 8.3.15.
7. Set the `[[FunctionKind]]` internal data property of F to `functionKind`.
8. Set the `[[Prototype]]` internal data property of F to `functionPrototype`.
9. Set the `[[Extensible]]` internal data property of F to `true`.
10. Set the `[[Realm]]` internal data property of F to the running execution context's Realm.
11. Return F .

8.3.15.6 FunctionInitialize Abstract Operation

The abstract operation `FunctionInitialize` requires the arguments: a function object F , `kind` which is one of `(Normal, Method, Arrow)`, an parameter list production specified by `ParameterList`, a body production specified by `Body`, a Lexical Environment specified by `Scope`, a Boolean flag `Strict`, and optionally, an object `homeObject` and a property key `methodName`. `FunctionInitialize` performs the following steps:

1. Set the `[[Prototype]]` internal data property of F to `functionPrototype`.
2. Set the `[[Scope]]` internal data property of F to the value of `Scope`.
3. Set the `[[FormalParameters]]` internal property of F to `ParameterList`.
4. Set the `[[Code]]` internal data property of F to `Body`.
5. If the `homeObject` argument was provided, set the `[[HomeObject]]` internal data property of F to `homeObject`.
6. If the `methodName` argument was provided, set the `[[MethodName]]` internal data property of F to `methodName`.
7. Set the `[[Strict]]` internal data property of F to `Strict`.
8. If `kind` is Arrow, then set the `[[ThisMode]]` internal data property of F to `lexical`.
9. Else if `Strict` is `true`, then set the `[[ThisMode]]` internal data property of F to `strict`.
10. Else set the `[[ThisMode]]` internal data property of F to `global`.
11. Let `len` be the `ExpectedArgumentCount` of `ParameterList`.
12. Call the `[[DefineOwnProperty]]` internal method of F with arguments `"length"` and `PropertyDescriptor {[[Value]]: len, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}`.
13. If `Strict` is `true`, then
 - a. Perform the `AddRestrictedFunctionProperties` abstract operation with argument F .
14. Return F .

8.3.15.7 FunctionCreate Abstract Operation

The abstract operation `FunctionCreate` requires the arguments: `kind` which is one of (Normal, Method, Arrow), an parameter list production specified by `ParameterList`, a body production specified by `Body`, a Lexical Environment specified by `Scope`, a Boolean flag `Strict`, and optionally, an object `functionPrototype`, an object `homeObject` and a string `methodName`. `FunctionCreate` performs the following steps:

1. If the `functionPrototype` argument was not passed, then
 - a. Let `functionPrototype` be the intrinsic object `%FunctionPrototype%`.
2. Let F be the result of performing `FunctionAllocate` with argument `functionPrototype`.
3. Return the result of performing `FunctionInitialize` with passing F , `kind`, `ParameterList`, `Body`, `Scope`, and `Strict`. Also pass `homeObject` and `methodName` if they are present.

8.3.15.7 GeneratorFunctionCreate Abstract Operation

The abstract operation `GeneratorFunctionCreate` requires the arguments: `kind` which is one of (Normal, Method, Arrow), an parameter list production specified by `ParameterList`, a body production specified by `Body`, a Lexical Environment specified by `Scope`, a Boolean flag `Strict`, and optionally, an object `functionPrototype`, an object `homeObject` and a string `methodName`. `GeneratorFunctionCreate` performs the following steps:

1. If the `functionPrototype` argument was not passed, then
 - a. Let `functionPrototype` be the intrinsic object `%Generator%`.
2. Let F be the result of performing `FunctionAllocate` with arguments `functionPrototype` and `"generator"`.
3. Return the result of performing `FunctionInitialize` with passing F , `kind`, `ParameterList`, `Body`, `Scope`, and `Strict`. Also pass `homeObject` and `methodName` if they are present.

8.3.15.8 AddRestrictedFunctionProperties Abstract Operation

The abstract operation is called with a function object F as its argument. It performs the following steps:

1. Let `thrower` be the `%ThrowTypeError%` intrinsic function `Object`.
2. Call the `[[DefineOwnProperty]]` internal method of F with arguments `"caller"` and `PropertyDescriptor {[[Get]]: thrower, [[Set]]: thrower, [[Enumerable]]: false, [[Configurable]]: false}`.
3. Call the `[[DefineOwnProperty]]` internal method of F with arguments `"arguments"` and `PropertyDescriptor {[[Get]]: thrower, [[Set]]: thrower, [[Enumerable]]: false, [[Configurable]]: false}`.

The `%ThrowTypeError%` object is a unique function object that is defined once for each Realm as follows:

1. Let the `scope` be the Global Environment.
2. Let `formalParameters` be the syntactic production: `FormalParameters : [empty]`.
3. Let `body` be the syntactic production: `FunctionBody : ThrowTypeError`.

4. Let F be the result of the abstract operation `FunctionCreate` with arguments `Normal`, `formalParameters`, `body`, `scope`, and `true`.
5. Call the `[[SetIntegrity]` internal method of F with argument `"nonextensible"`.
6. Let $\%ThrowTypeError\%$ be F .

8.3.15.9 MakeConstructor Abstract Operation

The abstract operation `MakeConstructor` requires a `Function` argument F and optionally, a Boolean `writablePrototype` and an object `prototype`. If `prototype` is provided it is assumed to already contain, if needed, a `"constructor"` property whose value is F . This operation converts F into a constructor by performing the following steps:

1. Let `installNeeded` be `false`.
2. If the `prototype` argument was not provided, then
 - a. Let `installNeeded` be `true`.
 - b. Let `prototype` be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
3. If the `writablePrototype` argument was not provided, then
 - a. Let `writablePrototype` be `true`.
4. Set F 's essential internal method `[[Construct]]` to the definition specified in 8.3.15.2.
5. If `installNeeded`, then
 - a. Call the `[[DefineOwnProperty]]` internal method of `prototype` with arguments `"constructor"` and Property Descriptor `{[[Value]]: F , [[Writable]]: writablePrototype, [[Enumerable]]: false, [[Configurable]]: writablePrototype}`.
7. Call the `[[DefineOwnProperty]]` internal method of F with arguments `"prototype"` and Property Descriptor `{[[Value]]: prototype, [[Writable]]: writablePrototype, [[Enumerable]]: false, [[Configurable]]: false}`.
8. Return.

8.4 Built-in Exotic Object Internal Methods and Data Fields

This specification defines several kinds of built-in exotic objects. These objects generally behave similar to ordinary objects except for a few specific situations. The following exotic objects use the ordinary object internal methods except where it is explicitly specified otherwise below:

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8.4.1 Bound Function Exotic Objects

A *bound function* is an exotic object that wraps another function object. A bound function is callable (it has `[[Call]]` and `[[Construct]]` internal methods). Calling a bound function generally results in a call of its wrapped function.

Bound function objects do not have the internal data properties of ordinary function objects defined in Table 13. Instead they have the internal data properties defined in Table 14.

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Table 14 -- Internal Data Properties of Exotic Bound Function Objects

<i>Internal Data Property</i>	<i>Type</i>	<i>Description</i>
<code>[[BoundTargetFunction]]</code>	Callable Object	The wrapped function object.
<code>[[BoundThis]]</code>	Any	The value that is always passed as the <code>this</code> value when calling the wrapped function.
<code>[[BoundArguments]]</code>	List of Any	A list of values that whose elements are used as the first arguments to any call to the wrapped function.

Unlike ordinary function objects, bound function objects do not use alternative definitions of the `[[Get]]` and `[[GetOwnProperty]]` internal methods. Bound function objects provide all of the essential internal methods as specified in 8.3. However, they use the following definitions for the essential internal methods of function objects.

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8.4.1.1 [[Call]]

When the `[[Call]]` internal method of an exotic bound function object, *F*, which was created using the `bind` function is called with parameters `thisArgument` and `argumentsList`, a List of ECMAScript language values, the following steps are taken:

1. Let `boundArgs` be the value of *F*'s `[[BoundArguments]]` internal data property.
2. Let `boundThis` be the value of *F*'s `[[BoundThis]]` internal data property.
3. Let `target` be the value of *F*'s `[[BoundTargetFunction]]` internal data property.
4. Let `args` be a new list containing the same values as the list `boundArgs` in the same order followed by the same values as the list `argumentsList` in the same order.
5. Return the result of calling the `[[Call]]` internal method of `target` providing `boundThis` as `thisArgument` and providing `args` as `argumentsList`.

8.4.1.2 [[Construct]]

When the `[[Construct]]` internal method of an exotic bound function object, *F* that was created using the `bind` function is called with a list of arguments `ExtraArgs`, the following steps are taken:

1. Let `target` be the value of *F*'s `[[BoundTargetFunction]]` internal data property.
2. If `target` has no `[[Construct]]` internal method, a **TypeError** exception is thrown.
3. Let `boundArgs` be the value of *F*'s `[[BoundArguments]]` internal data property.
4. Let `args` be a new list containing the same values as the list `boundArgs` in the same order followed by the same values as the list `ExtraArgs` in the same order.
5. Return the result of calling the `[[Construct]]` internal method of `target` providing `args` as the arguments.

8.4.1.3 BoundFunctionCreate Abstract Operation

The abstract operation `BoundFunctionCreate` with arguments `targetFunction`, `boundThis` and `boundArgs` is used to specify the creation of new Bound Function exotic objects. It performs the following steps:

1. Let `proto` be the intrinsic `%FunctionPrototype%`.
2. Let `obj` be a newly created ECMAScript object.
3. Set `obj`'s essential internal methods to the default ordinary object definitions specified in 8.3.
4. Set the `[[Call]]` internal method of `obj` as described in 8.4.1.1.
5. Set the `[[Construct]]` internal method of `obj` as described in 8.4.1.2.
6. Set the `[[Prototype]]` internal data property of `obj` to `proto`.
7. Set the `[[Extensible]]` internal data property of `obj` to `true`.
8. Set the `[[BoundTargetFunction]]` internal data property of `obj` to `targetFunction`.
9. Set the `[[BoundThis]]` internal data property of `obj` to the value of `boundThis`.
10. Set the `[[BoundArguments]]` internal data property of `obj` to `boundArgs`.
11. Return `obj`.

8.4.2 Array Exotic Objects

An `Array` object is an exotic object that gives 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 $2^{32}-1$. A property whose property name is an array index is also called an `element`. 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 own properties of an `Array` object and is unaffected by `length` or array index properties that may be inherited from its prototypes.

Exotic `Array` objects have the same internal data properties as ordinary objects. They also have an `[[ArrayInitialisationState]]` internal data property.

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Exotic Array objects always have a non-configurable property named `"length"`.

Exotic Array objects provide alternative definitions for the `[[Set]]` and `[[DefineOwnProperty]]` internal methods. Except for these two internal methods, exotic Array objects provide all of the other essential internal methods as specified in 8.3.

8.4.2.1 `[[DefineOwnProperty]]` (P, Desc)

When the `[[DefineOwnProperty]]` internal method of an exotic Array object *A* is called with property *P*, and Property Descriptor *Desc* the following steps are taken:

1. Assert: `IsPropertyKey(P)` is `true`.
2. If *P* is `"length"`, then
 - a. Return the result of calling `ArraySetLength` with arguments *A*, and *Desc*.
3. Else if *P* is an array index, then
 - a. Let *oldLenDesc* be the result of calling the `[[GetOwnProperty]]` internal method of *A* passing `"length"` as the argument. The result will never be `undefined` or an accessor descriptor because Array objects are created with a length data property that cannot be deleted or reconfigured.
 - b. Let *oldLen* be *oldLenDesc*`.[[Value]]`.
 - c. Let *index* be `ToUint32(P)`.
 - d. `ReturnIfAbrupt(index)`.
 - e. If *index* > *oldLen* and *oldLenDesc*`.[[Writable]]` is `false`, then return `false`.
 - f. Let *succeeded* be the result of calling `OrdinaryDefineOwnProperty` passing *A*, *P*, and *Desc* as arguments.
 - g. `ReturnIfAbrupt(succeeded)`.
 - h. If *succeeded* is `false`, then return `false`.
 - i. If *index* > *oldLen*
 - i. Set *oldLenDesc*`.[[Value]]` to *index* + 1.
 - ii. Let *succeeded* be the result of calling `OrdinaryDefineOwnProperty` passing *A*, `"length"`, and *oldLenDesc* as arguments.
 - iii. `ReturnIfAbrupt(succeeded)`.
 - j. Return `true`.
4. Return the result of calling `OrdinaryDefineOwnProperty` passing *A*, *P*, and *Desc* as arguments.

8.4.2.2 `ArrayCreate` Abstract Operation

The abstract operation `ArrayCreate` with argument *length* (a positive integer or `undefined`) and optional argument *proto* is used to specify the creation of new exotic Array objects. It performs the following steps:

1. If the *proto* argument was not passed, then let *proto* be the intrinsic object `%ArrayPrototype%`.
2. Let *A* be a newly created `Array` exotic object.
3. Set *A*'s essential internal methods to the default ordinary object definitions specified in 8.3.
4. Set the `[[DefineOwnProperty]]` internal method of *A* as specified in 8.4.2.1.
5. Set the `[[Prototype]]` internal data property of *A* to *proto*.
6. Set the `[[Extensible]]` internal data property of *A* to `true`.
7. If *length* is not `undefined`, then
 - a. Set the `[[ArrayInitialisationState]]` internal data property of *A* to `true`.
8. Else
 - a. Set the `[[ArrayInitialisationState]]` internal data property of *A* to `false`.
 - b. Let *length* be 0.
9. Call `OrdinaryDefineOwnProperty` with arguments *A*, `"length"` and Property Descriptor `{[[Value]]: length, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false}`.
10. Return *A*.

8.4.2.3 `ArraySetLength` Abstract Operation

When the abstract operation `ArraySetLength` is called with an exotic Array object *A*, and Property Descriptor *Desc* the following steps are taken:

1. If the `[[Value]]` field of *Desc* is absent, then

Deleted: Exotic Array objects have the same internal data properties as ordinary objects. They also have a `[[BuiltInBrand]]` internal data property whose value is `BuiltinArray`.¶

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Deleted: **8.4.2.1 `[[SetP]]` (*P, V, Receiver*)**
 When the `[[SetP]]` internal method of an exotic Array object *O* is called with property key *P*, value *V*, and ECMAScript language value *Receiver*, the following steps are taken:
 ↪ Assert: *P* is a valid property key, either a String or a Symbol Object.¶
 ↪ Let *ownDesc* be the result of calling `OrdinaryGetOwnProperty` with arguments *O* and *P*.¶
 ↪ ReturnIfAbrupt(*ownDesc*).¶
 ↪ If *desc* is `undefined`, then
 ↪ Let *parent* be the result of calling the `[[GetInheritance]]` internal method of *O*.¶
 ↪ ReturnIfAbrupt(*parent*).¶
 ↪ If *parent* is not `null`, then
 ↪ Return the result of calling the `[[SetP]]` internal method of *parent* with arguments *P, V*, and *Receiver*.¶
 ↪ Else
 ↪ If `Type(Receiver)` is not `Object`, return `false`.¶
 ↪ Return the result of performing `CreateOwnDataProperty(Receiver, P, V)`.¶
 ↪ If `IsDataDescriptor(ownDesc)` is `true`, then
 ↪ If *ownDesc*`.[[Writable]]` is `false`, return `false`.¶
 ↪ If `SameValue(O, Receiver)` is `true`, then
 ↪ Let *valueDesc* be the Property Descriptor `{[[Value]]: V}`.
 ↪ If *P* is `"length"`, then
 ↪ Return the result of calling `ArraySetLength` with arguments *O, P*, and *valueDesc*.¶
 ↪ Else
 ↪ Return the result of calling `OrdinaryDefineOwnProperty` with arguments *O, P*, and *valueDesc*.¶
 ↪ Else *O* and *Receiver* are different values,¶

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Deleted: ↪ Set the `[[SetP]]` internal method of *A* as specified in 8.4.2.1.¶

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Deleted: ↪ Let *oldLenDesc* be the result of calling the `[[GetOwnProperty]]` internal method of *A* passing `"length"` as the argument. The result will never be `undefined` or an

- a. Return the result of calling OrdinaryDefineOwnProperty passing *A*, "length", and *Desc* as arguments.
2. Let *newLenDesc* be a copy of *Desc*.
3. Let *newLen* be ToUint32(*Desc*.[[Value]]).
4. If *newLen* is not equal to ToNumber(*Desc*.[[Value]]), throw a RangeError exception.
5. Set *newLenDesc*.[[Value]] to *newLen*.
6. Let *oldLenDesc* be the result of calling the [[GetOwnProperty]] internal method of *A* passing "length" as the argument. The result will never be undefined or an accessor descriptor because Array objects are created with a length data property that cannot be deleted or reconfigured.
7. Let *oldLen* be *oldLenDesc*.[[Value]].
8. If *newLen* > *oldLen*, then
 - a. Return the result of calling OrdinaryDefineOwnProperty passing *A*, "length", and *newLenDesc* as arguments.
 9. If *oldLenDesc*.[[Writable]] is false, then return false.
 10. If *newLenDesc*.[[Writable]] is absent or has the value true, let *newWritable* be true.
 11. Else,
 - a. Need to defer setting the [[Writable]] attribute to false in case any elements cannot be deleted.
 - b. Let *newWritable* be false.
 - c. Set *newLenDesc*.[[Writable]] to true.
 12. Let *succeeded* be the result of calling OrdinaryDefineOwnProperty passing *A*, "length", and *newLenDesc* as arguments.
 13. ReturnIfAbrupt(*succeeded*).
 14. If *succeeded* is false, return false.
 15. While *newLen* < *oldLen* repeat,
 - a. Set *oldLen* to *oldLen* - 1.
 - b. Let *deleteSucceeded* be the result of calling the [[Delete]] internal method of *A* passing ToString(*oldLen*).
 - c. ReturnIfAbrupt(*succeeded*).
 - d. If *deleteSucceeded* is false, then
 - i. Set *newLenDesc*.[[Value]] to *oldLen* + 1.
 - ii. If *newWritable* is false, set *newLenDesc*.[[Writable]] to false.
 - iii. Let *succeeded* be the result of calling OrdinaryDefineOwnProperty passing *A*, "length" and *newLenDesc* as arguments.
 - iv. ReturnIfAbrupt(*succeeded*).
 - v. Return false.
 16. If *newWritable* is false, then
 - a. Call OrdinaryDefineOwnProperty passing *A*, "length", and Property Descriptor{[[Writable]]: false} as arguments. This call will always return true.
 17. Return true.

8.4.3 String Exotic Objects

A *String object* is an exotic object that encapsulates a *String* value and exposes virtual array index data properties corresponding to the individual code unit elements of the string value. Exotic String objects always have a data property named "length" whose value is the number of code unit elements in the encapsulated *String* value. Both the code unit data properties and the "length" property are non-writable and non-configurable.

Exotic String objects have the same internal data properties as ordinary objects. They also have a [[StringData]] internal data property.

Exotic String objects provide alternative definitions for the following internal methods. All of the other exotic String object essential internal methods that are not defined below are as specified in 8.3.

8.4.3.1 [[HasOwnProperty]] (P)

When the [[HasOwnProperty]] internal method of exotic String object *O* is called with property key *P*, the following steps are taken:

Comment [AWB1428]: Note that if [[Value]] is an object this sequence will call its valueOf method twice. That seems undesirable, but it's the legacy behaviour going back to at least E

Comment [AWB1429]: See bug https://bugs.ecmascript.org/show_bug.cgi?id=200 for why these two lines moved.

1. Assert: IsPropertyKey(P) is true.
2. Let has be the result of calling the ordinary object [[HasOwnProperty]] internal method (8.3.5) on O with argument P .
3. ReturnIfAbrupt(has).
4. If has is true, then return true.
5. Let $index$ be ToInteger(P).
6. ReturnIfAbrupt($index$).
7. Let $absIntIndex$ be ToString($abs(index)$).
8. ReturnIfAbrupt($absIntIndex$).
9. If SameValue($absIntIndex$, P) is false return false.
10. Let str be the String value of the [[StringData]] internal property of O , if the value of [[StringData]] is undefined the empty string is used as its value.
11. Let len be the number of elements in str .
12. If $len \leq index$, return false.
13. Return true.

8.4.3.2 [[GetOwnProperty]] (P)

When the [[GetOwnProperty]] internal method of an exotic String object S is called with property key P the following steps are taken:

1. Assert: IsPropertyKey(P) is true.
2. Let $desc$ be the result of OrdinaryGetOwnProperty(S , P).
3. ReturnIfAbrupt($desc$).
4. If $desc$ is not undefined return $desc$.
5. Let $index$ be ToInteger(P).
6. ReturnIfAbrupt($index$).
7. Let $absIntIndex$ be ToString($abs(index)$).
8. ReturnIfAbrupt($absIntIndex$).
9. If SameValue($absIntIndex$, P) is false return undefined.
10. Let str be the String value of the [[StringData]] internal data property of S , if the value of [[StringData]] is undefined the empty string is used as its value.
11. Let len be the number of elements in str .
12. If $len \leq index$, return undefined.
13. Let $resultStr$ be a String value of length 1, containing one code unit from str , specifically the code unit at position $index$, where the first (leftmost) element in str is considered to be at position 0, the next one at position 1, and so on.
14. Return a Property Descriptor { [[Value]]: $resultStr$, [[Enumerable]]: true, [[Writable]]: false, [[Configurable]]: false }.

8.4.3.3 [[DefineOwnProperty]] (P , $Desc$)

When the [[DefineOwnProperty]] internal method of an exotic String object O is called with property P , and Property Descriptor $Desc$ the following steps are taken:

1. Let $current$ be the result of calling the [[GetOwnProperty]] internal method of O with argument P .
2. Let $extensible$ be the value of the [[Extensible]] internal data property of O .
3. Return the result of ValidateAndApplyPropertyDescriptor with arguments O , P , $extensible$, $Desc$, and $current$.

NOTE This algorithm differs from the ordinary object OrdinaryDefineOwnProperty abstract operation algorithm only in invocation of [[GetOwnProperty]] in step 1.

8.4.3.4 [[Enumerate]] ()

When the [[Enumerate]] internal method of an exotic String object O is called the following steps are taken:

Deleted: Assert: P is a valid property key, either a String or a Symbol Object.

Deleted:

Deleted: P is a valid property key, either a String or a Symbol Object

Deleted: calling the default [[GetOwnProperty]] internal method (8.12.1) on

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Deleted: ToString($abs(ToInteger(P))$) is not the same value as

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Deleted: <#>Let $index$ be ToInteger(P).¶

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<#>8.4.3.3 [[GetProperty]] (P , Receiver)¶

When the [[GetProperty]] internal method of exotic String object O is called with property key P and ECMAScript language value $Receiver$ the following steps are taken:¶

Assert: P is a valid property key, either a String or a Symbol Object.¶

Let $desc$ be the result of calling the [[GetOwnProperty]] internal method of O with argument P .¶

ReturnIfAbrupt($desc$).¶

If $desc$ is undefined, then¶

Let $parent$ be the result of calling the [[GetInheritance]] internal method of O .¶

ReturnIfAbrupt($parent$).¶

If $parent$ is null, then return undefined.¶

Return the result of calling the [[GetProperty]] internal methods of $parent$ with arguments P and $Receiver$.¶

If IsDataDescriptor($desc$) is true, return $desc$.[[Value]].¶

Otherwise, IsAccessorDescriptor($desc$) must be true so, let $getter$ be $desc$.[[Get]].¶

If $getter$ is undefined, return undefined.¶

Return the result of calling the [[Call]] internal method of $getter$ with $targetThis$ as the thisArgument and an empty List $argumentsList$.¶

NOTE This algorithm differs from the ordinary object [[SetP]] algorithm only in invocation of [[GetProperty]] in step 2.¶

Deleted: 8.4.3.4 [[Delete]] (P)¶

When the [[Delete]] internal method of exotic String object O is called with property name P the following steps are taken:¶

<#>Assert: P is a valid property key, either a String or a Symbol Object.¶

<#>Let $desc$ be the result of calling the [[GetOwnProperty]] internal method of O with argument P .¶

<#>If $desc$ is undefined, then return true.¶

<#>If $desc$.[[Configurable]] is true, then¶

<#>Remove the own property with name P from O .¶

<#>Return true.¶

<#>Return false.¶

NOTE This algorithm differs from the ordinary object [[Delete]] algorithm only in invocation of [[GetOwnProperty]] in step 2.¶

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Deleted: Let $extensible$ be the result of calling the [[GetExtensible]] internal method of O .

Deleted: and [[IsExtensible]] in step 2

Comment [AWB1230]: TODO

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8.4.3.7 [[Keys]] ()

8.4.3.5 [[OwnPropertyKeys]] ()

When the `[[OwnPropertyKeys]]` internal method of an exotic String object O is called the following steps are taken:

8.4.3.6 StringCreate Abstract Operation

The abstract operation `StringCreate` with argument `prototype` is used to specify the creation of new exotic String objects. It performs the following steps:

1. Let A be a newly created String exotic object.
2. Set A 's essential internal methods to the default ordinary object definitions specified in 8.3.
3. Set the `[[HasOwnProperty]]` internal method of A as specified in 8.4.3.1.
4. Set the `[[GetOwnProperty]]` internal method of A as specified in 8.4.3.2.
5. Set the `[[DefineOwnProperty]]` internal method of A as specified in 8.4.3.3.
6. Set the `[[Enumerate]]` internal method of A as specified in 8.4.3.4.
7. Set the `[[OwnPropertyKeys]]` internal method of A as specified in 8.4.3.5.
8. Set the `[[Prototype]]` internal data property of A to `prototype`.
9. Set the `[[Extensible]]` internal data property of A to `true`.
10. Return A .

8.4.4 Exotic Arguments Objects

An `arguments` object is an exotic object whose array index properties map to the formal parameters bindings of an invocation of a non-strict function.

Exotic arguments objects have the same internal data properties as ordinary objects. They also have a `[[ParameterMap]]` internal data.

Exotic arguments objects provide alternative definitions for the following internal methods. All of the other exotic arguments object essential internal methods that are not defined below are as specified in 8.3.

8.4.5 Integer Indexed Delegation Exotic Objects

An `Integer Indexed object` is an exotic object that delegates `[[Get]]` and `[[Set]]` handling of integer property keys to methods of the object.

Integer Indexed exotic objects initially have the same internal data properties as ordinary objects.

Integer Indexed Exotic objects provide alternative definitions for the following internal methods. All of the other Integer Indexed exotic object essential internal methods that are not defined below are as specified in 8.3.

8.4.5.1 [[Get]] (P, Receiver)

When the `[[Get]]` internal method of an `Integer Indexed` exotic object O is called with property key P and ECMAScript language value `Receiver` the following steps are taken:

1. If `SameValue(O, Receiver)` is `true`, then
 - a. Let `intIndex` be `TolInteger(P)`.
 - b. If `SameValue(ToString(intIndex), P)` is `true`, then
 - i. Let `args` be a new List containing `intIndex`.
 - ii. Return the result of `Invoke(O, @@elementGet, args)`.
2. Return the result of calling the default ordinary object `[[Get]]` internal method (8.3.7) on O passing P and `Receiver` as arguments.

Comment [AWB1231]: TODO

Deleted: When the `[[Keys]]` internal method an exotic String object O is called the following steps are taken:
1. Let A be a newly created String exotic object.
2. Set A 's essential internal methods to the default ordinary object definitions specified in 8.3.
3. Set the `[[HasOwnProperty]]` internal method of A as specified in 8.4.3.1.
4. Set the `[[GetOwnProperty]]` internal method of A as specified in 8.4.3.2.
5. Set the `[[DefineOwnProperty]]` internal method of A as specified in 8.4.3.3.
6. Set the `[[Enumerate]]` internal method of A as specified in 8.4.3.4.
7. Set the `[[OwnPropertyKeys]]` internal method of A as specified in 8.4.3.5.
8. Set the `[[Prototype]]` internal data property of A to `prototype`.
9. Set the `[[Extensible]]` internal data property of A to `true`.
10. Return A .

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Comment [AWB1237]: Possibly unnecessary

Comment [AWB1238]: Possibly unnecessary

Deleted: 8.4.4 Exotic Symbol Objects

An `Symbol object` is an exotic object that may be used as a property key. Symbol exotic objects are unique in that they are always immutable and never observably reference another object.

Exotic String objects have the a single internal data properties named `[[Private]]` that is set when the object is created and never modified.

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8.4.5.2 [[Set]] (P, V, Receiver)

When the [[Set]] internal method of an IntegerIndexed exotic object O is called with property key P, value V, and ECMAScript language value Receiver, the following steps are taken:

1. If SameValue(O, Receiver) is true, then
 - a. Let intIndex be ToInteger(P).
 - a. If SameValue(ToString(intIndex), P) is true, then
 - i. Let args be a new List containing intIndex and V.
 - ii. Return the result of ToBoolean(Invoke(O, @@elementSet, args)).
2. Return the result of calling the default ordinary object [[Set]] internal method (8.3.7) on O passing P, V, and Receiver as arguments.

8.4.5.3 IntegerIndexedObjectCreate Abstract Operation

The abstract operation IntegerIndexedObjectCreate with argument prototype is used to specify the creation of new Integer Indexed exotic objects. It performs the following steps:

11. Let A be a newly created ECMAScript object.
12. Set A's essential internal methods to the default ordinary object definitions specified in 8.3.
13. Set the [[Get]] internal method of A as specified in 8.4.6.1.
14. Set the [[Set]] internal method of A as specified in 8.4.6.2.
15. Set the [[Prototype]] internal data property of A to prototype.
16. Set the [[Extensible]] internal data property of A to true.
17. Return A.

8.4.6 Built-in Function Objects

The function objects specified in Clause 15 may be implemented as either ordinary function objects whose behaviour is provided using ECMAScript code or as implementation provided exotic function objects whose behaviour is provided in some other manner. In either case, the effect of calling such functions must be that specified for each one in Clause 15.

If an implementation provided exotic object is used, the object must have the ordinary object behaviour specified in 8.3 except for [[Get]] and [[GetOwnProperty]] which must be as specified in 8.3.15. All such exotic function objects also have [[Prototype]] and [[Extensible]] internal data.

[[Call]] and [[Construct]]

8.5 Proxy Object Internal Methods and Internal Data Properties

A proxy object is an exotic object whose essential internal methods are partially implemented using ECMAScript code. Every proxy objects has an internal data property called [[ProxyHandler]]. The value of [[ProxyHandler]] is always an object, called the proxy's handler object. Methods of a handler object may be used to augment the implementation for one or more of the proxy object's internal methods. Every proxy object also has an internal data property called [[ProxyTarget]] whose value is either an object or the null value. This object is called the proxy's target object.

When a handler method is called to provide the implementation of a proxy object internal method, the handler method is passed the proxy's target object as a parameter. A proxy's handler object does not necessarily have a method corresponding to every essential internal method. Invoking an internal method on the proxy results in the invocation of the corresponding internal method on the proxy's target object if the handler object does not have a method corresponding to the internal trap.

The [[ProxyHandler]] and [[ProxyTarget]] internal data properties of a proxy object are always initialized when the object is created and typically may not be modified. Some proxy objects are created in a manner that permits them to be subsequently revoked. When a proxy is revoked, its [[ProxyHandler]] internal data property is set to a special revoked proxy handler object and its [[ProxyTarget]] internal data property is set to null.

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Comment [AWB1342]: If we make this a private symbol that is not exposed, then it is just a specification device. If we make it an exposed symbol (whether private or not) it becomes a ES programmer extension point.

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Comment [AWB1243]: TODO: need to talk about [[Call]] and [[Construct]] behaviour of chapter 15 native functions.

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Because proxy permit arbitrary ECMAScript code to be used to implement internal methods, it is possible to define a proxy object whose handler methods violates the invariants defined in 8.1.6.2. Some of the internal method invariants defined in 8.1.6.2 are essential integrity invariants. These invariants are explicitly enforced by the proxy internal methods specified in this section. An ECMAScript implementation must be robust in the presence of all possible invariant violations.

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In the following algorithm descriptions, assume O is an ECMAScript proxy object, P is a property key value, V is any ECMAScript language value, Desc is a Property Description record, and B is a Boolean flag.

8.5.1 $\text{[[GetInheritance]]}()$

When the $\text{[[GetInheritance]]}$ internal method of an exotic Proxy object O is called the following steps are taken:

1. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
2. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
3. Let $trap$ be the result of $\text{GetMethod}(handler, \text{"getPrototypeOf"})$.
4. ReturnIfAbrupt($trap$).
5. If $trap$ is **undefined**, then
 - a. Return the result of calling the $\text{[[GetInheritance]]}$ internal method of $target$.
6. Let $handlerProto$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the **this** value and a new List containing $target$.
7. ReturnIfAbrupt($handlerProto$).
8. Let $targetProto$ be the result of calling the $\text{[[GetInheritance]]}$ internal method of $target$.
9. ReturnIfAbrupt($targetProto$).
10. If $\text{SameValue}(handlerProto, targetProto)$ is **false**, then throw a **TypeError** exception.
11. Return $handlerProto$.

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NOTE $\text{[[GetInheritance]]}$ for proxy objects enforces the following invariant:

- $\text{[[GetInheritance]]}$ applied to the proxy object must return the same value as $\text{[[GetInheritance]]}$ applied to the proxy object's target object.

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8.5.2 $\text{[[SetInheritance]]}(V)$

When the $\text{[[SetInheritance]]}$ internal method of an exotic Proxy object O is called with argument V the following steps are taken:

1. Assert: Either $\text{Type}(V)$ is Object or $\text{Type}(V)$ is Null.
2. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
3. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
4. Let $trap$ be the result of $\text{GetMethod}(handler, \text{"setPrototypeOf"})$.
5. ReturnIfAbrupt($trap$).
6. If $trap$ is **undefined**, then
 - a. Return the result of calling the $\text{[[SetInheritance]]}$ internal method of $target$ with argument V .
7. Let $trapResult$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the **this** value and a new List containing $target$ and V .
8. ReturnIfAbrupt($trapResult$).
9. Let $trapResult$ be $\text{ToBoolean}(trapResult)$.
10. Let $extensibleTarget$ be the result of $\text{IsExtensible}(target)$.
11. ReturnIfAbrupt($extensibleTarget$).
12. Set $extensibleTarget$ to $\text{ToBoolean}(extensibleTarget)$.
13. If $extensibleTarget$ is **true**, then return $trapResult$.
14. Let $targetProto$ be the result of calling the $\text{[[GetInheritance]]}$ internal method of $target$.
15. ReturnIfAbrupt($targetProto$).
16. If $trapResult$ is **true** and $\text{SameValue}(V, targetProto)$ is **false**, then throw a **TypeError** exception.
17. Return $trapResult$.

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Deleted: <#>Let $getProtoTrap$ be the result of $\text{GetMethod}(handler, \text{"getPrototypeOf"})$.
 <#>ReturnIfAbrupt($getProtoTrap$).
 <#>If $getProtoTrap$ is **undefined**, then
 <#>Return $trapResult$.
 <#>Let $getProtoResult$ be the result of calling $getProtoTrap$ with $handler$ as the **this** value and a new List containing $target$.
 <#>ReturnIfAbrupt($getProtoResult$).
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Deleted: $[[\text{SetInheritance}]]$ call, $[[\text{GetInheritance}]]$ applied to the proxy object must may only return true if

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NOTE $\text{[[SetInheritance]]}$ for proxy objects enforces the following invariant:

- If the target object is not extensible, the argument value must be the same as the result of $\text{[[GetInheritance]]}$ applied to target object.

8.5.3 [[HasIntegrity]] (Level)

When the [[HasIntegrity]] internal method of an exotic Proxy object O is called the following steps are taken:

1. Assert: $Level$ is one of "nonextensible", "sealed", or "frozen".
2. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
3. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
4. If $Level$ is "nonextensible", then let $trapName$ be "isExtensible".
5. Else if $Level$ is "sealed", then let $trapName$ be "isSealed".
6. Else $Level$ is "frozen", so let $trapName$ be "isFrozen".
7. Let $trap$ be the result of GetMethod($handler$, $trapName$).
8. ReturnIfAbrupt($trap$).
9. If $trap$ is undefined, then
 - a. Return the result of calling the [[HasIntegrity]] internal method of $target$ with argument $Level$.
10. Let $trapResult$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the this value and a new List containing $target$.
11. ReturnIfAbrupt($trapResult$).
12. Let $booleanTrapResult$ be ToBoolean($trapResult$).
13. Let $targetResult$ be the result of calling the [[HasIntegrity]] internal method of $target$ with argument $Level$.
14. ReturnIfAbrupt($targetResult$).
15. If SameValue($booleanTrapResult$, $targetResult$) is false, then throw a **TypeError** exception.
16. Return $booleanTrapResult$.

NOTE [[HasIntegrity]] for proxy objects enforces the following invariant:

- [[HasIntegrity]] applied to the proxy object must return the same value as [[HasIntegrity]] applied to the proxy object's target object with the same argument.

8.5.4 [[SetIntegrity]] (Level)

When the [[SetIntegrity]] internal method of an exotic Proxy object O is the following steps are taken:

1. Assert: $Level$ is one of "nonextensible", "sealed", or "frozen".
2. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
3. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
4. If $Level$ is "nonextensible", then let $trapName$ be "preventExtensions".
5. Else if $Level$ is "sealed", then let $trapName$ be "seal".
6. Else $Level$ is "frozen", so let $trapName$ be "freeze".
7. Let $trap$ be the result of GetMethod($handler$, $trapName$).
8. ReturnIfAbrupt($trap$).
9. If $trap$ is undefined, then
 - a. Return the result of calling the [[SetIntegrity]] internal method of $target$ with argument $Level$.
10. Let $trapResult$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the this value and a new List containing $target$.
11. ReturnIfAbrupt($trapResult$).
12. Let $booleanTrapResult$ be ToBoolean($trapResult$).
13. Let $targetResult$ be the result of calling the [[HasIntegrity]] internal method of $target$ with argument $Level$.
14. ReturnIfAbrupt($targetResult$).
15. If SameValue($booleanTrapResult$, $targetResult$) is false, then throw a **TypeError** exception.
16. Return $booleanTrapResult$.

NOTE [[SetIntegrity]] for proxy objects enforces the following invariant:

- [[SetIntegrity]] applied to the proxy object must return the same value as [[HasIntegrity]] applied to the proxy object's target object with the same argument.

8.5.5 [[HasOwnProperty]] (P)

When the [[HasOwnProperty]] internal method of an exotic Proxy object O is called with property key P , the following steps are taken:

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Deleted: IsExtensible

Deleted: handler

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Deleted: "preventExtensions"

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Deleted: <#>Let $isTrap$ be the result of GetMethod($hand$ "isExtensible").
 <#>ReturnIfAbrupt($isTrap$).
 <#>If $isTrap$ is undefined, then
 <#>Return NormalCompletion(empty).
 <#>Let $isTrapResult$ be the result of calling $isTrap$ with $handler$ as the this value and a new List containing $target$.
 <#>ReturnIfAbrupt($isTrapResult$).
 <#>Let $proxyIsExtensible$ be ToBoolean($isTrapResult$).
Deleted: targetIsExtensible

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Deleted: SameValue($proxyIsExtensible$, $targetIsExtensible$) is false

Deleted: NormalCompletion(empty)

Deleted: PreventExtensions

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Deleted: [[PreventExtensions]] call, [[IsExtensible]] applied to the proxy object must return the same value [[IsExtensible]] applied to the proxy object's handler ob

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1. Assert: IsPropertyKey(*P*) is **true**.
2. Let *handler* be the value of the [[ProxyHandler]] internal data property of *O*.
3. Let *target* be the value of the [[ProxyTarget]] internal data property of *O*.
4. Let *trap* be the result of GetMethod(*handler*, "hasOwn").
5. ReturnIfAbrupt(*trap*).
6. If *trap* is **undefined**, then
 - a. Return the result of calling the [[HasOwnProperty]] internal method of *target* with argument *P*.
7. Let *trapResult* be the result of calling the [[Call]] internal method of *trap* with *handler* as the **this** value and a new List containing *target* and *P*.
8. ReturnIfAbrupt(*trapResult*).
9. Let *success* be ToBoolean(*trapResult*).
10. If *success* is **false**, then
 - a. Let *targetDesc* be the result of calling the [[GetOwnProperty]] internal method of *target* with argument *P*.
 - b. ReturnIfAbrupt(*targetDesc*).
 - c. If *targetDesc* is not **undefined**, then
 - i. If *targetDesc*.[[Configurable]] is **false**, then throw a **TypeError** exception.
 - ii. Let *extensibleTarget* be the result of calling the [[IsExtensible]] internal method of *target*.
 - iii. ReturnIfAbrupt(*extensibleTarget*).
 - iv. If ToBoolean(*extensibleTarget*) is **false**, then throw a **TypeError** exception.
11. Else *success* is **true**,
 - a. Let *extensibleTarget* be the result of IsExtensible(*target*).
 - b. ReturnIfAbrupt(*extensibleTarget*).
 - c. If ToBoolean(*extensibleTarget*) is **true**, then return *success*.
 - d. Let *targetDesc* be the result of calling the [[GetOwnProperty]] internal method of *target* with argument *P*.
 - e. ReturnIfAbrupt(*targetDesc*).
 - f. If *targetDesc* is **undefined**, then throw a **TypeError** exception.
12. Return *success*.

Deleted: *P* is a valid property key, either a String or a Symbol Object

- NOTE** [[HasOwnProperty]] for proxy objects enforces the following invariants:
- A property cannot be reported as non-existent, if it exists as a non-configurable own property of the target object.
 - A property cannot be reported as non-existent, if it exists as a own property of the target object and the target object is not extensible.
 - A property cannot be reported as existent, if it does not exists as a own property of the target object and the target object is not extensible.

8.5.6 [[GetOwnProperty]] (*P*)

When the [[GetOwnProperty]] internal method of an exotic Proxy object *O* is called with property key *P*, the following steps are taken:

1. Assert: IsPropertyKey(*P*) is **true**.
2. Let *handler* be the value of the [[ProxyHandler]] internal data property of *O*.
3. Let *target* be the value of the [[ProxyTarget]] internal data property of *O*.
4. Let *trap* be the result of GetMethod(*handler*, "getOwnPropertyDescriptor").
5. ReturnIfAbrupt(*trap*).
6. If *trap* is **undefined**, then
 - a. Return the result of calling the [[GetOwnProperty]] internal method of *target* with argument *P*.
7. Let *trapResultObj* be the result of calling the [[Call]] internal method of *trap* with *handler* as the **this** value and a new List containing *target* and *P*.
8. ReturnIfAbrupt(*trapResultObj*).
9. If Type(*trapResultObj*) is neither Object or Undefined, then throw a **TypeError** exception.
10. Let *targetDesc* be the result of calling the [[GetOwnProperty]] internal method of *target* with argument *P*.
11. ReturnIfAbrupt(*targetDesc*).
12. If *trapResultObj* is **undefined**, then
 - a. If *targetDesc* is **undefined**, then return **undefined**.
 - b. If *targetDesc*.[[Configurable]] is **false**, then throw a **TypeError** exception.
 - c. Let *extensibleTarget* be the result of IsExtensible(*target*).
 - d. ReturnIfAbrupt(*extensibleTarget*).

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e. If `ToBoolean(extensibleTarget)` is `false`, then throw a `TypeError` exception.
f. Return `undefined`.

13. Let `extensibleTarget` be the result of `IsExtensible(target)`.

14. `ReturnIfAbrupt(extensibleTarget)`.

15. Set `extensibleTarget` to `ToBoolean(extensibleTarget)`.

16. Let `resultDesc` be `ToPropertyDescriptor(trapResultObj)`.

17. `ReturnIfAbrupt(resultDesc)`.

18. Call `CompletePropertyDescriptor(resultDesc, targetDesc)`.

19. Let `valid` be the result of `IsCompatiblePropertyDescriptor(extensibleTarget, resultDesc, targetDesc)`.

20. If `valid` is `false`, then throw a `TypeError` exception.

21. If `resultDesc.[[Configurable]]` is `false`, then

a. If `targetDesc` is `undefined` or `targetDesc.[[Configurable]]` is `true`, then

i. Throw a `TypeError` exception.

22. Return `resultDesc`.

NOTE `[[GetOwnProperty]]` for proxy objects enforces the following invariants:

- The result of `[[GetOwnProperty]]` must be either an Object or `undefined`.
- A property cannot be reported as non-existent, if it exists as a non-configurable own property of the target object.
- A property cannot be reported as non-existent, if it exists as a own property of the target object and the target object is not extensible.
- A property cannot be reported as existent, if it does not exists as a own property of the target object and the target object is not extensible.
- A property cannot be reported as non-configurable, if it does not exists as a own property of the target object or if it exists as a configurable own property of the target object.
- The result of `[[GetOwnProperty]]` can be applied to the target object using `[[DefineOwnProperty]]` and will not throw an exception.

8.5.7 `[[DefineOwnProperty]]` (P, Desc)

When the `[[DefineOwnProperty]]` internal method of an exotic Proxy object `O` is called with property key `P` and property descriptor `Desc`, the following steps are taken:

1. Assert: `IsPropertyKey(P)` is `true`.
2. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of `O`.
3. Let `target` be the value of the `[[ProxyTarget]]` internal data property of `O`.
4. Let `trap` be the result of `GetMethod(handler, "defineProperty")`.
5. `ReturnIfAbrupt(trap)`.
6. If `trap` is `undefined`, then
 - a. Return the result of calling the `[[DefineOwnProperty]]` internal method of `target` with arguments `P` and `Desc`.
7. Let `descObj` be `FromPropertyDescriptor(Desc)`.
8. **NOTE** If `Desc` was originally generated from an object using `ToPropertyDescriptor`, then `descObj` will be that original object.
9. Let `trapResult` be the result of calling the `[[Call]]` internal method of `trap` with `handler` as the `this` value and a new List containing `target`, `P`, and `descObj`.
10. `ReturnIfAbrupt(trapResult)`.
11. If `ToBoolean(trapResult)` is `false`, then return `false`.
12. Let `targetDesc` be the result of calling the `[[GetOwnProperty]]` internal method of `target` with argument `P`.
13. `ReturnIfAbrupt(targetDesc)`.
14. Let `extensibleTarget` be the result of `IsExtensible(target)`.
15. `ReturnIfAbrupt(extensibleTarget)`.
16. Set `extensibleTarget` to `ToBoolean(extensibleTarget)`.
17. If `targetDesc` is `undefined`, then
 - a. If `extensibleTarget` is `false`, then throw a `TypeError` exception.
 - b. If `Desc.[[Configurable]]` is `false`, then throw a `TypeError` exception.
18. Else `targetDesc` is not `undefined`.
 - a. If `IsCompatiblePropertyDescriptor(extensibleTarget, Desc, targetDesc)` is `false`, then throw a `TypeError` exception.
 - b. If `Desc.[[Configurable]]` is `false` and `targetDesc.[[Configurable]]` is `true`, then throw a `TypeError` exception.
19. Return `true`.

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Comment [AWB1244]: Note the result descriptor defaults are set to the values in the targetDesc (if there is one) rather than the normal defaults. This is a change from the wiki spec.

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Comment [AWB1245]: The resultDesc carries a reference to the original descriptor returned by the trap copy is not made and missing attribute properties are added to it.

This is a change from the wiki spec.

NOTE [[DefineOwnProperty]] for proxy objects enforces the following invariants:

- A property cannot be added, if the target object is not extensible.
- A property cannot be added as or modified to be non-configurable, if it does not exist as a non-configurable own property of the target object.
- A property may not be non-configurable, if a corresponding configurable property of the target object exists.
- If a property has a corresponding target object property then apply the property descriptor of the property to the target object using [[DefineOwnProperty]] will not throw an exception.

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8.5.8 [[HasProperty]] (P)

When the [[HasProperty]] internal method of an exotic Proxy object O is called with property key P , the following steps are taken:

1. Assert: IsPropertyKey(P) is true.
2. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
3. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
4. Let $trap$ be the result of GetMethod($handler$, "has").
5. ReturnIfAbrupt($trap$).
6. If $trap$ is undefined, then
 - a. Return the result of calling the [[HasProperty]] internal method of $target$ with argument P .
7. Let $trapResult$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the this value and a new List containing $target$ and P .
8. ReturnIfAbrupt($trapResult$).
9. Let $success$ be ToBoolean($trapResult$).
10. If $success$ is false, then
 - a. Let $targetDesc$ be the result of calling the [[GetOwnProperty]] internal method of $target$ with argument P .
 - b. ReturnIfAbrupt($targetDesc$).
 - c. If $targetDesc$ is not undefined, then
 - i. If $targetDesc$.[[Configurable]] is false, then throw a **TypeError** exception.
 - ii. Let $extensibleTarget$ be the result of IsExtensible($target$).
 - iii. ReturnIfAbrupt($extensibleTarget$).
 - iv. If ToBoolean($extensibleTarget$) is false, then throw a **TypeError** exception.
11. Return $success$.

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NOTE [[HasProperty]] for proxy objects enforces the following invariants:

- A property cannot be reported as non-existent, if it exists as a non-configurable own property of the target object.
- A property cannot be reported as non-existent, if it exists as a own property of the target object and the target object is not extensible.

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8.5.9 [[Get]] (P, Receiver)

When the [[Get]] internal method of an exotic Proxy object O is called with property key P and ECMAScript language value $Receiver$ the following steps are taken:

1. Assert: IsPropertyKey(P) is true.
2. Let $handler$ be the value of the [[ProxyHandler]] internal data property of O .
3. Let $target$ be the value of the [[ProxyTarget]] internal data property of O .
4. Let $trap$ be the result of GetMethod($handler$, "get").
5. ReturnIfAbrupt($trap$).
6. If $trap$ is undefined, then
 - a. Return the result of calling the [[Get]] internal method of $target$ with arguments P and $Receiver$.
7. Let $trapResult$ be the result of calling the [[Call]] internal method of $trap$ with $handler$ as the this value and a new List containing $target$, P , and $Receiver$.
8. ReturnIfAbrupt($trapResult$).
9. Let $targetDesc$ be the result of calling the [[GetOwnProperty]] internal method of $target$ with argument P .
10. ReturnIfAbrupt($targetDesc$).
11. If $targetDesc$ is not undefined, then
 - a. If IsDataDescriptor($targetDesc$) and $targetDesc$.[[Configurable]] is false and $targetDesc$.[[Writable]] is false, then

i. If `SameValue(trapResult, targetDesc.[[Value]])` is **false**, then throw a **TypeError** exception.

b. If `IsAccessorDescriptor(targetDesc)` and `targetDesc.[[Configurable]]` is **false** and `targetDesc.[[Get]]` is **undefined**, then

i. If `trapResult` is not **undefined**, then throw a **TypeError** exception.

12. Return `trapResult`.

NOTE `[[Get]]` for proxy objects enforces the following invariants:

- The value reported for a property must be the same as the value of the corresponding target object property if the target object property is a non-writable, non-configurable data property.
- The value reported for a property must be **undefined** if the corresponding corresponding target object property is non-configurable accessor property that has **undefined** as its `[[Get]]` attribute.

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8.5.10 `[[Set]]` (P, V, Receiver)

When the `[[Set]]` internal method of an exotic Proxy object *O* is called with property key *P*, value *V*, and ECMAScript language value *Receiver*, the following steps are taken:

1. Assert: `IsPropertyKey(P)` is **true**.

2. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of *O*.

3. Let `target` be the value of the `[[ProxyTarget]]` internal data property of *O*.

4. Let `trap` be the result of `GetMethod(handler, "set")`.

5. ReturnIfAbrupt(`trap`).

6. If `trap` is **undefined**, then

a. Return the result of calling the `[[Set]]` internal method of *target* with arguments *P*, *V*, and *Receiver*.

7. Let `trapResult` be the result of calling the `[[Call]]` internal method of *trap* with `handler` as the `this` value and a new List containing *target*, *P*, *V*, and *Receiver*.

8. ReturnIfAbrupt(`trapResult`).

9. If `ToBoolean(trapResult)` is **false**, then return **false**.

10. Let `targetDesc` be the result of calling the `[[GetOwnProperty]]` internal method of *target* with argument *P*.

11. ReturnIfAbrupt(`targetDesc`).

12. If `targetDesc` is not **undefined**, then

a. If `IsDataDescriptor(targetDesc)` and `targetDesc.[[Configurable]]` is **false** and `targetDesc.[[Writable]]` is **false**, then

i. If `SameValue(V, targetDesc.[[Value]])` is **false**, then throw a **TypeError** exception.

b. If `IsAccessorDescriptor(targetDesc)` and `targetDesc.[[Configurable]]` is **false**, then

i. If `targetDesc.[[Set]]` is **undefined**, then throw a **TypeError** exception.

13. Return **true**.

NOTE `[[Set]]` for proxy objects enforces the following invariants:

- Cannot change the value of a property to be different from the value of the corresponding target object property if the corresponding target object property is a non-writable, non-configurable data property.
- Cannot set the value of a property if the corresponding corresponding target object property is a non-configurable accessor property that has **undefined** as its `[[Set]]` attribute.

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8.5.11 `[[Delete]]` (P)

When the `[[Delete]]` internal method of an exotic Proxy object *O* is called with property name *P* the following steps are taken:

1. Assert: `IsPropertyKey(P)` is **true**.

2. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of *O*.

3. Let `target` be the value of the `[[ProxyTarget]]` internal data property of *O*.

4. Let `trap` be the result of `GetMethod(handler, "deleteProperty")`.

5. ReturnIfAbrupt(`trap`).

6. If `trap` is **undefined**, then

a. Return the result of calling the `[[Delete]]` internal method of *target* with argument *P*.

7. Let `trapResult` be the result of calling the `[[Call]]` internal method of *trap* with `handler` as the `this` value and a new List containing *target* and *P*.

8. ReturnIfAbrupt(`trapResult`).

9. If `ToBoolean(trapResult)` is **false**, then return **false**.

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10. Let `targetDesc` be the result of calling the `[[GetOwnProperty]]` internal method of `target` with argument `P`.
11. `ReturnIfAbrupt(targetDesc)`.
12. If `targetDesc` is `undefined`, then return `true`.
13. If `targetDesc.[[Configurable]]` is `false`, then throw a `TypeError` exception.
14. Return `true`.

NOTE `[[Delete]]` for proxy objects enforces the following invariant:

- A property cannot be deleted, if it exists as a non-configurable own property of the target object.

8.5.12 [[Enumerate]] ()

When the `[[Enumerate]]` internal method of an exotic Proxy object `O` is called the following steps are taken:

1. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of `O`.
2. Let `target` be the value of the `[[ProxyTarget]]` internal data property of `O`.
3. Let `trap` be the result of `GetMethod(handler, "enumerate")`.
4. `ReturnIfAbrupt(trap)`.
5. If `trap` is `undefined`, then
 - a. Return the result of calling the `[[Enumerate]]` internal method of `target`.
6. Let `trapResult` be the result of calling the `[[Call]]` internal method of `trap` with `handler` as the `this` value and a new List containing `target`.
7. `ReturnIfAbrupt(trapResult)`.
8. If `Type(trapResult)` is not `Object`, then throw a `TypeError` exception.

TODO: we may need to add a lot of additional invariant checking here according to the wiki spec. But maybe it really isn't necessary. Tomvc response: I think it may be possible to waive the extra invariant checks for `[[Enumerate]]`. It's not a crucial primitive. My reasoning is that `[[Enumerate]]` deals with both own and inherited properties, and we don't really enforce any invariants on inherited properties. So I guess it's ok if the invariants for `[[Enumerate]]` are weakened.

Do note that this is a bit inconsistent with the way we treat internal methods like `[[HasProperty]]`, `[[GetProperty]]` and `[[SetP]]`: these also deal with own and inherited properties, but still enforce invariants on own properties.

9. `Return trapResult`.

NOTE `[[Enumerate]]` for proxy objects enforces the following invariants:

- The result of `[[Enumerate]]` must be an `Object`.

8.5.13 [[OwnPropertyKeys]] ()

When the `[[OwnPropertyKeys]]` internal method of an exotic Proxy object `O` is called the following steps are taken:

1. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of `O`.
2. Let `target` be the value of the `[[ProxyTarget]]` internal data property of `O`.
3. Let `trap` be the result of `GetMethod(handler, "ownKeys")`.
4. `ReturnIfAbrupt(trap)`.
5. If `trap` is `undefined`, then
 - a. Return the result of calling the `[[OwnPropertyKeys]]` internal method of `target`.
6. Let `trapResult` be the result of calling the `[[Call]]` internal method of `trap` with `handler` as the `this` value and a new List containing `target`.
7. `ReturnIfAbrupt(trapResult)`.
8. If `Type(trapResult)` is not `Object`, then throw a `TypeError` exception.
9. TODO: we may need to add a lot of additional invariant checking here according to the wiki spec. But maybe it really isn't necessary.
10. `Return trapResult`.

NOTE `[[OwnPropertyKeys]]` for proxy objects enforces the following invariants:

- The result of `[[OwnPropertyKeys]]` must be an `Object`.

8.5.14 [[Call]] (thisArgument, argumentsList)

The `[[Call]]` internal method of an exotic Proxy object `O` is called with parameters `thisArgument` and `argumentsList`, a List of ECMAScript language values. The following steps are taken:

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Deleted: 8.5.10 `[[DefineOwnProperty]] (P, Desc)`¶

When the `[[DefineOwnProperty]]` internal method of proxy object `O` is called with property key `P` and property descriptor `Desc`, the following steps are taken:¶

<#>Assert: `P` is a valid property key, either a String or a Symbol Object.¶

<#>Let `handler` the value of the `[[ProxyHandler]]` internal data property of `O`.¶

<#>Let `target` the value of the `[[ProxyTarget]]` internal data property of `O`.¶

<#>Let `trap` be the result of `GetMethod(handler, "defineProperty")`.¶

<#>Return `IfAbrupt(trap)`.¶

<#>If `trap` is `undefined`, then¶

<#>Return the result of calling the `[[DefineOwnProperty]]` internal method of `target` with arguments `P` and `Desc`.¶

<#>Let `descObj` be `FromPropertyDescriptor(Desc)`¶

<#>NOTE If `Desc` was originally generated from an object using `ToPropertyDescriptor`, the `descObj` will be that original object.¶

<#>Let `trapResult` be the result of calling `trap` with `handler` as the `this` value and a new List containing `target`, `P`, and `descObj`.¶

<#>Return `IfAbrupt(trapResult)`.¶

<#>If `ToBoolean(trapResult)` is `false`, then return `false`.¶

<#>Let `targetDesc` be the result of calling the `[[GetOwnProperty]]` internal method of `target` with argument `P`.¶

<#>Return `IfAbrupt(targetDesc)`.¶

<#>Let `extensibleTarget` be the result of calling the `[[IsExtensible]]` internal method of `target`.¶

<#>Return `IfAbrupt(extensibleTarget)`.¶

<#>Set `extensibleTarget` to `Boolean(extensibleTarget)`.¶

<#>If `targetDesc` is `undefined`, then¶

<#>If `extensibleTarget` is `false`, then throw a `TypeError` exception.¶

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Deleted: 8.5.12 `[[Keys]] ()`¶

When the `[[Keys]]` internal method of proxy object `O` is called the following steps are taken:

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Deleted: 8.5.14 `[[Freeze]] ()`¶

When the `[[Freeze]]` internal method of an exotic Proxy proxy object `O` is called the following steps are taken:¶

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1. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of `O`.
2. Let `target` be the value of the `[[ProxyTarget]]` internal data property of `O`.
3. Let `trap` be the result of `GetMethod(handler, "apply")`.
4. `ReturnIfAbrupt(trap)`.
5. If `trap` is `undefined`, then
 - a. Return the result of calling the `[[Call]]` internal method of `target` with arguments `thisArgument` and `argumentsList`.
6. Let `argArray` be the result of `CreateArrayFromList(argumentsList)`.
7. Return the result of calling the `[[Call]]` internal method of `trap` with `handler` as the `this` value and a new List containing `target`, `thisArgument`, and `argArray`.

NOTE An Proxy exotic object only has a `[[Call]]` internal method if the initial value of its `[[ProxyTarget]]` internal data property is an object that has a `[[Call]]` internal method.

8.5.15 `[[Construct]]` Internal Method

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The `[[Construct]]` internal method of an exotic Proxy object `O` is called with a single parameter `argumentsList` which is a possibly empty List of ECMAScript language values. The following steps are taken:

1. Let `handler` be the value of the `[[ProxyHandler]]` internal data property of `O`.
2. Let `target` be the value of the `[[ProxyTarget]]` internal data property of `O`.
3. Let `trap` be the result of `GetMethod(handler, "construct")`.
4. `ReturnIfAbrupt(trap)`.
5. If `trap` is `undefined`, then
 - a. Return the result of calling the `[[Construct]]` internal method of `target` with argument `argumentsList`.
6. Let `argArray` be the result of `CreateArrayFromList(argumentsList)`.
7. Let `newObj` be the result of calling `trap` with `handler` as the `this` value and a new List containing `target` and `argArray`.
8. `ReturnIfAbrupt(newObj)`.
9. If `Type(newObj)` is not `Object`, then throw a `TypeError` exception.
10. Return `newObj`.

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NOTE 1 An Proxy exotic object only has a `[[Construct]]` internal method if the initial value of its `[[ProxyTarget]]` internal data property is an object that has a `[[Construct]]` internal method.

NOTE 2 `[[Construct]]` for proxy objects enforces the following invariants:

- The result of `[[Construct]]` must be an `Object`.

9 Abstract Operations

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These operations are not a part of the ECMAScript language; they are defined here to solely to aid the specification of the semantics of the ECMAScript language. Other, more specialized abstract operations are defined throughout this specification.

9.1 Type Conversion and Testing

The ECMAScript language implicitly performs automatic type conversion as needed. To clarify the semantics of certain constructs it is useful to define a set of conversion abstract operations. The conversion abstract operations are polymorphic; they can accept a value of any ECMAScript language type or of a Completion Record value. But no other specification types are used with these operations.

9.1.1 ToPrimitive

The abstract operation `ToPrimitive` takes an input `argument` and an optional argument `PreferredType`. The abstract operation `ToPrimitive` converts its `input` 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 Table 15:

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Table 15.— ToPrimitive Conversions

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Input Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>ToPrimitive(argument.[[value]])</code> also passing the optional hint <i>PreferredType</i> .
Undefined	Return <i>argument</i> (no conversion).
Null	Return <i>argument</i> (no conversion).
Boolean	Return <i>argument</i> (no conversion).
Number	Return <i>argument</i> (no conversion).
String	Return <i>argument</i> (no conversion).
Symbol	Return <i>argument</i> (no conversion).
Object	Perform the steps following this table.

When the *InputType* is Object, the following steps are taken:

1. If *PreferredType* was not passed, let *hint* be "`default`".
2. Else if *PreferredType* is `String`, let *hint* be "`string`".
3. Else *PreferredType* is `Number`, let *hint* be "`number`".
4. Let *exoticToPrim* be the result of `Get(argument, @@ToPrimitive)`.
5. `ReturnIfAbrupt(exoticToPrim)`.
6. If *exoticToPrim* is not `undefined`, then
 - a. If `IsCallable(exoticToPrim)` is `false`, then throw a `TypeError` exception.
 - b. Let *result* be the result of calling the `[[Call]]` internal method of *exoticToPrim*, with *argument* as *thisArgument* and a List containing *hint* as *argumentsList*.
 - c. `ReturnIfAbrupt(result)`.
 - d. If *result* is an ECMAScript language value and `Type(result)` is not `Object`, then return *result*.
 - e. Else, throw a `TypeError` exception.
7. If *hint* is "`default`" then, let *hint* be "`number`".
8. Return the result of `OrdinaryToPrimitive(argument, hint)`.

When the `OrdinaryToPrimitive` is called with arguments *O* and *hint*, the following steps are taken:

1. Assert: `Type(O)` is `Object`
2. Assert: `Type(hint)` is `String` and its value is either "`string`" or "`number`".
3. If *hint* is "`string`", then
 - a. Let *tryFirst* be "`toString`".
 - b. Let *trySecond* be "`valueOf`".
4. Else
 - a. Let *tryFirst* be "`valueOf`".
 - b. Let *trySecond* be "`toString`".
5. Let *first* be the result of `Get(O, tryFirst)`.
6. `ReturnIfAbrupt(first)`.
7. If `IsCallable(first)` is `true` then
 - a. Let *result* be the result of calling the `[[Call]]` internal method of *first*, with *O* as *thisArgument* and an empty List as *argumentsList*.
 - b. `ReturnIfAbrupt(result)`.
 - c. If *result* is an ECMAScript language value and `Type(result)` is not `Object`, then return *result*.
8. Let *second* be the result of `Get(O, trySecond)`.
9. `ReturnIfAbrupt(second)`.
10. If `IsCallable(second)` is `true` then
 - a. Let *result* be the result of calling the `[[Call]]` internal method of *second*, with *O* as *thisArgument* and an empty argument list.
 - b. `ReturnIfAbrupt(result)`.
 - c. If *result* is an ECMAScript language value and `Type(result)` is not `Object`, then return *result*.
11. Throw a `TypeError` exception.

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<#>Let *default* be the result of calling the `[[DefaultValue]]` internal method of *argument*, passing the optional hint *PreferredType*.¶

<#>Return `ToPrimitive(default)`.¶
Return a default value for the Object. The default value of an object is retrieved by calling the `[[DefaultValue]]` internal method of the object, passing the optional hint *PreferredType*. The behaviour of the `[[DefaultValue]]` internal method is defined by this specification for all native ECMAScript objects in 8.12.8.

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NOTE When `ToPrimitive` is called with no hint, then it generally behaves as if the hint were `Number`. However, objects may over-ride this behaviour by defining a `@@ToPrimitive` method. Of the objects defined in this specification only `Date` objects (see 15.9.6) over-ride the default `ToPrimitive` behaviour. `Date` objects treat no hint as if the hint were `String`.

9.1.2 ToBoolean

The abstract operation `ToBoolean` converts its *argument* to a value of type `Boolean` according to [Table 16](#):

Table 16 — `ToBoolean` Conversions

Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return the argument. Otherwise return <code>ToBoolean(argument.[value])</code>
Undefined	Return <code>false</code>
Null	Return <code>false</code>
Boolean	Return the input argument (no conversion).
Number	Return <code>false</code> if the argument is <code>+0</code> , <code>-0</code> , or <code>NaN</code> ; otherwise return <code>true</code> .
String	Return <code>false</code> if the argument is the empty String (its length is zero); otherwise return <code>true</code> .
Symbol	Return <code>true</code>
Object	Return <code>true</code>

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9.1.3 ToNumber

The abstract operation `ToNumber` converts its *argument* to a value of type `Number` according to [Table 17](#):

Table 17 — `ToNumber` Conversions

Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>ToNumber(argument.[value])</code>
Undefined	Return <code>NaN</code>
Null	Return <code>+0</code>
Boolean	Return <code>1</code> if <i>argument</i> is <code>true</code> . Return <code>+0</code> if <i>argument</i> is <code>false</code> .
Number	Return <i>argument</i> (no conversion).
String	See grammar and note below.
Symbol	Return <code>NaN</code>
Object	Apply the following steps: 1. Let <i>primValue</i> be <code>ToPrimitive(argument, hint Number)</code> . 2. Return <code>ToNumber(primValue)</code> .

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9.1.3.1 ToNumber Applied to the String Type

`ToNumber` applied to Strings applies the following grammar to the input String. If the grammar cannot interpret the String as an expansion of `StringNumericLiteral`, then the result of `ToNumber` is `NaN`.

Syntax

```
StringNumericLiteral ::=
  StrWhiteSpaceopt
  StrWhiteSpaceopt StrNumericLiteral StrWhiteSpaceopt
```

StrWhiteSpace :::
StrWhiteSpaceChar StrWhiteSpace_{opt}

StrWhiteSpaceChar :::
WhiteSpace
LineTerminator

StrNumericLiteral :::
StrDecimalLiteral
HexIntegerLiteral

StrDecimalLiteral :::
StrUnsignedDecimalLiteral
+ StrUnsignedDecimalLiteral
- StrUnsignedDecimalLiteral

StrUnsignedDecimalLiteral :::
Infinity
DecimalDigits . DecimalDigits_{opt} ExponentPart_{opt}
. DecimalDigits ExponentPart_{opt}
DecimalDigits ExponentPart_{opt}

DecimalDigits :::
DecimalDigit
DecimalDigits DecimalDigit

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

ExponentPart :::
ExponentIndicator SignedInteger

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

SignedInteger :::
DecimalDigits
+ DecimalDigits
- DecimalDigits

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

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

NOTE 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**.
- **Infinity and -Infinity are recognised as a *StringNumericLiteral* but not as a *NumericLiteral*.**

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Runtime Semantics

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_{opt}* *StrNumericLiteral* *StrWhiteSpace_{opt}* 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 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 signless mathematical zero to a floating-point **+0** or **-0** as appropriate.)
- The MV of *StrUnsignedDecimalLiteral*:: **Infinity** is 10^{1000} (a value so large that it will round to **+∞**).
- 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^{-n}), 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^{-n})) times 10^e , where *n* is the number of characters in the second *DecimalDigits* and *e* is the MV of *ExponentPart*.
- The MV of *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^{e-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 *DecimalDigits* :: *DecimalDigits* *DecimalDigit* is (the MV of *DecimalDigits* times 10) plus the MV of *DecimalDigit*.
- The MV of *ExponentPart* :: *ExponentIndicator* *SignedInteger* is the MV of *SignedInteger*.
- The MV of *SignedInteger* :: *DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger* :: + *DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger* :: - *DecimalDigits* is the negative of the MV of *DecimalDigits*.
- The MV of *DecimalDigit* :: 0 or of *HexDigit* :: 0 is 0.
- The MV of *DecimalDigit* :: 1 or of *HexDigit* :: 1 is 1.
- The MV of *DecimalDigit* :: 2 or of *HexDigit* :: 2 is 2.
- The MV of *DecimalDigit* :: 3 or of *HexDigit* :: 3 is 3.
- The MV of *DecimalDigit* :: 4 or of *HexDigit* :: 4 is 4.
- The MV of *DecimalDigit* :: 5 or of *HexDigit* :: 5 is 5.
- The MV of *DecimalDigit* :: 6 or of *HexDigit* :: 6 is 6.
- The MV of *DecimalDigit* :: 7 or of *HexDigit* :: 7 is 7.
- The MV of *DecimalDigit* :: 8 or of *HexDigit* :: 8 is 8.
- The MV of *DecimalDigit* :: 9 or of *HexDigit* :: 9 is 9.
- The MV of *HexDigit* :: a or of *HexDigit* :: A is 10.
- The MV of *HexDigit* :: b or of *HexDigit* :: B is 11.
- The MV of *HexDigit* :: c or of *HexDigit* :: C is 12.

- The MV of *HexDigit* :::: **d** or of *HexDigit* :::: **D** is 13.
- The MV of *HexDigit* :::: **e** or of *HexDigit* :::: **E** is 14.
- The MV of *HexDigit* :::: **f** or of *HexDigit* :::: **F** is 15.
- The MV of *HexIntegerLiteral* :::: **0x HexDigit** is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral* :::: **0x HexDigit** is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral* :::: *HexIntegerLiteral HexDigit* is (the MV of *HexIntegerLiteral* times 16) plus the MV of *HexDigit*.

Once the exact MV for a String numeric literal has been determined, it is then rounded to a value of the Number type. If the MV is 0, then the rounded value is +0 unless the first non 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.

9.1.4 ToInteger

The abstract operation *ToInteger* converts its argument to an integral numeric value. This abstract operation functions as follows:

1. Let *number* be the result of calling *ToNumber* on the input argument.
2. ReturnIfAbrupt(*number*).
3. If *number* is **NAN**, return **+0**.
4. If *number* is **+0**, **-0**, **+∞**, or **-∞**, return *number*.
5. Return the result of computing *sign(number)* × *floor(abs(number))*.

9.1.5ToInt32: (Signed 32 Bit Integer)

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

1. Let *number* be the result of calling *ToNumber* on the input argument.
2. ReturnIfAbrupt(*number*).
3. If *number* is **NAN**, **+0**, **-0**, **+∞**, or **-∞**, return **+0**.
4. Let *int* be *sign(number)* × *floor(abs(number))*.
5. Let *int32bit* be *int* modulo 2^{32} .
6. If *int32bit* $\geq 2^{31}$, return *int32bit* - 2^{32} , otherwise return *int32bit*.

NOTE Given the above definition of *ToInt32*:

- The *ToInt32* abstract operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.
- *ToInt32(ToInt32(*x*))* is equal to *ToInt32(*x*)* for all values of *x*. (It is to preserve this latter property that **+∞** and **-∞** are mapped to **+0**.)
- *ToInt32* maps **-0** to **+0**.

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9.1.6 ToUint32: (Unsigned 32 Bit Integer)

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

1. Let *number* be the result of calling *ToNumber* on the input argument.
2. ReturnIfAbrupt(*number*).
3. If *number* is **NAN**, **+0**, **-0**, **+∞**, or **-∞**, return **+0**.

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4. Let *int* be $\text{sign}(\text{number}) \times \text{floor}(\text{abs}(\text{number}))$.
5. Let *int32bit* be *int* modulo 2^{32} .
6. Return *int32bit*.

NOTE Given the above definition of `ToUInt32`:

- Step 6 is the only difference between `ToUInt32` and `ToInt32`.
- The `ToUInt32` abstract operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.
- `ToUInt32(ToInt32(x))` is equal to `ToUInt32(x)` for all values of *x*. (It is to preserve this latter property that $+\infty$ and $-\infty$ are mapped to $+0$.)
- `ToUInt32` maps -0 to $+0$.

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Deleted: ; that is, a finite integer value *k* of Number type with positive sign and less than 2^{32} in magnitude such that the mathematical difference of *posInt* and *k* is mathematically an integer multiple of 2^{32}

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9.1.7 `ToUInt16`: (Unsigned 16 Bit Integer)

The abstract operation `ToUInt16` converts its argument to one of 2^{16} integer values in the range 0 through $2^{16}-1$, inclusive. This abstract operation functions as follows:

1. Let *number* be the result of calling `ToNumber` on the input argument.
2. ReturnIfAbrupt(*number*).
3. If *number* is `NaN`, $+0$, -0 , $+\infty$, or $-\infty$, return $+0$.
4. Let *int* be $\text{sign}(\text{number}) \times \text{floor}(\text{abs}(\text{number}))$.
5. Let *int16bit* be *int* modulo 2^{16} .
6. Return *int16bit*.

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`.
- `ToUInt16` maps -0 to $+0$.

Deleted: *posInt*

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Deleted: ; that is, a finite integer value *k* of Number type with positive sign and less than 2^{16} in magnitude such that the mathematical difference of *posInt* and *k* is mathematically an integer multiple of 2^{16}

9.1.8 `ToString`

The abstract operation `ToString` converts its *argument* to a value of type String according to [Table 18](#):

Table 18—`ToString` Conversions

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Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>ToString(argument.[[value]])</code>
Undefined	" <code>undefined</code> "
Null	" <code>null</code> "
Boolean	If <i>argument</i> is <code>true</code> , then return " <code>true</code> ". If <i>argument</i> is <code>false</code> , then return " <code>false</code> ".
Number	See 9.8.1.
String	Return <i>argument</i> (no conversion)
Symbol	" <code>[object Symbol]</code> "
Object	Apply the following steps: 1. Let <i>primValue</i> be <code>ToPrimitive(argument, hint String)</code> . 2. Return <code>ToString(primValue)</code> .

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9.1.8.1 `ToString` Applied to the Number Type

The abstract operation `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 $+\infty$, return the String "`Infinity`".

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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 $s \times 10^{n-k}$ 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 $k \leq n \leq 21$, return the String consisting of the k digits of the decimal representation of s (in order, with no leading zeroes), 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 $-6 < n \leq 0$, 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 $\text{abs}(n-1)$ (with no leading zeroes).
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 $\text{abs}(n-1)$ (with no leading zeroes).

NOTE 1 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 -0 , then $\text{ToNumber}(\text{ToString}(x))$ 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.

NOTE 2 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 $k \geq 1$, $10^{k-1} \leq s < 10^k$, the Number value for $s \times 10^{n-k}$ is m , and k is as small as possible. If there are multiple possibilities for s , choose the value of s for which $s \times 10^{n-k}$ is closest in value to m . If there are two such possible values of s , 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.

NOTE 3 Implementers of ECMAScript may find useful the paper and code written by David M. Gay for binary-to-decimal conversion of floating-point numbers:

Gay, David M. Correctly Rounded Binary-Decimal and Decimal-Binary Conversions. Numerical Analysis, Manuscript 90-10. AT&T Bell Laboratories (Murray Hill, New Jersey). November 30, 1990. Available as <http://cm.bell-labs.com/cm/cs/doc/90/4-10.ps.gz>. Associated code available as <http://netlib.sandia.gov/fp/dtoa.c> and as http://netlib.sandia.gov/fp/g_fmt.c and may also be found at the various `netlib` mirror sites.

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9.1.9 ToObject

The abstract operation `ToObject` converts its argument to a value of type Object according to Table 19:

Table 19.— ToObject Conversions

Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>ToObject(argument.[[value]])</code>
Undefined	Throw a TypeError exception.
Null	Throw a TypeError exception.
Boolean	Return a new Boolean object whose <code>[[BooleanData]]</code> internal <code>data</code> property is set to the value of <i>argument</i> . See 15.6 for a description of Boolean objects.
Number	Return a new Number object whose <code>[[NumberData]]</code> internal <code>data</code> property is set to the value of <i>argument</i> . See 15.7 for a description of Number objects.
String	Return a new String object whose <code>[[StringData]]</code> internal <code>data</code> property is set to the value of <i>argument</i> . See 15.5 for a description of String objects.
Symbol	Throw a TypeError exception.
Object	Return <i>argument</i> (no conversion).

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9.1.10 ToPropertyKey

The abstract operation `ToPropertyKey` converts its *argument* to a value that can be used as a property key by performing the following steps:

1. `ReturnIfAbrupt(argument)`.
2. If `Type(argument)` is `Symbol`, then
 - a. Return *argument*.
3. Return `ToString(argument)`.

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The abstract operation `ToInteger` converts its argument an integral numeric value. This abstract operation functions as follows:

```
<#>Let number be the result of calling ToNumber on the argument.  

<#>ReturnIfAbrupt(number).  

<#>If number is Nan, return +0.  

<#>If number is  $\infty$ , or  $-\infty$ , return number.  

<#>If number  $\leq 0$ , return +0.  

<#>Return the result of computing floor(number).
```

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9.2 Testing and Comparison Operations

9.2.1 CheckObjectCoercible

The abstract operation `CheckObjectCoercible` throws an error if its argument is a value that cannot be converted to an Object using `ToObject`. It is defined by [Table 20](#):

Table 20.— CheckObjectCoercible Results

Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>CheckObjectCoercible(argument.[[value]])</code>
Undefined	Throw a TypeError exception.
Null	Throw a TypeError exception.
Boolean	Return <i>argument</i>
Number	Return <i>argument</i>
String	Return <i>argument</i>
Symbol	Throw a TypeError exception.
Object	Return <i>argument</i>

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9.2.2 IsCallable

The abstract operation `IsCallable` determines if its *argument*, which must be an ECMAScript language value or a Completion Record, is a callable function Object according to [Table 21](#):

Table 21 — IsCallable Results

Argument Type	Result
Completion Record	If <i>argument</i> is an abrupt completion, return <i>argument</i> . Otherwise return <code>IsCallable(argument.[[value]])</code>
Undefined	Return false .
Null	Return false .
Boolean	Return false .
Number	Return false .
String	Return false .
Symbol	Return false .
Object	If <i>argument</i> has a [[Call]] internal method, then return true , otherwise return false .

9.2.3 SameValue(*x*, *y*)

The internal comparison abstract operation `SameValue(x, y)`, where *x* and *y* are ECMAScript language values, produces **true** or **false**. Such a comparison is performed as follows:

1. `ReturnIfAbrupt(x)`.
2. `ReturnIfAbrupt(y)`.
3. If `Type(x)` is different from `Type(y)`, return **false**.
4. If `Type(x)` is `Undefined`, return **true**.
5. If `Type(x)` is `Null`, return **true**.
6. 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**.
 - e. Return **false**.
7. If `Type(x)` is `String`, then
 - a. If *x* and *y* are exactly the same sequence of code units (same length and same code units in corresponding positions) return **true**; otherwise, return **false**.
8. If `Type(x)` is `Boolean`, then
 - a. If *x* and *y* are both **true** or both **false**, then return **true**; otherwise, return **false**.
9. If `Type(x)` is `Symbol`, then
 - a. If *x* and *y* are both the same `Symbol` value, then return **true**; otherwise, return **false**.
10. Return **true** if *x* and *y* are the same `Object` value. Otherwise, return **false**.

9.2.4 SameValueZero(*x*, *y*)

The internal comparison abstract operation `SameValueZero(x, y)`, where *x* and *y* are ECMAScript language values, produces **true** or **false**. Such a comparison is performed as follows:

1. `ReturnIfAbrupt(x)`.
2. `ReturnIfAbrupt(y)`.
3. If `Type(x)` is different from `Type(y)`, return **false**.
4. If `Type(x)` is `Undefined`, return **true**.
5. If `Type(x)` is `Null`, return **true**.
6. 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 **true**.
 - c. If *x* is `-0` and *y* is `+0`, return **true**.
 - d. If *x* is the same `Number` value as *y*, return **true**.
 - e. Return **false**.
7. If `Type(x)` is `String`, then
 - a. If *x* and *y* are exactly the same sequence of code units (same length and same code units in corresponding positions) return **true**; otherwise, return **false**.

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<#>If *y* is an Completion Record, let *y* be *y.[[value]]*. ¶
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8. If Type(*x*) is Boolean, then
 - a. If *x* and *y* are both true or both false, then return true; otherwise, return false.
9. If Type(*x*) is Symbol, then
 - a. If *x* and *y* are both the same Symbol value, then return true; otherwise, return false.
10. Return true if *x* and *y* are the same Object value. Otherwise, return false.

NOTE SameValueZero differs from SameValue only in its treatment of +0 and -0.

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9.2.5 IsConstructor

The abstract operation IsConstructor determines if its argument, which must be an ECMAScript language value or a Completion Record, is a function object with a [[Construct]] internal method.

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1. ReturnIfAbrupt(argument).
2. If Type(argument) is not Object, return false.
3. If argument has a [[Construct]] internal method, return true.
4. Return false.

9.2.6 IsPropertyKey

The abstract operation IsPropertyKey determine if its argument, which must be an ECMAScript language value or a Completion Record, is a value that may be used as a property key.

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1. ReturnIfAbrupt(argument).
2. If Type(argument) is String, return true.
3. If Type(argument) is Symbol, return true.
4. Return false.

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9.2.7 IsExtensible (*O*)

The abstract operation IsExtensible is used to determine whether additional properties can be added to an object. A Boolean value is returned. The the argument *O* where *O* is the object that is tested. This abstract operation performs the following steps:

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1. Assert: Type(*O*) is Object.
2. Let *notExtensible* be the result of calling the [[HasIntegrity]] internal method of *O* with argument "nonextensible".
3. ReturnIfAbrupt(*notExtensible*).
4. If *notExtensible* is true, then return false; else return true.

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9.3 Operations on Objects

9.3.1 Get (*O*, *P*)

The abstract operation Get is used to retrieve the value of an specific property of an object. The operation is called with arguments *O* and *P* where *O* is the object and *P* is the property key. This abstract operation performs the following steps:

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1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.
3. Return the result of calling the [[Get]] internal method of *O* passing *P* and *O* as the arguments.

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9.3.2 Put (*O*, *P*, *V*, *Throw*)

The abstract operation Put is used to set the value of a specific property of an object. The operation is called with arguments *O*, *P*, *V*, and *Throw* where *O* is the object, *P* is the property key, *V* is the new value for the property and *Throw* is a Boolean flag. This abstract operation performs the following steps:

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1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.

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Deleted: Either Type(*P*) is String or Type(*O*) is Object and *O* is a Symbol object

3. Assert: Type(Throw) is Boolean.
4. Let *success* be the result of calling the [[Set]] internal method of *O* passing *P*, *V* and *O* as the arguments.
5. ReturnIfAbrupt(*success*).
6. If *success* is false and *Throw* is true, then throw a **TypeError** exception.
7. Return *success*.

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9.3.3 CreateOwnProperty (*O*, *P*, *V*)

The abstract operation `CreateOwnProperty` is used to create a new own property of an object. The operation is called with arguments *O*, *P*, and *V* where *O* is the object, *P* is the property key, and *V* is the new value for the property. This abstract operation performs the following steps:

1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.
3. Assert: *O* does not have an own property whose key is *P*.
4. Let *newDesc* be the Property Descriptor `{[[Value]]: V, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
5. Return the result of calling the [[DefineOwnProperty]] internal method of *O* passing *P* and *newDesc* as arguments.

NOTE This abstract operation creates a property whose attributes are set to the same defaults used for properties created by the ECMAScript language assignment operator.

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Deleted: <#>Let *noteExtensible* be the result of calling the [[GetIsExtensibleIntegrity]] internal method of *O* with argument "nonextensible".
<#>ReturnIfAbrupt(*notExtensible*).
<#>If *notExtensible* is false, then return false.

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9.3.4 DefinePropertyOrThrow (*O*, *P*, *desc*)

The abstract operation `DefinePropertyOrThrow` is used to call the [[DefineOwnProperty]] internal method of an object in a manner that will throw a **TypeError** exception if the requested property update cannot be performed. The operation is called with arguments *O*, *P*, and *desc* where *O* is the object, *P* is the property key, and *desc* is the Property Descriptor for the property. This abstract operation performs the following steps:

1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.
3. Let *success* be the result of calling the [[DefineOwnProperty]] internal method of *O* passing *P* and *desc* as arguments.
4. ReturnIfAbrupt(*success*).
5. If *success* is false, then throw a **TypeError** exception.
6. Return *success*.

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Deleted: Either Type(*P*) is String or Type(*O*) is Object and *O* is a Symbol object

Deleted: <#>Let *obj* be *O*.
<#>Repeat,
<#>If *obj* is null, then return false.
<#>If Type(*obj*) is not Object, then throw a **TypeError** exception.
<#>Let *has* be the result of calling the [[HasOwnProperty]] internal method of *obj* argument *P*.
<#>ReturnIfAbrupt(*has*).
<#>If *has* is true, return *has*.
<#>Set *obj* to the result of calling the [[GetInheritance]] internal method of *obj*.

Deleted: IfAbrupt(*obj*).

9.3.5 DeletePropertyOrThrow (*O*, *P*)

The abstract operation `Put` is used to remove a specific own property of an object. It throws an exception if the property is not configurable. The operation is called with arguments *O* and *P* where *O* is the object and *P* is the property key. This abstract operation performs the following steps:

1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.
3. Let *success* be the result of calling the [[Delete]] internal method of *O* passing *P* as the argument.
4. ReturnIfAbrupt(*success*).
5. If *success* is false, then throw a **TypeError** exception.
6. Return *success*.

9.3.6 HasProperty (*O*, *P*)

The abstract operation `HasProperty` is used to determine whether an object has a property with the specified property key. The property may be either an own or inherited. A Boolean value is returned. The operation is called with arguments *O* and *P* where *O* is the object and *P* is the property key. This abstract operation performs the following steps:

1. Assert: Type(*O*) is Object.
2. Assert: IsPropertyKey(*P*) is true.
3. Return the result of calling the [[HasProperty]] internal method of *O* with argument *P*.

9.3.7 GetMethod (O, P)

The abstract operation `GetMethod` is used to get the value of a specific property of an object when the value of the property is expected to be a function. The operation is called with arguments `O` and `P` where `O` is the object, `P` is the property key. This abstract operation performs the following steps:

1. Assert: `Type(O)` is Object.
2. Assert: `IsPropertyKey(P)` is true.
3. Let `func` be the result of calling the `[[Get]]` internal method of `O` passing `P` and `O` as the arguments.
4. ReturnIfAbrupt(`func`).
5. If `func` is undefined, then return undefined.
6. If `IsCallable(func)` is false, then throw a `TypeError` exception.
7. Return `func`.

9.3.8 Invoke(O,P,[args])

The abstract operation `Invoke` is used to call a method property of an object. The operation is called with arguments `P`, `O`, and optionally `args` where `P` is the property key, `O` serves as both the lookup point for the property and the `this` value of the call, and `args` is the list of arguments values passed to the method. If `args` is not present, an empty List is used as its value. This abstract operation performs the following steps:

1. Assert: `P` is a valid property key.
2. If `args` was not passed, then let `args` be a new empty List.
3. Let `obj` be `ToObject(O)`.
4. ReturnIfAbrupt(`obj`).
5. Let `func` be the result of `GetMethod(obj,P)`.
6. ReturnIfAbrupt(`func`).
7. If `func` is undefined, throw a `TypeError` exception.
8. Return the result of calling the `[[Call]]` internal method of `func` passing `O` as `thisArgument` and `args` as `argumentsList`.

9.3.9 SetIntegrityLevel (O, level)

The abstract operation `SetIntegrityLevel` is used to fix the set of own properties of an object. This abstract operation performs the following steps:

1. Assert: `Type(O)` is Object.
2. Assert: `level` is either "sealed" or "frozen".
3. Let `keys` be the result of calling the `[[OwnPropertyKeys]]` internal method of `O`.
4. ReturnIfAbrupt(`keys`).
5. Let `pendingException` be undefined.
6. If `level` is "sealed", then
 - a. Repeat for each element `k` of `keys`.
 - i. Let `status` be the result of `DefinePropertyOrThrow(O, k,PropertyDescriptor{[[Configurable]]: false})`.
 - ii. If `status` is an Abrupt Completion, then
 1. If `pendingException` is undefined, then set `pendingException` to `status`.
7. Else `level` is "frozen".
 - a. Repeat for each element `k` of `keys`.
 - i. Let `status` be the result of calling the `[[GetOwnProperty]]` internal method of `O` with `k`.
 - ii. If `status` is an Abrupt Completion, then
 1. If `pendingException` is undefined, then set `pendingException` to `status`.
 - iii. Else,
 1. Let `currentDesc` be `status.[[value]]`.
 2. If `currentDesc` is not undefined, then
 - a. If `IsAccessorDescriptor(currentDesc)` is true, then
 - i. Let `desc` be `PropertyDescriptor{[[Configurable]]: false}`.
 - b. Else,
 - i. Let `desc` be `PropertyDescriptor{[[Configurable]]: false, [[Writable]]: false}`.

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Deleted: `MakeObjectSecure`

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Deleted: <#>Assert: `Type(immutable)` is Boolean.

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Comment [AWB1449]: TODO: don't freeze private symbol properties.

- c. Let *status* be the result of `DefinePropertyOrThrow(O, k, desc)`.
- d. If *status* is an Abrupt Completion, then
 - i. If *pendingException* is `undefined`, then set *pendingException* to *status*.
8. If *pendingException* is not `undefined`, then return *pendingException*.
9. Return the result of calling the `[[PreventExtensions]]` internal method of *O*.

9.3.10 TestIntegrityLevel (*O*, *level*)

The abstract operation `TestIntegrityLevel` is used to determine if the set of own properties of an object are fixed. This abstract operation performs the following steps:

1. Assert: `Type(O)` is `Object`.
2. Assert: *level* is either `"sealed"` or `"frozen"`.
3. Let *status* be the result of `IsExtensible(O)`.
4. ReturnIfAbrupt(*status*).
5. If *status* is `true`, then return `false`.
6. NOTE If the object is extensible, none of its properties are examined.
7. Let *keys* be the result of calling the `[[OwnPropertyKeys]]` internal method of *O*.
8. ReturnIfAbrupt(*keys*).
9. Let *pendingException* be `undefined`.
10. Let *configurable* be `false`.
11. Let *writable* be `false`.
12. Repeat for each element *k* of *keys*.
 - a. Let *status* be the result of calling the `[[GetOwnProperty]]` internal method of *O* with *k*.
 - b. If *status* is an Abrupt Completion, then
 - i. If *pendingException* is `undefined`, then set *pendingException* to *status*.
 - ii. Let *configurable* be `true`.
 - c. Else,
 - i. Let *currentDesc* be *status*`[[value]]`.
 - ii. If *currentDesc* is not `undefined`, then
 1. Set *configurable* to *configurable* logically ored with *currentDesc*`[[Configurable]]`.
 2. If `IsDataDescriptor(currentDesc)` is `true`, then
 - a. Set *writable* to *writable* logically ored with *currentDesc*`[[Writable]]`.
13. If *pendingException* is not `undefined`, then return *pendingException*.
14. If *level* is `"frozen"` and *writable* is `true`, then return `false`.
15. If *configurable* is `true`, then return `false`.
16. Return `true`.

9.3.11 CreateArrayFromList (*elements*)

The abstract operation `CreateArrayFromList` is used to create an `Array` object whose elements are provided by an internal List. This abstract operation performs the following steps:

1. Assert: *elements* is a List whose elements are all ECMAScript language values.
2. Let *array* be the result of the abstract operation `ArrayCreate` with argument *O*.
3. Let *n* be `0`.
4. For each element *e* of *elements*
 - a. Call `CreateOwnProperty(array, ToString(n), e)`.
 - b. Assert: the call in step 4.a will never result in an abrupt completion.
 - c. Increment *n* by `1`.
5. Return *array*.

9.3.12 OrdinaryHasInstance (*C*, *O*)

The abstract operation `OrdinaryHasInstance` implements the default algorithm for determining if an object *O* inherits from the instance object inheritance path provided by constructor *C*. This abstract operation performs the following steps:

1. If `IsCallable(C)` is `false`, return `false`.

Comment [AWB1550]: We're going to get write of `Get/SetIntegrity` so this will be valid again soon.

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Deleted: If the Boolean argument `immutable` true a check is also made to determine whether all own data properties are non-writable.

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Deleted: <#>Assert: `Type(immutable)` is Boolean.

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Deleted: <#>If `immutable` is `false`, then

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2. If C has a `[[BoundTargetFunction]]` internal data property, then
 - a. Let BC be the value of C 's `[[BoundTargetFunction]]` internal data property.
 - b. Return the result of `instanceofOperator(O, BC)` (see 11.8).
3. If `Type(O)` is not `Object`, return `false`.
4. Let P be the result of `Get(C, "prototype").`
5. ReturnIfAbrupt(P).
6. If `Type(P)` is not `Object`, throw a `TypeError` exception.
7. Repeat
 - a. Set O to the result of calling the `[[GetInheritance]]` internal method of O with no arguments.
 - b. ReturnIfAbrupt(O).
 - c. If O is `null`, return `false`.
 - d. If `SameValue(P, O)` is `true`, return `true`.

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9.3.13 GetPrototypeFromConstructor (constructor, intrinsicDefaultProto)

The abstract operation `GetPrototypeFromConstructor` determines the `[[Prototype]]` value that should be used to create an object corresponding to a specific constructor. The value is retrieved from the constructor's `prototype` property, if it exists. Otherwise the supplied default is used for `[[Prototype]]`. This abstract operation performs the following steps:

1. Assert: `intrinsicProto` is a string value that is this specification's name of an intrinsic object. The corresponding object must be an intrinsic that is intended to be used as the `[[Prototype]]` value of an object.
2. If `IsConstructor(constructor)` is `false`, then throw a `TypeError` exception.
3. Let $proto$ be the result of `Get(constructor, "prototype").`
4. ReturnIfAbrupt($proto$).
5. If `Type(proto)` is not `Object`, then
 - a. If `constructor` has a `[[Realm]]` internal data property, let $realm$ be `constructor`'s `[[Realm]]`.
 - b. Else,
 - i. Let ctx be the running execution context.
 - ii. Let $realm$ be ctx 's `Realm`.
 - c. Let $proto$ be $realm$'s intrinsic object named `intrinsicDefaultProto`.
6. Return $proto$.

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NOTE If `constructor` does not supply a `[[Prototype]]` value, the default value that is used is obtained from the Code Realm of the `constructor` function rather than from the running execution context. This accounts for the possibility that a built-in `@@create` method from a different Code Realm might be installed on `constructor`.

9.3.14 OrdinaryCreateFromConstructor (constructor, intrinsicDefaultProto, internalDataList)

The abstract operation `OrdinaryCreateFromConstructor` creates an ordinary object whose `[[Prototype]]` value is retrieved from a constructor's `prototype` property, if it exists. Otherwise the supplied default is used for `[[Prototype]]`. The optional `internalDataList` is a List of the names of internal data property names that should be defined as part of the object. If the list is not provided, an empty List is used. This abstract operation performs the following steps:

1. Assert: `intrinsicDefaultProto` is a string value that is this specification's name of an intrinsic object. The corresponding object must be an intrinsic that is intended to be used as the `[[Prototype]]` value of an object.
2. Let $proto$ be the result of `GetPrototypeFromConstructor(constructor, intrinsicDefaultProto).`
3. ReturnIfAbrupt($proto$).
4. Return the result of the abstract operation `ObjectCreate(proto, internalDataList)`.

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Deleted: <#>If `Type(constructor)` is not `Object`, then throw a `TypeError` exception.
<#>Let $proto$ be the result of `Get(constructor, "prototype").
<#>ReturnIfAbrupt($proto$).
<#>If Type(proto) is not Object, then
<#>If constructor has a [[Realm]] internal data property, let $realm$ be F 's [[Realm]].
<#>Else,
<#>Let ctx be the running execution context.
<#>Let $realm$ be ctx 's Realm.
<#>Let $proto$ be $realm$'s intrinsic object named intrinsicDefaultProto.`

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Deleted: NOTE If `constructor` does not supply a `[[Prototype]]` value, the default value that is used is obtained from the Code Realm of the `constructor` function rather than from the running execution context. This accounts for the possibility that a built-in `@@create` method from a different Code Realm might be installed on `constructor`.
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10 Executable Code and Execution Contexts

10.1 Types of Executable Code

There are four types of ECMAScript executable code:

- *Global code* is source text that is treated as an ECMAScript *Script*. The global code of a particular *Script* does not include any source text that is parsed as part of a *FunctionBody*, *GeneratorBody*, *ConciseBody*, *ClassBody*, or *ModuleBody*.
- *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 *Script*. The eval code for a particular invocation of *eval* is the global code portion of that *Script*.
- *Function code* is source text that is parsed to supply the value of the *[[Code]]* internal data property (see 8.3.15) of function and generator objects. The *function code* of a particular function or generator does not include any source text that is parsed as the *function code* of a nested *FunctionBody*, *GeneratorBody*, *ConciseBody*, or *ClassBody*.
- *Module code* is source text that is parse code that is provided as a *ModuleBody*. It is the code that is directly evaluated when a module is initialized. The *module code* of a particular module does not include any source text that is parsed as part of a nested *FunctionBody*, *GeneratorBody*, *ConciseBody*, *ClassBody*, or *ModuleBody*.

NOTE Function code is generally provided as the bodies of Function Definitions (13.1), Arrow Function Definitions (13.2), Method Definitions (13.3) and Generator Definitions (13.4). Function code is also derived from the last argument to the Function constructor (15.3).

10.1.1 Strict Mode Code

An ECMAScript *Script* syntactic unit may be processed using either unrestricted or strict mode syntax and semantics. When processed using strict mode the four types of ECMAScript code are referred to as *module code*, strict global code, strict eval code, and strict function code. Code is interpreted as strict mode code in the following situations:

- Global code is strict global code if it begins with a Directive Prologue that contains a Use Strict Directive (see 14.1).
- *Module code is always strict code.*
- *All code contained in a *ClassBody* is strict code.*
- Eval code is strict eval code if it begins with a Directive Prologue that contains a Use Strict Directive or if the call to eval is a direct call (see 15.1.2.1.1) to the eval function that is contained in strict mode code.
- Function code that is part of a *FunctionDeclaration*, *FunctionExpression*, or accessor *PropertyDefinition* is strict function code if its *FunctionDeclaration*, *FunctionExpression*, or *PropertyDefinition* is contained in strict mode code or if the function code begins with a Directive Prologue that contains a Use Strict Directive.
- 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* begins with a Directive Prologue that contains a Use Strict Directive.

10.1.2 Non-ECMAScript Functions

An ECMAScript implementation may support the evaluation of function objects whose evaluative behaviour is expressed in some implementation defined form of executable code other than via ECMAScript code. Whether a function object is an ECMAScript code function or a non-ECMAScript function is not semantically observable from the perspective of an ECMAScript code function that calls or is called by such a non-ECMAScript function.

10.2 Lexical Environments

A *Lexical Environment* is a specification type 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

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Comment [AWB751]: TODO: may need an additional reference to the <i>[[Code]]</i> of a generator.
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Deleted: <#> Generator code is source text that is parsed to supply the value of the <i>[[Code]]</i> internal data property (see 13.5) of generator objects. The <i>generator code</i> of a particular generator does not include any source text that is parsed as the function code of a nested <i>FunctionBody</i> , <i>ConciseBody</i> , or <i>ClassBody</i> . All generator code is also considered to be function code, but only function code that is defined within a generator is generator code. ¶
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Deleted: Function code also denotes the source text supplied when using the built-in <i>Function</i> object as a constructor. More precisely, the last parameter provided to the <i>Function</i> constructor is converted to a String and treated as the <i>FunctionBody</i> . If more than one parameter is provided to the <i>Function</i> constructor, all parameters except the last one are converted to Strings and concatenated together, separated by commas. The resulting String is interpreted as the <i>FormalParameterList</i> for the <i>FunctionBody</i> defined by the last parameter. The function code for a particular instantiation of a <i>Function</i> does not include any source text that is parsed as part of a nested <i>FunctionBody</i> .
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Deleted: Generator code is provided as the bodies of Generator Definitions 13.4 and Generator Expressions (11.????).
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Deleted: <#> Unless specified otherwise, extended code (10.21.12) is also considered strict mode code. ¶
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<i>Extended code</i> is any any code contained in ECMAScript <i>Program</i> syntactic unit that contains occurrences of lexical or syntactic production defined subsequent to the Fifth Edition of the

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 *BlockStatement*, or a *Catch* clause of a *TryStatement* and a new Lexical Environment is created each time such code is evaluated.

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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 logical nesting of Lexical Environment values. 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 *evaluation* of the surrounding function.

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A *global environment* is a Lexical Environment which does not have an outer environment. The global environment's outer environment reference is *null*. A global environment's environment record may be prepopulated with identifier bindings and includes an associated *global object* whose properties provide some of the global environment's identifier bindings. This *global object* is the value of a global environment's *this* binding. As ECMAScript code is executed, additional properties may be added to the *global object* and the initial properties may be modified.

A method environment is a Lexical Environment that corresponds to the invocation of an ECMAScript function object that establishes a new *this* binding. A method environment also captures the state necessary to support *super* method invocations.

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Lexical Environments and Environment Record values are purely specification mechanisms and need not correspond to any specific artefact of an ECMAScript implementation. It is impossible for an ECMAScript program to directly access or manipulate such values.

10.2.1 Environment Records

There are two primary kinds of Environment Record values 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 ECMAScript language values. Object environment records are used to define the effect of ECMAScript elements such as *WithStatement* that associate identifier bindings with the properties of some object. *Global Environment Records* and *Function Environment Records* are specializations that are used for specifically for *Script* global declarations and for top-level declarations within functions.

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For specification purposes Environment Record values can be thought of as existing in a simple object-oriented hierarchy where Environment Record is an abstract class with three concrete subclasses, declarative environment record, object environment record, and global environment record. Function environment records are a subclass of declarative environment record. The abstract class includes the abstract specification methods defined in Table 22. These abstract methods have distinct concrete algorithms for each of the concrete subclasses.

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Table 22 — Abstract Methods of Environment Records

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Method	Purpose
HasBinding(N)	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 <i>N</i> is the text of the identifier.
CreateMutableBinding(N, D)	Create a new <u>but uninitialised mutable</u> binding in an environment record. The String value <i>N</i> is the text of the bound name. If the optional Boolean argument <i>D</i> is true the binding is may be subsequently deleted.
<u>CreateImmutableBinding(N)</u>	<u>Create a new but uninitialised immutable binding in an environment record. The String value N is the text of the bound name.</u>
<u>InitialiseBinding(N,V)</u>	<u>Set the value of an already existing but uninitialised 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 a value of any ECMAScript language type.</u>
SetMutableBinding(N,V, S)	Set the value of an already existing mutable binding in an environment record. The String value <i>N</i> is the text of the bound name. <i>V</i> is the value for the binding and may be a value of any ECMAScript language type. <i>S</i> is a Boolean flag. If <i>S</i> is true and the binding cannot be set throw a TypeError exception. <i>S</i> is used to identify strict mode references.
GetBindingValue(N,S)	Returns the value of an already existing binding from an environment record. The String value <i>N</i> is the text of the bound name. <i>S</i> is used to identify strict mode references. If <i>S</i> is true and the binding does not exist or is uninitialised throw a ReferenceError exception.
DeleteBinding(N)	Delete a binding from an environment record. The String value <i>N</i> is the text of the bound name. If a binding for <i>N</i> exists, remove the binding and return true . If the binding exists but cannot be removed return false . If the binding does not exist return true .
<u>HasThisBinding()</u>	<u>Determine if an environment record establishes a this binding. Return true if it does and false if it does not.</u>
<u>HasSuperBinding()</u>	<u>Determine if an environment record establishes a super method binding. Return true if it does and false if it does not.</u>
<u>WithBaseObject()</u>	<u>If this environment record is associated with a with statement, return the with object. Otherwise, return undefined.</u>

Deleted: InitializeBinding

Deleted: CreateVarBinding(N, D)

Deleted: ImplicitThisValue

Deleted: Returns the value to use as the **this** value on calls to function objects that are obtained as binding values from this environment record.

10.2.1.1 Declarative Environment Records

Each declarative environment record is associated with an ECMAScript program scope containing variable, constant, let, class, module, import, and/or function declarations. A declarative environment record binds the set of identifiers defined by the declarations contained within its scope.

The behaviour of the concrete specification methods for Declarative Environment Records is defined by the following algorithms.

10.2.1.1.1 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. Let *envRec* be the declarative environment record for which the method was invoked.
2. If *envRec* 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**.

10.2.1.1.2 CreateMutableBinding (N, D)

The concrete Environment Record method `CreateMutableBinding` for declarative environment records creates a new mutable binding for the name *N* that is uninitialised. A binding must not already exist in this Environment Record for *N*. If Boolean argument *D* is provided and has the value **true** the new binding is marked as being subject to deletion.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Assert: *envRec* does not already have a binding for *N*.
3. Create a mutable binding in *envRec* for *N* and record that it is uninitialised. If *D* is **true** record that the newly created binding may be deleted by a subsequent `DeleteBinding` call.
4. Return `NormalCompletion(empty)`.

Deleted: to the value **undefined**

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10.2.1.1.3 CreateImmutableBinding (N)

The concrete Environment Record method `CreateImmutableBinding` for declarative environment records creates a new immutable binding for the name *N* that is uninitialised. A binding must not already exist in this environment record for *N*.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Assert: *envRec* does not already have a binding for *N*.
3. Create an immutable binding in *envRec* for *N* and record that it is uninitialised.

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Deleted: set its bound value to **undefined**

Comment [AWB52]: This probably needs a *D* option argument, just like `createMutableEnvironment`

10.2.1.1.4 InitialiseBinding (N,V)

The concrete Environment Record method `InitialiseBinding` 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*. An uninitialised binding for *N* must already exist.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Assert: *envRec* must have an uninitialised binding for *N*.
3. Set the bound value for *N* in *envRec* to *V*.
4. Record that the binding for *N* in *envRec* has been initialised.

Deleted: `InitializeBinding`

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10.2.1.1.5 SetMutableBinding (N,V,S)

The concrete Environment Record method `SetMutableBinding` 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 thrown if *S* is **true**.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Assert: *envRec* must have a binding for *N*.
3. If the binding for *N* in *envRec* has not yet been initialized throw a **ReferenceError** exception.
4. Else if the binding for *N* in *envRec* is a mutable binding, change its bound value to *V*.
5. Else this must be an attempt to change the value of an immutable binding so if *S* is **true** throw a **TypeError** exception.
6. Return `NormalCompletion(empty)`.

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Deleted: <#>If the binding for *N* in *envRec* is a mutable binding, change its bound value to *V*
Else i

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Deleted: **undefined**

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10.2.1.1.6 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 uninitialised immutable binding throw a **ReferenceError** exception.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Assert: *envRec* has a binding for *N*.
3. If the binding for *N* in *envRec* is an uninitialised binding, then
 - a. If *S* is **false**, return the value **undefined**, otherwise throw a **ReferenceError** exception.

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4. Else

- a. Return the value currently bound to N in $envRec$.

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10.2.1.1.7 DeleteBinding (N)

The concrete Environment Record method `DeleteBinding` for declarative environment records can only delete bindings that have been explicitly designated as being subject to deletion.

1. Let $envRec$ be the declarative environment record for which the method was invoked.
2. If $envRec$ does not have a binding for the name that is the value of N , return **true**.
3. If the binding for N in $envRec$ cannot be deleted, return **false**.
4. Remove the binding for N from $envRec$.
5. Return **true**.

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Deleted: 10.2.1.1.6 `CreateVarBinding` (N)
The concrete Environment Record method `CreateVarBinding` for declarative environment records performs the same action as the `CreateMutableBinding` concrete method of the same environment Record.
Let $envRec$ be the declarative environment record for which the method was invoked. Return the result of calling $envRec$'s `CreateMutableBinding` concrete method with arguments N and D . ¶

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Comment [AWB53]: This probably needs a option argument, just like `createMutableEnvironment`

Deleted: 10.2.1.1.7.10 `CreateImmutableBinding` (N)
¶

The concrete Environment Record method `CreateImmutableBinding` for declarative environment records creates a new immutable binding for the name N that is initialised to the value `undefined`. A binding must not already exist in this environment record for N . ¶

Let $envRec$ be the declarative environment record for which the method was invoked. Assert: $envRec$ does not already have a binding for N . ¶

Create an immutable binding in $envRec$ and record that it is uninitialised. ¶

10.2.1.1.8.11 `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 . An uninitialised immutable binding for N must already exist. ¶

Let $envRec$ be the declarative environment record for which the method was invoked.

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Deleted: This capability is used to specify the behaviour of With Statement (12.10) induced

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Deleted: the `[[HasProperty]]` internal method of

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10.2.1.1.8 HasThisBinding ()

Regular Declarative Environment Records do not provide a `this` binding.

1. Return **false**.

10.2.1.1.9 HasSuperBinding ()

Regular Declarative Environment Records do not provide a `super` binding.

1. Return **false**.

10.2.1.1.10 WithBaseObject()

Declarative Environment Records always return `undefined` as their `WithBaseObject`.

1. Return `undefined`.

10.2.1.2 Object Environment Records

Each object environment record is associated with an object called its *binding object*. An object environment record binds the set of identifier names that directly correspond to the property names of its binding object. Property names that are not an *IdentifierName* are not included in the set of bound identifiers. Both own and inherited properties are included in the set regardless of the setting of their `[[Enumerable]]` attribute. 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 are considered to be a mutable binding even if the `Writable` attribute of the corresponding property has the value `false`. Immutable bindings do not exist for object environment records.

Object environment records created for `with` statements (12.10) can provide their binding object as an implicit this value for use in function calls. The capability is controlled by a `withEnvironment` Boolean value that is associated with each object environment record. By default, the value of `withEnvironment` is `false` for any object environment record.

The behaviour of the concrete specification methods for Object Environment Records is defined by the following algorithms.

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. Let $envRec$ be the object environment record for which the method was invoked.
2. Let $bindings$ be the binding object for $envRec$.
3. Return the result of `HasProperty`($bindings$, N).

10.2.1.2.2 CreateMutableBinding (N, D)

The concrete Environment Record method `CreateMutableBinding` for object environment records creates in an environment record's associated binding object a property whose name is the String value and initialises it to the value `undefined`. A property named *N* must not already exist in the binding object. If Boolean argument *D* is provided and has the value `true` the new property's `[[Configurable]]` attribute is set to `true`, otherwise it is set to `false`.

1. Let *envRec* be the object environment record for which the method was invoked.
2. Let *bindings* be the binding object for *envRec*.
3. Assert: The result of `HasProperty(bindings, N)` is `false`.
4. If *D* is `true` then let *configValue* be `true` otherwise let *configValue* be `false`.
5. Return the result of `DefinePropertyOrThrow(bindings, N, Property Descriptor {[[Value]]:undefined, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: configValue})`.

10.2.1.2.3 CreateImmutableBinding (N)

The concrete Environment Record method `CreateImmutableBinding` is never used within this specification in association with Object environment records.

10.2.1.2.4 InitialiseBinding (N,V)

The concrete Environment Record method `InitialiseBinding` for object 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*. An uninitialised binding for *N* must already exist.

1. Let *envRec* be the object environment record for which the method was invoked.
2. Assert: *envRec* must have an uninitialised binding for *N*.
3. Record that the binding for *N* in *envRec* has been initialised.
4. Call the `SetMutableBinding` concrete method of *envRec* with *N*, *V*, and `false` as arguments.

10.2.1.2.5 SetMutableBinding (N,V,S)

The concrete Environment Record method `SetMutableBinding` 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* normally already exists but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument *S*.

1. Let *envRec* be the object environment record for which the method was invoked.
2. Let *bindings* be the binding object for *envRec*.
3. Return the result of `Put(bindings, N, V, and S)`.

10.2.1.2.6 GetBindingValue(N,S)

The concrete Environment Record method `GetBindingValue` for object environment records returns the value of its associated binding object's property whose name is the String value of the argument identifier *N*. The property should already exist but if it does not the result depends upon the value of the *S* argument:

1. Let *envRec* be the object environment record for which the method was invoked.
2. Let *bindings* be the binding object for *envRec*.
3. Let *value* be the result of `HasProperty(bindings, N)`.
4. ReturnIfAbrupt(*value*).
5. If *value* is `false`, then
 - a. If *S* is `false`, return the value `undefined`, otherwise throw a `ReferenceError` exception.
6. Return the result of `Get(bindings, N)`.

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Comment [AWB54]: This probably needs a *D* option argument, just like `createMutableEnvironment`
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10.2.1.2.7 DeleteBinding (N)

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The concrete Environment Record method `DeleteBinding` for object environment records can only delete bindings that correspond to properties of the environment object whose `[[Configurable]]` attribute have the value `true`.

1. Let `envRec` be the object environment record for which the method was invoked.
2. Let `bindings` be the binding object for `envRec`.
3. Return the result of calling the `[[Delete]]` internal method of `bindings` passing `N` as the argument.

10.2.1.2.8 HasThisBinding ()

Regular Object Environment Records do not provide a `this` binding.

1. Return `false`.

10.2.1.2.9 HasSuperBinding ()

Regular Object Environment Records do not provide a `super` binding.

1. Return `false`.

10.2.1.2.10 WithBaseObject()

Object Environment Records return `undefined` as their `WithBaseObject` unless their `withEnvironment` flag is `true`.

1. Let `envRec` be the object environment record for which the method was invoked.
2. If the `withEnvironment` flag of `envRec` is `true`, return the binding object for `envRec`.
3. Otherwise, return `undefined`.

10.2.1.3 Function Environment Records

A function environment record is a declarative environment record that is used to represent the outermost scope of a function that provides a `this` binding. In addition to its identifier bindings, a function environment record contains the `this` value used within its scope. If such a function references `super`, its function environment record also contains the state that is used to perform `super` method invocations from within the function.

Function environment records store their `this` binding as the value of their `thisValue`. If the associated function references `super`, the environment record stores in `HomeObject` the object that the function is bound to as a method and in `MethodName` the property key used for unqualified `super` invocations from within the function. The default value for `HomeObject` and `MethodName` is `undefined`.

Methods environment records support all of Declarative Environment Record methods listed in Table 22 and share the same specifications for all of those methods except for `HasThisBinding` and `HasSuperBinding`. In addition, declarative environment records support the methods listed in Table 23.

Table 23.— Additional Methods of Function Environment Records

Method	Purpose
<code>GetThisBinding()</code>	Return the value of this environment record's <code>this</code> binding.
<code>GetSuperBase()</code>	Return the object that is the base for <code>super</code> property accesses bound in this environment record. The object is derived from this environment record's <code>HomeObject</code> binding. If the value is <code>Empty</code> , return <code>undefined</code> .
<code>GetMethodName()</code>	Return the value of this environment record's <code>MethodName</code> binding.

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Deleted: 10.2.1.12.6 CreateVarBinding (N D)¶
The concrete Environment Record method `CreateVarBinding` for object environment records performs the same action as the `CreateMutableBinding` concrete method on the same environment Record.¶
Let `envRec` be the declarative environment record for which the method was invoked.
Return the result of calling `envRec`'s `CreateMutableBinding` concrete method with arguments `N` and `D`. ¶

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The behaviour of the additional concrete specification methods for Function Environment Records is defined by the following algorithms:

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10.2.1.3.1 HasThisBinding ()

Function Environment Records always provide a `this` binding.

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1. Return `true`.

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10.2.1.3.2 HasSuperBinding ()

1. If this environment record's `HomeObject` has the value `Empty`, then return `false`. Otherwise, return `true`.

10.2.1.3.3 GetThisBinding ()

1. Return the value of this environment record's `thisValue`.

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10.2.1.3.4 GetSuperBase ()

1. Let `home` be the value of this environment record's `HomeObject`.

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2. If `home` has the value `Empty`, then return `undefined`.

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3. Assert `Type(home)` is `Object`.

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4. Return the result of calling `home`'s `[[GetInheritance]]` internal method.

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10.2.1.3.5 GetMethodName ()

1. Return the value of this environment record's `MethodName`.

10.2.1.4 Global Environment Records

A global environment record is used to represent the outer most scope that is shared by all of the ECMAScript `Script` elements that are processed in a common Realm (10.3). A global environment provides the bindings for built-in globals (15.1), properties of the global object, and for all declarations that are not function code and that occur within `Script` productions.

A global environment record is logically a single record but it is specified as a composite encapsulating an object environment record and a declarative environment record. The object environment record has as its base object the global object of the associated Realm. This global object is also the value of the global environment record's `thisValue`. The object environment record component of a global environment record contains the bindings for all built-in globals (15.1) and all bindings introduced by a `FunctionDeclaration` or `VariableStatement` contained in global code. The bindings for all other ECMAScript declarations in global code are contained in the declarative environment record component of the global environment record.

Properties may be created directly on a global object. Hence, the object environment record component of a global environment record may contain both bindings created explicitly by `FunctionDeclaration` or `VariableStatement` declarations and binding created implicitly as properties of the global object. In order to identify which bindings were explicitly created using declarations, a global environment record maintains a list of the names bound using its `CreateGlobalVarBindings` and `CreateGlobalFunctionBindings` concrete methods.

Global environment records have the additional state components listed in Table 24 and the additional methods listed in Table 25.

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Table 24 -- Components of Global Environment Records

Component	Purpose
<u>ObjectEnvironment</u>	A Object Environment Record whose base object is the global object. Contains global built-in bindings as well as bindings for <i>FunctionDeclaration</i> or <i>VariableStatement</i> declarations in global code for the associated Realm.
<u>DeclarativeEnvironment</u>	A Declarative Environment Record that contains bindings for all declarations in global for the associated Realm code except for <i>FunctionDeclaration</i> and <i>VariableStatement</i> declarations.
<u>VarNames</u>	A List containing the string names bound by <i>FunctionDeclaration</i> or <i>VariableStatement</i> declarations in global code for the associated Realm.

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Table 25 — Additional Methods of Global Environment Records

Method	Purpose
<u>GetThisBinding()</u>	Return the value of this environment record's <i>this</i> binding.
<u>HasVarDeclaration (N)</u>	Determines if the argument identifier has a binding in this environment record that was created using a <i>VariableStatement</i> or a <i>FunctionDeclaration</i> .
<u>HasLexicalDeclaration (N)</u>	Determines if the argument identifier has a binding in this environment record that was created using a lexical declaration such as a <i>LexicalDeclaration</i> or a <i>ClassDeclaration</i> .
<u>CanDeclareGlobalVar (N)</u>	Determines if a corresponding <i>CreateGlobalVarBinding</i> call would succeed if called for the same argument <i>N</i> .
<u>CanDeclareGlobalFunction (N)</u>	Determines if a corresponding <i>CreateGlobalFunctionBinding</i> call would succeed if called for the same argument <i>N</i> .
<u>CreateGlobalVarBinding(N, D)</u>	Used to create global <i>var</i> bindings in the <i>ObjectEnvironmentComponent</i> of the environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values appropriate for a <i>var</i> . The String value <i>N</i> is the text of the bound name. <i>V</i> is the initial value of the binding. If the optional Boolean argument <i>D</i> is <i>true</i> the binding may be subsequently deleted. This is logically equivalent to <i>CreateMutableBinding</i> but it allows <i>var</i> declarations to receive special treatment.
<u>CreateGlobalFunctionBinding(N, V, D)</u>	Used to create and initialize global <i>function</i> bindings in the <i>ObjectEnvironmentComponent</i> of the environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values appropriate for a <i>function</i> . The String value <i>N</i> is the text of the bound name. If the optional Boolean argument <i>D</i> is <i>true</i> the binding may be subsequently deleted. This is logically equivalent to <i>CreateMutableBinding</i> followed by a <i>SetMutableBinding</i> but it allows function declarations to receive special treatment.

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The behaviour of the concrete specification methods for Global Environment Records is defined by the following algorithms.

10.2.1.4.1 HasBinding(N)

The concrete environment record method *HasBinding* for global environment records simply determines if the argument identifier is one of the identifiers bound by the record:

1. Let *envRec* be the global environment record for which the method was invoked.
2. Let *DclRec* be *envRec*'s DeclarativeEnvironment.
3. If the result of calling *DclRec*'s HasBinding concrete method with argument *N* is true, return true.
4. Let *ObjRec* be *envRec*'s ObjectEnvironment.
5. Return the result of calling *ObjRec*'s HasBinding concrete method with argument *N*.

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10.2.1.4.2 CreateMutableBinding (N, D)

The concrete environment record method CreateMutableBinding for global environment records creates a new mutable binding for the name *N* that is uninitialized. The binding is created in the associated DeclarativeEnvironment. A binding for *N* must not already exist in the DeclarativeEnvironment. If Boolean argument *D* is provided and has the value true the new binding is marked as being subject to deletion.

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1. Let *envRec* be the global environment record for which the method was invoked.
2. Let *DclRec* be *envRec*'s DeclarativeEnvironment.
3. Assert: *DclRec* does not already have a binding for *N*.
4. Create a mutable binding in *DclRec* for *N* and record that it is uninitialized. If *D* is true record that the newly created binding may be deleted by a subsequent DeleteBinding call.
5. Return NormalCompletion(empty)

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10.2.1.4.3 CreateImmutableBinding (N)

The concrete Environment Record method CreateImmutableBinding for declarative environment records creates a new immutable binding for the name *N* that is uninitialized. A binding must not already exist in this environment record for *N*.

Comment [AWB55]: This probably needs a D option argument, just like createMutableEnvironment

1. Let *envRec* be the global environment record for which the method was invoked.
2. Assert: *envRec* does not already have a binding for *N*.
3. Create an immutable binding in *envRec* for *N* and record that it is uninitialized.

10.2.1.4.4 InitialiseBinding (N,V)

The concrete Environment Record method InitialiseBinding for global 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*. An uninitialized binding for *N* must already exist.

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1. Let *envRec* be the global environment record for which the method was invoked.
2. Let *DclRec* be *envRec*'s DeclarativeEnvironment.
3. If the result of calling *DclRec*'s HasBinding concrete method with argument *N* is true, then
 - a. Return the result of calling *DclRec*'s InitialiseBinding concrete method with arguments *N* and *V*.
4. Let *ObjRec* be *envRec*'s ObjectEnvironment.
5. If the result of calling *ObjRec*'s HasBinding concrete method with argument *N* is true, then
 - a. Set the bound value for *N* in *envRec* to *V*.
 - b. Record that the binding for *N* in *envRec* has been initialised.

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10.2.1.4.5 SetMutableBinding (N,V,S)

The concrete Environment Record method SetMutableBinding for global 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*. If the binding is an immutable binding, a **TypeError** is thrown if *S* is true. A property named *N* normally already exists but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument *S*.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Let *DclRec* be *envRec*'s DeclarativeEnvironment.
3. If the result of calling *DclRec*'s HasBinding concrete method with argument *N* is true, then
 - a. Return the result of calling the SetMutableBinding concrete method of *DclRec* with arguments *N*, *V*, and *S*.
4. Let *ObjRec* be *envRec*'s ObjectEnvironment.
5. Return the result of calling the SetMutableBinding concrete method of *ObjRec* with arguments *N*, *V*, and *S*.

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10.2.1.4.6 GetBindingValue(N,S)

The concrete Environment Record method `GetBindingValue` for global environment records simply returns the value of its bound identifier whose name is the value of the argument `N`. If `S` is `true` and the binding is an uninitialised binding throw a `ReferenceError` exception. A property named `N` normally already exists but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument `S`.

1. Let `envRec` be the declarative environment record for which the method was invoked.
2. Let `DclRec` be `envRec`'s `DeclarativeEnvironment`.
3. If the result of calling `DclRec`'s `HasBinding` concrete method with argument `N` is `true`, then
 - a. Return the result of calling the `GetBindingValue` concrete method of `DclRec` with arguments `N`, and `S`.
4. Let `ObjRec` be `envRec`'s `ObjectEnvironment`.
5. Return the result of calling the `GetBindingValue` concrete method of `ObjRec` with arguments `N`, and `S`.

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10.2.1.4.7 DeleteBinding (N)

The concrete Environment Record method `DeleteBinding` for global environment records can only delete bindings that have been explicitly designated as being subject to deletion.

1. Let `envRec` be the declarative environment record for which the method was invoked.
2. Let `DclRec` be `envRec`'s `DeclarativeEnvironment`.
3. If the result of calling `DclRec`'s `HasBinding` concrete method with argument `N` is `true`, then
 - a. Return the result of calling the `DeleteBinding` concrete method of `DclRec` with argument `N`.
4. Let `ObjRec` be `envRec`'s `ObjectEnvironment`.
5. If the result of calling `ObjRec`'s `HasBinding` concrete method with argument `N` is `true`, then
 - a. Let `status` be the result of calling the `DeleteBinding` concrete method of `ObjRec` with argument `N`.
 - b. `ReturnIfAbrupt(status)`.
 - c. If `status` is `true`, then
 - i. Let `varNames` be `envRec`'s `VarNames` List.
 - ii. If `N` is an element of `varNames`, then remove that element from the `varNames`.
 - d. Return `status`.
6. Return `true`.

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10.2.1.4.8 HasThisBinding ()

Global Environment Records always provide a `this` binding whose value is the associated global object.

1. Return `true`.

10.2.1.4.9 HasSuperBinding ()

1. Return `false`.

10.2.1.4.10 WithBaseObject()

Global Environment Records always return `undefined` as their `WithBaseObject`.

1. Return `undefined`.

10.2.1.4.11 GetThisBinding ()

2. Let `envRec` be the global environment record for which the method was invoked.
3. Let `ObjRec` be `envRec`'s `ObjectEnvironment`.
4. Let `bindings` be the binding object for `ObjRec`.
5. Return `bindings`.

10.2.1.4.12 HasVarDeclaration (N)

The concrete environment record method `HasVarDeclaration` for global environment records determines if the argument identifier has a binding in this record that was created using a `VariableStatement` or a `FunctionDeclaration`:

1. Let `envRec` be the global environment record for which the method was invoked.
2. Let `varDeclaredNames` be `envRec`'s `VarNames` List.
3. If `varDeclaredNames` contains the value of `N`, return `true`.
4. Return `false`.

10.2.1.4.13 HasLexicalDeclaration (N)

The concrete environment record method `HasLexicalDeclaration` for global environment records determines if the argument identifier has a binding in this record that was created using a lexical declaration such as a `LexicalDeclaration` or a `ClassDeclaration`:

1. Let `envRec` be the global environment record for which the method was invoked.
2. Let `DclRec` be `envRec`'s `DeclarativeEnvironment`.
3. Return the result of calling `DclRec`'s `HasBinding` concrete method with argument `N`.

10.2.1.4.14 CanDeclareGlobalVar (N)

The concrete environment record method `CanDeclareGlobalVar` for global environment records determines if a corresponding `CreateGlobalVarBinding` call would succeed if called for the same argument `N`. Redundant var declarations and var declarations for pre-existing global object properties are allowed.

1. Let `envRec` be the global environment record for which the method was invoked.
2. Let `ObjRec` be `envRec`'s `ObjectEnvironment`.
3. If the result of calling `ObjRec`'s `HasBinding` concrete method with argument `N` is `true`, return `true`.
4. Let `bindings` be the binding object for `ObjRec`.
5. Let `extensible` be the result of `IsExtensible(bindings)`.
6. Return `extensible`.

Deleted: <#>If the result of calling the [[GetIsExtensible] internal propertymethod of `bindings` is `true`, return `true`.¶

Deleted: `false`

10.2.1.4.15 CanDeclareGlobalFunction (N)

The concrete environment record method `CanDeclareGlobalVar` for global environment records determines if a corresponding `CreateGlobalFunctionBinding` call would succeed if called for the same argument `N`.

1. Let `envRec` be the global environment record for which the method was invoked.
2. Let `ObjRec` be `envRec`'s `ObjectEnvironment`.
3. Let `globalObject` be the binding object for `ObjRec`.
4. Let `extensible` be the result of `IsExtensible(globalObject)`.
5. Return `IfAbrupt(extensible)`.
6. If the result of calling `ObjRec`'s `HasBinding` concrete method with argument `N` is `false`, then return `extensible`.
7. Let `existingProp` be the result of calling the [[GetOwnProperty]] internal method of `globalObject` with argument `N`.
8. If `existingProp` is `undefined`, then return `extensible`.
9. If `existingProp.[[Configurable]]` is `true`, then return `true`.
10. If `IsDataDescriptor(existingProp)` is `true` and `existingProp` has attribute values `{[[Writable]]: true, [[Enumerable]]: true}`, then return `true`.
11. Return `false`.

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Comment [AWB1156]: Carry over from ES5, but perhaps unnecessary

10.2.1.4.16 CreateGlobalVarBinding (N, D)

The concrete Environment Record method `CreateVarBinding` for global environment records creates a mutable binding in the associated object environment record and records the bound name in the associated `VarNames` List. If a binding already exists, it is reused.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Let *ObjRec* be *envRec*'s ObjectEnvironment.
3. Assert: The result of calling *envRec*'s *CanDeclareGlobalVar* concrete method with argument *N* is **true**.
4. If the result of calling *ObjRec*'s *HasBinding* concrete method with argument *N* is **false**, then
 - a. Call the *CreateMutableBinding* concrete method of *ObjRec* with arguments *N* and *D*.
5. Let *varDeclaredNames* be *envRec*'s VarNames List.
6. If *varDeclaredNames* does not contain the value of *N*, then
 - a. Append *N* to *varDeclaredNames*.
7. Return.

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10.2.1.4.17 CreateGlobalFunctionBinding (N, V, D)

The concrete Environment Record method *CreateFunctionBinding* for global environment records creates a mutable binding in the associated object environment record and records the bound name in the associated VarNames List. If a binding already exists, it is replaced.

1. Let *envRec* be the declarative environment record for which the method was invoked.
2. Let *ObjRec* be *envRec*'s ObjectEnvironment.
3. Assert: The result of calling *envRec*'s *CanDeclareGlobalFunction* concrete method with argument *N* is **true**.
4. Let *globalObject* be the binding object for *ObjRec*.
5. Let *existingProp* be the result of calling the *[[GetOwnProperty]]* internal method of *globalObject* with argument *N*.
6. If *existingProp* is **undefined** or *existingProp.[[Configurable]]* is **true**, then
 - a. Call the *[[DefineOwnProperty]]* internal method of *globalObject*, passing *N* and Property Descriptor *{[[Value]]:V, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: D}* as arguments.
7. Else,
 - a. Call the *[[DefineOwnProperty]]* internal method of *globalObject*, passing *N* and Property Descriptor *{[[Value]]:V }* as arguments.
8. NOTE The assertion in step 3 means that the above *[[DefineOwnProperty]]* calls will never return **false** or an abrupt completion.
9. Let *varDeclaredNames* be *envRec*'s VarNames List.
10. If *varDeclaredNames* does not contain the value of *N*, then
 - a. Append *N* to *varDeclaredNames*.
11. Return.

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Comment [AWB1257]: TODO: need to reconsider this? May not be true if the global object can be a Proxy.

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NOTE Global function declarations are always represented as a own property of the global object. If possible, an existing own property is reconfigured to have a standard set of attribute values.

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

10.2.2 Lexical Environment Operations

10.2.2.1 GetIdentifierReference (lex, name, strict)

The abstract operation *GetIdentifierReference* is called with a Lexical Environment *lex*, a String *name*, and a Boolean flag *strict*. The value of *lex* may be **null**. When called, the following steps are performed:

1. If *lex* is the value **null**, then
 - a. Return a value of type Reference whose base value is **undefined**, whose referenced name is *name*, and whose strict reference flag is *strict*.
2. Let *envRec* be *lex*'s environment record.
3. Let *exists* be the result of calling the *HasBinding(N)* concrete method of *envRec* passing *name* as the argument *N*.
4. If *exists* is **true**, then
 - a. Return a value of type Reference whose base value is *envRec*, whose referenced name is *name*, and whose strict reference flag is *strict*.
5. Else
 - a. Let *outer* be the value of *lex*'s outer environment reference.
 - b. Return the result of calling *GetIdentifierReference* passing *outer*, *name*, and *strict* as arguments.

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10.2.2.2 NewDeclarativeEnvironment (E)

When the abstract operation `NewDeclarativeEnvironment` is called with either a Lexical Environment or `null` as argument E the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let $envRec$ be a new declarative environment record containing no bindings.
3. Set env 's environment record to be $envRec$.
4. Set the outer lexical environment reference of env to E .
5. Return env .

10.2.2.3 NewObjectEnvironment (O, E)

When the abstract operation `NewObjectEnvironment` is called with an Object O and a Lexical Environment E (or `null`) as arguments, the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let $envRec$ be a new object environment record containing O as the binding object.
3. Set env 's environment record to be $envRec$.
4. Set the outer lexical environment reference of env to E .
5. Return env .

10.2.2.4 NewFunctionEnvironment (F, T)

When the abstract operation `NewFunctionEnvironment` is called with an ECMAScript function Object F and a ECMAScript value T as arguments, the following steps are performed:

1. Assert: The value of F 's `[[ThisMode]]` internal data property is not lexical.
2. Let env be a new Lexical Environment.
3. Let $envRec$ be a new Function environment record containing containing no bindings.
4. Set $envRec$'s `thisValue` to T .
5. If F has a `[[HomeObject]]` internal data property, then
 - a. Set $envRec$'s `HomeObject` to the value of F 's `[[HomeObject]]` internal data property.
 - b. Set $envRec$'s `MethodName` to the value of F 's `[[MethodName]]` internal data property.
6. Else
 - a. Set $envRec$'s `HomeObject` to Empty.
7. Set env 's environment record to be $envRec$.
8. Set the outer lexical environment reference of env to the value of F 's `[[Scope]]` internal data property.
9. Return env .

10.3 Code Realms

Before it is evaluated, all ECMAScript code must be associated with a *Realm*. Conceptually, a realm consists of a set of intrinsic objects, an ECMAScript global environment, all of the ECMAScript code that is loaded within the scope of that global environment, a Loader object that can associate new ECMAScript code with the realm, and other associated state and resources.

A Realm is specified as a Record with the fields specified in Table 26:

Table 26 — Realm Record Fields

Field Name	Value	Meaning
<code>[[Intrinsics]]</code>	A record whose field names are intrinsic keys and whose values are objects	These are the intrinsic values used by code associated with this Realm
<code>[[GlobalThis]]</code>	An ECMAScript object	The global object for this Realm
<code>[[GlobalEnv]]</code>	A ECMAScript environment	The global environment for this Realm
<code>[[Loader]]</code>	any ECMAScript identifier or empty	The Loader object that can associate ECMAScript code with this Realm

The intrinsic objects associated with a code Realm include the well-known intrinsics listed in Table 11 and additional intrinsics specified by Table 27.

Table 27.— Additional Intrinsic Objects with Realm Specific Bindings

Intrinsic Name	ECMAScript Language Association
???	???
???	???

10.4 Execution Contexts

An execution context is a specification device that is used to track the runtime evaluation of code by an ECMAScript implementation. At any point in time, there is at most one execution context that is actually executing code. This is known as the running execution context. A stack is used to track execution contexts. The running execution context is always the top element of this stack. 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 implementation specific state is necessary to track the execution progress of its associated code. Each execution context has the state components listed in Table 28.

Table 28.—State Components for All Execution Contexts

Component	Purpose
code evaluation state	Any state needed to perform, suspend, and resume evaluation of the code associated with this execution context.
Realm	The Realm from which associated code accesses ECMAScript resources.

Evaluation of code by the running execution context may be suspended at various points defined within this specification. Once the running execution context has been suspended a different execution context may become the running execution context and commence evaluating its code. At some latter time a suspended execution context may again become the running execution context and continue evaluating its code at the point where it had previously been suspended. Transition of the running execution context status among execution contexts usually occurs in stack-like last-in/first-out manner. However, some ECMAScript features require non-LIFO transitions of the running execution context.

The value is the Realm component of the running execution context is also called the current Realm.

Execution contexts for ECMAScript code have the additional state components listed in Table 29.

Table 29.—Additional State Components for ECMAScript Code Execution Contexts

Component	Purpose
LexicalEnvironment	Identifies the Lexical Environment used to resolve identifier references made by code within this execution context.
VariableEnvironment	Identifies the Lexical Environment whose environment record holds bindings created by VariableStatements within this execution context.

The LexicalEnvironment and VariableEnvironment components of an execution context are always Lexical Environments. When an execution context is created its LexicalEnvironment and VariableEnvironment components initially 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.

- Deleted:** are
- Deleted:** Within this specification a reference such as %name% means the value with this intrinsic name in the [[intrinsics]] record of the Realm of the running execution context.
- Deleted:** 272725
- Deleted:** %Object%
- Deleted:** The initial value of the global object property named "Object".
- Comment [AWB1359]:** This is where we should list all the per realm intrinsics that don't have %names%
- Deleted:** %ObjectPrototype%
- Deleted:** The initial value of the "prototype" data property of the intrinsic %Object%.
- Deleted:** %ObjProto_toString%
- Deleted:** 10.2.3 The Global Environment
The global environment is a unique Lexical Environment which is created before any other environments.
- Deleted:** 3
- Deleted:** n
- Deleted:** When control is transferred to another execution context.
- Deleted:** to
- Deleted:** At any point in time, there is at most one running execution context.
- Deleted:** t
- Deleted:** and
- Deleted:** In addition, e
- Deleted:**
- Deleted:** Execution Context
- Deleted:** ECMAScript
- Deleted:** PreviousContext
- Deleted:** within which the associated code is evaluated
- Deleted:** code is evaluated
- Deleted:** LexicalEnvironment
- Deleted:** ThisBinding
- Deleted:** The code evaluation state
- Deleted:** current
- Deleted:** current
- Deleted:** current
- Deleted:** ECMAScript
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- Deleted:** Table 29Table 29Table 27Table 27
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Execution contexts representing the evaluation of generator objects have the additional state components listed in Table 30.

Table 30 -- Additional State Components for Generator Execution Contexts

Component	Purpose
Generator	The GeneratorObject that this execution context is evaluating.

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”, and “VariableEnvironment” are used without qualification they are in reference to those components of the running execution context.

Deleted: and “ThisBinding”

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 directly access or observe an execution context.

10.4.1 Identifier Resolution

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Identifier resolution is the process of determining the binding of an *IdentifierName* using the LexicalEnvironment of the running execution context. During execution of ECMAScript code, Identifier Resolution is performed using the following algorithm:

Deleted: the syntactic production *PrimaryExpression* : *Identifier* is evaluated

1. Let *env* be the running execution context’s LexicalEnvironment.
2. If the syntactic production that is being evaluated is contained in strict mode code, then let *strict* be **true**, else let *strict* be **false**.
3. Return the result of calling GetIdentifierReference abstract operation passing *env*, the StringValue of IdentifierName, and *strict* as arguments.

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Deleted: Identifier

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The result of evaluating an identifier is always a value of type Reference with its referenced name component equal to the *IdentifierName* String.

10.4.2 GetThisEnvironment

Deleted: It starts search with the LexicalEnvironment of the current execution context.

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The abstract operation GetThisEnvironment finds the lexical environment that currently supplies the binding of the keyword **this**. GetThisEnvironment performs the following steps:

1. Let *lex* be the running execution context’s LexicalEnvironment.
2. Repeat
 - a. Let *envRec* be *lex*’s environment record.
 - b. Let *exists* be the result of calling the HasThisBinding concrete method of *envRec*.
 - c. If *exists* is **true**, then return *envRec*.
 - d. Let *outer* be the value of *lex*’s outer environment reference.
 - e. Let *lex* be *outer*.

NOTE The loop in step 2 will always terminate because the list of environments always ends with the global environment which has a **this** binding.

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10.4.3 This Resolution

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The abstract operation ThisResolution is the process of determining the binding of the keyword **this** using the LexicalEnvironment of the running execution context. ThisResolution performs the following steps:

1. Let *env* be the result of performing the GetThisEnvironment abstract operation.
2. Return the result of calling the GetThisBinding concrete method of *env*.

10.4.4 GetGlobalObject

The abstract operation `GetGlobalObject` returns the global object used by the currently running execution context. `GetGlobalObject` performs the following steps:

1. Let `ctx` be the running execution context.
2. Let `currentRealm` be `ctx`'s Realm.
3. Return `currentRealm.[[globalThis]]`.

10.5 Declaration Binding Instantiation

10.5.1 Global Declaration Instantiation

NOTE When an execution context is established for evaluating `scripts`, declarations are instantiated in the current global environment. Each global binding declared in the code is instantiated.

Global Declaration Instantiation is performed as follows using arguments `script`, `env`, and `deletableBindings`. `script` is the `ScriptBody` that for which the execution context is being established. `env` is the global environment record in which bindings are to be created. `deletableBindings` is `true` if the bindings that are created should be deletable.

1. Let `strict` be `IsStrict of script`.
2. Let `lexNames` be the `LexicallyDeclaredNames of script`.
3. Let `varNames` be the `VarDeclaredNames of script`.
4. For each `name` in `lexNames`, do
 - a. If the result of calling `env`'s `HasVarDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
 - b. If the result of calling `env`'s `HasLexicalDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
5. For each `name` in `varNames`, do
 - a. If the result of calling `env`'s `HasLexicalDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
6. Let `varDeclarations` be the `VarScopedDeclarations of script`.
7. Let `functionsToInitialize` be an empty List.
8. Let `declaredFunctionNames` be an empty List.
9. For each `d` in `varDeclarations`, in reverse list order do
 - a. If `d` is a `FunctionDeclaration` then
 - i. NOTE If there are multiple `FunctionDeclarations` for the same name, the last declaration is used.
 - ii. Let `fn` be the sole element of the `BoundNames` of `d`.
 - iii. If `fn` is not an element of `declaredFunctionNames`, then
 1. Let `fnDefinable` be the result of calling `env`'s `CanDeclareGlobalFunction` concrete method passing `fn` as the argument.
 2. If `fnDefinable` is `false`, throw `TypeError` exception.
 3. Append `fn` to `declaredFunctionNames`.
 4. Append `d` to `functionsToInitialize`.
10. Let `declaredVarNames` be an empty List.
11. For each `d` in `varDeclarations`, do
 - a. If `d` is a `VariableStatement` then
 - i. For each `String vn` in the `BoundNames` of `d`, do
 1. If `vn` is not an element of `declaredFunctionNames`, then
 - a. Let `vnDefinable` be the result of calling `env`'s `CanDeclareGlobalVar` concrete method passing `vn` and `deletableBindings` as the arguments.
 - b. If `vnDefinable` is `false`, throw `TypeError` exception.
 - c. If `vn` is not an element of `declaredVarNames`, then
 - i. Append `vn` to `declaredVarNames`.
 12. NOTE: No abnormal terminations occur after this algorithm step.
 13. For each `FunctionDeclaration f` in `functionsToInitialize`, do
 - a. Let `fn` be the sole element of the `BoundNames` of `f`.
 - b. Let `fo` be the result of performing `InstantiateFunctionObject` for `f` with argument `env`.

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Deleted: 10.4 Establishing an Execution Context

Evaluation of global code or code using the `eval` function (15.1.2.1) establishes and enters a new execution context. Every invocation of an ECMAScript code function (13.2.1) also establishes and 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` and initial `LexicalEnvironment` are defined, and declaration binding instantiation (10.5) is performed. The exact manner in which the actions occur depend on the type of code being entered.¶

10.4.1 Entering Global Code¶

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

Initialise the execution context using the global code as described in 10.4.1.1.¶

Perform Declaration Binding Instantiation described in 10.5 using the global code.¶

10.4.1.1 Initial Global Execution Context¶

The following steps are performed to initialise a global execution context for ECMAScript code `C`:¶

Set the `VariableEnvironment` to the `GlobalEnvironment`.¶

Set the `LexicalEnvironment` to the `GlobalEnvironment`.¶

Set the `ThisBinding` to the global object.¶

10.4.2 Entering Eval Code¶

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

Deleted: 10.5 Declaration Binding Instantiation¶

Comment [AWB60]: It may make sense to split eval code out into a separate subsection.

Deleted: Every execution context has an associated `VariableEnvironment`. Variable and functions declared in ECMAScript code

Deleted: Base Code

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Deleted: Top-level Declaration Instantiation base code is performed as follows: ¶

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- c. Call `env`'s `CreateGlobalFunctionBinding` concrete method passing `fn`, `fo`, and `deletableBindings` as the arguments.
14. For each String `vn` in `declaredVarNames`, in list order do
- a. Call `env`'s `CreateGlobalVarBinding` concrete method passing `vn` and `deletableBindings` as the argument.
15. Let `lexDeclarations` be the LexicallyScopedDeclarations of `script`.
16. For each element `d` in `lexDeclarations` do
- a. NOTE Lexically declared names are only instantiated here but not initialized.
 - b. For each element `dn` of the `BoundNames` of `d` do
 - i. If `IsConstantDeclaration` of `d` is `true`, then
 - 1. Call `env`'s `CreateImmutableBinding` concrete method passing `dn` as the argument.
 - ii. Else,
 - 1. Call `env`'s `CreateMutableBinding` concrete method passing `dn` and `false` as the arguments.
 - c. If `d` is a `GeneratorDeclaration` production, then
 - i. Let `fn` be the sole element of the `BoundNames` of `d`.
 - ii. Let `fo` be the result of performing `InstantiateFunctionObject` for `d` with argument `env`.
 - iii. Call `env`'s `SetMutableBinding` concrete method passing `fn`, `fo`, and `false` as the arguments.
17. Return `NormalCompletion(empty)`

NOTE Early errors specified in 14.1 prevent name conflicts between function/var declarations and let/const/class/module declarations as well as redeclaration of let/const/class/module bindings for declaration contained within a single `Script`. However, such conflicts and redeclarations that span more than one `Script` are detected as runtime errors during Global Declaration Instantiation. If any such errors are detected, no bindings are instantiated for the `script`.

Unlike explicit var or function declarations, properties that are directly created on the global object result in global bindings that may be shadowed by let, const, class, and module declarations.

10.5.2 Module Declaration Instantiation

10.5.3 Function Declaration Instantiation

This version reflects the consensus as of the Sept. 2012 TC39 meeting. However, it now appears that the binding semantics of formal parameters is like to change again.

NOTE When an execution context is established for evaluating function code a new Declarative Environment Record is created and bindings for each formal parameter, and each function level variable, constant, or function declared in the function are instantiated in the environment record. Formal parameters and functions are initialized as part of this process. All other bindings are initialized during execution of the function code.

Function Declaration Instantiation is performed as follows using arguments `func`, `argumentsList`, and `env`. `func` is the function object that for which the execution context is being established. `env` is the declarative environment record in which bindings are to be created.

1. Let `code` be the value of the `[[Code]]` internal data property of `func`.
2. Let `strict` be the value of the `[[Strict]]` internal data property of `func`.
3. Let `formals` be the value of the `[[FormalParameters]]` internal data property of `func`.
4. Let `parameterNames` be the `BoundNames` of `formals`.
5. Let `varDeclarations` be the VarScopedDeclarations of `code`.
6. Let `functionsToInitialize` be an empty List.
7. Let `argumentsObjectNotNeeded` be `false`.
8. For each `d` in `varDeclarations`, in reverse list order do
 - a. If `d` is a `FunctionDeclaration` then

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Deleted: `code`

Comment [AWB61]: The exact details of declaration instantiation for module code still need to be worked out.

Deleted: If `code` is function code, then
 Let `func` be the function whose `[[Call]]` internal method initiated execution of `code`. Let `names` be the value of `func`'s `[[FormalParameters]]` internal property.
 Let `argCount` be the number of elements in `args`.
 Let `n` be the number `0`.
 For each String `argName` in `names`, in list order do
 Let `n` be the current value of `n` plus `1`.
 If `n` is greater than `argCount`, let `v` be undefined otherwise let `v` be the value of the `n`'th element of `args`.
 Let `argAlreadyDeclared` be the result of calling `env`'s `HasBinding` concrete method passing `argName` as the argument.
 If `argAlreadyDeclared` is false, then
 call `Call env`'s `CreateMutableBinding` concrete method passing `argName` as the argument.
 Call `env`'s `InitializeBinding` concrete method passing `argName`, and `undefined` as the arguments.
 Call `env`'s `SetMutableBinding` concrete method passing `argName`, `v`, and `strict` as the arguments.

Deleted: For each `FunctionDeclaration` `f` in `code`, in source text order do
 Let `fn` be the Identifier in `FunctionDeclaration` `f`.
 Let `fo` be the result of performing `InstantiateFunctionDeclaration` for instantiating `FunctionDeclaration` `f` described in Clause 13.
 Let `funcAlreadyDeclared` be the result of calling `env`'s `HasBinding` concrete method passing `fn` as the argument.
 If `funcAlreadyDeclared` is false, then
 call `Call env`'s `CreateMutableVarBinding` concrete method passing `fn` and `configurableBindings` as the arguments.
 Call `env`'s `InitializeBinding` concrete method passing `fn`, and `undefined` as the arguments.
 Else if `env` is the environment record component of the global environment then
 Let `go` be the global object.
 Let `existingProp` be the resulting of calling the `[[GetOwnProperty]]` internal method of `go` with argument `fn`.
 If `existingProp` is undefined or `existingProp`.`[[Configurable]]` is true, then
 Call the `[[DefineOwnProperty]]` internal method of `go` passing `fn`, `Property Descriptor` {`[[Value]]`: `undefined`, `[[Writable]]`: `true`, `[[Enumerable]]`: `true`, `[[Configurable]]`: `configurableBindings` }, and `true` as arguments.
 Else if `IsAccessorDescriptor`(`existingProp`) or `existingProp` not have attribute values {`[[Writable]]`: `true`, `[[Enumerable]]`: `true`}, then
 Throw a `TypeError` exception.
 Let `status` be the result of calling `Call env`'s `SetMutableBinding` concrete method passing `fn`, and `strict` as the arguments.
`ReturnIfAbrupt(status)`.

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- i. NOTE If there are multiple *FunctionDeclarations* for the same name, the last declaration is used.
 - ii. Let *fn* be the sole element of the *BoundNames* of *d*.
 - iii. If *fn* is "arguments", then let *argumentsObjectNotNeeded* be true.
 - iv. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *fn* as the argument.
 - v. If *alreadyDeclared* is false, then
 - 1. Let *status* be the result of calling *env*'s *CreateMutableBinding* concrete method passing *fn* as the argument.
 - 2. Assert: *status* is never an Abrupt Completion.
 - 3. Append *d* to *functionsToInitialize*.
9. For each String *paramName* in *parameterNames*, do
- a. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *paramName* as the argument.
 - b. NOTE Duplicate parameter names can only occur in non-strict functions. Parameter names that are the same as function declaration names do not get initialized to undefined.
 - c. If *alreadyDeclared* is false, then
 - i. If *paramName* is "arguments", then let *argumentsObjectNotNeeded* be true.
 - ii. Let *status* be the result of calling *env*'s *CreateMutableBinding* concrete method passing *paramName* as the argument.
 - iii. Assert: *status* is never an Abrupt Completion.
 - iv. Call *env*'s *InitialiseBinding* concrete method passing *paramName*, and undefined as the arguments.
10. NOTE If there is a function declaration or formal parameter with the name "arguments" then an argument object is not created.
11. If *argumentsObjectNotNeeded* is false, then
- a. If *strict* is true, then
 - i. Call *env*'s *CreateImmutableBinding* concrete method passing the String "arguments" as the argument.
 - b. Else,
 - i. Call *env*'s *CreateMutableBinding* concrete method passing the String "arguments" as the argument.
12. Let *varNames* be the *VarDeclaredNames* of *code*.
13. For each String *varName* in *varNames*, in list order do
- a. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *varName* as the argument.
 - b. NOTE A *VarDeclaredNames* is only instantiated and initialied here if it is not also the name of a formal parameter or a *FunctionDeclarations*.
 - c. If *alreadyDeclared* is false, then
 - i. Call *env*'s *CreateMutableBinding* concrete method passing *varName* as the argument.
14. Let *lexDeclarations* be the *LexicalDeclarations* of *code*.
15. For each element *d* in *lexDeclarations* do
- a. NOTE A lexically declared name cannot be the same as a function declaration, formal parameter, or a var name. Lexically declared names are only instantiated here but not initialized.
 - b. For each element *dn* of the *BoundNames* of *d* do
 - i. If *IsConstantDeclaration* of *d* is true, then
 - 1. Call *env*'s *CreateImmutableBinding* concrete method passing *dn* as the argument.
 - ii. Else,
 - 1. Call *env*'s *CreateMutableBinding* concrete method passing *dn* and false as the arguments.
 - c. If *d* is a *GeneratorDeclaration* production, then
 - i. Append *d* to *functionsToInitialize*.
16. For each production *f* in *functionsToInitialize*, do
- a. Let *fn* be the sole element of the *BoundNames* of *f*.
 - b. Let *fo* be the result of performing *InstantiateFunctionObject* for *f* with argument *env*.
 - c. Call *env*'s *SetMutableBinding* concrete method passing *fn*, *fo*, and false as the arguments.
17. NOTE Function declarations are initialised prior to parameter initialisation so that default value expressions may reference them. "arguments" is not initialized until after parameter initialization.
18. Let *ao* be the result of *InstantiateArgumentsObject* with argument *argumentsList*.

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Deleted: arg
Deleted: ReturnIfAbrupt(status).
Deleted: <#>If strict is false, then!
Deleted: InitializeBinding
Deleted: arg
Comment [AWB762]: TODO: don't create arguments binding for arrow functions (and perhaps for concise methods)

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19. NOTE If `argumentsObjectNotNeeded` is `true` then the value of `ao` is not directly observable to ECMAScript code and need not actually exist. In that case, its use in the above steps is strictly as a device for specifying formal parameter initialisation semantics.
20. Let `formalStatus` be the result of performing Binding Initialisation for `formals` with `ao` and `undefined` as arguments.
21. `ReturnIfAbrupt(formalStatus).`
22. If `argumentsObjectNotNeeded` is `false`, then
 - a. If `strict` is `true`, then
 - i. Perform the abstract operation `CompleteStrictArgumentsObject` with argument `ao`.
 - b. Else,
 - i. Perform the abstract operation `CompleteMappedArgumentsObject` with arguments `ao, func, formals, and env`.
 - c. Call `env`'s `InitialiseBinding` concrete method passing "`arguments`" and `ao` as arguments.
23. `Return NormalCompletion(empty)`.

10.5.4 Block Declaration Instantiation

NOTE When a `Block` or `CaseBlock` production is evaluated a new Declarative Environment Record is created and bindings for each block scoped variable, constant, or function declared in the block are instantiated in the environment record.

Block Declaration Instantiation is performed as follows using arguments `code` and `env`. `code` is the grammar production corresponding to the body of the block. `env` is the declarative environment record in which bindings are to be created.

1. Let `declarations` be the LexicalDeclarations of `code`.
2. Let `functionsToInitialize` be an emptyList.
3. For each element `d` in `declarations` do
 - a. For each element `dn` of the BoundNames of `d` do
 - i. If `IsConstantDeclaration` of `d` is `true`, then
 1. Call `env`'s `CreateImmutableBinding` concrete method passing `dn` as the argument.
 - ii. Else,
 1. Call `env`'s `CreateMutableBinding` concrete method passing `dn` and `false` as the arguments.
 - b. If `d` is a `GeneratorDeclaration` production or a `FunctionDeclaration` production, then
 - i. Append `d` to `functionsToInitialize`.
4. For each production `f` in `declarations`, in list order do
 - a. Let `fn` be the sole element of the BoundNames of `f`.
 - b. Let `fo` be the result of performing `InstantiateFunctionObject` for `f` with argument `env`.
 - c. Call `env`'s `InitialiseBinding` concrete method passing `fn`, and `fo` as the arguments.

10.5.5 Eval Declaration Instantiation

10.6 Arguments Object

When function `code` is evaluated, an arguments object is created unless (as specified in 10.5) the identifier `arguments` occurs as an `Identifier` in the function's `FormalParameters` or occurs as the `BindingIdentifier` of a `FunctionDeclaration` contained in the outermost `StatementList` of the function code.

The abstract operation `InstantiateArgumentsObject` called with an argument `args` performs the following steps:

1. Let `len` be the number of elements in `args`.
2. Let `obj` be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
3. Call the `[[DefineOwnProperty]]` internal method on `obj` passing "`length`" and the Property Descriptor `{[[Value]]: len, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}` as arguments.
4. Let `indx = len - 1`.
5. Repeat while `indx > 0`.
 - a. Let `val` be the element of `args` at 0-origin list position `indx`.

Comment [AWB663]: TODO This is no longer true needs o be taken into account

- Deleted:** <#>Let `declarations` be the LexicalDeclarations code.
Deleted: <#>If `strict` is `true`, then
Deleted: <#>Let `ao` be the result of `CreateStrictArgumentsObject`. w argument `argumentsList`. ¶
Deleted: <#>Let `formalStatus` be the result of `Performperforming` Binding InitializationInitialisation for `formals` with `ao` and e as arguments. ¶
Deleted: <#>Else, ¶
Deleted: <#>Let `names` be `BoundNames` of `formals`. ¶
Deleted: <#>NOTE . Because `F` is a none strict function it is n extended code. Hence `formals` does not contain the
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Comment [AWB764]: TODO: don't create an
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Deleted: `argumentsAlreadyDeclared`
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Deleted: `0`
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Deleted: `InitializeBinding`
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Deleted: .
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Comment [AWB765]: Jan 19 meeting notes: Current
Deleted: contained in extended code
Deleted: <#>Assert: `parameterNames` has no duplicate
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Deleted: `FunctionDeclaration`
Deleted: `FunctionDeclaration`
Deleted: Instantiate Function Declaration
Deleted: instantiating `FunctionDeclaration`
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Deleted: <#>Call `env`'s `CreateMutableBinding` concrete
Deleted: `InitializeBinding`
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Deleted: For each `LetDeclaration` and `ConstDeclaration`
Deleted: control enters an execution context for
Deleted: `FormalParameterList`
Comment [AWB 266]: Additional modification to this
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Deleted: `Function`
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- b. Call the `[[DefineOwnProperty]]` internal method on `obj` passing `ToString(idx)` and the Property Descriptor `{[[Value]]: val, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}` as arguments.
 - c. Let `idx = idx - 1`
6. Return `obj`

The abstract operation `CompleteStrictArgumentsObject` is called with argument `obj` which must have been previously created by the abstract operation `InstantiateArgumentsObject`. The following steps are performed:

1. Perform the `AddRestrictedFunctionProperties` abstract operation with argument `obj`.
2. Return.

The abstract operation `CompleteMappedArgumentsObject` is called with object `obj`, object `func`, grammar production `formals`, and environment record `env`. `obj` must have been previously created by the abstract operation `InstantiateArgumentsObject`. The following steps are performed:

1. Let `len` be the result of `Get(obj, "length")`.
2. Let `mappedNames` be an empty List.
3. Let `numberOfNonRestFormals` be `NumberOfParameters` of `formals`.
4. Let `map` be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
5. Let `idx = len - 1`.
6. Repeat while `idx >= 0`.
 - a. If `idx` is less than the `numberOfNonRestFormals`, then
 - i. Let `param` be `getParameter` of `formals` with argument `idx`.
 - ii. If `param` is a `BindingIdentifier`, then
 1. Let `name` be the sole element of `BoundNames` of `param`.
 2. If `name` is not an element of `mappedNames`, then
 - a. Add `name` as an element of the list `mappedNames`.
 - b. Let `g` be the result of calling the `MakeArgGetter` abstract operation with arguments `name` and `env`.
 - c. Let `p` be the result of calling the `MakeArgSetter` abstract operation with arguments `name` and `env`.
 - d. Call the `[[DefineOwnProperty]]` internal method of `map` passing `ToString(idx)` and the Property Descriptor `{[[Set]]: p, [[Get]]: g, [[Configurable]]: true}` as arguments.
 - b. Let `idx = idx - 1`.
 7. If `mappedNames` is not empty, then
 - a. Set the `[[ParameterMap]]` internal data property of `obj` to `map`.
 - b. Set the `[[Get]]`, `[[GetOwnProperty]]`, `[[DefineOwnProperty]]`, and `[[Delete]]` internal methods of `obj` to the definitions provided below.
 8. Call the `[[DefineOwnProperty]]` internal method on `obj` passing `"callee"` and the Property Descriptor `{[[Value]]: func, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}` as arguments.
 9. Return `obj`.

The abstract operation `MakeArgGetter` called with String `name` and environment record `env` creates a function object that when executed returns the value bound for `name` in `env`. It performs the following steps:

1. Let `bodyText` be the result of concatenating the Strings `"return "`, `name`, and `";"`.
2. Let `body` be the result of parsing `bodyText` using `FunctionBody` as the goal symbol.
3. Let `parameters` be a `FormalParameters`:`[empty]` production.
4. Return the result of calling the abstract operation `FunctionCreate` using `Normal` as the `kind`, `parameters` as `FormalParameterList`, `body` for `FunctionBody`, `env` as `Scope`, and `true` for `Strict`.

The abstract operation `MakeArgSetter` called with String `name` and environment record `env` creates a function object that when executed sets the value bound for `name` in `env`. It performs the following steps:

1. Let `paramText` be the String `name` concatenated with the String `"_arg"`.
2. Let `parameters` be the result of parsing `paramText` using `FormalParameters` as the goal symbol.
3. Let `bodyText` be the String `"<name> = <param>;"` with `<name>` replaced by the value of `name` and `<param>` replaced by the value of `paramText`.

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Deleted: <code><#>Let len be the number of elements in args.</code>
<code><#>Let obj be the result of the abstraction operation <code>InstantiateArgumentsObject</code> with argument <code>len</code>.</code>
<code><#>Let <code>idx = len - 1</code>.</code>
<code><#>Repeat while <code>idx >= 0</code>.</code>
Deleted: <code>or</code>
Deleted: <code><#>Call the <code>[[DefineOwnProperty]]</code></code>
Deleted: <code>obj</code>
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Deleted: <code>ion</code>
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Deleted: calling the <code>[[</code>
Deleted: <code>]]</code> internal method of
Deleted: with
Deleted: argument
Deleted: . <code>args</code> .
Deleted: <code><#>Let obj be the result of the</code>
Deleted: <code>>=</code>
Deleted: <code><#>Let val be the element of args at</code>
Deleted: number of elements in <code>names</code>
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Deleted: no <code>FormalParameterList</code>
Deleted: <code>List</code>

4. Let *body* be the result of parsing *bodyText* using *FunctionBody* as the goal symbol.
5. Return the result of calling the abstract operation *FunctionCreate* using *Normal* as the *kind*, *parameters* as *FormalParameterList*, *body* for *FunctionBody*, *env* as *Scope*, and *true* for *Strict*.

The **[[Get]]** internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name *P* performs the following steps:

1. Let *args* be the arguments object.
2. Let *map* be the value of the **[[ParameterMap]]** internal *data* property of the arguments object.
3. Let *isMapped* be the result of calling the **[[GetOwnProperty]]** internal method of *map* passing *P* as the argument.
4. If the value of *isMapped* is **undefined**, then
 - a. Let *v* be the result of calling the default **ordinary object [[Get]]** internal method (8.12.3) on *args* passing *P* and *args* as the arguments.
 - b. If *P* is "**caller**" and *v* is a strict mode Function object, throw a **TypeError** exception.
 - c. Return *v*.
5. Else, *map* contains a formal parameter mapping for *P*.
 - a. Return the result of calling **Get(*map*, *P*)**.

The **[[GetOwnProperty]]** internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name *P* performs the following steps:

1. Let *desc* be the result of calling the default **[[GetOwnProperty]]** internal method (8.12.1) on the arguments object passing *P* as the argument.
2. If *desc* is **undefined** then return *desc*.
3. Let *map* be the value of the **[[ParameterMap]]** internal *data* property of the arguments object.
4. Let *isMapped* be the result of calling the **[[GetOwnProperty]]** internal method of *map* passing *P* as the argument.
5. If the value of *isMapped* is not **undefined**, then
 - a. Set *desc.[[Value]]* to the result of calling **Get(*map*, *P*)**.
6. Return *desc*.

The **[[DefineOwnProperty]]** internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name *P* and Property Descriptor *Desc* performs the following steps:

1. Let *map* be the value of the **[[ParameterMap]]** internal *data* property of the arguments object.
2. Let *isMapped* be the result of calling the **[[GetOwnProperty]]** internal method of *map* passing *P* as the argument.
3. Let *allowed* be the result of calling the default **[[DefineOwnProperty]]** internal method (8.3.9) on the arguments object passing *P* and *Desc* as the arguments.
4. **ReturnIfAbrupt(*allowed*)**.
5. If *allowed* is **false**, then return **false**.
6. If the value of *isMapped* is not **undefined**, then
 - a. If **IsAccessorDescriptor(*Desc*)** is **true**, then
 - i. Call the **[[Delete]]** internal method of *map* passing *P* as the argument.
 - b. Else
 - i. If *Desc.[[Value]]* is present, then
 1. **Assert: the follow Put call will always succeed because formal parameters mapped by argument objects are always writable.**
 2. Call **Put(*map*, *P*, *Desc.[[Value]]*, **false**)**.
 - ii. If *Desc.[[Writable]]* is present and its value is **false**, then
 1. Call the **[[Delete]]** internal method of *map* passing *P* as the argument.
7. Return **true**.

The **[[Delete]]** internal method of an arguments object for a non-strict mode function with formal parameters when called with a property key *P* performs the following steps:

1. Let *map* be the value of the **[[ParameterMap]]** internal *data* property of the arguments object.
2. Let *isMapped* be the result of calling the **[[GetOwnProperty]]** internal method of *map* passing *P* as the argument.

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Deleted: a List containing the single String
Deleted: *param*

Comment [AWB1267]: TODO: keep reference up to date
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Deleted:]] internal method of
Deleted: passing
Deleted: as the argument
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Deleted:, and Boolean flag *Throw*
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Deleted:, and **false**
Deleted: ¶
Deleted: ¶
Deleted: If *Throw* is true then throw a **TypeError** exception, otherwise
Deleted:, and **false**
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Deleted:
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Deleted: and *Throw*
Deleted: as the arguments
Deleted: and **false**
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Deleted: name
Deleted: and Boolean flag *Throw*

3. Let *result* be the result of calling the default [[Delete]] internal method for ordinary objects (8.3.10) on the arguments object passing *P* as the argument.
 4. If *result* is **true** and the value of *isMapped* is not **undefined**, then
 - a. Call the [[Delete]] internal method of *map* passing *P* as the argument.
 5. Return *result*.

NOTE 1 For non-strict mode functions the array index (defined in 15.4) data properties of an arguments object whose numeric name values are less than the number of formal parameters of the corresponding function object initially share their values with the corresponding argument bindings in the function's execution context. This means that changing the property changes the corresponding value of the argument binding and vice-versa. This correspondence is broken if such a property is deleted and then redefined or if the property is changed into an accessor property. For strict mode functions, the values of the arguments object's properties are simply a copy of the arguments passed to the function and there is no dynamic linkage between the property values and the formal parameter values.

NOTE 2 The ParameterMap object and its property values are used as a device for specifying the arguments object correspondence to argument bindings. The ParameterMap object and the objects that are the values of its properties are not directly accessible from ECMAScript code. An ECMAScript implementation does not need to actually create or use such objects to implement the specified semantics.

NOTE 3 Arguments objects for strict mode functions define non-configurable accessor properties named "`caller`" and "`callee`" which throw a `TypeError` exception on access. The "`callee`" property has a more specific meaning for non-strict mode functions and a "`caller`" property has historically been provided as an implementation-defined extension by some ECMAScript implementations. The strict mode definition of these properties exists to ensure that neither of them is defined in any other manner by conforming ECMAScript implementations.

11 Expressions

11.1 Primary Expressions

Syntax

PrimaryExpression :
 this
 Identifier
 Literal
 ArrayInitialiser
 ObjectLiteral
 FunctionExpression
 ClassExpression
 GeneratorExpression
 GeneratorComprehension
 RegularExpressionLiteral
 TemplateLiteral
 CoverParenthesisedExpressionAndArrowParameterList

CoverParenthesisedExpressionAndArrowParameterList :

(Expression)
()
(... Identifier)
(Expression , ... Identifier)

Supplemental Syntax

When processing the production *PrimaryExpression* : *CoverParenthesisedExpressionAndArrowParameterList* the following grammar is used to refine the interpretation of *CoverParenthesisedExpressionAndArrowParameterList*.

ParenthesisedExpression :

Static Semantics

Static Semantics: Covered Parenthesised Expression

- Deleted:** 12
- Deleted:** 7
- Deleted:** and *Throw*
- Deleted:** s
- Deleted:** , and false
- Deleted:** s
- Deleted:** named

Deleted: *ArrayLiteral*

Deleted: *[Lexical goal InputElementRegExp]*

Deleted: *Quasi*

Deleted: *z*

Deleted: *(Expression)*

Deleted: *z*

Deleted: *z*

Deleted: *z*

Deleted: *z*

Deleted: *FormalParameterList*

Deleted: **Static Semantics: Early Errors**

PrimaryExpression :
CoverParenthesizedExpressionAndArrowParamList ¶

<#> It is a Syntax Error if the lexical token sequence matched by
CoverParenthesizedExpressionAndArrowParamList cannot be parsed with no tokens left over using *ParenthesizedExpression* as the goal symbol.

<#> All Early Errors rules for *ParenthesizedExpression* and its derived productions also apply to the *CoveredParenthesizedExpression* of *CoverParenthesizedExpressionAndArrowParamList*. ¶

¶

Deleted: *z*

CoverParenthesisedExpressionAndArrowParameterList : (Expression)

1. Return the result of parsing the lexical token stream matched by CoverParenthesisedExpressionAndArrowParameterList using ParenthesisedExpression as the goal symbol.

Static Semantics: IsValidSimpleAssignmentTarget

PrimaryExpression :

this
Literal
ArrayInitialiser
ObjectLiteral
FunctionExpression
ClassExpression
GeneratorExpression
GeneratorComprehension
RegularExpressionLiteral
TemplateLiteral

1. Return **false**.

PrimaryExpression : Identifier

1. If this PrimaryExpression is contained in strict code and StringValue of Identifier is "**eval**" or "**arguments**", then return **false**.
2. Return **true**.

PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList

1. Let expr be CoveredParenthesisedExpression of CoverParenthesisedExpressionAndArrowParameterList.
2. Return IsValidSimpleAssignmentTarget of expr.

11.1.1 The this Keyword

Runtime Semantics: Evaluation

PrimaryExpression : this

1. Return the result of calling the ThisResolution abstract operation.

11.1.2 Identifier Reference

Runtime Semantics: Evaluation

PrimaryExpression : Identifier

1. Let ref be the result of performing Identifier Resolution as specified in 10.4.1 using the IdentifierName corresponding to Identifier.
2. Return ref.

NOTE: The result of evaluating an Identifier is always a value of type Reference.

11.1.3 Literals

Syntax

Literal :

NullLiteral
ValueLiteral

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Deleted: z

Deleted: <#>Let env be the result of performing the GetThisEnvironment abstract operation.¶

Deleted: GetThisBinding

Deleted: concrete method of env

Deleted: The this keyword evaluates to Return the value of the ThisBinding of the current execution context.¶

Comment [AWB868]: It may make sense to define some of the static semantic rules related static name resolution

Deleted: 3

Deleted: An Identifier is evaluated by performing Identifier Resolution as specified in 10.3.1 using the IdentifierName corresponding to Identifier.

Deleted: Reference

ValueLiteral :

BooleanLiteral
NumericLiteral
StringLiteral

Deleted:
RegularExpressionLiteral

Runtime Semantics

Runtime Semantics: Evaluation

Literal : NullLiteral

1. Return **null**.

ValueLiteral : BooleanLiteral

1. Return **false** if *BooleanLiteral* is the token *BooleanLiteral :: false*
2. Return **true** if *BooleanLiteral* is the token *BooleanLiteral :: true*

ValueLiteral : NumericLiteral

1. Return the number whose value is MV of *NumericLiteral* as defined in 7.8.3.

ValueLiteral : StringLiteral

1. Return the string whose elements are the SV of *StringLiteral* as defined in 7.8.4.

Deleted: character

Deleted: A *Literal* is evaluated as described 7.8.

11.1.4 Array Initialiser

Syntax

ArrayInitialiser :
ArrayLiteral
ArrayComprehension

Deleted: *SealedArrayInitialiser* :
ArrayInitialiser :
ArrayInitialiser

11.1.4.1 Array Literal

NOTE An *ArrayLiteral* is an expression describing the initialisation of an *Array* object, using 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*.

Deleted: *array initialiser*

Deleted: written in a form of a literal. It is

Deleted: ,

Syntax

ArrayLiteral :
 [*Elision_{opt}*]
 [*ElementList*]
 [*ElementList* , *Elision_{opt}*]

ElementList :
Elision_{opt} *AssignmentExpression*
Elision_{opt} *SpreadElement*
ElementList , *Elision_{opt}* *AssignmentExpression*
ElementList , *Elision_{opt}* *SpreadElement*

Deleted: ... *AssignmentExpression*

Deleted: ... *AssignmentExpression*

Elision :

' Elision ,

SpreadElement :

... AssignmentExpression

Static Semantics

Static Semantics: Elision Width

Elision :

1. Return the numeric value 1.

Elision : Elision ,

1. Let *preceding* be the Elision Width of *Elision*.
2. Return *preceding*+1.

Runtime Semantics

Runtime Semantics: Array Accumulation

With parameters *array* and *nextIndex*.

ElementList : Elision_{opt} AssignmentExpression

1. Let *padding* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Let *initResult* be the result of evaluating *AssignmentExpression*.
3. Let *initValue* be *GetValue(initResult)*.
4. ReturnIfAbrupt(*initValue*).
5. Call the *[[DefineOwnProperty]]* internal method of *array* with arguments *ToString(ToInt32(nextIndex+padding))* and the Property Descriptor { *[[Value]]*: *initValue*, *[[Writable]]*: *true*, *[[Enumerable]]*: *true*, *[[Configurable]]*: *true* }.
6. Assert: the above call to *[[DefineOwnProperty]]* will never return **false** or an abrupt completion value.
7. Return *nextIndex+padding*+1.

ElementList : Elision_{opt} SpreadElement

1. Let *padding* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Return the result of performing Array Accumulation for *SpreadElement* with arguments *array* and *nextIndex+padding*.

ElementList : ElementList , Elision_{opt} AssignmentExpression

1. Let *postIndex* be the result of performing Array Accumulation for *ElementList* with arguments *array* and *nextIndex*.
2. ReturnIfAbrupt(*postIndex*).
3. Let *padding* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
4. Let *initResult* be the result of evaluating *AssignmentExpression*.
5. Let *initValue* be *GetValue(initResult)*.
6. ReturnIfAbrupt(*initValue*).
7. Call the *[[DefineOwnProperty]]* internal method of *array* with arguments *ToString(ToInt32(postIndex+padding))* and the Property Descriptor { *[[Value]]*: *initValue*, *[[Writable]]*: *true*, *[[Enumerable]]*: *true*, *[[Configurable]]*: *true* }.
8. Assert: the above call to *[[DefineOwnProperty]]* will never return **false** or an abrupt completion value.
9. Return *postIndex+padding*+1.

ElementList : ElementList , Elision_{opt} SpreadElement

Deleted: ...

Deleted: *ArrayComprehension : Expression ComprehensionForList Expression ComprehensionForList if (Expression) ComprehensionForList : ComprehensionFor ComprehensionForList ComprehensionForComprehensionFor : for (LeftHandSideExpression of Expression)*

Deleted: 11.1.4.1

Deleted: **Static Semantics: Early Errors**

Early Errors
The static semantics of the production *SpreadElementElementList : Elision_{opt} AssignmentExpression* are:
<#> It is a Syntax Error if the source code parsed with this production is not extended code.

Deleted: *ElementList : ElementList , Elision_{opt} ... AssignmentExpression*

<#> It is a Syntax Error if the source code parsed with this production is not extended code.

Deleted: *Elision : [empty]*

<#> Return the numeric value 0.

Deleted: 11.1.4.2

Deleted: *opt*

Deleted: If *initValue* is an abrupt completion, return *initValue*.

Deleted: ,

Deleted: , and false

Deleted: *opt*

Deleted: If *postIndex* is an abrupt completion, return *postIndex*

Deleted: *opt*

Deleted: If *initValue* is an abrupt completion, return *initValue*

Deleted: (

Deleted: , and false

1. Let *postIndex* be the result of performing Array Accumulation for *ElementList* with arguments *array* and *nextIndex*.
2. ReturnIfAbrupt(*postIndex*).
3. Let *padding* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
4. Return the result of performing Array Accumulation for *SpreadElement* with arguments *array* and *postIndex+padding*.

SpreadElement : ... AssignmentExpression

1. Let *spreadRef* be the result of evaluating *AssignmentExpression*.
2. Let *spreadValue* be *GetValue(spreadRef)*.
3. Let *spreadObj* be *ToObject(spreadValue)*.
4. ReturnIfAbrupt(*spreadObj*).
5. Let *lenVal* be the result of calling *Get(spreadObj, "length")*.
6. Let *spreadLen* be *ToUint32(lenVal)*.
7. ReturnIfAbrupt(*spreadLen*).
8. Let *n=0*:
9. Repeat, while *n < spreadLen*
 - a. Let *exists* be the result of *HasProperty(spreadObj, ToString(n))*.
 - b. ReturnIfAbrupt(*exists*).
 - c. If *exists* is true then,
 - i. Let *v* be the result of calling the *[[Get]]* internal method of *spreadObj* passing *ToString(n)* as the argument.
 - ii. ReturnIfAbrupt(*v*).
 - iii. Call the *[[DefineOwnProperty]]* internal method of *array* with arguments *ToString(ToUint32(nextIndex))* and Property Descriptor *{[[Value]]: v, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}*.
 - iv. Assert: the above call to *[[DefineOwnProperty]]* will never return *false* or an abrupt completion value.
 - d. Let *n = n+1*.
 - e. Let *nextIndex = nextIndex + 1*.
10. Return *nextIndex*.

NOTE *[[DefineOwnProperty]]* is used to ensure that own properties are defined for the array even if the standard built-in Array prototype object has been modified in a manner that would preclude the creation of new own properties using *[[Set]]*.

Runtime Semantics: Evaluation

ArrayLiteral : [Elision_{opt}]

1. Let *array* be the result of the abstract operation *ArrayCreate* with argument 0.
2. Let *pad* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
3. Call *Put(array, "length", pad, false)*.
4. Return *array*.

ArrayLiteral : [ElementList]

1. Let *array* be the result of the abstract operation *ArrayCreate* with argument 0.
2. Let *len* be the result of performing Array Accumulation for *ElementList* with arguments *array* and 0.
3. ReturnIfAbrupt(*len*).
4. Call *Put(array, "length", len, false)*.
5. Return *array*.

ArrayLiteral : [ElementList , Elision_{opt}]

1. Let *array* be the result of the abstract operation *ArrayCreate* with argument 0.
2. Let *len* be the result of performing Array Accumulation for *ElementList* with arguments *array* and 0.
3. ReturnIfAbrupt(*len*).

Deleted: If *postIndex* is an abrupt completion, return *postIndex*

Deleted: Let *pad* be the result of evaluating *Elision_{opt}*; if not present, use the numeric value zero.

Deleted: ...

Comment [AW69]: Note that the value the spread operator is applied to is coerced to an Object.

Deleted: If *spreadObj* is an abrupt completion, return *spreadObj*

Deleted: the *[[...et()]]* internal method of

Deleted: calling the *[[HasProperty]]* internal method of *...spreadObj* with

Comment [AW70]: Note that indices wrap. For example consider:

[..., ..., { 4294967293: "x", length: Math.pow(2,32)-2}]

Deleted: ...and Property Descriptor *{[[Value]]*

Deleted: Put

Deleted: P

Deleted: The production *...rrayLiteral :*

Deleted: ion

Deleted: (15.4)

Deleted: the result of creating a new object as if the expression *new Array()* where *Array* the standard built-in constructor with that name

Deleted: result of evaluating

Deleted: opt

Deleted: ; if not present, use the numeric value zero

Deleted: the *[[...ut]]* internal method of *...rray*

Deleted: The production *...rrayLiteral :*

Deleted: ion

Deleted: (15.4)

Deleted: the result of creating a new object as if the expression *new Array()* where *Array* the standard built-in constructor with that name

Deleted: Return the *...t* and *len* be the result of

Deleted: If *len* is an abrupt completion, return *len*

Deleted: the *[[...ut]]* internal method of *...rray*

Deleted: The production *...rrayLiteral :*

Deleted: ion

Deleted: (15.4)

Deleted: the result of creating a new object as if the expression *new Array()* where *Array* the standard built-in constructor with that name

Deleted: <#>Let *array* be the result of evaluating *ElementList*.

Deleted: If *len* is an abrupt completion, return *len*

4. Let `padding` be the Elision Width of `Elision`; if `Elision` is not present, use the numeric value zero.
5. Call `PutArray["length", ToUint32(padding+len), false]`.
6. Return `array`.

11.1.4.2 Array Comprehension

Syntax

ArrayComprehension :

[Comprehension]

Comprehension :

ComprehensionFor ComprehensionQualifierTail

ComprehensionQualifierTail :

AssignmentExpression
 ComprehensionQualifier ComprehensionQualifierTail

ComprehensionQualifier :

ComprehensionFor
 ComprehensionIf

ComprehensionFor :

for (ForBinding of AssignmentExpression)

ComprehensionIf :

if (AssignmentExpression)

ForBinding :

BindingIdentifier
 BindingPattern

Static Semantics

Static Semantics: Early Errors

ComprehensionFor : for (ForBinding of AssignmentExpression)

- It is a Syntax Error if the BoundNames of `ForBinding` contains any duplicate entries.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments `value` and `environment`.

NOTE `undefined` is passed for `environment` to indicate that a `PutValue` operation should be used to assign the initialisation value. This is the case for `var` statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initializer.

ForBinding : BindingPattern

1. Let `obj` be `ToObject(value)`.
2. ReturnIfAbrupt(`obj`).
3. Return the result of performing Binding Initialisation for `BindingPattern` passing `obj` and `environment` as the arguments.

Runtime Semantics: ComprehensionEvaluation

With argument `accumulator`.

Deleted: Let `pad` be the Elision Width of result of evaluating `Elisionopt`; if not present, use the numeric value zero.

Deleted: <#>Let `len` be the result of calling the [[Get]] internal method of `array` with argument "`length`".

Deleted: the [[]] internal method of

Deleted:

Deleted: with arguments

Deleted: and

Deleted: [AssignmentExpression ComprehensionForList]

Deleted: Assignment Expression

Deleted: ComprehensionForList if (Expression)

Deleted:)

Deleted:

Deleted: Comprehension :|| ComprehensionQualification AssignmentExpression|| ComprehensionQualification :|| ComprehensionFor ComprehensionQualifierList_{opt}||

Deleted: ComprehensionForQualifierList :|| ComprehensionForQualifier .

Deleted: ComprehensionForQualifierList ComprehensionForQualifier

Deleted: (

Deleted: LeftHandSideExpression

Deleted: Expression

Deleted:)

NOTE **undefined** is passed for accumulator to indicate that a comprehension component is being evaluated as part of a generator comprehension. Otherwise, the value of accumulator is the array object into the elements of an array comprehension are to be accumulated.

Comprehension : ComprehensionFor ComprehensionQualifierTail

1. Return the result of performing QualifierEvaluation for ComprehensionFor with arguments ComprehensionQualifierTail and accumulator.

ComprehensionQualifierTail: ComprehensionQualifier ComprehensionQualifierTail

1. Return the result of performing QualifierEvaluation for ComprehensionQualifier with arguments ComprehensionQualifierTail and accumulator.

ComprehensionQualifierTail: AssignmentExpression

1. Let valueRef be the result of evaluating AssignmentExpression.
2. Let value be GetValue(valueRef).
3. ReturnIfAbrupt(value).
4. If accumulator is not undefined, then
 - a. Assert: this is part of an array comprehension.
 - b. Assert: accumulator is an exotic array object so access to its length property should never fail.
 - c. Let len be the result of Get(accumulator, "length").
 - d. If len> 2^{32} -1, then throw a RangeError exception.
 - e. Let putStatus be the result of Put(O, ToString(len), value, true).
 - f. ReturnIfAbrupt(putStatus).
 - g. Increase len by 1.
 - h. Let putStatus be the result of Put(O, "length", len, true).
 - i. ReturnIfAbrupt(putStatus).
 - j. Return NormalCompletion(undefined).
5. Assert: accumulator is undefined, so this is part of a generator comprehension.
6. Let yieldStatus be the result of GeneratorYield(CreateItrResultObject(value, false)).
7. ReturnIfAbrupt(yieldStatus).
8. Return NormalCompletion(undefined).

Runtime Semantics: QualifierEvaluation

With arguments tail and accumulator.

NOTE **undefined** is passed for accumulator to indicate that a comprehension component is being evaluated as part of a generator comprehension. Otherwise, the value of accumulator is the array object into the elements of an array comprehension are to be accumulated.

ComprehensionFor : for (ForBinding of AssignmentExpression)

1. Let exprRef be the result of evaluating AssignmentExpression.
2. Let exprValue be GetValue(exprRef).
3. Let obj be ToObject(exprValue).
4. ReturnIfAbrupt(obj).
5. Let iterator be the result of performing Invoke with arguments obj @@iterator, and an empty List.
6. Let keys be ToObject(iterator).
7. ReturnIfAbrupt(keys).
8. Let oldEnv be the running execution context's LexicalEnvironment.
9. Let noArgs be an empty List.
10. Repeat
 - a. Let nextResult be the result of Invoke(keys, "next").
 - b. ReturnIfAbrupt(nextResult).
 - c. If Type(nextResult) is not Object, then throw a TypeError exception.
 - d. Let done be IteratorComplete(nextResult).

- e. ReturnIfAbrupt(done).
- f. If done is **true**, then return **true**.
- g. Let nextValue be IteratorValue(nextResult).
- h. ReturnIfAbrupt(nextValue).
- i. Let forEnv be the result of calling NewDeclarativeEnvironment passing oldEnv as the argument.
- j. For each element name of the BoundNames of ForBinding do
 - i. Call forEnv's CreateMutableBinding concrete method with argument name.
- k. Let status be the result of performing Binding Initialisation for ForBinding passing value and environment as the arguments.
- l. ReturnIfAbrupt(status).
- m. Set the running execution context's LexicalEnvironment to forEnv.
- n. Let continue the result of performing ComprehensionEvaluation for tail with argument accumulator.
- o. Set the running execution context's LexicalEnvironment to oldEnv.
- p. ReturnIfAbrupt(continue).

ComprehensionFor : if (AssignmentExpression)

- 1. Let valueRef be the result of evaluating AssignmentExpression.
- 2. Let value be GetValue(valueRef).
- 3. Let boolValue be ToBoolean(value).
- 4. ReturnIfAbrupt(boolValue).
- 5. If exprValue is **true**, then
 - a. Return the result of performing ComprehensionEvaluation for tail with argument accumulator.
- 6. Else,
 - a. Return NormalCompletion(undefined).

Runtime Semantics: Evaluation

ArrayComprehension : [Comprehension]

- 1. Let array be the result of the abstract operation ArrayCreate with argument **0**.
- 2. Let status be the result of performing ComprehensionEvaluation for Comprehension with argument array.
- 3. ReturnIfAbrupt(status).
- 4. Return array.

11.1.5 Object Initialiser

NOTE 1 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 :
 { }
 { PropertyDefinitionList }
 { PropertyDefinitionList , }

PropertyDefinitionList :
PropertyDefinition
PropertyDefinitionList , PropertyDefinition

PropertyDefinition :
IdentifierName
CoverInitialisedName
PropertyName : AssignmentExpression
MethodDefinition

Deleted: **Runtime Semantics: Binding Initialisation**
 With arguments value and environment.
 NOTE **undefined** is passed for environment to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for **var** statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior evaluation of its initialiser.
ForBinding : BindingIdentifier
 <#> Perform Binding Initialisation for BindingIdentifier passing value and env as the arguments.
ForBinding: BindingPattern
 <#> Perform Binding Initialisation for BindingPattern passing value and env as the arguments.

Deleted: **ArrayComprehensionLiteral : [ElementList]**
 Let array be the result of the abstraction operation ArrayCreate (15.4) with argument **0**.
 Let len be result of performing Array Accumulation for ElementList with arguments array and **0**.
ReturnIfAbrupt(len) If len is an abrupt completion, return len.
 Call the [[Put]] internal method of array with arguments "length", len, and **false**.
Return array.

Deleted: The production ElementList : Elision_{opt} AssignmentExpression is evaluated as follows:
 Let array be the result of creating a new object as is by the expression new Array() where Array is the standard built-in constructor with that name.
 Let firstIndex be the result of evaluating Elision; if present, use the numeric value zero.
 Let initResult be the result of evaluating AssignmentExpression.
 Let initValue be GetValue(initResult).
 Call the [[DefineOwnProperty]] internal method of array with arguments ToString(firstIndex), the Property Descriptor { [[Value]]: initValue, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true** }, and **false**.
Return array.
 The production ElementList : Elision_{opt} ... AssignmentExpression is evaluated as follows:
 Let array be the result of creating a new object as is by the expression new Array() where Array is the standard built-in constructor with that name.
 Let index be the result of evaluating Elision; if not present, use the numeric value zero.
 Let spreadRef be the result of evaluating AssignmentExpression.
 Let spreadValue be GetValue(spreadRef).
 Let spreadObj be ToObject(spreadValue).
 Let lenVal be the result of calling the [[Get]] internal method of spreadObj with argument "length".
 Let spreadLen be ToUint32(lenVal).
 Let n=0;
 Repeat, while n < spreadLen
 Let exists be the result of calling the [[HasProperty]] internal method of spreadObj with ToString(n).
 If exists is true then,

Deleted: PropertyNameAndValueList
Deleted: PropertyNameAndValueList
Deleted: PropertyNameAndValueList
Deleted: PropertyNameAssignment
Deleted: PropertyNameAndValueList
Deleted: PropertyNameAssignment
Deleted: PropertyNameAssignment

PropertyName :
 IdentifierName
 StringLiteral
 NumericLiteral

CoverInitialisedName :
IdentifierName Initialiser

Initialiser :
= AssignmentExpression

NOTE 2 MethodDefinition is defined in 13.3.

NOTE 3 In certain contexts, ObjectLiteral is used as a cover grammar for a more restricted secondary grammar. The CoverInitialisedName production is necessary to fully cover these secondary grammars. However, use of this production results in an early Syntax Error in normal contexts where an actual ObjectLiteral is expected.

Static Semantics

Static Semantics: Early Errors

In addition to describing an actual object initialiser the ObjectLiteral productions are also used as a cover grammar for ObjectAssignmentPattern (11.13.1). When ObjectLiteral appears in a context where ObjectAssignmentPattern is required, the following Early Error rules are **not** applied.

ObjectLiteral : { PropertyDefinitionList }

and

ObjectLiteral : { PropertyDefinitionList , }

- It is a Syntax Error if PropertyNameList of PropertyDefinitionList contains any duplicate entries, unless one of the following conditions are true for each duplicate entry:
 1. The source code corresponding to PropertyDefinitionList is not strict code and all occurrences in the list of the duplicated entry were obtained from productions of the form PropertyDefinition : PropertyName : AssignmentExpression.
 2. The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor MethodDefinition and the other occurrence was obtained from a set accessor MethodDefinition.

PropertyDefinition : MethodDefinition

- It is a Syntax Error if ReferencesSuper of MethodDefinition is true.

PropertyDefinition : IdentifierName

- It is a Syntax Error if IdentifierName is a ReservedWord.

PropertyDefinition : CoverInitialisedName

- Always throw a Syntax Error if this production is present

NOTE This production exists so that ObjectLiteral can serve as a cover grammar for ObjectAssignmentPattern (11.13.1). It cannot occur in an actual object initialiser.

Static Semantics: Contains

with parameter symbol.

PropertyDefinition : MethodDefinition

Deleted:
~~PropertyName (FormalParameterList { FunctionBody } * PropertyName (FormalParameterList { FunctionBody } get PropertyName () { FunctionBody } set PropertyName (PropertySetParameterList { FunctionBody }) { FunctionBody }~~

Deleted: 1

Deleted: 2

Deleted: PropertySetParameterList .¶
BindingIdentifier
BindingPattern ¶

Deleted: Identifier¶
Semantics¶

Deleted: 11.1.5.1

Deleted: e

Deleted: PropertyNameAndValueList :
PropertyNameAndValueList , PropertyAssignment

Deleted: a

Deleted: property definition

Deleted: property definition

Deleted: i

Comment [AWB871]: The currently prevailing position in TC39 is that use of super should not be allowed in object literals. This restriction is arbitrary in the sense that the runtime semantics would work.

Deleted: i

Deleted:

Deleted: <#>It is a Syntax Error if this production is contained in strict code, PropertyAssignment is the production PropertyAssignment : PropertyName : AssignmentExpression, and PropertyDefinitionList(PropertyName of PropertyAssignment) of PropertyNameAndValueList is not the empty List.¶

<#>It is a Syntax Error if PropertyAssignment the production PropertyAssignment : IdentifierName and PropertyDefinitionList(PropertyName of PropertyAssignment) of PropertyNameAndValueList is not the empty List.¶

<#>It is a Syntax Error if PropertyAssignment the production PropertyAssignment : PropertyName (FormalParameterList { FunctionBody }) and PropertyDefinitionList(PropertyName of PropertyAssignment) of PropertyNameAndValueList is not the empty List.¶

<#>It is a Syntax Error if PropertyAssignment the production PropertyAssignment : * PropertyName (FormalParameterList { FunctionBody }) and PropertyDefinitionList(PropertyName of PropertyAssignment) of PropertyNameAndValueList is not the empty List.¶

<#>It is a Syntax Error if PropertyAssignment the production .

Deleted: W

Deleted: PropertyDefinition : MethodDefinition

1. If *symbol* is MethodDefinition, return true.
2. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

PropertyName : IdentifierName

1. If *symbol* is a ReservedWord, return false.
2. If *symbol* is an Identifier and StringValue of *symbol* is the same value as the StringValue of *IdentifierName*, return true;
3. Return false.

Static Semantics: IsValidSimpleAssignmentTarget

PrimaryExpression : Literal

1. Return false.

Static Semantics: PropName

PropertyDefinition : IdentifierName

1. Return StringValue of *IdentifierName*.

PropertyDefinition : PropertyName : AssignmentExpression

1. Return PropName of *PropertyName*.

PropertyName : StringLiteral

1. Return a String value whose characters are the SV of the *StringLiteral*.

PropertyName : NumericLiteral

1. Let *nbr* be the result of forming the value of the *NumericLiteral*.
2. Return *ToString(nbr)*.

Static Semantics: PropertyNameList

PropertyDefinitionList : PropertyDefinition

1. Return a new List containing PropName of *PropertyDefinition*.

PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition

1. Let *list* be PropertyNameList of *PropertyDefinitionList*.
2. Append PropName of *PropertyDefinition* to the end of *list*.
3. Return *list*.

Runtime Semantics

Runtime Semantics: Evaluation

ObjectLiteral : { } .

1. Return a new object created as if by the expression **new Object()** where **Object** is the standard built-in constructor with that name.

Deleted:

Deleted:

Deleted: NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

Deleted: Static Semantics: ExpectedArgumentCount

PropertySetParameterList : BindingIdentifier ¶

<#>Return 1.¶

PropertySetParameterList : BindingPattern ¶

<#>Return 1.¶

Static Semantics: HasInitialiser

PropertySetParameterList : BindingIdentifier ¶

<#>Return false.¶

PropertySetParameterList : BindingPattern ¶

<#>Return false.¶

Static Semantics: PropertyDefinitionList(name)

PropertyNameAndValueList : *PropertyAssignment* :

PropertyName : AssignmentExpression ¶

<#>If PropName of *PropertyAssignment* is not name return the empty List.¶

<#>Return a List containing *PropertyAssignment*.¶

PropertyNameAndValueList : *PropertyNameAndValueList* ¶

PropertyAssignment ¶

<#>Let previous be *PropertyDefinitionList(name)* of *PropertyNameAndValueList*.¶

<#>If PropName of *PropertyAssignment* is name then,¶

<#>Append *PropertyAssignment* to the end of previous.¶

<#>Return previous.¶

Deleted: *PropertyAssignment*

Deleted:

Deleted: *PropertyAssignment*

Deleted: *PropertyDefinition* : MethodDefinition ¶

<#>Return PropName of *MethodDefinition*.¶

Deleted: *PropertyAssignment* : *PropertyName* (*FormalParameterList*) { *FunctionBody* } ¶

<#>Return PropName of *PropertyName*.¶

PropertyAssignment : * *PropertyName* (*FormalParameterList*) { *FunctionBody* } ¶

<#>Return PropName of *PropertyName*.¶

PropertyAssignment : **get** *PropertyName* () { *FunctionBody* } ¶

<#>Return PropName of *PropertyName(PropertyName)*.¶

PropertyAssignment : **set** *PropertyName* (*PropertySetParameterList*) { *FunctionBody* } ¶

<#>Return PropName of *PropertyName(PropertyName)*.¶

Deleted: *PropertyName* : IdentifierName ¶

<#>Return PropName(of *IdentifierName*).¶

Deleted: the

Deleted: s

Comment [AWB1072]: Issue: static semantic rules probably should call *ToString* (a runtime operation).

Deleted: 11.1.5.2

Deleted: The production

Deleted: is evaluated as follows:

ObjectLiteral :

```
{ PropertyDefinitionList }
{ PropertyDefinitionList , }
```

1. Let *obj* be the result of the abstract operation *ObjectCreate* with the intrinsic object %ObjectPrototype% as its argument.
2. Let *status* be the result of performing *Property Definition Evaluation* of *PropertyDefinitionList* with argument *obj*.
3. ReturnIfAbrupt(*status*).
4. Return *obj*.

Runtime Semantics: Property Definition Evaluation

With parameter *object* and optional parameter *functionPrototype*.

PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition

1. Let *status* be the result of performing *Property Definition Evaluation* of *PropertyDefinitionList* with argument *object*.
2. ReturnIfAbrupt(*status*).
3. Return the result of performing *Property Definition Evaluation* of *PropertyDefinition* with argument *object*.

PropertyDefinition : IdentifierName

1. Let *propName* be *StringValue* of *IdentifierName*.
2. Let *exprValue* be the result of performing *Identifier Resolution* as specified in 10.3.1 using *IdentifierName*.
3. Let *propValue* be *GetValue*(*exprValue*).
4. ReturnIfAbrupt(*propValue*).
5. Let *desc* be the *Property Descriptor* {[[Value]]: *propValue*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}
6. Return the result of *DefinePropertyOrThrow*(*object*, *propName*, *desc*).

PropertyDefinition : PropertyName : AssignmentExpression

1. Let *propName* be *PropertyName* of *PropertyName*.
2. Let *exprValue* be the result of evaluating *AssignmentExpression*.
3. Let *propValue* be *GetValue*(*exprValue*).
4. ReturnIfAbrupt(*propValue*).
5. Let *desc* be the *Property Descriptor* {[[Value]]: *propValue*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}
6. Return the result of *DefinePropertyOrThrow*(*object*, *propName*, *desc*).

11.1.6 Function Defining Expressions

See 13.1 for *PrimaryExpression : FunctionExpression*.

See 13.4 for *PrimaryExpression : GeneratorExpression*.

See 13.5 for *PrimaryExpression : ClassExpression*.

11.1.7 Generator Comprehensions

Syntax

GeneratorComprehension :

```
( Comprehension )
```

Static Semantics

Static Semantics: Early Errors

Deleted: <i>PropertyNameAndValueList...roperty</i>
Deleted: <i>ObjectLiteral</i> :
Deleted: <i>ion</i>
Deleted: (15.2)
Deleted: creating a new object as if by the
Deleted: <i>P</i>
Deleted: <i>success</i>
Deleted: <i>D</i>
Deleted: <i>PropertyNameAndValueList</i>
Deleted: If <i>successstatus</i> is an abrupt completion
Deleted: the result of evaluating
Deleted: .
Deleted: The production
Deleted: The production
Deleted: <i>PropertyNameAndValueList...roperty</i>
Deleted: .
Deleted: <#>Let <i>obj</i> be the result of evaluating
Deleted: <#>Let <i>previous</i> be the result of calling
Deleted: <i>success</i>
Deleted: <i>P...forming Property Definition</i>
Deleted: <i>PropertyNameAndValueList</i>
Deleted: Call the [[DefineOwnProperty]] internal
Deleted: If <i>successstatus</i> is an abrupt completion
Deleted: <i>P...forming Property Definition</i>
Deleted: <i>PropertyAssignment</i>
Deleted: Return <i>obj</i> .
Deleted: 1
Deleted: The production
Deleted: <i>PropertyAssignment</i>
Deleted: is evaluated as follows:
Deleted: <i>PropName</i>
Deleted:)
Deleted: as the <i>Identifier</i>
Deleted: If <i>propValue</i> is an abrupt completion,
Deleted: Call
Deleted: calling the
Deleted: ,
Deleted: and
Deleted: , and false.
Deleted: <#>Return <i>Property Identifier</i>
Deleted: The production
Deleted: <i>PropertyAssignment</i>
Deleted: is evaluated as follows:
Deleted: the result of evaluating
Deleted: (...of <i>PropertyName</i>)
Deleted: If <i>propValue</i> is an abrupt completion,
Deleted: calling Call the [[...efineOwn...roperty]
Deleted: ,
Deleted: and
Deleted: , and false
Deleted: Return <i>Property Identifier</i> (<i>propName</i> ,
Comment [AWB673]: Need a actual
Deleted: <i>PropertyDefinition : MethodDefinition</i>
Deleted: <i>PropertyAssignment : PropertyName</i>
Deleted: Runtime Semantics: Evaluation

GeneratorComprehension : (Comprehension)

- It is a Syntax Error if *Comprehension* Contains *YieldExpression* is **true**.

Runtime Semantics

Runtime Semantics: Evaluation

GeneratorComprehension : (Comprehension)

1. If *GeneratorComprehension* is contained in strict mode code, then let *strict* be **true**; otherwise let *strict* be **false**.
2. Let *scope* be the LexicalEnvironment of the running execution context.
3. Let *parameters* be the production: *FormalParameters* : [empty].
4. Using *Comprehension* from the production that is being evaluated, let *body* be the supplemental syntactic grammar production: *GeneratorBody* : *Comprehension*.
5. Let *closure* be the result of performing the GeneratorFunctionCreate abstract operation with arguments *Arrow*, *parameters*, *body*, *scope*, and *strict*.
6. Let *prototype* be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
7. Perform the abstract operation MakeConstructor with arguments *closure*, **true**, and *prototype*.
8. Let *iterator* be the result of calling the [[Call]] internal method of *closure* with **undefined** as *thisArgument* and a empty List as *argumentsList*.
9. Return *iterator*.

NOTE The GeneratorFunction object created in step 5 is not observable from ECMAScript code so an implementation may choose to avoid its allocation and initialization. In that case use other semantically equivalent means must be used to allocate and initialize the *iterator* object in step 8. In either case, the *prototype* object created in step 6 must be created because it is potentially observable as the value of the *iterator* object's [[Prototype]] internal data property.

11.1.8 Regular Expression Literals

Syntax

See 7.8.4.

Deleted: 5

Static Semantics

Static Semantics: Early Errors

PrimaryExpression : RegularExpressionLiteral

- It is a Syntax Error if BodyText of *RegularExpressionLiteral* cannot be recognised using the goal symbol *Pattern* of the ECMAScript RegExp grammar specified in 15.10.
- It is a Syntax Error if FlagText of *RegularExpressionLiteral* contains any character other than "g", "i", "m", "u", or "y", or if it contains the same character more than once.

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Runtime Semantics

Runtime Semantics: Evaluation

PrimaryExpression : RegularExpressionLiteral

1. A regular expression literal evaluates to a value of the Object type that is an instance of the standard built-in constructor *RegExp*. 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*.

Comment [AWB874]: Should convert to a multistep algorithm and breakout a static semantic rule for the error

11.1.9 Template Literals

Syntax

TemplateLiteral :

NoSubstitutionTemplate

TemplateHead Expression [Lexical goal InputElementTemplateTail] TemplateSpans

Deleted: Quasi

Deleted: Quasi

Deleted: FullQuasi...oSubstitutionTemplate

TemplateSpans :

TemplateTail

TemplateMiddleList [Lexical goal InputElementTemplateTail] TemplateTail

Deleted: Quasi

Deleted: [Lexical goal InputElementQuasiTail]

Deleted: Quasi...templateMiddle Expression .

Static Semantics

Static Semantics: TemplateStrings

With parameter raw.

Deleted: QuasiStrings

TemplateLiteral : NoSubstitutionTemplate

Deleted: Quasi...templateLiteral : FullQuasi

1. If raw is false, then
 - a. Let string be the TV of NoSubstitutionTemplate.
2. Else
 - a. Let string be the TRV of NoSubstitutionTemplate.
3. Return a List containing the single element, string.

Deleted: QV...V of FullQuasi

Deleted:

Deleted: QRV...RV of FullQuasi

TemplateLiteral : TemplateHead Expression [Lexical goal InputElementTemplateTail] TemplateSpans

Deleted: Quasi...templateLiteral :

1. If raw is false, then
 - a. Let head be the TV of TemplateHead.
2. Else,
 - a. Let head be the TRV of TemplateHead.
3. Let tail be TemplateStrings of TemplateSpans with argument raw.
4. Return a List containing head followed by the element, in order of tail.

Deleted: QV...V of Quasi

Deleted: <#>Let tail be the QV of QuasiTail.■

Deleted: QRV...RV of Quasi

Deleted: the QRV ...f Quasi...templateTail

TemplateSpans : TemplateTail

1. If raw is false, then
 - a. Let tail be the TV of TemplateTail.
2. Else,
 - a. Let tail be the TRV of TemplateTail.
3. Return a List containing the single element, tail.

Deleted: Quasi...templateLiteral...pans :

1. Let middle be TemplateStrings of TemplateMiddleList with argument raw.
2. If raw is false, then
 - a. Let tail be the TV of TemplateTail.
3. Else,
 - a. Let tail be the TRV of TemplateTail.
4. Return a List containing the elements, in order, of middle followed by tail.

Deleted: <#>Let head be the QV of QuasiHead.

Deleted: <#>Let head be the QRV of QuasiHead.

Deleted: <#>Let middle be QuasiStrings of QuasiMiddleList with argument raw.■

Deleted: Quasi...templateMiddleList : [Lexical

TemplateMiddleList : TemplateMiddle Expression

Deleted: QV...V of Quasi

1. If raw is false, then
 - a. Let string be the TV of TemplateMiddle.

2. Else.
 - a. Let *string* be the TRV of *TemplateMiddle*.
3. Return a List containing the single element, *string*.

Deleted: QRV...RV of *Quasi*

TemplateMiddleList : *TemplateMiddleList* [Lexical goal *InputElementTemplateTail*] *TemplateMiddle Expression*

1. Let *front* be *TemplateStrings* of *TemplateMiddleList* with argument *raw*.
2. If *raw* is *false*, then
 - a. Let *last* be the TV of *TemplateMiddle*.
3. Else.
 - a. Let *last* be the TRV of *TemplateMiddle*.
4. Append *last* as the last element of the List *front*.
5. Return *front*.

Deleted: Quasi...templateMiddleList :

Deleted: QuasiStrings...templateStrings of *Quasi*

Deleted: QV...V of *Quasi*

Deleted: QRV...RV of *Quasi*

Runtime Semantics

Runtime Semantics: ArgumentListEvaluation

TemplateLiteral : *NoSubstitutionTemplate*

1. Let *siteObj* be the result of the abstract operation *GetTemplateCallSite* passing this *TemplateLiteral* production as the argument.
2. Return a List containing the one element which is *siteObj*.

Deleted: Quasi...templateLiteral : FullQuasi

Deleted: the

Deleted: ion

Deleted: Quasi...templateCallSite passing this *Quasi*

TemplateLiteral : *TemplateHead Expression* [Lexical goal *InputElementTemplateTail*] *TemplateSpans*

1. Let *siteObj* be the result of the abstract operation *GetTemplateCallSite* passing this *TemplateLiteral* production as the argument.
2. Let *firstSub* be the result of evaluating *Expression*.
3. ReturnIfAbrupt(*firstSub*).
4. Let *restSub* be SubstitutionEvaluation of *TemplateSpans*.
5. ReturnIfAbrupt(*restSub*).
6. Assert, *restSub* is a List.
7. Return a List whose first element is *siteObj*, whose second elements is *firstSub*, and whose subsequent elements are the elements of *restSub*, in order. *restSub* may contain no elements.

Deleted: QuasiLiteral : QuasiHead Expression [Lexical g InputElementQuasiTail] QuasiTail¶

<#>Let *siteObj* be the result of the abstraction operation *GetQuasiCallSite* passing this *QuasiLiteral* production as the argument.¶

<#>Let *firstSub* be the result of evaluating *Expression*. ¶

<#>ReturnIfAbrupt(*sub*).¶

<#>Return a List whose first element is *siteObj*, whose second elements *sub*. ¶

Quasi...templateLiteral : Quasi...templateHead Expression

Deleted: the

Deleted: ion

Deleted: Quasi...templateCallSite passing this *Quasi*

Deleted: Quasi...templateMiddleList

Deleted: Quasi...templateCallSite is called with a gramm

Runtime Semantics: GetTemplateCallSite Abstract Operation

The abstract operation *GetTemplateCallSite* is called with a grammar production, *templateLiteral*, as an argument. It performs the following steps:

1. If a call site object for the source code corresponding to *templateLiteral* has already been created by a previous call to this abstract operation, then return that call site object.
2. Let *cookedStrings* be *TemplateStrings* of *templateLiteral* with argument *false*.
3. Let *rawStrings* be *TemplateStrings* of *templateLiteral* with argument *true*.
4. Let *count* be the number of elements in the List *cookedStrings*.
5. Let *siteObj* be the result of the abstract operation *ArrayCreate* with argument *count*.
6. Let *rawObj* be the result of the abstract operation *ArrayCreate* with argument *count*.
7. Let *index* be 0.
8. Repeat while *index* < *count*
 - a. Let *prop* be *ToString(index)*.
 - b. Let *cookedValue* be the string value at 0-based position *index* of the List *cookedStrings*.
 - c. Call the *[[DefineOwnProperty]]* internal method of *siteObj* with arguments *prop* and *PropertyDescriptor* {*[[Value]]*: *cookedValue*, *[[Writable]]*: *false*, *[[Configurable]]*: *false*}.
 - d. Let *rawValue* be the string value at 0-based position *index* of the List *rawStrings*.
 - e. Call the *[[DefineOwnProperty]]* internal method of *rawObj* with arguments *prop* and *PropertyDescriptor* {*[[Value]]*: *rawValue*, *[[Writable]]*: *false*, *[[Configurable]]*: *false*}.
 - f. Let *index* be *index*+1.
9. Call the *[[Freeze]]* internal method of *rawObj*.

Deleted: quasi

Deleted: QuasiStrings...templateStrings of quasi

Deleted: QuasiStrings...templateStrings of quasi

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Deleted: ,

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Deleted: , and false

Deleted: Object... internal method of abstract operation v

10. Call the `[[DefineOwnProperty]]` internal method of `siteObj` with arguments `"raw"` and Property Descriptor `{[[Value]]: rawObj, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}`.
11. Call the `[[Freeze]]` internal method of `siteObj`.
12. Remember an association between the source code corresponding to `templateLiteral` and `siteObj` such that `siteObj` can be retrieved in subsequent calls to this abstract operation.
13. Return `siteObj`.

NOTE 1 The creation of a call site object cannot result in an abrupt completion.

NOTE 2 Each `TemplateLiteral` in the program code is associated with a unique `Template` call site object that is used in the evaluation of tagged `Templates` (11.2.6). The same call site object is used each time a specific tagged `Template` is evaluated. Whether call site objects are created lazily upon first evaluation of the `TemplateLiteral` or eagerly prior to first evaluation is an implementation choice that is not observable to ECMAScript code.

Runtime Semantics: SubstitutionEvaluation

`TemplateSpans` : `TemplateTail`

1. Return an empty List.

`TemplateSpans` : `TemplateMiddleList` [Lexical goal `InputElementTemplateTail`] `TemplateTail`

1. Return the result of `SubstitutionEvaluation` of `TemplateMiddleList`.

`TemplateMiddleList` : `TemplateMiddle Expression`

1. Let `sub` be the result of evaluating `Expression`.
2. ReturnIfAbrupt(`sub`).
3. Return a List containing only `sub`.

`TemplateMiddleList` : `TemplateMiddleList` [Lexical goal `InputElementTemplateTail`] `TemplateMiddle Expression`

1. Let `preceeding` be the result of `SubstitutionEvaluation` of `TemplateMiddleList`.
2. ReturnIfAbrupt(`preceeding`).
3. Let `next` be the result of evaluating `Expression`.
4. ReturnIfAbrupt(`next`).
5. Append `next` as the last element of the List `preceeding`.
6. Return `preceeding`.

Runtime Semantics: Evaluation

`TemplateLiteral` : `NoSubstitutionTemplate`

1. Return the string value whose elements are the TV of `NoSubstitutionTemplate` as defined in 7.8.5.

`TemplateLiteral` : `TemplateHead Expression` [Lexical goal `InputElementTemplateTail`] `TemplateSpans`

1. Let `head` be the TV of `TemplateHead` as defined in 7.8.5.
2. Let `sub` be the result of evaluating `Expression`.
3. Let `middle` be `ToString(sub)`.
4. ReturnIfAbrupt(`middle`).
5. Let `tail` be the result of evaluating `TemplateSpans`.
6. ReturnIfAbrupt(`tail`).
7. Return the string value whose elements are the code units of `head` followed by the code units of `tail`.

`TemplateSpans` : `TemplateTail`

1. Let `tail` be the TV of `TemplateTail` as defined in 7.8.5.
2. Return the string whose elements are the code units of `tail`.

Deleted: ,
Deleted: , and `false`
Deleted: Object
Deleted: abstract operation with argument
Deleted: `quasi`
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Deleted: `Quasi`
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Deleted: `Quasi`

Deleted: `Quasi`
Deleted: [Lexical goal `InputElementQuasiTail`]
Deleted: `Quasi`
Deleted: `middle`
Deleted: `Quasi`
Deleted: `list`
Deleted: `Quasi`
Deleted: `FullQuasi`
Deleted: `QV`
Deleted: `FullQuasi`
Deleted: `6`
Deleted: `Quasi`
Deleted: `Quasi`
Deleted: `Quasi`
Deleted: `Quasi`
Deleted: `Tail`
Deleted: `QV`
Deleted: `Quasi`
Deleted: `6`

Comment [AWB975]: Note that the conversion semantics are like `String.prototype.concat` rather than the `+ operator`.

Deleted: <#>Let `tail` be the QV of `QuasiTail` as defined in 7.8.6.
Deleted: followed by the elements of `middle`
Deleted: `6`

TemplateSpans : TemplateMiddleList [Lexical goal InputElementTemplateTail] TemplateTail

1. Let *head* be the result of evaluating *TemplateMiddleList*.
2. ReturnIfAbrupt(*head*).
3. Let *tail* be the TV of *TemplateTail* as defined in 7.8.5.
4. Return the string whose elements are the elements of *head* followed by the elements of *tail*.

Deleted: Quasi...emplateLiteral...pans : QuasiHead

Comment [AWB976]: Note that the conversion semantics are like String.prototype.concat rather than + operator.

Deleted: <#>Let *head* be the QV of *QuasiHead* as defined in 7.8.6.¶

<#>Let *sub* be the result of evaluating *Expression*.¶

<#>Let *first* be *ToString*(*sub*).¶

<#>ReturnIfAbrupt(*first*).¶

<#>Let *rest* be the result of evaluating *QuasiMiddleList*.¶

Deleted: *rest*

Deleted: QV...V of *Quasi*

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Deleted: code units

Deleted: followed by the elements of *first* followed by the code units of *rest*

Deleted: code units

Deleted: Quasi...emplateMiddleList : [Lexical goal

Deleted: QV...V of *Quasi*

Deleted: 6

Comment [AWB977]: Note that the conversion semantics are like String.prototype.concat rather than + operator.

Deleted: Quasi...emplateMiddleList :

Deleted: *Quasi*

Deleted: QV...V of *Quasi*

Deleted: 6

Comment [AWB978]: Note that the conversion semantics are like String.prototype.concat rather than + operator.

Deleted: ComprehensionForList :¶ ComprehensionForForComprehensionForList ComprehensionForForComprehensionForFor (LeftHandSideExpression of Expression)

Deleted: The production *PropertyName* : *IdentifierName* is evaluated as follows:¶

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Deleted: z

Deleted: z...edExpressionAndArrowParameterList cannot

Deleted: z...dExpression and its derived productions also

Deleted: z

Deleted: z...edExpression of *CoverParenthesiz*

Deleted: z

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Deleted: z...edExpression of *CoverParenthesiz*

Deleted: The production

Deleted: z

Deleted: PrimaryExpression

Deleted: is evaluated as follows:

TemplateMiddleList : TemplateMiddle Expression

1. Let *head* be the TV of *TemplateMiddle* as defined in 7.8.5.
2. Let *sub* be the result of evaluating *Expression*.
3. Let *middle* be *ToString*(*sub*).
4. ReturnIfAbrupt(*middle*).
5. Return the sequence of characters consisting of the code units of *head* followed by the elements of *middle*.

TemplateMiddleList : TemplateMiddleList [Lexical goal InputElementTemplateTail] TemplateMiddle Expression

1. Let *rest* be the result of evaluating *TemplateMiddleList*.
2. ReturnIfAbrupt(*rest*).
3. Let *middle* be the TV of *TemplateMiddle* as defined in 7.8.5.
4. Let *sub* be the result of evaluating *Expression*.
5. Let *last* be *ToString*(*sub*).
6. ReturnIfAbrupt(*last*).
7. Return the sequence of characters consisting of the elements of *rest* followed by the code units of *middle* followed by the elements of *last*.

11.1.10 The Grouping Operator

Static Semantics: Early Errors

PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList

- It is a Syntax Error if the lexical token sequence matched by *CoverParenthesisedExpressionAndArrowParameterList* cannot be parsed with no tokens left over using *ParenthesisedExpression* as the goal symbol.
- All Early Errors rules for *ParenthesisedExpression* and its derived productions also apply to the *CoveredParenthesisedExpression* of *CoverParenthesisedExpressionAndArrowParameterList*.

Static Semantics: IsValidSimpleAssignmentTarget

PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList

1. Let *expr* be *CoveredParenthesisedExpression* of *CoverParenthesisedExpressionAndArrowParameterList*.
2. Return *IsValidSimpleAssignmentTarget* of *expr*.

ParenthesisedExpression : (Expression)

1. Return *IsValidSimpleAssignmentTarget* of *Expression*.

Runtime Semantics: Evaluation

PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList

1. Let *expr* be *CoveredParenthesisedExpression* of *CoverParenthesisedExpressionAndArrowParameterList*.
2. Return the result of evaluating *expr*.

ParenthesisedExpression : (Expression)

1. Return the result of evaluating *Expression*. This may be of type Reference.

NOTE This algorithm does not apply GetValue to the result of evaluating *Expression*. The principal motivation for this is so that operators such as `delete` and `typeof` may be applied to parenthesised expressions.

11.2 Left-Hand-Side Expressions

Syntax

MemberExpression :

```

Lexical goal InputElementRegExp1 PrimaryExpression
MemberExpression [ Expression ]
MemberExpression . IdentifierName
MemberExpression TemplateLiteral
super [ Expression ]
super . IdentifierName
new super Argumentsopt
new MemberExpression Arguments

```

Deleted: FunctionExpression

Deleted: Quasi

Deleted: MemberExpression <| TriangleLiteral

NewExpression :

```

MemberExpression
new NewExpression

```

Deleted: MemberExpression <| SealedArrayLiteral

MemberExpression <| SealedObjectLiteral

MemberExpression <| FunctionExpression

MemberExpression <| ValueLiteral

CallExpression :

```

MemberExpression Arguments
super Arguments
CallExpression Arguments
CallExpression [ Expression ]
CallExpression . IdentifierName
CallExpression TemplateLiteral

```

Deleted: Quasi

Deleted:

CallExpression <| TriangleLiteral

Arguments :

```

()
( ArgumentList )

```

Deleted: TriangleLiteral :|

SealedArrayLiteral

SealedObjectLiteral

FunctionExpression

ArrowFunction

ValueLiteral

ArgumentList :

```

AssignmentExpression
... AssignmentExpression
ArgumentList , AssignmentExpression
ArgumentList , ... AssignmentExpression

```

LeftHandSideExpression :

```

NewExpression
CallExpression

```

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Deleted:

Deleted:

Static Semantics

Static Semantics: Contains

With parameter *symbol*.

MemberExpression : MemberExpression . IdentifierName

1. If *MemberExpression* Contains *symbol* is **true**, return **true**.
2. If *symbol* is a ReservedWord, return **false**.
3. If *symbol* is an Identifier and StringValue of *symbol* is the same value as the StringValue of *IdentifierName*, return **true**.
4. Return **false**.

MemberExpression : super . IdentifierName

1. If *symbol* is the ReservedWord **super**, return **true**.
2. If *symbol* is a ReservedWord, return **false**.
3. If *symbol* is an Identifier and StringValue of *symbol* is the same value as the StringValue of *IdentifierName*, return **true**.
4. Return **false**.

Deleted:

Deleted:

CallExpression : CallExpression . IdentifierName

1. If *CallExpression* Contains *symbol* is **true**, return **true**.
2. If *symbol* is a ReservedWord, return **false**.
3. If *symbol* is an Identifier and StringValue of *symbol* is the same value as the StringValue of *IdentifierName*, return **true**.
4. Return **false**.

Deleted: c

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Deleted:

MemberExpression : new super

1. If *symbol* is the ReservedWord **super**, return **true**.
2. If *symbol* is the ReservedWord **new**, return **true**.
3. Return **false**.

MemberExpression : new super Arguments

1. If *symbol* is the ReservedWord **super**, return **true**.
2. If *symbol* is the ReservedWord **new**, return **true**.
3. Return the result of *Arguments* Contains *symbol*.

Static Semantics: IsValidSimpleAssignmentTarget

CallExpression :

- CallExpression [Expression]
- CallExpression . IdentifierName

MemberExpression :

- MemberExpression [Expression]
- MemberExpression . IdentifierName
- super [Expression]
- super . IdentifierName

1. Return **true**.

CallExpression :

- MemberExpression Arguments
- super Arguments
- CallExpression Arguments
- CallExpression TemplateLiteral

NewExpression : new NewExpression

MemberExpression :

- new super Arguments_{opt}
- new MemberExpression Arguments

1. Return **false**.

11.2.1 Property Accessors

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

Deleted: Static Semantics:

Deleted: InvalidAssignmentPattern

LeftHandSideExpression : NewExpression
 <#>If the source code corresponding to *NewExpression* can be parsed as *ArrayLiteral*, then
 <#>If the source code corresponding to *NewExpression* can be parsed as *ObjectLiteral*, then return **false**.
 <#>If the source code corresponding to *NewExpression* can be parsed using *AssignmentPattern* (11.13.1) as the goal symbol, return **true**.
 <#>Return **false**.
LeftHandSideExpression : CallExpression
 <#>Return **false**.

Deleted: MemberExpression Arguments
Deleted: super Arguments
Deleted: CallExpression Arguments

Comment [AWB1079]: These are false, because we disallow host functions returning reference values.

Deleted: CallExpression : CallExpression TemplateLiteral

Deleted: MemberExpression : new MemberExpression Arguments

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 [<identifier-name-string>]

and similarly

CallExpression . IdentifierName

is identical in its behaviour to

CallExpression [<identifier-name-string>]

where *<identifier-name-string>* is a string literal containing the same sequence of characters after processing of Unicode escape sequences as the *IdentifierName*.

Runtime Semantics: Evaluation

MemberExpression : MemberExpression [Expression]

1. Let *baseReference* be the result of evaluating *MemberExpression*.
2. Let *baseValue* be *GetValue(baseReference)*.
3. ReturnIfAbrupt(baseValue).
4. Let *propertyNameReference* be the result of evaluating *Expression*.
5. Let *propertyNameValue* be *GetValue(propertyNameReference)*.
6. ReturnIfAbrupt(propertyNameValue).
7. Let *bv* be *CheckObjectCoercible(baseValue)*.
8. ReturnIfAbrupt(bv).
9. Let *propertyNameString* be *ToString(propertyNameValue)*.
10. If the code matched by the syntactic production that is being evaluated is strict mode code, let *strict* be **true**, else let *strict* be **false**.
11. Return a value of type Reference whose base value is *bv* and whose referenced name is *propertyNameString*, and whose strict reference flag is *strict*.

CallExpression : CallExpression [Expression]

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

11.2.2 The new Operator

Runtime Semantics: Evaluation

NewExpression : new NewExpression

1. Let *ref* be the result of evaluating *NewExpression*.
2. Let *constructor* be *GetValue(ref)*.
3. ReturnIfAbrupt(constructor).
4. If *Type(constructor)* is not *Object*, throw a **TypeError** exception.
5. If *constructor* does not implement the **[[Construct]]** internal method, throw a **TypeError** exception.
6. Return the result of calling the **[[Construct]]** internal method on *constructor*, with an empty List as the argument.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *baseValue* is an abrupt completion, return *baseValue*

Deleted: If *propertyNameValue* is an abrupt completion, return *propertyNameValue*

Deleted: Call

Deleted: If the result of

Deleted:

Deleted: *CheckObjectCoercible(baseValue)*

Deleted: is an abrupt completion, return that re

Deleted: contained in

Deleted: *baseValue*

Deleted: mode

Deleted: The production

Deleted: is

Deleted:,

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *constructor* is an abrupt completion, return *constructor*

Deleted: , providing no arguments (that is,

Deleted: list

Deleted: of

Comment [AWB980]: TODO probably need to do something about new operators in tail position.

Deleted: arguments)

MemberExpression : new MemberExpression Arguments

1. Let *ref* be the result of evaluating *MemberExpression*.
2. Let *constructor* be *GetValue(ref)*.
3. ReturnIfAbrupt(*constructor*).
4. Let *argList* be the result of evaluating *Arguments*, producing an internal List of argument values (11.2.4).
5. ReturnIfAbrupt(*argList*).
6. If *Type(constructor)* is not Object, throw a **TypeError** exception.
7. If *constructor* does not implement the [[Construct]] internal method, throw a **TypeError** exception.
8. Return the result of calling the [[Construct]] internal method on *constructor*, passing *argList* as the argument.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *constructor* is an abrupt completion, return *constructor*

Deleted: list

Deleted: If *argList* is an abrupt completion, return *argList*

Deleted: providing the list

Deleted: values

11.2.3 Function Calls

Runtime Semantics: Evaluation

CallExpression : MemberExpression Arguments

1. Let *ref* be the result of evaluating *MemberExpression*.
2. If this *CallExpression* is in a tail position (13.6) then let *tailCall* be **true**, otherwise let *tailCall* be **false**.
3. Return the result of the abstract operation *EvaluateCall* with arguments *ref Arguments*, and *tailCall*.

Comment [AWB781]: TODO: tail calls.

Jan 19 meeting notes: Tentative decision is to support calls in strict mode only.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: 7

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CallExpression : CallExpression Arguments

1. Let *ref* be the result of evaluating *CallExpression*.
2. If this *CallExpression* is in a tail position (13.6) then let *tailCall* be **true**, otherwise let *tailCall* be **false**.
3. Return the result of the abstract operation *EvaluateCall* with arguments *ref Arguments*, and *tailCall*.

Deleted: 7

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Deleted: and

A tail position call must either release any transient internal resources associated with the currently executing function execution context before invoking the target function or reuse those resources in support of the target function.

NOTE 1 For example, a tail position call should only grow an implementation's activation record stack by the amount that the size of the target function's activation record exceeds the size of the calling function's activation record. If the target function's activation record is smaller, then the total size of the stack should decrease.

Runtime Semantics: EvaluateCall Abstract Operation

The abstract operation *EvaluateCall* takes as arguments a value *ref* and a syntactic grammar production *arguments*, and a Boolean argument *tailPosition*. It performs the following steps:

1. Let *func* be *GetValue(ref)*.
2. ReturnIfAbrupt(*func*).
3. Let *argList* be the result of performing *ArgumentListEvaluation* of *arguments*.
4. ReturnIfAbrupt(*argList*).
5. If *Type(func)* is not Object, throw a **TypeError** exception.
6. If *IsCallable(func)* is **false**, throw a **TypeError** exception.
7. If *Type(ref)* is Reference, then
 - a. If *IsPropertyReference(ref)* is **true**, then
 - i. Let *thisValue* be *GetThisValue(ref)*.
 - ii. Else, the base of *ref* is an Environment Record
 - i. Let *thisValue* be the result of calling the WithBaseObject concrete method of *GetBase(ref)*.
8. Else, *Type(ref)* is not Reference,
 - a. Let *thisValue* be **undefined**.
9. If *tailPosition* is **true**, then
 - a. Let *leafContext* be the running execution context.
 - b. Suspend leafContext.
 - c. Pop *leafContext* from the execution context stack. The execution context now on the top of the stack becomes the running execution context, however it remains in its suspended state.
 - d. Assert: *leafContext* has no further use. It will never be activated as the running execution context.

Deleted:

Deleted: Reference,

Deleted: <#>Let *ref* be the result of evaluating *MemberExpression*.

Deleted: If *func* is an abrupt completion, return *func*

Deleted: evaluating

Deleted: *Arguments*

Deleted: , producing an internal list of argument values (see 11.2.4)

Deleted: If *argList* is an abrupt completion, return *argList*

Deleted: *GetBase*

Deleted: *ImplicitThisValue*

Deleted: ,

Deleted: .

Deleted: <#>Let *leafCallerContext* be *leafContext*'s PreviousContext

Deleted: context

Deleted: Make *leafCallerContext*

Comment [AWB982]: Is this really true. Need to think about whether generators may impact this assertion.

10. Let *result* be the result of calling the [[Call]] internal method on *func*, passing *thisValue* as the *thisArgument* and *argList* as the *argumentsList*.
11. Assert: If *tailPosition* is **true**, the above call will not return here, but instead evaluation will continue with the resumption of *leafCallerContext* as the running execution context.
12. Assert: Type(*result*) is an ECMAScript language type
13. Return *result*.

11.2.4 The super Keyword

Static Semantics

Static Semantics: Early Errors

MemberExpression :

```
super [ Expression ]
super . IdentifierName
new super Argumentsopt
```

CallExpression : super Arguments

- It is a Syntax Error if the source code parsed with this production is global code that is not eval code.
- It is a Syntax Error if the source code parsed with this production is eval code and the source code is not being processed by a direct call to eval that is contained in function code.

Runtime Semantics: Evaluation

MemberExpression : super [Expression]

1. Let *propertyNameReference* be the result of evaluating *Expression*.
2. Let *propertyNameValue* be GetValue(*propertyNameReference*).
3. Let *propertyKey* be ToPropertyKey(*propertyNameValue*).
4. If the code matched by the syntactic production that is being evaluated is strict mode code, let *strict* be **true**, else let *strict* be **false**.
5. Return the result of MakeSuperReference(*propertyKey*, *strict*).

MemberExpression : super . IdentifierName

1. Let *propertyKey* be StringValue of *IdentifierName*.
2. If the code matched by the syntactic production that is being evaluated is strict mode code, let *strict* be **true**, else let *strict* be **false**.
3. Return the result of MakeSuperReference(*propertyKey*, *strict*).

MemberExpression : new super Arguments_{opt}

1. If the code matched by the syntactic production that is being evaluated is strict mode code, let *strict* be **true**, else let *strict* be **false**.
2. Let *ref* be the result of MakeSuperReference(**undefined**, *strict*).
3. Let *constructor* be GetValue(*ref*).
4. ReturnIfAbrupt(*constructor*).
5. If *Arguments* is present, then
 - a. Let *argList* be the result of evaluating *Arguments*, producing an internal List of argument values (11.2.4).
 - b. ReturnIfAbrupt(*argList*).
6. Else,
 - a. Let *argList* be a new empty List.
7. If Type(*constructor*) is not Object, throw a **TypeError** exception.
8. If *constructor* does not implement the [[Construct]] internal method, throw a **TypeError** exception.
9. Return the result of calling the [[Construct]] internal method on *constructor*, passing *argList* as the argument.

Deleted: Return
Deleted: providing
Deleted: as the <i>this</i> value
Deleted: providing the list
Deleted: argument values
Deleted: .
Deleted: A tail position call must either release any transient internal resources associated with the currently executing function execution context before invoking the target function or reuse those resources in support of the target function. ¶
NOTE 1 For example, a tail position call should only grow an implementation's activation record stack by the amount that the size of the target function's activation record exceeds the size of the calling function's activation record; the target function's activation record is small, then the total size of the stack should decrease.
Deleted: The This production <i>CallExpression CallExpression Arguments</i> is evaluated in exactly the same manner, as <i>CallExpression MemberExpression Arguments</i> except that the contained <i>CallExpression</i> is evaluated in step 1.
Deleted: NOTE 2 The returned result will never be of type Reference if <i>func</i> is an native ordinary ECMAScript object. Whether calling host exotic 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. ¶
Deleted: 3
Deleted: <#>It is a Syntax Error if the source code parsed with this production is global code that is not eval code.¶
Deleted: <#>It is a Syntax Error if the source code parsed with this production is not
Deleted: code
Deleted: that is also global code
Deleted: <#>It is a Syntax Error if the source code parsed with this production is not
Deleted: <#>Let <i>env</i> be the result of performing the GetThisEnvironment abstract operation.¶
Deleted: <#>Let <i>baseReference</i> be the result of evaluating <i>MemberExpression</i> .¶
Deleted: <#>ReturnIfAbrupt(CheckObjectCoercible(<i>baseValue</i>).Call)
Deleted: <i>NameString</i>
Deleted: String
Deleted: a value of type Reference that is a SuperReference whose base value is <i>baseValue</i> and,
Deleted: <#>Let <i>env</i> be the result of performing the GetThisEnvironment abstract operation.¶
Deleted:
Deleted: a value of type Reference that is a SuperReference whose base value is <i>baseValue</i> , whose
Deleted: .

CallExpression : super Arguments

1. If the code matched by the syntactic production that is being evaluated is strict mode code, let `strict` be `true`, else let `strict` be `false`.
2. Let `ref` be the result of `MakeSuperReference(undefined, strict)`.
3. `ReturnIfAbrupt(ref)`.
4. If this `CallExpression` is in a tail position (13.7) then let `tailCall` be `true`, otherwise let `tailCall` be `false`.
5. Return the result of the abstract operation `EvaluateCall` with arguments `ref`, `Arguments`, and `tailCall`.

Runtime Semantics: Abstract Operation MakeSuperReference(propertyKey, strict)

1. Let `env` be the result of performing the `GetThisEnvironment` abstract operation.
2. If the result of calling the `HasSuperBinding` concrete method of `env` is `false`, then throw a `ReferenceError` exception.
3. Let `actualThis` be the result of calling the `GetThisBinding` concrete method of `env`.
4. Let `baseValue` be the result of calling the `GetSuperBase` concrete method of `env`.
5. Let `bv` be `CheckObjectCoercible(baseValue)`.
6. `ReturnIfAbrupt(bv)`.
7. If `propertyKey` is `undefined`, then
 - a. Let `propertyKey` be the result of calling the `GetMethodName` concrete method of `env`.
8. Return a value of type Reference that is a Super Reference whose base value is `bv`, whose referenced name is `propertyKey`, whose `thisValue` is `actualThis`, and whose strict reference flag is `strict`.

11.2.5 Argument Lists

The evaluation of an argument list produces a List of values (see 8.7).

Runtime Semantics

Runtime Semantics: ArgumentListEvaluation

Arguments : ()

1. Return an empty List.

ArgumentList : AssignmentExpression

1. Let `ref` be the result of evaluating `AssignmentExpression`.
2. Let `arg` be `GetValue(ref)`.
3. `ReturnIfAbrupt(arg)`.
4. Return a List whose sole item is `arg`.

ArgumentList : ... AssignmentExpression

1. Let `list` be an empty List.
2. Let `spreadRef` be the result of evaluating `AssignmentExpression`.
3. Let `spreadValue` be `GetValue(spreadRef)`.
4. Let `spreadObj` be `ToObject(spreadValue)`.
5. `ReturnIfAbrupt(spreadObj)`.
6. Let `lenVal` be the result of calling `Get(spreadObj, "length")`.
7. Let `spreadLen` be `ToUint32(lenVal)`.
8. `ReturnIfAbrupt(spreadLen)`.
9. Let `n = 0`.
10. Repeat, while `n < spreadLen`
 - a. Let `nextArg` be the result of calling `Get(spreadObj, ToString(n))`.
 - b. `ReturnIfAbrupt(nextArg)`.
 - c. Append `nextArg` as the last element of `list`.
 - d. Let `n = n+1`.
11. Return `list`.

Deleted: <#>Let `env` be the result of performing the `GetThisEnvironment` abstract operation.
 <#>If the result of calling the `HasSuperBinding` concrete method of `env` is `false`, then throw a `ReferenceError` exception.
 <#>Let `actualThis` be the result of calling the `GetThisBinding` concrete method of `env`.
 <#>Let `baseValue` be the result of calling the `GetSuperBase` concrete method of `env`.
 <#>ReturnIfAbrupt(`CheckObjectCoercible(baseValue)`).
 <#>Let `propertyKey` be the result of calling the `GetMethodName` concrete method of `env`.

Deleted: be a value of type Reference that is a Super Reference whose base value is `baseValue`, whose referenced name is `propertyKey`, whose `thisValue`

Deleted:

Deleted: and

Deleted: 4

Deleted: 8

Deleted: 11.2.45.1 Static Semantics
Static Semantics: Early Errors
 The production `Arguments : ()` is evaluated as follows:
 Return an empty List.
 The production `Arguments : (ArgumentList)` is evaluated as follows:
 Return the result of evaluating `ArgumentList`.
 The production `ArgumentList : AssignmentExpression` evaluated as follows:
 Let `ref` be the result of evaluating `AssignmentExpression`.
 Let `arg` be `GetValue(ref)`.
 Return a List whose sole item is `arg`.

Deleted: Evaluation

Deleted: The production

Deleted: is evaluated as follows:

Deleted: The production `Arguments : (ArgumentList)` is evaluated as follows:

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If `arg` is an abrupt completion, return `arg`

Deleted: ...

Comment [AW83]: Note that the value the spread operator is applied to is coerced to an Object.

Deleted: If `spreadObj` is an abrupt completion, return `spreadObj`

Deleted: the `[[`

Deleted: `]]` internal method of

Deleted:

Deleted: with argument

Deleted: "

Deleted: "

Deleted: the `[[`

Deleted: `]]` internal method of

Deleted: passing

Deleted:

Deleted: as the argument

ArgumentList : ArgumentList , AssignmentExpression

1. Let *precedingArgs* be the result of evaluating *ArgumentList*.
2. ReturnIfAbrupt(*precedingArgs*)
3. Let *ref* be the result of evaluating *AssignmentExpression*.
4. Let *arg* be *GetValue*(*ref*).
5. ReturnIfAbrupt(*arg*)
6. Return a List whose length is one greater than the length of *precedingArgs* and whose items are the items of *precedingArgs*, in order, followed at the end by *arg* which is the last item of the new list.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *precedingArgs* is an abrupt completion, return *precedingArgs*

Deleted: If *arg* is an abrupt completion, return *arg*

ArgumentList : ArgumentList , ... AssignmentExpression

1. Let *precedingArgs* be an empty List.
2. Let *spreadRef* be the result of evaluating *AssignmentExpression*.
3. Let *spreadValue* be *GetValue*(*spreadRef*).
4. Let spreadObj be ToObject(spreadValue).
5. ReturnIfAbrupt(*spreadObj*)
6. Let *lenVal* be the result of calling Get(spreadObj, "length").
7. Let *spreadLen* be *ToInt32*(*lenVal*).
8. ReturnIfAbrupt(*spreadLen*)
9. Let *n* = 0.
10. Repeat, while *n* < *spreadLen*
 - a. Let *nextArg* be the result of calling Get(spreadObj, ToString(*n*)).
 - b. ReturnIfAbrupt(*nextArg*).
 - c. Append *nextArg* as the last element of *precedingArgs*.
 - d. Let *n* = *n*+1.
11. Return *precedingArgs*.

Deleted: The production

Deleted: ...

Deleted: is evaluated as follows:

Comment [AW84]: Note that the value the spread operator is applied to is coerced to an Object.

Deleted: If *spreadObj* is an abrupt completion, return *spreadObj*

Deleted: the [[

Deleted:]] internal method of

Deleted:

Deleted: with argument

Deleted: "

Deleted: "

Deleted: the [[

Deleted:]] internal method of

Deleted:

Deleted: passing

Deleted: as the argument

Deleted: Quasi

Deleted: The runtime semantics of production

CallExpression : CallExpression
QuasiTemplateLiteral¶
is identical to that of ¶
MemberExpression : MemberExpression
QuasiTemplateLiteral¶
but with evaluation of *CallExpression* substituted for the evaluation of *MemberExpression*.¶

Deleted: Quasi

Deleted: Quasi

11.2.6 Tagged Templates

Runtime Semantics

Runtime Semantics: Evaluation

MemberExpression : MemberExpression TemplateLiteral

1. Let *tagRef* be the result of evaluating *MemberExpression*.
2. If this *MemberExpression* is in a tail position (13.7) then let *tailCall* be **true**, otherwise let *tailCall* be **false**.
3. Return the result of the abstract operation EvaluateCall with arguments *tagRef*, *TemplateLiteral*, and *tailCall*.

CallExpression : CallExpression TemplateLiteral

1. Let *tagRef* be the result of evaluating *CallExpression*.
2. If this *CallExpression* is in a tail position (13.7) then let *tailCall* be **true**, otherwise let *tailCall* be **false**.
3. Return the result of the abstract operation EvaluateCall with arguments *tagRef*, *TemplateLiteral*, and *tailCall*.

11.3 Postfix Expressions

Syntax

PostfixExpression :

```
LeftHandSideExpression
LeftHandSideExpression [no LineTerminator here] ++
LeftHandSideExpression [no LineTerminator here] --
```

Static Semantics

Static Semantics: Early Errors

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

- It is an early Reference Error if IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

11.3.1 Postfix Increment Operator

Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression [no LineTerminator here] ++

1. Let *lhs* be the result of evaluating *LeftHandSideExpression*.
2. Let *oldValue* be ToNumber(GetValue(*lhs*)).
3. ReturnIfAbrupt(*oldValue*).
4. Let *newValue* be the result of adding the value 1 to *oldValue*, using the same rules as for the + operator (see 11.6.3).
5. Let *status* be PutValue(*lhs*, *newValue*).
6. ReturnIfAbrupt(*status*).
7. Return *oldValue*.

11.3.2 Postfix Decrement Operator

Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression [no LineTerminator here] --

1. Let *lhs* be the result of evaluating *LeftHandSideExpression*.
2. Let *oldValue* be ToNumber(GetValue(*lhs*)).
3. Let *newValue* be the result of subtracting the value 1 from *oldValue*, using the same rules as for the - operator (11.6.3).
4. Let *status* be PutValue(*lhs*, *newValue*).
5. ReturnIfAbrupt(*status*).
6. Return *oldValue*.

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

<#> It is a Syntax Error if the derived
LeftHandSideExpression is *PrimaryExpression* : *ObjectLiteral* and ContainsNonObjectLiteralProductions of *ObjectLiteral* true.
<#> It is a Syntax Error if the derived
LeftHandSideExpression is *PrimaryExpression* :
(*Expression*) and *Expression* derived a production that used in place of *LeftHandSideExpression* would produce a Syntax Error according to these rules. This rule is recursively applied.

Deleted: It is a Syntax Error if the *PostfixExpression* is contained in strict code and *LeftHandSideExpression* is the *Identifier eval* or the *Identifier arguments*.

Deleted: ¶
<#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and the *LeftHandSideExpression* is a *Literal* or a *FunctionExpression*.
<#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and the *LeftHandSideExpression* is an *Identifier* that does not statically resolve to a declarative environment record binding or if the resolved binding is an immutable binding. It is a Syntax Error if the *LeftHandSideExpression* is *PrimaryExpression* : (*Expression*) and *Expression* derived a production that if used in place of *LeftHandSideExpression* that would produce a Syntax Error according to these rules. This rule is recursively applied.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: <#> Throw a *SyntaxError* exception if the following conditions are all true:
<#> Type(*lhs*) is Reference is true¶
<#> IsStrictReference(*lhs*) is true¶
<#> Type(GetBase(*lhs*)) is Environment Record¶
<#> GetReferencedName(*lhs*) is either "eval" or "arguments"¶

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

Deleted: Call

Deleted: If

Deleted: The production

Deleted: is evaluated as follows:

Deleted: <#> Throw a *SyntaxError* exception if the following conditions are all true:
<#> Type(*lhs*) is Reference is true¶
<#> IsStrictReference(*lhs*) is true¶
<#> Type(GetBase(*lhs*)) is Environment Record¶
<#> GetReferencedName(*lhs*) is either "eval" or "arguments"¶

Deleted: If Call

11.4 Unary Operators

Syntax

UnaryExpression :
PostfixExpression
delete *UnaryExpression*
void *UnaryExpression*
typeof *UnaryExpression*
++ *UnaryExpression*
-- *UnaryExpression*
+ *UnaryExpression*
- *UnaryExpression*
~ *UnaryExpression*
! *UnaryExpression*

Static Semantics

Static Semantics: Early Errors

UnaryExpression :
++ *UnaryExpression*
-- *UnaryExpression*

- It is an early Reference Error if *IsValidSimpleAssignmentTarget* of *UnaryExpression* is false.

Static Semantics: IsValidSimpleAssignmentTarget

UnaryExpression :
delete *UnaryExpression*
void *UnaryExpression*
typeof *UnaryExpression*
++ *UnaryExpression*
-- *UnaryExpression*
+ *UnaryExpression*
- *UnaryExpression*
~ *UnaryExpression*
! *UnaryExpression*

1. Return false.

11.4.1 The delete Operator

Static Semantics: Early Errors

UnaryExpression : **delete** *UnaryExpression*

- It is a Syntax Error if the *UnaryExpression* is contained in strict code and the derived *UnaryExpression* is
PrimaryExpression : Identifier.
- It is a Syntax Error if the derived *UnaryExpression* is
PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList
and derives a production that is used in place of *UnaryExpression* would produce a Syntax Error according to these rules. This rule is recursively applied.

Deleted: *UnaryExpression* :
delete *UnaryExpression*¶
<#>

<#> ++ *UnaryExpression* .

<#> -- *UnaryExpression*¶

<#> It is a Syntax Error if the *UnaryExpression* contained in strict code and the derived *UnaryExpression* is the Identifier eval or the Identifier arguments.¶

<#> It is a Syntax Error if the *UnaryExpression* contained in extended code and the derived *UnaryExpression* is a Literal or a FunctionExpression.¶

<#> It is a Syntax Error if the *UnaryExpression* contained in extended code and the derived *UnaryExpression* is an Identifier that does not statically resolve to a declarative environment record binding or if the resolved binding is an immutable binding.¶

<#> It is a Syntax Error if the derived *UnaryExpression* is

PrimaryExpression :
(CoverParenthesisedExpressionAndArrowParameterList)
and Expression derives a production that if used in place of LeftHandSideUnaryExpression would produce a Syntax Error according to these rules. This rule is recursively applied.¶

Deleted: derives an

Deleted: that statically resolves to a environment record

Deleted: z

Deleted: The production

Deleted: is evaluated as follows:

1. Let *ref* be the result of evaluating *UnaryExpression*.
2. **ReturnIfAbrupt(*ref*)**
3. If *Type(ref)* is not Reference, return **true**.
4. If *IsUnresolvableReference(ref)* is **true**, then
 - a. If *IsStrictReference(ref)* is **true**, then throw a **SyntaxError** exception.
 - b. **Return true**.
5. If *IsPropertyReference(ref)* is **true**, then
 - a. If *IsSuperReference(ref)*, then throw a **ReferenceError** exception.
 - b. Let *deleteStatus* be the result of calling the **[[Delete]]** internal method on *ToObject(GetBase(*ref*))*, providing *GetReferencedName(*ref*)* as the argument.
 - c. **ReturnIfAbrupt(*deleteStatus*)**.
 - d. If *deleteStatus* is **false** and *IsStrictReference(*ref*)* is **true**, then throw a **TypeError** exception.
 - e. **Return *deleteStatus***.
6. Else *ref* is a Reference to an Environment Record binding.
 - a. Let *bindings* be *GetBase(*ref*)*.
 - b. Return the result of calling the *DeleteBinding* concrete method of *bindings*, providing *GetReferencedName(*ref*)* as the argument.

NOTE When a **delete** operator occurs within strict mode code, a **SyntaxError** exception is thrown if its *UnaryExpression* is a direct reference to a variable, function argument, or function name. In addition, if a **delete** operator occurs within strict mode code and the property to be deleted has the attribute **{ [[Configurable]]: false }**, a **TypeError** exception is thrown.

11.4.2 The **void** Operator

Runtime Semantics: Evaluation

UnaryExpression : **void** *UnaryExpression*

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *status* be *GetValue(expr)*.
3. **ReturnIfAbrupt(*status*)**.
4. **Return undefined**.

NOTE *GetValue* must be called even though its value is not used because it may have observable side-effects.

Deleted: If *ref* is an abrupt completion, return *ref*.

Deleted: Else, r

Deleted: Return

Deleted: and *IsStrictReference(*ref*)*

Deleted: s

Deleted: t

Deleted: true

Deleted: ,

Deleted: so

Deleted: <#>If *IsStrictReference(*ref*)* is **true**, throw a **SyntaxError** exception.||

11.4.3 The **typeof** Operator

Runtime Semantics: Evaluation

UnaryExpression : **typeof** *UnaryExpression*

1. Let *val* be the result of evaluating *UnaryExpression*.
2. If *Type(*val*)* is Reference, then
 - a. If *IsUnresolvableReference(*val*)* is **true**, return "**undefined**".
 - b. Let *val* be *GetValue(*val*)*.
3. **ReturnIfAbrupt(*val*)**.
4. Return a String determined by *Type(*val*)* according to **Table 31**.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: Call

Deleted: <#>**ReturnIfAbrupt(*exprref*)**.If *ref* is an abrupt completion, return *ref*.||

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *val* is an abrupt completion, return *val*.

Deleted: Table 30Table 30Table 28Table 26

Deleted: 30302826

Table 31—**typeof** Operator Results

Type of val	Result
Undefined	"undefined"
Null	"object"
Boolean	"boolean"
Number	"number"
String	"string"
Symbol	"symbol"
Object (ordinary and does not implement [[Call]])	"object"
Object (standard exotic and does not implement [[Call]])	"object"
Object (implements [[Call]])	"function"
Object (non-standard exotic and does not implement [[Call]])	Implementation-defined. May not be "undefined", "boolean", "number", "symbol", or "string".

Deleted: native

Deleted: native or host and does

Deleted:

Deleted: host

Deleted: unless explicitly specified

Deleted: except m

NOTE Implementations are discouraged from defining new `typeof` result values for non-standard exotic objects. If possible "object" should be used for such objects.

11.4.4 Prefix Increment Operator

Runtime Semantics: Evaluation

UnaryExpression : ++ UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *oldValue* be `ToNumber(GetValue(expr))`.
3. ReturnIfAbrupt(*oldValue*).
4. Let *newValue* be the result of adding the value **1** to *oldValue*, using the same rules as for the `+` operator (see 11.6.3).
5. Let *status* be `PutValue(expr, newValue)`.
6. ReturnIfAbrupt(*status*).
7. Return *newValue*.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: `<#>`Throw a `SyntaxError` exception if the following conditions are all true:
`<#>`Type(*expr*) is Reference is true
`<#>`IsStrictReference(*expr*) is true
`<#>`Type(*GetBase(expr)*) is Environment Record
`<#>`GetReferencedName(*expr*) is either "`eval`" or "`arguments`".

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

Deleted: If

Deleted: Call

Deleted: The production

Deleted: is evaluated as follows:

Deleted: `<#>`Throw a `SyntaxError` exception if the following conditions are all true:
`<#>`Type(*expr*) is Reference is true
`<#>`IsStrictReference(*expr*) is true
`<#>`Type(*GetBase(expr)*) is Environment Record
`<#>`GetReferencedName(*expr*) is either "`eval`" or "`arguments`".

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

Deleted: Call

Deleted: If

11.4.5 Prefix Decrement Operator

Runtime Semantics: Evaluation

UnaryExpression : -- UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *oldValue* be `ToNumber(GetValue(expr))`.
3. ReturnIfAbrupt(*oldValue*).
4. Let *newValue* be the result of subtracting the value **1** from *oldValue*, using the same rules as for the `-` operator (see 11.6.3).
5. Let *status* be `PutValue(expr, newValue)`.
6. ReturnIfAbrupt(*status*).
7. Return *newValue*.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: `<#>`Throw a `SyntaxError` exception if the following conditions are all true:
`<#>`Type(*expr*) is Reference is true
`<#>`IsStrictReference(*expr*) is true
`<#>`Type(*GetBase(expr)*) is Environment Record
`<#>`GetReferencedName(*expr*) is either "`eval`" or "`arguments`".

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

Deleted: Call

Deleted: If

11.4.6 Unary + Operator

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

Runtime Semantics: Evaluation

UnaryExpression : + UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Return *ToNumber*(*GetValue*(*expr*)).

Deleted: The production

Deleted: is evaluated as follows:

11.4.7 Unary - Operator

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

Deleted: Note that negating

Runtime Semantics: Evaluation

UnaryExpression : - UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *oldValue* be *ToNumber*(*GetValue*(*expr*)).
3. ReturnIfAbrupt(*oldValue*)
4. If *oldValue* is NaN, return NaN.
5. Return the result of negating *oldValue*; that is, compute a Number with the same magnitude but opposite sign.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

11.4.8 Bitwise NOT Operator (~)

Runtime Semantics: Evaluation

UnaryExpression : ~ UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *oldValue* be *ToInt32*(*GetValue*(*expr*)).
3. ReturnIfAbrupt(*oldValue*)
4. Return the result of applying bitwise complement to *oldValue*. The result is a signed 32-bit integer.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

11.4.9 Logical NOT Operator (!)

Runtime Semantics: Evaluation

UnaryExpression : ! UnaryExpression

1. Let *expr* be the result of evaluating *UnaryExpression*.
2. Let *oldValue* be *ToBoolean*(*GetValue*(*expr*)).
3. ReturnIfAbrupt(*oldValue*)
4. If *oldValue* is true, return false.
5. Return true.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *oldValue* is an abrupt completion, return *oldValue*.

11.5 Multiplicative Operators

Syntax

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

Static Semantics: IsValidSimpleAssignmentTarget

MultiplicativeExpression :

MultiplicativeExpression * UnaryExpression

MultiplicativeExpression / UnaryExpression

MultiplicativeExpression % UnaryExpression

1. Return **false**.

Runtime Semantics: Evaluation

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

Deleted: Semantics¶

1. Let *left* be the result of evaluating *MultiplicativeExpression*.
2. Let *leftValue* be *GetValue(left)*.
3. **ReturnIfAbrupt(leftValue)**
4. Let *right* be the result of evaluating *UnaryExpression*.
5. Let *rightValue* be *GetValue(right)*.
6. Let *lnum* be *ToNumber(leftValue)*.
7. **ReturnIfAbrupt(lnum)**
8. Let *rnum* be *ToNumber(rightValue)*.
9. **ReturnIfAbrupt(rnum)**
10. Return the result of applying the specified operation (*, /, or %) to *lnum* and *rnum*. See the Notes below 11.5.1, 11.5.2, 11.5.3.

Deleted: *lval*

Deleted: If *leftValue* is an abrupt completion, return *leftValue*.

Deleted: *leftNum*

Deleted: *n*

Deleted: If *leftNum* is an abrupt completion, return *leftNum*.

Deleted: *rightNum*

Deleted: *n*

Deleted: If *rightNum* is an abrupt completion, return *rightNum*.

Deleted: *leftNum*

Deleted: *rightNum*

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 binary double-precision arithmetic:

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

11.5.2 Applying the / Operator

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

- If either operand is **NaN**, the result is **NaN**.
- The sign of the result is positive if both operands have the same sign, negative if the operands have different signs.
- Division of an infinity by an infinity results in **NaN**.
- Division of an infinity by a zero results in an infinity. The sign is determined by the rule already stated above.

- Division of an infinity by a nonzero finite value results in a signed infinity. The sign is determined by the rule already stated above.
- Division of a finite value by an infinity results in zero. The sign is determined by the rule already stated above.
- Division of a zero by a zero results in **NaN**; division of zero by any other finite value results in zero, with the sign determined by the rule already stated above.
- Division of a nonzero 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 an 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 nonzero and 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 $r = n - (d \times q)$ 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 . r is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode.

11.6 Additive Operators

Syntax

AdditiveExpression :

MultiplicativeExpression

AdditiveExpression `+` *MultiplicativeExpression*

AdditiveExpression `-` *MultiplicativeExpression*

Static Semantics: IsValidSimpleAssignmentTarget

AdditiveExpression :

AdditiveExpression `+` *MultiplicativeExpression*

AdditiveExpression `-` *MultiplicativeExpression*

1. Return false.

11.6.1 The Addition operator (+)

NOTE The addition operator either performs string concatenation or numeric addition.

Formatted: Note

Runtime Semantics: Evaluation

AdditiveExpression : AdditiveExpression + MultiplicativeExpression

1. Let *lref* be the result of evaluating *AdditiveExpression*.
2. Let *lval* be *GetValue(lref)*.
3. ReturnIfAbrupt(*lval*)
4. Let *rref* be the result of evaluating *MultiplicativeExpression*.
5. Let *rval* be *GetValue(rref)*.
6. ReturnIfAbrupt(*rval*)
7. Let *lprim* be *ToPrimitive(*lval*)*.
8. ReturnIfAbrupt(*lprim*)
9. Let *rprim* be *ToPrimitive(*rval*)*.
10. ReturnIfAbrupt(*rprim*)
11. If *Type(*lprim*)* is String or *Type(*rprim*)* is String, then
 - a. Return the String that is the result of concatenating *ToString(*lprim*)* followed by *ToString(*rprim*)*
12. Return the result of applying the addition operation to *ToNumber(*lprim*)* and *ToNumber(*rprim*)*. See the Note below 11.6.3.

NOTE 1 No hint is provided in the calls to *ToPrimitive* in steps 5 and 6. All standard 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. Exotic objects may handle the absence of a hint in some other manner.

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Deleted: Host

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NOTE 2 Step 7 differs from step 3 of the comparison algorithm for the relational operators (11.8.1), by using the logical-or operation instead of the logical-and operation.

11.6.2 The Subtraction Operator (-)

Runtime Semantics: Evaluation

AdditiveExpression : AdditiveExpression - MultiplicativeExpression

1. Let *lref* be the result of evaluating *AdditiveExpression*.
2. Let *lval* be *GetValue(lref)*.
3. ReturnIfAbrupt(*lval*)
4. Let *rref* be the result of evaluating *MultiplicativeExpression*.
5. Let *rval* be *GetValue(rref)*.
6. ReturnIfAbrupt(*rval*)
7. Let *lnum* be *ToNumber(*lval*)*.
8. ReturnIfAbrupt(*lnum*)
9. Let *rnum* be *ToNumber(*rval*)*.
10. ReturnIfAbrupt(*rnum*)
11. Return the result of applying the subtraction operation to *lnum* and *rnum*. See the note below 11.6.3.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: .If *lval* is an abrupt completion, return *lval*.

Deleted: If *rval* is an abrupt completion, return *rval*.

Deleted: If *lnum* is an abrupt completion, return *lnum*.

Deleted: If *rnum* is an abrupt completion, return *rnum*.

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

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

11.7 Bitwise Shift Operators

Syntax

ShiftExpression :

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

Static Semantics: IsValidSimpleAssignmentTarget

ShiftExpression :

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

- Return **false**.

11.7.1 The Left Shift Operator (`<<`)

NOTE _____ Performs a bitwise left shift operation on the left operand by the amount specified by the right operand.

← Formatted: Note

Runtime Semantics: Evaluation

ShiftExpression : *ShiftExpression* `<<` *AdditiveExpression*

- Let *lref* be the result of evaluating *ShiftExpression*.
- Let *lval* be *GetValue(lref)*.
- ReturnIfAbrupt(*lval*)
- Let *rref* be the result of evaluating *AdditiveExpression*.
- Let *rval* be *GetValue(rref)*.
- ReturnIfAbrupt(*rval*)
- Let *lnum* be *ToInt32(lval)*.
- ReturnIfAbrupt(*lnum*)
- Let *rnum* be *ToUint32(rval)*.
- ReturnIfAbrupt(*rnum*)
- Let *shiftCount* be the result of masking out all but the least significant 5 bits of *rnum*, that is, compute *rnum* & `0x1F`.
- Return the result of left shifting *lnum* by *shiftCount* bits. The result is a signed 32-bit integer.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *lval* is an abrupt completion, return *lval*.

Deleted: If *rval* is an abrupt completion, return *rval*.

Deleted: *n*

Deleted: If *lnum* is an abrupt completion, return *lnum*.

Deleted: *n*

Deleted: If *rnum* is an abrupt completion, return *rnum*.

11.7.2 The Signed Right Shift Operator (>>)

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

Formatted: Note

Runtime Semantics: Evaluation

ShiftExpression : *ShiftExpression* **>>** *AdditiveExpression*

1. Let *lref* be the result of evaluating *ShiftExpression*.
2. Let *lval* be *GetValue(lref)*.
3. **ReturnIfAbrupt(*lval*)**
4. Let *rref* be the result of evaluating *AdditiveExpression*.
5. Let *rval* be *GetValue(rref)*.
6. **ReturnIfAbrupt(*rval*)**
7. Let *lnum* be *ToInt32(*lval*)*.
8. **ReturnIfAbrupt(*lnum*)**
9. Let *rnum* be *ToInt32(*rval*)*.
10. **ReturnIfAbrupt(*rnum*)**
11. Let *shiftCount* be the result of masking out all but the least significant 5 bits of *rnum*, that is, compute *rnum* & 0x1F.
12. Return the result of performing a sign-extending right shift of *lnum* by *shiftCount* bits. The most significant bit is propagated. The result is a signed 32-bit integer.

Deleted: The production

Deleted: is evaluated as follows:

- Deleted:** If *lval* is an abrupt completion, return *lval*.
- Deleted:** If *rval* is an abrupt completion, return *rval*.
- Deleted:** *n*
- Deleted:** If *lnum* is an abrupt completion, return *lnum*.
- Deleted:** *n*
- Deleted:** If *rnum* is an abrupt completion, return *rnum*.

11.7.3 The Unsigned Right Shift Operator (>>>)

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

Formatted: Note

Runtime Semantics: Evaluation

ShiftExpression : *ShiftExpression* **>>>** *AdditiveExpression*

1. Let *lref* be the result of evaluating *ShiftExpression*.
2. Let *lval* be *GetValue(lref)*.
3. **ReturnIfAbrupt(*lval*)**
4. Let *rref* be the result of evaluating *AdditiveExpression*.
5. Let *rval* be *GetValue(rref)*.
6. **ReturnIfAbrupt(*rval*)**
7. Let *lnum* be *ToInt32(*lval*)*.
8. **ReturnIfAbrupt(*lnum*)**
9. Let *rnum* be *ToInt32(*rval*)*.
10. **ReturnIfAbrupt(*rnum*)**
11. Let *shiftCount* be the result of masking out all but the least significant 5 bits of *rnum*, that is, compute *rnum* & 0x1F.
12. Return the result of performing a zero-filling right shift of *lnum* by *shiftCount* bits. Vacated bits are filled with zero. The result is an unsigned 32-bit integer.

Deleted: The production

Deleted: is evaluated as follows:

- Deleted:** If *lval* is an abrupt completion, return *lval*.
- Deleted:** If *rval* is an abrupt completion, return *rval*.
- Deleted:** *n*
- Deleted:** If *lnum* is an abrupt completion, return *lnum*.
- Deleted:** *n*
- Deleted:** If *rnum* is an abrupt completion, return *rnum*.

11.8 Relational Operators

NOTE 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.

Formatted: Note

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*

The semantics of the *RelationalExpressionNoIn* productions are the same as the *RelationalExpression* productions except that the contained *RelationalExpressionNoIn* is used in place of the contained *RelationalExpression*.

NOTE The “Noln” variants are needed to avoid confusing the *in* operator in a relational expression with the *in* operator in a *for* statement.

Deleted: evaluated in
Deleted: manner
Deleted: evaluated instead

Static Semantics: IsValidSimpleAssignmentTarget

RelationalExpression :

- RelationalExpression < ShiftExpression*
- RelationalExpression > ShiftExpression*
- RelationalExpression <= ShiftExpression*
- RelationalExpression >= ShiftExpression*
- RelationalExpression instanceof ShiftExpression*
- RelationalExpression in ShiftExpression*

1. Return **false**.

11.8.1 Runtime Semantics

Runtime Semantics: 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 parameter’s 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. ReturnIfAbrupt(x)
2. ReturnIfAbrupt(y)
3. If the *LeftFirst* flag is **true**, then
 - a. Let px be the result of calling *ToPrimitive*(x , hint Number).
 - b. ReturnIfAbrupt(px)
 - c. Let py be the result of calling *ToPrimitive*(y , hint Number).
 - d. ReturnIfAbrupt(py)
4. 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).

Deleted: Semantics¶
The result of evaluating a relational operator is always of type Boolean, reflecting whether the relationship named by the operator holds between 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*.¶

Deleted: If x is an abrupt completion, return x .
Deleted: If y is an abrupt completion, return y .

Deleted: If px is an abrupt completion, return px .
Deleted: If py is an abrupt completion, return py .

- b. ReturnIfAbrupt(py)
- c. Let px be the result of calling $\text{ToPrimitive}(x, \text{hint Number})$.
- d. ReturnIfAbrupt(px)
5. If both px and py are Strings, then
- 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.)
 - If px is a prefix of py , return **true**.
 - 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.)
 - Let m be the integer that is the code unit value for the character at position k within px .
 - Let n be the integer that is the code unit value for the character at position k within py .
 - If $m < n$, return **true**. Otherwise, return **false**.
6. Else
- Let nx be the result of calling $\text{ToNumber}(px)$. Because px and py are primitive values evaluation order is not important.
 - Let ny be the result of calling $\text{ToNumber}(py)$.
 - If nx is **NaN**, return **undefined**.
 - If ny is **NaN**, return **undefined**.
 - If nx and ny are the same Number value, return **false**.
 - If nx is **+0** and ny is **-0**, return **false**.
 - If nx is **-0** and ny is **+0**, return **false**.
 - If nx is **+∞**, return **false**.
 - If ny is **+∞**, return **true**.
 - If ny is **-∞**, return **false**.
 - If nx is **-∞**, return **true**.
 - If the mathematical value of nx is less than the mathematical value of ny —note that these mathematical values are both finite and not both zero—return **true**. Otherwise, return **false**.

NOTE 1 Step 3 differs from step 7 in the algorithm for the addition operator + (11.6.1) in using and instead of or.

NOTE 2 The comparison of Strings uses a simple lexicographic ordering on sequences of code unit 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 String values 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. Also, note that for strings containing supplementary characters, lexicographic ordering on sequences of UTF-16 code unit values differs from that on sequences of code point values.

Runtime Semantics: Evaluation

RelationalExpression : RelationalExpression < ShiftExpression

- Let $lref$ be the result of evaluating *RelationalExpression*.
- Let $lval$ be $\text{GetValue}(lref)$.
- ReturnIfAbrupt($lval$)
- Let $rref$ be the result of evaluating *ShiftExpression*.
- Let $rval$ be $\text{GetValue}(rref)$.
- Let r be the result of performing abstract relational comparison $lval < rval$. (see 11.8.5)
- ReturnIfAbrupt(r)
- If r is **undefined**, return **false**. Otherwise, return r .

RelationalExpression : RelationalExpression > ShiftExpression

- Let $lref$ be the result of evaluating *RelationalExpression*.
- Let $lval$ be $\text{GetValue}(lref)$.
- ReturnIfAbrupt($lval$)
- Let $rref$ be the result of evaluating *ShiftExpression*.
- Let $rval$ be $\text{GetValue}(rref)$.
- Let r be the result of performing abstract relational comparison $rval < lval$ with *LeftFirst* equal to **false**.

Deleted: If py is an abrupt completion, return py .

Deleted: If px is an abrupt completion, return px .

Deleted: If it is not the case that

Deleted: both $\text{Type}(px)$ is **String** and $\text{Type}(py)$ is **String**, then

Deleted: <#> Else, both px and py are **Strings**.

<#> 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.)

<#> If px is a prefix of py , return **true**.

<#> 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.)

<#> Let m be the integer that is the code unit value for the character at position k within px .

<#> Let n be the integer that is the code unit value for the character at position k within py .

<#> If $m < n$, return **true**. Otherwise, return **false**.

Deleted: 11.8.1 The Less-than Operator (<)¶ The production

Deleted: is evaluated as follows:

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: 11.8.2 The Greater-than Operator (>)¶ The production

Deleted: is evaluated as follows:

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: . (see 11.8.5).

7. `ReturnIfAbrupt(r)`.

8. If `r` is `undefined`, return `false`. Otherwise, return `r`.

RelationalExpression : RelationalExpression <= ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. `ReturnIfAbrupt(lval)`.
4. Let `rref` be the result of evaluating `ShiftExpression`.
5. Let `rval` be `GetValue(rref)`.
6. Let `r` be the result of performing abstract relational comparison `rval < lval` with `LeftFirst` equal to `false`.
7. `ReturnIfAbrupt(r)`.
8. If `r` is `true` or `undefined`, return `false`. Otherwise, return `true`.

Deleted: 11.8.3 The Less-than-or-equal Operator (`<=`)

The production

Deleted: is evaluated as follows:

Deleted: If `lval` is an abrupt completion, return `lval`.

Deleted: . (see 11.8.5).

RelationalExpression : RelationalExpression >= ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. `ReturnIfAbrupt(lval)`.
4. Let `rref` be the result of evaluating `ShiftExpression`.
5. Let `rval` be `GetValue(rref)`.
6. Let `r` be the result of performing abstract relational comparison `lval < rval`.
7. `ReturnIfAbrupt(r)`.
8. If `r` is `true` or `undefined`, return `false`. Otherwise, return `true`.

Deleted: 11.8.4 The Greater-than-or-equal Operator (`>=`)

The production

Deleted: is evaluated as follows:

Deleted: If `lval` is an abrupt completion, return `lval`.

Deleted: (see 11.8.5)

RelationalExpression: RelationalExpression instanceof ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. `ReturnIfAbrupt(lval)`.
4. Let `rref` be the result of evaluating `ShiftExpression`.
5. Let `rval` be `GetValue(rref)`.
6. `ReturnIfAbrupt(rval)`.
7. Return the result of `instanceofOperator(lval, rval)`.

The abstract operation `instanceofOperator(O, C)` implements the generic algorithm for determining if an object `O` inherits from the inheritance path defined by constructor `C`. This abstract operation performs the following steps:

1. If `Type(C)` is not `Object`, throw a `TypeError` exception.
2. Let `instOfHandler` be the result of `GetMethod(C @@hasInstance)`.
3. `ReturnIfAbrupt(instOfHandler)`.
4. If `instOfHandler` is not `undefined`, then
 - a. Let `result` be the result of calling the `[[Call]]` internal method of `instOfHandler` passing `C` as `thisArgument` and a new List containing `O` as `argumentsList`.
 - b. `Return ToBoolean(result)`.
5. If `IsCallable(C)` is `false`, then throw a `TypeError` exception.
6. `Return the result of OrdinaryHasInstance(C, O)`.

NOTE Steps 5 and 6 provide compatibility with previous editions of ECMAScript that did not use a `@@hasInstance` method to define the `instanceof` operator semantics. If a function object does not define or inherit `@@hasInstance` it uses the default `instanceof` semantics.

RelationalExpression : RelationalExpression in ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. `ReturnIfAbrupt(lval)`.
4. Let `rref` be the result of evaluating `ShiftExpression`.

Deleted: assumed that it implements

Deleted: 11.8.7 The `in` operator

The production

Deleted: is evaluated as follows:

Deleted: If `lval` is an abrupt completion, return `lval`.

5. Let *rval* be GetValue(*rref*).
6. ReturnIfAbrupt(*rval*).
7. If Type(*rval*) is not Object, throw a **TypeError** exception.
8. Return the result of HasProperty(*rval*, *ToPropertyKey(lval)*).

Deleted: If *rval* is an abrupt completion, return *rval*.

Deleted: of calling the [[HasProperty]] internal method of

Deleted: with argument

Deleted: ToString

Formatted: Note

11.9 Equality Operators

NOTE 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.

Syntax

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

Deleted:
EqualityExpression [no LineTerminator here] **isnt** *RelationalExpression*

Deleted:
EqualityExpression [no LineTerminator here] **isnt** *RelationalExpression*
EqualityExpression [no LineTerminator here] **isnt** *RelationalExpression*

Deleted: 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.¶

Deleted: evaluated in

Deleted: manner

Deleted: evaluated instead

Deleted:
EqualityExpression [no LineTerminator here] **isnt** *RelationalExpression*
EqualityExpression [no LineTerminator here] **isnt** *RelationalExpression*

Deleted: 1

Deleted: <#>ReturnIfAbrupt(*x*).If *x* is an abrupt completion, return *x*.¶
<#>ReturnIfAbrupt(*y*).If *y* is an abrupt completion, return *y*.¶

Deleted: <#> If Type(*x*) is Undefined, return true.¶
<#> If Type(*x*) is Null, return true.¶
<#> If Type(*x*) is Number, then¶
<#> If *x* is NaN, return false.¶
<#> If *y* is NaN, return false.¶
<#> If *x* is the same Number value as *y*, return true.¶
<#> If *x* is +0 and *y* is -0, return true.¶
<#> If *x* is -0 and *y* is +0, return true.¶
<#> Return false.¶
<#> 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.¶
<#> If Type(*x*) is Boolean, return true if *x* and *y* are both true or both false. Otherwise, return false.¶
<#> Return true if *x* and *y* refer to the same objectObject value. Otherwise, return false.¶

EqualityExpressionNoIn :
RelationalExpressionNoIn
EqualityExpressionNoIn **==** *RelationalExpressionNoIn*
EqualityExpressionNoIn **!=** *RelationalExpressionNoIn*
EqualityExpressionNoIn **====** *RelationalExpressionNoIn*
EqualityExpressionNoIn **!==** *RelationalExpressionNoIn*

The semantics of the *EqualityExpressionNoIn* productions are the same as the *EqualityExpression* productions except that the contained *EqualityExpressionNoIn* and *RelationalExpressionNoIn* are used in place of the contained *EqualityExpression* and *RelationalExpression*, respectively.

Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return **false**.

11.9.1 Runtime Semantics

Runtime Semantics: 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 the same as Type(*y*), then
 - a. Return the result of performing strict equality comparison algorithm *x* === *y*.
2. If *x* is **null** and *y* is **undefined**, return **true**.
3. If *x* is **undefined** and *y* is **null**, return **true**.
4. If Type(*x*) is Number and Type(*y*) is String, return the result of the comparison *x* == ToNumber(*y*).
5. If Type(*x*) is String and Type(*y*) is Number, return the result of the comparison ToNumber(*x*) == *y*.
6. If Type(*x*) is Boolean, return the result of the comparison ToNumber(*x*) == *y*.
7. If Type(*y*) is Boolean, return the result of the comparison *x* == ToNumber(*y*).
8. If Type(*x*) is either String or Number and Type(*y*) is Object, return the result of the comparison *x* == ToPrimitive(*y*).

9. If Type(x) is Object and Type(y) is either String or Number, return the result of the comparison ToPrimitive(x) == y.
10. Return **false**.

NOTE 1 Given the above definition of equality:

- String comparison can be forced by: "" + a == "" + b.
- Numeric comparison can be forced by: +a == +b.
- Boolean comparison can be forced by: !a == !b.

NOTE 2 The equality operators maintain the following invariants:

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

NOTE 3 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. For Example:

- new String("a") == "a" and "a" == new String("a") are both **true**.
- new String("a") == new String("a") is **false**.

NOTE 4 Comparison of Strings uses a simple equality test on sequences of code unit 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 values 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.

Runtime Semantics: 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 Number, then
 - a. If x is NaN, return **false**.
 - b. If y is NaN, return **false**.
 - c. If x is the same Number value as y, return **true**.
 - d. If x is +0 and y is -0, return **true**.
 - e. If x is -0 and y is +0, return **true**.
 - f. Return **false**.
5. If Type(x) is String, then
 - a. If x and y are exactly the same sequence of characters (same length and same characters in corresponding positions), return **true**.
 - b. Else, return **false**.
6. If Type(x) is Boolean, then
 - a. If x and y are both **true** or both **false**, return **true**.
 - b. Else, return **false**.
7. If x and y are the same Symbol value, return **true**.
8. If x and y are the same Object value, return **true**.
9. Return **false**.

NOTE This algorithm differs from the SameValue Algorithm (9.12) in its treatment of signed zeroes and NaNs.

Runtime Semantics: Evaluation

EqualityExpression : EqualityExpression == RelationalExpression

1. Let lref be the result of evaluating *EqualityExpression*.
2. Let lval be GetValue(lref).
3. **ReturnIfAbrupt(lval)**.

Deleted: <#>ReturnIfAbrupt(x).If x is an abrupt completion, return x.
Deleted: <#>ReturnIfAbrupt(y).If y is an abrupt completion, return y.

Deleted: return true i

Deleted:; otherwise

Deleted: return true i

Deleted: ;

Deleted: otherwise

Deleted: Return true i

Deleted: refer to

Deleted: object

Deleted: .

Deleted: Otherwise, r

Deleted: 11.9.1 The Equals Operator (==)
The production

Deleted: is evaluated as follows:

Deleted: If lval is an abrupt completion, return lval.

4. Let $rref$ be the result of evaluating *RelationalExpression*.
5. Let $rval$ be $\text{GetValue}(rref)$.
- 6. ReturnIfAbrupt(rval)**
7. Return the result of performing abstract equality comparison algorithm $rval == lval$.

EqualityExpression : EqualityExpression != RelationalExpression

1. Let $lref$ be the result of evaluating *EqualityExpression*.
2. Let $lval$ be $\text{GetValue}(lref)$.
- 3. ReturnIfAbrupt(lval)**
4. Let $rref$ be the result of evaluating *RelationalExpression*.
5. Let $rval$ be $\text{GetValue}(rref)$.
- 6. ReturnIfAbrupt(rval)**
7. Let r be the result of performing abstract equality comparison algorithm $rval == lval$.
8. If r is **true**, return **false**. Otherwise, return **true**.

EqualityExpression : EqualityExpression === RelationalExpression

1. Let $lref$ be the result of evaluating *EqualityExpression*.
2. Let $lval$ be $\text{GetValue}(lref)$.
- 3. ReturnIfAbrupt(lval)**
4. Let $rref$ be the result of evaluating *RelationalExpression*.
5. Let $rval$ be $\text{GetValue}(rref)$.
- 6. ReturnIfAbrupt(rval)**
7. Return the result of performing the strict equality comparison algorithm $rval === lval$.

EqualityExpression : EqualityExpression !== RelationalExpression

1. Let $lref$ be the result of evaluating *EqualityExpression*.
2. Let $lval$ be $\text{GetValue}(lref)$.
- 3. ReturnIfAbrupt(lval)**
4. Let $rref$ be the result of evaluating *RelationalExpression*.
5. Let $rval$ be $\text{GetValue}(rref)$.
- 6. ReturnIfAbrupt(rval)**
7. Let r be the result of performing strict equality comparison algorithm $rval === lval$.
8. If r is **true**, return **false**. Otherwise, return **true**.

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

Deleted: (see 11.9.3).

Deleted: 11.9.2 The Does-not-equals Operator ($!=$)
The production

Deleted: is evaluated as follows:

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: If $rval$ is an abrupt completion, return $rval$.

Deleted: (see 11.9.3).

Deleted: 11.9.4 The Strict Equals Operator ($==$)
The production

Deleted: is evaluated as follows:

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: (See 11.9.6)

Deleted: 11.9.5 The Strict Does-not-equals Operator ($!==$)
The production

Deleted: is evaluated as follows:

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: (See 11.9.6)

Deleted: <#>ReturnIfAbrupt(r)>

Deleted: *EqualityExpression : EqualityExpression [no LineTerminator here] is RelationalExpression*

<#>Let $lref$ be the result of evaluating *EqualityExpression*.

<#>Let $lval$ be $\text{GetValue}(lref)$.

<#>ReturnIfAbrupt(lval).If $lval$ is an abrupt completion, return $lval$.

<#>Let $rref$ be the result of evaluating *RelationalExpression*.

<#>Let $rval$ be $\text{GetValue}(rref)$.

<#>If $rval$ is an abrupt completion, return $rval$.

<#>Return the result of performing *SavmeValue(rval, lval)*.

EqualityExpression : EqualityExpression [no LineTerminator here] isnt RelationalExpression

<#>Let $lref$ be the result of evaluating *EqualityExpression*.

<#>Let $lval$ be $\text{GetValue}(lref)$.

<#>ReturnIfAbrupt(lval).If $lval$ is an abrupt completion, return $lval$.

<#>Let $rref$ be the result of evaluating *RelationalExpression*.

<#>Let $rval$ be $\text{GetValue}(rref)$.

<#>If $rval$ is an abrupt completion, return $rval$.

<#>Let r be the result of performing *SavmeValue(rval, lval)*.

<#>ReturnIfAbrupt(r).

<#>If r is **true**, return **false**. Otherwise, return **true**.

BitwiseORExpressionNoIn :
BitwiseXORExpressionNoIn
BitwiseORExpressionNoIn | BitwiseXORExpressionNoIn

Static Semantics: IsValidSimpleAssignmentTarget

BitwiseANDExpression : BitwiseANDExpression & EqualityExpression
BitwiseXORExpression : BitwiseXORExpression ^ BitwiseANDExpression
BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

1. Return false.

Runtime Semantics: Evaluation

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

Deleted: Semantics¶

1. Let $lref$ be the result of evaluating A .
2. Let $lval$ be $\text{GetValue}(lref)$.
3. ReturnIfAbrupt($lval$)
4. Let $rref$ be the result of evaluating B .
5. Let $rval$ be $\text{GetValue}(rref)$.
6. ReturnIfAbrupt($rval$)
7. Let $lnum$ be $\text{ToInt32}(lval)$.
8. ReturnIfAbrupt($lnum$)
9. Let $rnum$ be $\text{ToInt32}(rval)$.
10. ReturnIfAbrupt($rnum$)
11. Return the result of applying the bitwise operator $@$ to $lnum$ and $rnum$. The result is a signed 32 bit integer.

Deleted: If $lval$ is an abrupt completion, return $lval$.

Deleted: If $rval$ is an abrupt completion, return $rval$.

Deleted: If $lnum$ is an abrupt completion, return $lnum$.

Deleted: If $rnum$ is an abrupt completion, return $rnum$.

11.11 Binary Logical Operators

Syntax

LogicalANDExpression :
BitwiseORExpression
LogicalANDExpression && BitwiseORExpression

LogicalANDExpressionNoIn :
BitwiseORExpressionNoIn
LogicalANDExpressionNoIn && BitwiseORExpressionNoIn

LogicalORExpression :
LogicalANDExpression
LogicalORExpression || LogicalANDExpression

LogicalORExpressionNoIn :
LogicalANDExpressionNoIn
LogicalORExpressionNoIn || LogicalANDExpressionNoIn

The semantics of the *LogicalANDExpressionNoIn* and *LogicalORExpressionNoIn* productions are the same manner as the *LogicalANDExpression* and *LogicalORExpression* productions except that the contained *LogicalANDExpressionNoIn*, *BitwiseORExpressionNoIn* and *LogicalORExpressionNoIn* are used in place of the contained *LogicalANDExpression*, *BitwiseORExpression* and *LogicalORExpression*, respectively.

Deleted: evaluated in

Deleted: evaluated instead

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

Static Semantics: IsValidSimpleAssignmentTarget

LogicalANDExpression : LogicalANDExpression **&&** BitwiseORExpression
LogicalORExpression : LogicalORExpression **||** LogicalANDExpression

1. Return **false**.

Runtime Semantics: Evaluation

LogicalANDExpression : LogicalANDExpression **&&** BitwiseORExpression

1. Let *lref* be the result of evaluating *LogicalANDExpression*.
2. Let *lval* be GetValue(*lref*).
3. Let *lbool* be ToBoolean(*lval*).
4. **ReturnIfAbrupt(*lbool*)**
5. If *lbool* is **false**, return *lval*.
6. Let *rref* be the result of evaluating *BitwiseORExpression*.
7. Return GetValue(*rref*).

LogicalORExpression : LogicalORExpression **||** LogicalANDExpression

1. Let *lref* be the result of evaluating *LogicalORExpression*.
2. Let *lval* be GetValue(*lref*).
3. Let *lbool* be ToBoolean(*lval*).
4. **ReturnIfAbrupt(*lbool*)**
5. If *lbool* is **true**, return *lval*.
6. Let *rref* be the result of evaluating *LogicalANDExpression*.
7. Return GetValue(*rref*).

11.12 Conditional Operator (**? :**)

Syntax

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

ConditionalExpressionNoIn :
 LogicalORExpressionNoIn
 LogicalORExpressionNoIn **?** AssignmentExpression : AssignmentExpressionNoIn

The semantics of the *ConditionalExpressionNoIn* production is the same as the *ConditionalExpression* production except that the contained *LogicalORExpressionNoIn*, *AssignmentExpression* and *AssignmentExpressionNoIn* are used in place 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.

Static Semantics: IsValidSimpleAssignmentTarget

ConditionalExpression : LogicalORExpression **?** AssignmentExpression : AssignmentExpression

1. Return **false**.

Runtime Semantics: Evaluation

ConditionalExpression : LogicalORExpression **?** AssignmentExpression : AssignmentExpression

1. Let *lref* be the result of evaluating *LogicalORExpression*.

Deleted: Semantics¶
 The production

Deleted: is evaluated as follows:

Deleted: *lval*

Deleted: If *lval* is an abrupt completion, return *lval*.

Deleted: *lval*ToBoolean(*lval*)

Deleted: The production

Deleted: is evaluated as follows:

Deleted: *lval*

Deleted: If *lval* is an abrupt completion, return *lval*.

Deleted: *lval*ToBoolean(*lval*)

Deleted: 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 a **&&** or **||** operator is not necessarily of type Boolean. The value produced will always be the value of one of the two operand expressions.¶

Deleted: evaluated in

Deleted: manner

Deleted: evaluated instead

2. Let *lval* be `ToBoolean(GetValue(lref))`.
3. ReturnIfAbrupt(*lval*)
4. If *lval* is `true`, then
 - a. Let *trueRef* be the result of evaluating the first *AssignmentExpression*.
 - b. Return `GetValue(trueRef)`.
5. Else
 - a. Let *falseRef* be the result of evaluating the second *AssignmentExpression*.
 - b. Return `GetValue(falseRef)`.

11.13 Assignment Operators

Syntax

AssignmentExpression :
 ConditionalExpression
 YieldExpression
 ArrowFunction
 LeftHandSideExpression = *AssignmentExpression*
 LeftHandSideExpression *AssignmentOperator* *AssignmentExpression*

AssignmentExpressionNoIn :
 ConditionalExpressionNoIn
 YieldExpression
 ArrowFunction
 LeftHandSideExpression = *AssignmentExpressionNoIn*
 LeftHandSideExpression *AssignmentOperator* *AssignmentExpressionNoIn*

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

The semantics of the *AssignmentExpressionNoIn* productions are the same manner as the *AssignmentExpression* productions except that the contained *ConditionalExpressionNoIn* and *AssignmentExpressionNoIn* are used in place of the contained *ConditionalExpression* and *AssignmentExpression*, respectively.

Static Semantics

Static Semantics: Early Errors

AssignmentExpression : *LeftHandSideExpression* = *AssignmentExpression*

- It is a Syntax Error if *LeftHandSideExpression* is either an *ObjectLiteral* or an *ArrayLiteral* and if the lexical token sequence matched by *LeftHandSideExpression* cannot be parsed with no tokens left over using *AssignmentPattern* as the goal symbol.
- If *LeftHandSideExpression* is either an *ObjectLiteral* or an *ArrayLiteral* and if the lexical token sequence matched by *LeftHandSideExpression* can be parsed with no tokens left over using *AssignmentPattern* as the goal symbol then the following rules are not applied. Instead, the Early Error rules for *AssignmentPattern* are used.
- It is a Syntax Error if *LeftHandSideExpression* is an *Identifier* that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
- It is an early Reference Error if *LeftHandSideExpression* is neither an *ObjectLiteral* nor an *ArrayLiteral* and `IsValidSimpleAssignmentTarget` of *LeftHandSideExpression* is `false`.

AssignmentExpression : *LeftHandSideExpression* *AssignmentOperator* *AssignmentExpression*

- It is a Syntax Error if the *LeftHandSideExpression* is an *Identifier* that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
- It is an early Reference Error if `IsValidSimpleAssignmentTarget` of *LeftHandSideExpression* is `false`.

Static Semantics: IsValidSimpleAssignmentTarget

Deleted: If *lval* is an abrupt completion, return *lval*.

Deleted: `ToBoolean(GetValue(lref))`

Deleted: Supplemental Syntax

In certain circumstances when processing the production *AssignmentExpression* :
 $\text{LeftHandSideExpression} = \text{AssignmentExpression}$ the following grammar is used to refine the interpretation of *LeftHandSideExpression*.
AssignmentPattern :||
ObjectAssignmentPattern
ArrayAssignmentPattern ||
ObjectAssignmentPattern :||
{ }
{ *AssignmentPropertyList* }
{ *AssignmentPropertyList* , }||
ArrayAssignmentPattern :||
[*Elision_{opt}* *AssignmentRestElement_{opt}*]
[*AssignmentElementList* , *Elision_{opt}*]
AssignmentRestElement_{opt}]||
AssignmentPropertyList :||
AssignmentProperty
AssignmentPropertyList , *AssignmentProperty*||
AssignmentElementList :||
Elision_{opt} *AssignmentElement* .
AssignmentElementList , *Elision_{opt}* .
AssignmentElement :||
AssignmentProperty :||
Identifier
PropertyName : *LeftHandSideExpression*||
AssignmentElement :||
LeftHandSideExpression||
AssignmentRestElement :||
... *LeftHandSideExpression*||

Deleted: *AssignmentExpression* :||

LeftHandSideExpression = *AssignmentExpression*

LeftHandSideExpression *AssignmentOperator* *AssignmentExpression*||
AssignmentExpression||

<#> Semantics||

<#> 11.13.1 Simple Assignment (=)||

<#> The static semantics of *AssignmentExpression* :
 $\text{LeftHandSideExpression} = \text{AssignmentExpression}$ are:
 ||

<#> It is a Syntax Error if the *AssignmentExpression* is contained in strict code and *LeftHandSideExpression* is the *Identifier eval* or the *Identifier arguments*.||

<#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and the *LeftHandSideExpression* is the *Identifier this* or the *Identifier super*.||

<#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and the *LeftHandSideExpression* is a *Literal* or a *FunctionExpression*.||

<#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and the *LeftHandSideExpression* is an *Identifier* that can be determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.||

<#> It is a Syntax Error if the *LeftHandSideExpression* is a *PrimaryExpression* : (*Expression*) and *Expression* derives a production that would produce a Syntax Error according to these rules. This rule is recursively applied.||

Deleted: the

Deleted: <#> It is a Syntax Error if the *AssignmentExpression* is contained in extended code and `IsValidAssignmentPattern` of the *LeftHandSideExpression* is `false`.
 An *ObjectLiteral* or an *ArrayLiteral* and the source code corresponding to *LeftHandSideExpression* cannot be parsed using *AssignmentPattern* as the goal symbol true.||

AssignmentExpression :**YieldExpression****ArrowFunction****LeftHandSideExpression = AssignmentExpression****LeftHandSideExpression AssignmentOperator AssignmentExpression**

1. Return false.

Runtime Semantics**Runtime Semantics: Evaluation****AssignmentExpression : LeftHandSideExpression = AssignmentExpression**

1. If LeftHandSideExpression is neither an ObjectLiteral nor an ArrayLiteral then
 - a. Let lref be the result of evaluating LeftHandSideExpression.
 - b. ReturnIfAbrupt(lref).
 - c. Let rref be the result of evaluating AssignmentExpression.
 - d. Let rval be GetValue(rref).
 - e. Let status be PutValue(lref, rval).
 - f. ReturnIfAbrupt(status).
 - g. Return rval.
2. Let AssignmentPattern be the parse of the source code corresponding to LeftHandSideExpression using AssignmentPattern as the goal symbol.
3. Let rref be the result of evaluating AssignmentExpression.
4. Let rval be ToObject(GetValue(rref)).
5. ReturnIfAbrupt(rval).
6. Let status be the result of performing Destructuring Assignment Evaluation of AssignmentPattern using rval as the argument.
7. ReturnIfAbrupt(status).
8. Return rval.

AssignmentExpression : LeftHandSideExpression AssignmentOperator AssignmentExpression

1. Let lref be the result of evaluating LeftHandSideExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating AssignmentExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let operator be the @ where AssignmentOperator is @=.
8. Let r be the result of applying operator @ to lval and rval.
9. Let status be PutValue(lref, r).
10. ReturnIfAbrupt(status).
11. Return r.

NOTE When an assignment occurs within strict mode code, it is an runtime error if lref in step 1.e of the first algorithm or step 9 of the second algorithm is an unresolvable reference. If it is, a **ReferenceError** exception is thrown. The LeftHandSide also may not be a reference to a data property with the attribute value {[[Writable]]:false}, to an accessor property with the attribute value {[[Set]]:undefined}, nor to a non-existent property of an object for which the IsExtensible predicate returns the value false. In these cases a **TypeError** exception is thrown.

11.13.1 Destructuring Assignment**Supplemental Syntax**

In certain circumstances when processing the production AssignmentExpression : LeftHandSideExpression = AssignmentExpression the following grammar is used to refine the interpretation of LeftHandSideExpression.

Deleted: The production**Deleted:** is evaluated as follows:**Deleted:** If lref is an abrupt completion, return

Deleted: <#> Throw a **SyntaxError** exception the following conditions are all true:
 <#> Type(lref) is Reference is true
 <#> IsStrictReference(lref) is true
 <#> Type(GetBase(lref)) is Environment Record
 <#> GetReferencedName(lref) is either "eval"
 "arguments"

Deleted: Call**Deleted:** If the result of

Deleted: <#> If this is not extended code, throw **ReferenceError** exception.

Deleted: If rval is an abrupt completion, return rval.

Deleted: P**Deleted:** Evaluate**Deleted:** obj parameter

Deleted: If status is an abrupt completion, return rval.

Deleted: where AssignmentOperator is @= and @ represents one of the operators indicated above

Deleted: If lval is an abrupt completion, return lval.

Deleted: If rval is an abrupt completion, return rval.

Deleted: <#> Throw a **SyntaxError** exception the following conditions are all true:
 Deleted:

Deleted: If the result of**Deleted:** Call**Deleted:** is an abrupt completion, return that result**Deleted:** ¶**Formatted:** Note**Deleted:** its LeftHandSide must not evaluate to**Deleted:** d**Deleted:****Deleted:** must not be**Deleted:** an**Deleted:** does**Deleted:** upon assignment**Deleted:** whose**Deleted:** where calling its**Deleted:** ¶**Deleted:** Get**Deleted:**]] internal property method**Deleted:** has**Deleted:** ¶**Deleted:** .1

AssignmentPattern :

ObjectAssignmentPattern
ArrayAssignmentPattern

ObjectAssignmentPattern :

{ }
{ AssignmentPropertyList }
{ AssignmentPropertyList , }

ArrayAssignmentPattern :

[Elision_{opt} AssignmentRestElement_{opt}]
[AssignmentElementList]
[AssignmentElementList , Elision_{opt} AssignmentRestElement_{opt}]

AssignmentPropertyList :

AssignmentProperty
AssignmentPropertyList , AssignmentProperty

AssignmentElementList :

Elision_{opt} AssignmentElement
AssignmentElementList , Elision_{opt} AssignmentElement

AssignmentProperty :

Identifier Initialiser_{opt}
PropertyName : AssignmentElement

AssignmentElement :

DestructuringAssignmentTarget Initialiser_{opt}

AssignmentRestElement :

... DestructuringAssignmentTarget

DestructuringAssignmentTarget :

LeftHandSideExpression

Static Semantics

Static Semantics: Early Errors

AssignmentProperty : Identifier Initialiser_{opt}

- It is a Syntax Error if Identifier is the Identifier eval or the Identifier arguments.
- It is a Syntax Error if Identifier does not statically resolve to a declarative environment record binding or if the resolved binding is an immutable binding.

AssignmentRestElement : ... DestructuringAssignmentTarget

- It is a Syntax Error if IsValidSimpleAssignmentTarget of DestructuringAssignmentTarget is false.

DestructuringAssignmentTarget : LeftHandSideExpression

- It is a Syntax Error LeftHandSideExpression is either an ObjectLiteral or an ArrayLiteral and if the lexical token sequence matched by LeftHandSideExpression cannot be parsed with no tokens left over using AssignmentPattern as the goal symbol.
- It is a Syntax Error if LeftHandSideExpression is neither an ObjectLiteral nor an ArrayLiteral and IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

Deleted: LeftHandSideExpression

Deleted: LeftHandSideExpression

Deleted: ...

Deleted: LeftHandSideExpression

Deleted: PropertyName

Deleted: :

Deleted: LeftHandSideExpression

Deleted: <#>It is a Syntax Error if Identifier is the Identifier this or the Identifier super.¶

Comment [AW85]: This part probably doesn't need to be here if 11.1.2 has this as a static semantic for extended code.

- It is a Syntax Error if the *LeftHandSideExpression* is an *Identifier* that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
- It is a Syntax Error if *LeftHandSideExpression* is the *Identifier eval* or the *Identifier arguments*.
- It is a Syntax Error if *IsInvalidAssignmentPattern* of *LeftHandSideExpression* is *true*.
- It is a Syntax Error if the *LeftHandSideExpression* is *CoverParenthesisedExpressionAndArrowParameterList : (Expression)*, and *Expression* derived a production that would produce a Syntax Error according to these rules. This rule is recursively applied.

Runtime Semantics

Runtime Semantics: Destructuring Assignment Evaluation

with parameter *obj*

ObjectAssignmentPattern : { }

and

ArrayAssignmentPattern :

[₁
[*Elision*]]

1. Return NormalCompletion(empty).

AssignmentPropertyList : AssignmentPropertyList , AssignmentProperty

1. Let *status* be the result of performing Destructuring Assignment Evaluation for *AssignmentPropertyList* using *obj* as the argument.
2. ReturnIfAbrupt(*status*).
3. Return the result of performing Destructuring Assignment Evaluation for *AssignmentProperty* using *obj* as the argument.

AssignmentProperty : Identifier Initialiser_{opt}

1. Let *P* be *StringValue* of *Identifier*.
2. Let *v* be the result of calling *Get(obj, P)*.
3. ReturnIfAbrupt(*v*).
4. If *Initialiser_{opt}* is present and *v* is *undefined*, then
 - a. Let *defaultValue* be the result of evaluating *Initialiser*.
 - b. Let *v* be *ToObject(GetValue(defaultValue))*.
5. ReturnIfAbrupt(*v*).
6. Let *lref* be the result of performing Identifier Resolution(10.3.1) with the *IdentifierName* corresponding to *Identifier*.
7. Return *PutValue(lref, v)*.

AssignmentProperty : PropertyName : AssignmentElement

1. Let *name* be *PropName* of *PropertyName*.
2. Return the result of performing Keyed Destructuring Assignment Evaluation of *AssignmentElement* with *obj* and *name* as the arguments.

ArrayAssignmentPattern : [Elision_{opt} AssignmentRestElement]

1. Let *skip* be the *Elision Width* of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Return the result of performing Indexed Destructuring Assignment Evaluation of *AssignmentRestElement* with *obj* and *skip* as the arguments.

ArrayAssignmentPattern : [AssignmentElementList]

Deleted: <i>AssignmentElement</i> :
Comment [AW86]: This part probably does
Deleted: <#>It is a Syntax Error if
Deleted: It is a Syntax Error if the
Deleted: <i>z</i>
Deleted: <i>PrimaryExpression ... (Expression)</i>
Deleted: <i>AssignmentRestElement : ...</i>
Deleted: The supplemental production
Deleted: The supplemental production
Deleted: , the production
Deleted: <i>ObjectAssignmentPattern : { </i>
Deleted: The supplemental production
Deleted: is evaluated with the parameter <i>o</i>
Deleted: Perform
Deleted: of
Deleted: Evaluate
Deleted: with
Deleted: using ... <i>bj</i> as the <i>obj</i> parameter
Deleted: If <i>status</i> is an abrupt completion,
Deleted: Perform
Deleted: of Evaluate <i>AssignmentProperty</i>
Deleted: with
Deleted: using ... <i>bj</i> as the <i>obj</i> ...rgumentparam
Deleted: The supplemental production
Deleted:
Deleted: <#>Let <i>exists</i> be the result of calling
Deleted: the [[... <i>et()</i>]] internal method of ... <i>bj</i> w
Deleted: <#>Else ¶
Deleted: <i>v</i>
Deleted: Else,
Deleted: <#> Let <i>v</i> be <i>undefined</i> .¶
Deleted: using
Deleted: Call
Deleted: ¶
Deleted: The static semantics of the
Deleted: <i>LeftHandSideExpression</i>
Deleted: is evaluated with the parameter <i>obj</i>
Deleted: the result of evaluating ...ropName of
Deleted: Indexed
Deleted: <#>Let <i>v</i> be the result of calling the
Deleted: The supplemental production
Deleted:
Deleted: is evaluated with the parameter <i>obj</i>
Deleted: If <i>Elision</i> is present, then let <i>skip</i> be the
Deleted: Perform
Deleted: Evaluate ...ssignmentRestElement wi
Deleted: 0
Deleted: index ...rgumentsparameter...¶

1. Return the result of performing Indexed Destructuring Assignment Evaluation of *AssignmentElementList* using *obj* and 0 as the arguments.

ArrayAssignmentPattern : $\lceil \text{AssignmentElementList} , \text{Elision}_{\text{opt}} \text{ AssignmentRestElement}_{\text{opt}} \rceil$

1. Let *lastIndex* be the result of performing Indexed Destructuring Assignment Evaluation of *AssignmentElementList* using *obj* and 0 as the arguments.
2. ReturnIfAbrupt(*lastIndex*).
3. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
4. If *AssignmentRestElement* is present, then return the result of performing Indexed Destructuring Assignment Evaluation of *AssignmentRestElement* with *obj* and *lastIndex+skip* as the arguments.
5. Return *lastIndex*.

Runtime Semantics: Indexed Destructuring Assignment Evaluation

with parameters *obj* and *index*

AssignmentElementList : *Elision*_{opt} *AssignmentElement*

1. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Let *name* be *ToString(index+skip)*.
3. Let *status* be the result of performing Keyed Destructuring Assignment Evaluation of *AssignmentElement* with *obj* and *name* as the arguments.
4. ReturnIfAbrupt(*status*).
5. Return *index+skip+1*.

AssignmentElementList : *AssignmentElementList* , *Elision*_{opt} *AssignmentElement*

1. Let *listNext* be the result of performing Indexed Destructuring Assignment Evaluation of *AssignmentElementList* using *obj* as the *obj* parameter and *index* as the *index* parameter.
2. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
3. ReturnIfAbrupt(*listNext*).
4. Let *name* be *ToString(listNext+skip)*.
5. Let *status* be the result of performing Keyed Destructuring Assignment Evaluation of *AssignmentElement* with *obj* and *name* as the arguments.
6. ReturnIfAbrupt(*status*).
7. Return *listNext+skip+1*.

AssignmentRestElement : ... *DestructuringAssignmentTarget*

1. Let *lref* be the result of evaluating *DestructuringAssignmentTarget*.
2. ReturnIfAbrupt(*lref*).
3. Let *lenVal* be the result of *Get(obj, "length")*.
4. Let *len* be *ToUint32(lenVal)*.
5. ReturnIfAbrupt(*len*).
6. Let *A* be the result of the abstract operation *ArrayCreate* with argument 0.
7. Let *n=0*;
8. Repeat, while *index < len*
 - a. Let *P* be *ToString(index)*.
 - b. Let *exists* be the result of *HasProperty(obj, P)*.
 - c. ReturnIfAbrupt(*exists*).
 - d. If *exists* is true, then
 - i. Let *v* be the result of *Get(obj, ToString(index))*.
 - ii. ReturnIfAbrupt(*len*).
 - iii. Call the *[[DefineOwnProperty]]* internal method of *A* with arguments *ToString(n)* and *PropertyDescriptor* $\{[[Value]]: v, [[Writable]]: \text{true}, [[Enumerable]]: \text{true}, [[Configurable]]: \text{true}\}$.
 - e. Let *n = n+1*.
 - f. Let *index = index+1*.
9. Return *PutValue(lref, A)*.

Runtime Semantics: Keyed Destructuring Assignment Evaluation

with parameters *obj* and *propertyName*

AssignmentElement : *DestructuringAssignmentTarget Initialiser_{opt}*

1. Let *v* be the result of *Get(obj, propertyName)*.
2. *ReturnIfAbrupt(v)*.
3. If *Initialiser_{opt}* is present and *v* is **undefined**, then
 - a. Let *defaultValue* be the result of evaluating *Initialiser*.
 - b. Let *v* be *GetValue(defaultValue)*.
4. If *DestructuringAssignmentTarget* is an *ObjectLiteral* or an *ArrayLiteral* then
 - a. Let *AssignmentPattern* be the parse of the source code corresponding to *DestructuringAssignmentTarget* using *AssignmentPattern* as the goal symbol
 - b. Let *vObj* be *ToObject(v)*.
 - c. *ReturnIfAbrupt(vObj)*.
 - d. Return the result of performing Destructuring Assignment Evaluation of *AssignmentPattern* with *vObj* as the argument.
5. *ReturnIfAbrupt(v)*.
6. Let *lref* be the result of evaluating *DestructuringAssignmentTarget*.
7. *Return PutValue(lref, v)*.

Deleted: *LeftHandSideExpression*

Deleted: calling the *[[*

Deleted: *]]*

Deleted: internal method of

Deleted: with argument

Deleted: *v*

Deleted: *LeftHandSideExpression*

Deleted: *LeftHandSideExpression*

Deleted: *LeftHandSideExpression*

11.14 Comma Operator (,)

Syntax

Expression :

AssignmentExpression
Expression , *AssignmentExpression*

ExpressionNoIn :

AssignmentExpressionNoIn
ExpressionNoIn , *AssignmentExpressionNoIn*

Deleted: evaluated in

Deleted: evaluated instead

Static Semantics: IsValidSimpleAssignmentTarget

Expression : *Expression* , *AssignmentExpression*

1. Return **false**.

Runtime Semantics: Evaluation

Expression : *Expression* , *AssignmentExpression*

1. Let *lref* be the result of evaluating *Expression*.
2. *ReturnIfAbrupt(GetValue(lref))*.
3. Let *rref* be the result of evaluating *AssignmentExpression*.
4. Return *GetValue(rref)*.

Deleted: Semantics¶
 The production

Deleted: is evaluated as follows:

Deleted: Call

Deleted: If the result of

Deleted:

Deleted: is an abrupt completion, return that re

Deleted: .

NOTE *GetValue* must be called even though its value is not used because it may have observable side-effects.

12 Statements and Declarations

Syntax

Statement :

- BlockStatement
- VariableStatement
- EmptyStatement
- ExpressionStatement
- IfStatement
- BreakableStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- WithStatement
- LabelledStatement
- ThrowStatement
- TryStatement
- DebuggerStatement

Declaration :

- FunctionDeclaration
- GeneratorDeclaration
- ClassDeclaration
- LexicalDeclaration

BreakableStatement :

- IterationStatement
- SwitchStatement

Static Semantics

Static Semantics: VarDeclaredNames

Statement :

- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- ThrowStatement
- DebuggerStatement

1. Return a new empty List.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument labelSet.

BreakableStatement : IterationStatement

1. Let *stmtResult* be the result of performing Labelled Evaluation of *IterationStatement* with argument *labelSet*.
2. If *stmtResult*.[[type]] is **break** and *stmtResult*.[[target]] is **empty**, then
 - a. If *stmtResult*.[[value]] is **empty**, then let *stmtResult* be NormalCompletion(**undefined**).
 - b. Else, let *stmtResult* be NormalCompletion(*stmtResult*.[[value]])
3. Return *stmtResult*.

Deleted: *IterationStatement*

Deleted:
SwitchStatement

Deleted: *LetDeclaration*
Const

Deleted: 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 semantic of individual statements. A *LabelledStatement* has no semantic meaning other than the introduction of 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.

Deleted: **Static Semantics: BoundNames**
The BoundNames of the *Declaration* productions are determined as follows:
<#>Return the BoundNames of the single non-terminal symbol that is the right hand side of the production.

Deleted: The VarDeclaredNames of the productions:
Statement : *EmptyStatement*
Statement : *ExpressionStatement*
Statement : *ContinueStatement*
Statement : *BreakStatement*
Statement : *ReturnStatement*
Statement : *ThrowStatement*
Statement : *DebuggerStatement*
is determined as follows:

Deleted: *Statement* :
BlockStatement
VariableStatement
IterationStatement
WithStatement
LabelledStatement
SwitchStatement
TryStatement

The VarDeclaredNames of the productions:

Statement : *BlockStatement*
Statement : *IfStatement*
Statement : *IterationStatement*
Statement : *WithStatement*
Statement : *LabelledStatement*
Statement : *SwitchStatement*
Statement : *TryStatement*

is determined as follows:

Return the VarDeclaredNames of the single non-terminal symbol that is the right hand side of the production.

The VarDeclaredNames of the production
Statement : *VariableStatement* is determined as follows:

Return the BoundNames of *VariableStatement*.

Deleted: L

BreakableStatement : SwitchStatement

1. Let *stmtResult* be the result of evaluating *SwitchStatement*.
2. If *stmtResult*.[[type]] is **break** and *stmtResult*.[[target]] is empty, then
 - a. If *stmtResult*.[[value]] is empty, then let *stmtResult* be NormalCompletion(**undefined**).
 - b. Else, let *stmtResult* be NormalCompletion(*stmtResult*.[[value]])
3. Return *stmtResult*.

NOTE A *BreakableStatement* is one that can be exited via an unlabelled *BreakStatement*.

Deleted: L

Deleted: s

Comment [AWB 387]: Need to have an evaluation semantics in section 13 for *FunctionDeclaration*

Deleted: The *Statement* productions are all evaluated as follows¶

<#>Return the result of evaluating the single non-terminal symbol that is the right hand side of the production.¶

The *Declaration* productions are all evaluated as follows¶

<#>Return the result of evaluating the single non-terminal symbol that is the right hand side of the production.¶

NOTE The result of evaluating a *Statement* or *Declaration* is always a Completion value.¶

Deleted: The *BoundNames* of the *Declaration* productions are determined as follows:¶

Return the *BoundNames* of the single non-terminal symbol that is the right hand side of the production.¶

The *Declaration* productions are all evaluated as follows¶

Return the result of evaluating the single non-terminal symbol that is the right hand side of the production.¶

Deleted: NOTE Several widely used implementations of ECMAScript are known to support the use of *FunctionDeclaration* as a *Statement*. However there are significant and irreconcilable variations among the implementations in the semantics applied to such *FunctionDeclarations*. Because of these irreconcilable differences, the use of a *FunctionDeclaration* as a *Statement* results in code that is not reliably portable among implementations. It is recommended that ECMAScript implementations either disable this usage of *FunctionDeclaration* or issue a warning when such a usage is encountered. Future editions of ECMAScript may define alternative portable means for declaring functions in a *Statement* context.¶

Deleted: <#>It is a Syntax Error if *StatementList* includes a *StatementListItem*: *Declaration* production whose *Declaration* is a *FunctionDeclaration* production and the source code matching this *Block* production is not contained in extended code.¶

Deleted: i

Deleted: *StatementList* : *StatementListItem* ¶

<#>Return the LexicalDeclarations of *StatementListItem*.¶

Deleted: names

Runtime Semantics: Evaluation

BreakableStatement :
IterationStatement
SwitchStatement

1. Let *newLabelSet* be a new empty List.
2. Return the result of performing Labelled Evaluation of this *BreakableStatement* with argument *newLabelSet*.

12.1 Block

Syntax

BlockStatement :
Block

Block :
{ *StatementList*_{opt} }

StatementList :
StatementListItem
StatementList StatementListItem

StatementListItem :
Statement
Declaration

Static Semantics

Static Semantics: Early Errors

Block : { *StatementList* }

- It is a Syntax Error if the LexicallyDeclaredNames of *StatementList* contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of *StatementList* also occurs in the VarDeclaredNames of *StatementList*.

Static Semantics: LexicalDeclarations

StatementList : *StatementList* *StatementListItem*

1. Let *declarations* be LexicalDeclarations of *StatementList*.
2. Append to *declarations* the elements of the LexicalDeclarations of *StatementListItem*.
3. Return *declarations*.

StatementListItem : *Statement*

1. Return a new empty List.

StatementListItem : *Declaration*

1. Return a new List containing *Declaration*.

Deleted: return

Static Semantics: LexicallyDeclaredNames

Block : { }_{*}

1. Return a new empty List.

Deleted: The VarDeclaredNames of the production *BlockStatement* : *Block* is determined as follows:
 <#>Return the VarDeclaredNames of *Block*.
 The production *BlockStatement* : *Block* is evaluated as follows:
 <#>Return the result of evaluating *Block*.

StatementList : *StatementList StatementListItem*

1. Let *names* be LexicallyDeclaredNames of *StatementList*.
2. Append to *names* the elements of the LexicallyDeclaredNames of *StatementListItem*.
3. Return *names*.

Deleted: The LexicallyDeclaredNames of the production *StatementList* : *StatementList Item* is determined as follows:
Deleted: *Block* : { *StatementList* }
 <#>Return the LexicallyDeclaredNames of *StatementList*.
StatementList : *StatementListItem* ¶
 <#>Return the LexicallyDeclaredNames of *StatementListItem*.

StatementListItem : *Statement*

1. Return a new empty List.

StatementListItem : *Declaration*

1. Return the BoundNames of *Declaration*.

Static Semantics: TopLevelLexicallyDeclaredNames

StatementList : *StatementList StatementListItem*

1. Let *names* be TopLevelLexicallyDeclaredNames of *StatementList*.
2. Append to *names* the elements of the TopLevelLexicallyDeclaredNames of *StatementListItem*.
3. Return *names*.

StatementListItem : *Statement*

1. Return a new empty List.

StatementListItem : *Declaration*

1. If *Declaration* is *Declaration* : *FunctionDeclaration*, then return a new empty List.
2. Return the BoundNames of *Declaration*.

NOTE At the top level of a function, or script, function declarations are treated like var declarations rather than like lexical declarations.

Deleted: ..

Static Semantics: TopLevelLexicallyScopedDeclarations

StatementList : *StatementList StatementListItem*

1. Let *declarations* be TopLevelLexicallyScopedDeclarations of *StatementList*.
2. Append to *declarations* the elements of the TopLevelLexicallyScopedDeclarations of *StatementListItem*.
3. Return *declarations*.

StatementListItem : *Statement*

1. Return a new empty List.

StatementListItem : *Declaration*

1. If *Declaration* is *Declaration* : *FunctionDeclaration*, then return a new empty List.
2. Return a new List containing *Declaration*.

Static Semantics: TopLevelVarDeclaredNames

StatementList : StatementList StatementListItem

1. Let *names* be TopLevelVarDeclaredNames of *StatementList*.
2. Append to *names* the elements of the TopLevelVarDeclaredNames of *StatementListItem*.
3. Return *names*.

StatementListItem : Declaration

1. If *Declaration* is *Declaration : FunctionDeclaration*, then return the LexicallyDeclaredNames of *Declaration*.
2. Return a new empty List.

StatementListItem : Statement

1. Return VarDeclaredNames of *Statement*.

NOTE At the top level of a function or script, inner function declarations are treated like var declarations.

Static Semantics: TopLevelVarScopedDeclarations

StatementList : StatementList StatementListItem

1. Let *declarations* be TopLevelVarScopedDeclarations of *StatementList*.
2. Append to *declarations* the elements of the TopLevelVarScopedDeclarations of *StatementListItem*.
3. Return *declarations*.

StatementListItem : Statement

1. If *Statement* is *Statement : VariableStatement*, then return a new List containing *VariableStatement*.
2. Return a new empty List.

StatementListItem : Declaration

1. If *Declaration* is *Declaration : FunctionDeclaration*, then return a new List containing *Declaration*.
2. Return a new empty List.

Static Semantics: VarDeclaredNames

Block : { }

1. Return a new empty List.

StatementList : StatementList StatementListItem

1. Let *names* be VarDeclaredNames of *StatementList*.
2. Append to *names* the elements of the VarDeclaredNames of *StatementListItem*.
3. Return *names*.

StatementListItem : Declaration

2. Return a new empty List.

Runtime Semantics

Runtime Semantics: Evaluation

Block : { }

1. Return NormalCompletion(**undefined**).

Deleted: BlockStatement : Block ¶
<#>Return the VarDeclaredNames of Block.¶

Deleted: The VarDeclaredNames of the production

Deleted: is determined as follows:

Deleted: Block : { StatementList } ¶
<#>Return the VarDeclaredNames of StatementList.¶
StatementList : StatementListItem ¶
<#>Return the VarDeclaredNames of StatementListItem.¶

Deleted: StatementListItem : Statement ¶
<#>Return the VarDeclaredNames of Statement.

Deleted: BlockStatement : Block ¶
<#>Return the result of evaluating Block.¶

Deleted: The production

Deleted: is evaluated as follows:

Comment [AWB1388]: Breaking change: completion reform

Comment [AWB1389]: TODO, need to verify that under completion reform empty blocks evaluate to undefined.

Deleted: normal,

Deleted: empty

Deleted: , empty

Block : { StatementList }

1. Let *oldEnv* be the *running execution context's LexicalEnvironment*.
2. Let *blockEnv* be the result of calling *NewDeclarativeEnvironment* passing *oldEnv* as the argument.
3. Perform *Block Declaration Instantiation* using *StatementList* and *blockEnv*.
4. Set the *running execution context's LexicalEnvironment* to *blockEnv*.
5. Let *blockValue* be the result of evaluating *StatementList*.
6. Set the *running execution context's LexicalEnvironment* to *oldEnv*.
7. If *blockValue*.[[type]] is *normal* and *blockValue*.[[value]] is *empty*, then
 - a. Return *NormalCompletion(undefined)*.
8. Return *blockValue*.

NOTE No matter how control leaves the *Block* the *LexicalEnvironment* is always restored to its former state.

StatementList : StatementList StatementListItem

1. Let *sl* be the result of evaluating *StatementList*.
2. **ReturnIfAbrupt(sl)**.
3. Let *s* be the result of evaluating *StatementListItem*.
4. If *s*.[[type]] is *throw*, return *s*.
5. If *s*.[[value]] is *empty*, let *V* = *sl*.[[value]], otherwise let *V* = *s*.[[value]].
6. Return *Completion* {[[[type]]: *s*.[[type]], [[value]]: *V*, [[target]]: *s*.[[target]]]}.

NOTE Steps 4 and 5 of the above algorithm ensure that the value of a *StatementList* is the value of the last value producing *Statement* in the *StatementList*. For example, the following calls to the *eval* function all return the value 1:

```
eval("1;;;;")
eval("1;{}")
eval("1;var a;")
```

12.2 Declarations and the Variable Statement

12.2.1 Let and Const Declarations

NOTE A *let* and *const* declarations define variables that are scoped to the *running execution context's LexicalEnvironment*. The variables are created when their containing Lexical Environment is instantiated but may not be accessed in any way until the variable's *LexicalBinding* is evaluated. A variable defined by a *LexicalBinding* with an *Initialiser* is assigned the value of its *Initialiser's AssignmentExpression* when the *LexicalBinding* is evaluated, not when the variable is created. If a *LexicalBinding* in a *let* declaration does not have an *Initialiser* the variable is assigned the value *undefined* when the *LexicalBinding* is evaluated.

Syntax

LexicalDeclaration :

 LetOrConst BindingList ;

LexicalDeclarationNoIn :

 LetOrConst BindingListNoIn

LetOrConst :

 let

 const

BindingList :

 LexicalBinding

 BindingList , LexicalBinding

BindingListNoIn :

 LexicalBindingNoIn

 BindingListNoIn , LexicalBindingNoIn

Deleted: The static semantics of the production *Block* { *StatementList* } are.

<#> It is a Syntax Error if *StatementList* includes a *StatementListItem* : *Declaration* production whose *Declaration* is a *Declaration* : *FunctionDeclaration* production and the source code matching this *Block* production is not contained in extended code.

<#> It is a Syntax Error if the LexicallyDeclaredNames *StatementList* contains any duplicate entries.

<#> It is a Syntax Error if any element of the LexicallyDeclaredNames of *StatementList* also occurs in the VarDeclaredNames of *StatementList*. The LexicallyDeclaredNames of the production *Block* { *StatementList* } is determined as follows:

<#> Return the LexicallyDeclaredNames of *StatementList*. The VarDeclaredNames of the production *Block* { *StatementList* } is determined as follows:

Deleted: running

Deleted: current

Deleted: For each element *param*, of *formals*,

Deleted: running

Deleted: current

Deleted: running

Deleted: current

Comment [AWB1390]: Breaking change: completion

Comment [AW91]: If evaluation of code starts

Deleted: The LexicallyDeclaredNames of the production

Deleted: The production *StatementList* : *StatementList* {

Deleted: The LexicallyDeclaredNames of the production

Deleted: If *sl* is an abrupt completion, return *sl*

Deleted: an exception was thrown, return (...[[type]]) is

Deleted: value

Deleted: (...completion {[[[type]]: *s.type*...[type]], [[value]]: *s.value*})

Deleted: 5 ... and 6

Comment [AWB1392]: ISSUE: above changes to

Deleted: The LexicallyDeclaredNames and the

Deleted: The production *StatementListItem* : *Statement*

Deleted: The LexicallyDeclaredNames of the

Deleted: The production *StatementListItem* : *Declaration*

Deleted: s

Deleted: current

Deleted: Let...he variables are created when their

Deleted: t

Deleted: executed...valuated, not when the variable is

Deleted: t...icalBinding is executed

Deleted: Let

Deleted: let Let

Deleted: Let

Deleted: Let...exicalBinding

Deleted: Let

Deleted: Let...exicalBindingNoIn .

LexicalBinding :
BindingIdentifier Initialiser_{opt}
BindingPattern Initialiser

LexicalBindingNoIn :
BindingIdentifier InitialiserNoIn_{opt}
BindingPattern InitialiserNoIn

BindingIdentifier :
Identifier

InitialiserNoIn :
= AssignmentExpressionNoIn

The semantics of the LexicalDeclarationNoIn, BindingListNoIn, LexicalBindingNoIn and InitialiserNoIn productions are the same as the LexicalDeclaration, BindingList, LexicalBinding and Initialiser productions except that the contained BindingListNoIn, LexicalBindingNoIn, InitialiserNoIn and AssignmentExpressionNoIn are used in place of the contained BindingList, LexicalBinding, Initialiser and AssignmentExpression, respectively.

Static Semantics

Static Semantics: Early Errors

LexicalBinding : BindingIdentifier

- It is a Syntax Error if IsConstantDeclaration of the LexicalDeclaration containing this production is true.

BindingIdentifier : Identifier

- It is a Syntax Error if the BindingIdentifier is contained in strict code and if the Identifier is eval or arguments.

Static Semantics: BoundNames

LexicalDeclaration : LetOrConst BindingList ;

1. Return the BoundNames of BindingList.

BindingList : BindingList , LexicalBinding

1. Let names be the BoundNames of BindingList.
2. Append to names the elements of the BoundNames of LexicalBinding.
3. Return names.

LexicalBinding : BindingIdentifier Initialiser_{opt}

1. Return the BoundNames of BindingIdentifier.

LexicalBinding : BindingPattern Initialiser

1. Return the BoundNames of BindingPattern.

BindingIdentifier : Identifier

1. Return a new List containing the StringValue of Identifier.

Static Semantics: IsConstantDeclaration

LexicalDeclaration : LetOrConst BindingList ;

Deleted: Let

Deleted: Let

Deleted: Initialiser : = AssignmentExpression_{opt}

Deleted: Let

Deleted: NOTE A let declaration defines variables that are scoped to the current execution context's LexicalEnvironment. Local variables are created when their containing Lexical Environment is instantiated but may not be accessed in any way until the variable's LetBinding is executed. A variable defined by a LetBinding with an Initialiser is assigned the value of its Initialiser's AssignmentExpression when the LetBinding is executed, not when the variable is created. A LetBinding does not have an Initialiser.

Deleted: if the BindingIdentifier

Comment [AWB893]: Consider disallowing

Deleted: Semantics

Deleted: The static semantics of the

Deleted: Bound Names

Deleted: The BoundNames of the production

Deleted: Let

Deleted: let LetBindingList

Deleted: is determined as follows:

Deleted: Bound Names

Deleted: Let

Deleted: LetBindingList : LetLexicalBinding_{opt}

Deleted: Let

Deleted: Let

Deleted: Let

Deleted: N

Deleted:

Deleted: Let

Deleted: of

Deleted: Bound Names

Deleted: Let

Deleted: Let

Deleted: Bound Names

Deleted: Let

Deleted: Bound Names

Deleted:

1. Return IsConstantDeclaration of *LetOrConst*.

LetOrConst : let

1. Return false.

LetOrConst : const

1. Return true.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments *value* and *environment*.

NOTE *undefined* is passed for *environment* to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for *var* statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initialiser.

BindingIdentifier : Identifier

1. If *environment* is not *undefined*, then

- a. Let *name* be StringValue of *Identifier*.
- b. Let *env* be the environment record component of *environment*.
- c. Call the *InitialiseBinding* concrete method of *env* passing *name* and *value* as the arguments.
- d. Return NormalCompletion(*undefined*).

2. Else

- a. Let *lhs* be the result of evaluating *Identifier* as described in 11.1.2.
- b. Return PutValue(*lhs*, *value*).

Runtime Semantics: Evaluation

LexicalDeclaration ; *LetOrConst* *BindingList* ;

1. Let *next* be the result of evaluating *BindingList*.
2. ReturnIfAbrupt(*next*).
3. Return NormalCompletion(empty).

BindingList : *BindingList* , *LexicalBinding*

1. Let *next* be the result of evaluating *BindingList*.
2. ReturnIfAbrupt(*next*).
3. Return the result of evaluating *LexicalBinding*.

LexicalBinding : *BindingIdentifier*

1. Let *env* be the running execution context's LexicalEnvironment.
2. Return the result of performing BindingInitialisation for *BindingIdentifier* passing *undefined* and *env* as the arguments.

NOTE A static semantics rule ensures that this form of *LexicalBinding* never occurs in a *const* declaration.

LexicalBinding : *BindingIdentifier* *Initialiser*

1. Let *rhs* be the result of evaluating *Initialiser*.
2. Let *value* be GetValue(*rhs*).
3. ReturnIfAbrupt(*value*).
4. Let *env* be the running execution context's LexicalEnvironment.

Deleted: ... <i>BindingList</i>
Deleted: ... <i>BindingList</i>
Deleted: false
Deleted: RuntimeStatic Semantics: String Value <i>BindingIdentifier</i> : Identifier ¶ Return the String Value of <i>Identifier</i> .¶
Deleted: Initialization
Deleted: <i>enviornment</i>
Deleted: initialization
Deleted: the
Deleted: z...ed prior to evaluation of its initializ
Deleted: <i>BindingIdentifier</i> <i>BindingIdentifier</i> : Identifier ¶ <#>PReturn the result of performing Binding InitializationInitialisation for Identifier passing value and env as the arguments.¶ Token: Identifier ¶
Deleted: <i>enviornment</i>
Deleted:
Deleted: InitializeBinding
Deleted: <i>enviornment</i>
Deleted: <i>environment</i> ...assing name <i>Identifier</i>
Deleted: Value
Deleted: Call
Deleted: The production
Deleted: <i>LetDeclaration</i> ... <i>LetOrConst</i> let <i>Let</i>
Deleted: is evaluated as follows:
Deleted: Evaluate <i>Let</i>
Deleted: If <i>next</i> is an abrupt completion, return <i>next</i>
Deleted: (normal, ...mpty, empty)
Deleted: <i>LetBindingList</i> : <i>LetLexicalBinding</i> is evaluated as follows:¶
Deleted: <i>Let...indingList</i> : <i>Let...indingList</i> , <i>Let</i>
Deleted: is evaluated as follows:
Deleted: Evaluate <i>Let</i>
Deleted: If <i>next</i> is an abrupt completion, return <i>next</i>
Deleted: Evaluate <i>Let</i>
Deleted: <i>Let</i>
Deleted: is evaluated as follows:
Deleted: running
Deleted: current
Deleted: Perform ...inding Initialization
Deleted: e
Deleted: The production
Deleted: <i>Let</i>
Deleted: is evaluated as follows:
Deleted: If <i>value</i> is an abrupt completion, return <i>rval</i> .
Deleted: running
Deleted: current

5. Return the result of performing *Binding Initialisation* for *BindingIdentifier* passing *value* and *env* as the arguments.

LexicalBinding : BindingPattern Initialiser

1. Let *rhs* be the result of evaluating *Initialiser*.
2. Let *value* be *ToObject(GetValue(rhs))*.
3. ReturnIfAbrupt(*value*).
4. Let *env* be the running execution context's *LexicalEnvironment*.
5. Return the result of performing *Binding Initialisation* for *BindingPattern* using *value* and *env* as the arguments.

Deleted: Perform
Deleted: Initialization
Deleted: <i>Let</i>
Deleted: is evaluated as follows:
Deleted: <i>rval</i>
Deleted: If <i>rval</i> is an abrupt completion, return
Deleted:
Deleted: <i>rval</i>
Deleted: running
Deleted: current
Deleted: Perform
Deleted: Initialization
Deleted: Evaluate
Deleted: <i>rval</i>
Deleted: as the <i>obj</i> parameter
Deleted: <i>environment</i> parameter
Deleted: <i>BindingIdentifier</i> : <i>Identifier</i> is evaluated as follows: Return the result of evaluating <i>Identifier</i> as described in 11.1.2.¶

Deleted: The production *Initialiser* := *AssignmentExpression* is evaluated as follows:
Return the result of evaluating *AssignmentExpression*.¶

Deleted: The *LetBindingListNoIn*, *LetBindingNoIn* and *InitialiserNoIn* productions are evaluated in the same manner as the *LetBindingList*, *LetBinding* and *Initialiser* productions except that the contained *LetBindingListNoIn*, *LetBindingNoIn* and *AssignmentExpressionNoIn* are evaluated instead of the contained *LetBindingList*, *LetBinding*, *Initialiser* and *AssignmentExpression*, respectively.¶

Deleted: 12.2.2 Const Declaration¶
NOTE A *const* declaration defines read-only variables that are scoped to the current execution context's *LexicalEnvironment*. Constant variables are created when their containing *Lexical Environment* is instantiated but may not be accessed in any way until the variable's *ConstBinding* is executed. A variable defined by a *ConstBinding* is assigned the value of its *Initialiser*'s *AssignmentExpression* when *ConstBinding* is executed, not when the variable is created.¶

Syntax¶
ConstDeclaration :¶

Deleted: 3
Deleted: current
Deleted: ¶

Deleted: NOTE A *var* statement declares variables that are scoped to the current

Deleted: Static Semantics: Early Errors¶
VariableDeclaration : *BindingPattern Initialiser*

Deleted: The *BoundNames* of the production
VariableStatement : *var* *VariableDeclarationList*

12.2.2 Variable Statement

NOTE A *var* statement declares variables that are scoped to the running execution context's *VariableEnvironment*. Var variables are created when their containing *Lexical Environment* is instantiated and are initialised to *undefined* when created. Within the scope of any *VariableEnvironment* a common *Identifier* may appear in more than one *VariableDeclaration* but those declarations collectively define only one variable. A variable defined by a *VariableDeclaration* with an *Initialiser* is assigned the value of its *Initialiser*'s *AssignmentExpression* when the *VariableDeclaration* is executed, not when the variable is created.

Syntax

VariableStatement :
 var *VariableDeclarationList* ;

VariableDeclarationList :
 VariableDeclaration
 VariableDeclarationList , *VariableDeclaration*

VariableDeclarationListNoIn :
 VariableDeclarationNoIn
 VariableDeclarationListNoIn , *VariableDeclarationNoIn*

VariableDeclaration :
 *BindingIdentifier Initialiser*_{opt}
 BindingPattern Initialiser

VariableDeclarationNoIn :
 *BindingIdentifier InitialiserNoIn*_{opt}
 BindingPattern InitialiserNoIn

The semantics of the *VariableDeclarationListNoIn*, *VariableDeclarationNoIn* and *InitialiserNoIn* productions are the same as the *VariableDeclarationList*, *VariableDeclaration* and *Initialiser* productions except that the contained *VariableDeclarationListNoIn*, *VariableDeclarationNoIn*, *InitialiserNoIn* and *AssignmentExpressionNoIn* are used in of the contained *VariableDeclarationList*, *VariableDeclaration*, *Initialiser* and *AssignmentExpression*, respectively.

Static Semantics

Static Semantics: BoundNames

VariableDeclarationList : *VariableDeclarationList* , *VariableDeclaration*

1. Let *names* be *BoundNames* of *VariableDeclarationList*.
2. Append to *names* the elements of *BoundNames* of *VariableDeclaration*.
3. Return *names*.

VariableDeclaration : *BindingIdentifier Initialiser*_{opt}

1. Return the BoundNames of *BindingIdentifier*.

VariableDeclaration : BindingPattern Initialiser

1. Return the BoundNames of *BindingPattern*.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments *value* and *environment*.

NOTE *undefined* is passed for *environment* to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for *var* statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initializer.

VariableDeclaration : BindingIdentifier

1. Return the result of performing Binding Initialisation for *BindingIdentifier* passing *value* and *undefined* as the arguments.

VariableDeclaration : BindingIdentifier Initialiser

1. Return the result of performing Binding Initialisation for *BindingIdentifier* passing *value* and *undefined* as the arguments.

VariableDeclaration : BindingPattern Initialiser

1. Return the result of performing Binding Initialisation for *BindingPattern* passing *value* and *undefined* as the arguments.

Runtime Semantics: Evaluation

VariableStatement : var VariableDeclarationList ;

1. Let *next* be the result of evaluating *VariableDeclarationList*.
2. ReturnIfAbrupt(*next*).
3. Return NormalCompletion(*empty*).

VariableDeclarationList : VariableDeclarationList , VariableDeclaration

1. Let *next* be the result of evaluating *VariableDeclarationList*.
2. ReturnIfAbrupt(*next*).
3. Return the result of evaluating *VariableDeclaration*.

VariableDeclaration : BindingIdentifier

1. Return NormalCompletion(*empty*).

VariableDeclaration : BindingIdentifier Initialiser

1. Let *rhs* be the result of evaluating *Initialiser*.
2. Let *value* be GetValue(*rhs*).
3. ReturnIfAbrupt(*value*).
4. Return the result of performing Binding Initialisation for *BindingIdentifier* passing *value* and *undefined* as the arguments.

NOTE If a *VariableDeclaration* is nested within a *with* statement and the *Identifier* in the *VariableDeclaration* is the same as a property name of the binding object of the *with* statement's object environment record, then step 3 will assign *value* to the property instead of to the *VariableEnvironment* binding of the *Identifier*.

Deleted: the

Deleted: *z*

Deleted: The production

Deleted: is evaluated as follows:

Deleted: Evaluate

Deleted: If *next* is an abrupt completion, return *next*

Deleted: (normal,

Deleted: *y*, empty)

Deleted: The BoundNames of the production
VariableDeclarationList : VariableDeclaration is determined as follows:
 ↪ Return BoundNames of *VariableDeclaration*.¶

Deleted: The production

VariableDeclarationList : VariableDeclaration is evaluated as follows:
 ↪ Return the result of evaluating Evaluate *VariableDeclaration*.¶

Deleted: The BoundNames of the production
VariableDeclarationList : VariableDeclarationList , VariableDeclaration is determined as follows:
 ↪ Let *names* be BoundNames of *VariableDeclarationList*
 ↪ Append to *names* the elements of BoundNames of *VariableDeclaration*.¶
 ↪ Return *names*.¶
 The production

Deleted: is evaluated as follows:

Deleted: Evaluate

Deleted: If *next* is an abrupt completion, return *next*

Deleted: Evaluate

Deleted: The BoundNames of the production
VariableDeclaration : BindingIdentifier Initialiser_{opt} is determined as follows: ¶
 ↪ Return the BoundNames of *BindingIdentifier*.¶
 The production

Deleted: is evaluated as follows:

Deleted: the String value of *BindingIdentifier*

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *value* is an abrupt completion, return *value*
Deleted: Perform
Deleted: Initialization

Deleted: NOTE 1 The String value of a *VariableDeclaration* is used in the evaluation of for-in statements (12.6.4).¶

Deleted: 2

Deleted: 4

VariableDeclaration : BindingPattern Initialiser

2. Let rhs be the result of evaluating Initialiser.
3. Let rval be ToObject(GetValue(rhs)).
4. ReturnIfAbrupt(rval).
5. Return the result of performing Binding Initialisation for BindingPattern passing rval and undefined as arguments.

12.2.4 Destructuring Binding Patterns

Syntax

BindingPattern :
ObjectBindingPattern
ArrayBindingPattern

ObjectBindingPattern :
{
{ BindingPropertyList , }
{ BindingPropertyList , , }

ArrayBindingPattern :
[Elision_{opt} BindingRestElement_{opt}]
[BindingElementList]
[BindingElementList , Elision_{opt} BindingRestElement_{opt}]

BindingPropertyList :
BindingProperty
BindingPropertyList , BindingProperty

BindingElementList :
Elision_{opt} BindingElement
BindingElementList , Elision_{opt} BindingElement

BindingProperty :
SingleNameBinding
PropertyName : BindingElement

BindingElement :
SingleNameBinding
BindingPattern Initialiser_{opt}

SingleNameBinding :
BindingIdentifier Initialiser_{opt}

BindingRestElement :
... BindingIdentifier

Static Semantics

Static Semantics: Early Errors

BindingPattern : ObjectBindingPattern

- It is a Syntax Error if the BoundNames of ObjectBindingPattern contains the string “eval” or the string “arguments”.

BindingPattern : ArrayBindingPattern

Deleted: The static semantics of the production <u>VariableDeclaration : BindingPattern Initialiser</u> are: ↪ It is a Syntax Error if the source code matching this production is not contained in extended code. ↪ The BoundNames of the production <u>VariableDeclaration : BindingPattern Initialiser</u> determined as follows: ↪ Return the BoundNames of <u>BindingPattern</u> . The production
Deleted: is evaluated as follows:
Deleted: <u>ToObject(</u>
Deleted: <u>)</u>
Deleted: If <u>rval</u> is an abrupt completion, return <u>rval</u>
Deleted: Perform
Deleted: Initialization
Deleted: Evaluate
Deleted: using
Deleted: as the <u>obj</u> parameter
Deleted: the environment parameter
Deleted: The <u>VariableDeclarationListNoIn</u> , <u>VariableDeclarationNoIn</u> and <u>InitialiserNoIn</u> productions are evaluated in the same manner as the <u>VariableDeclarationList</u> , <u>VariableDeclaration</u> and <u>Initialiser</u> production except that the contained <u>VariableDeclarationListNoIn</u> , <u>VariableDeclarationNoIn</u> , <u>InitialiserNoIn</u> and <u>AssignmentExpressionNoIn</u> are evaluated instead of the contained <u>VariableDeclarationList</u> , <u>VariableDeclaration</u> , <u>Initialiser</u> and <u>AssignmentExpression</u> , respectively. ↪
Deleted: <u>VariableStatement :</u> <u>var VariableDeclarationList ;</u> <u>VariableDeclarationList :;</u> <u>VariableDeclaration</u> <u>VariableDeclarationList , VariableDeclaration</u> <u>VariableDeclarationListNoIn :</u> <u>VariableDeclarationNoIn .</u> <u>VariableDeclarationListNoIn ,</u> <u>VariableDeclarationNoIn</u>
Comment [AW94]: The destructuring wiki page argues for allowing empty binding patterns.
Comment [AW95]: See above comment about empty binding patterns.
Comment [AW96]: See above comment about empty binding patterns.
Deleted: <u>Identifier</u>
Deleted: <u>PropertyName : SingleNameBinding</u>
Deleted: <u>PropertyName : BindingPattern Initialiser_{opt}</u>
Deleted: <u>Identifier</u>
Deleted: <u>...</u>
Deleted: <u>Identifier</u>
Deleted: <u>Bound Names</u>
Deleted: <u>Object</u>

- It is a Syntax Error if the BoundNames of ArrayBindingPattern contains the string “eval” or the string “arguments”.

Static Semantics: BoundNames

ObjectBindingPattern : { }

1. Return an empty List.

ArrayBindingPattern : [Elision_{opt}]

1. Return an empty List.

ArrayBindingPattern : [Elision_{opt} BindingRestElement]

1. Return the BoundNames of BindingRestElement.

ArrayBindingPattern : [BindingElementList , Elision_{opt}]

1. Return the BoundNames of BindingElementList.

ArrayBindingPattern : [BindingElementList , Elision_{opt} BindingRestElement]

1. Let names be BoundNames of BindingElementList.
2. Append to names the elements of BoundNames of BindingRestElement.
3. Return names.

BindingPropertyList : BindingPropertyList , BindingProperty

1. Let names be BoundNames of BindingPropertyList.
2. Append to names the elements of BoundNames of BindingProperty.
3. Return names.

BindingElementList : Elision_{opt} BindingElement

1. Return BoundNames of BindingElement.

BindingElementList : BindingElementList , Elision_{opt} BindingElement

1. Let names be BoundNames of BindingElementList.
2. Append to names the elements of BoundNames of BindingElement.
3. Return names.

BindingProperty : PropertyName : BindingElement

1. Return the BoundNames of BindingElement.

SingleNameBinding : BindingIdentifier Initialiser_{opt}

1. Return the BoundNames of BindingIdentifier.

BindingElement : BindingPattern Initialiser_{opt}

1. Return the BoundNames of BindingPattern.

Static Semantics: HasInitialiser

BindingElement : BindingPattern

Deleted: Bound Names

Deleted: Bound Names

Deleted: Semantics¶

Deleted: A variable statement declares variables that are created as defined in 10.5. Variables are initialised undefined when created. A variable with an Initialiser assigned the value of its AssignmentExpression when the VariableStatement is executed, not when the variable is created.¶

Semantics¶

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

<#> Evaluate VariableDeclarationList.¶

<#> Return (normal, empty, empty).¶

The production VariableDeclarationList : VariableDeclaration is evaluated as follows:¶

<#> Evaluate VariableDeclaration.¶

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

<#> Evaluate VariableDeclarationList.¶

<#> Evaluate VariableDeclaration.¶

The production VariableDeclaration : Identifier is evaluated as follows:¶

<#> Return a String value containing the same sequence of characters as in the Identifier.¶

The production VariableDeclaration : Identifier Initialiser is evaluated as follows:¶

<#> Let lhs be the result of evaluating Identifier as described in 11.1.2.¶

<#> Let rhs be the result of evaluating Initialiser.¶

<#> Let value be GetValue(rhs).¶

<#> Call PutValue(lhs, value).¶

<#> Return a String value containing the same sequence of characters as in the Identifier.¶

NOTE 1 The String value of a VariableDeclaration is used in the evaluation of for-in statements (12.6.4).¶

Deleted: The BoundNames of the production BindingPattern : ObjectBindingPattern is determined as follows:¶

<#> Return the Bound Names of ObjectBindingPattern.¶

Comment [AW97]: The destructuring wiki page argues for allowing empty binding patterns. I'm not really convinced.

Deleted: ObjectBindingPattern : { BindingPropertyList } .
{ BindingPropertyList , }¶

<#> Return the BoundNames of BindingPropertyList.¶

Deleted: List

Deleted: ArrayBindingPattern : [BindingElementList] .
<#> Return the BoundNames of BindingElementList.¶

Deleted: BindingPropertyList : BindingProperty ¶
<#> Return BoundNames of BindingProperty.¶

Deleted: BindingProperty : SingleNameBinding ¶
<#> Return the BoundNames of SingleNameBinding.¶

Deleted: BindingElement : SingleNameBinding ¶
<#> Return the BoundNames of SingleNameBinding.¶

Deleted: BindingRestElement : ... BindingIdentifier ¶
<#> Return the BoundNames of BindingIdentifier.¶

Deleted: BindingElement : SingleNameBinding ¶
<#> Return HasInitializer of SingleNameBinding.¶

1. Return false.

BindingElement : BindingPattern Initialiser

1. Return true.

SingleNameBinding : BindingIdentifier

1. Return false.

SingleNameBinding : BindingIdentifier Initialiser

1. Return true.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With parameters value and environment.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

BindingPattern : ObjectBindingPattern

1. Assert: Type(value) is Object

2. Return the result of performing Binding Initialisation for ObjectBindingPattern using value and environment as arguments.

BindingPattern : ArrayBindingPattern

1. Assert: Type(value) is Object

2. Return the result of performing Indexed Binding Initialisation for ArrayBindingPattern using value, 0, and environment as arguments.

ObjectBindingPattern : { }

1. Return NormalCompletion(empty).

BindingPropertyList : BindingPropertyList , BindingProperty

1. Let status be the result of performing Binding Initialisation for BindingPropertyList using value and environment as arguments.

2. ReturnIfAbrupt(status).

3. Return the result of performing Binding Initialisation for BindingProperty using value and environment as arguments.

BindingProperty : SingleNameBinding

1. Let name be the string that is the only element of BoundNames of SingleNameBinding.

2. Return the result of performing Keyed Binding Initialisation for SingleNameBinding using value, environment, and name as the arguments.

BindingProperty : PropertyName : BindingElement

1. Let P be the PropName of PropertyName

2. Return the result of performing Keyed Binding Initialisation for BindingElement using value, environment, and P as arguments.

Deleted: Initialization

Deleted: enviornment

Deleted: initialization

Deleted: the

Deleted: z

Deleted: The production

Deleted: If value is neither of null or undefined

Deleted: <#>Let obj be ToObject(value).¶

Deleted: is evaluated with parameters value

Deleted: Perform ...inding Initialization

Deleted: value as the

Deleted: obj

Deleted: parameter ...nd env as the ...nvironment

Deleted: The BoundNames of the production

Deleted: If value is neither of null or undefined

Deleted: <#>Let array be ToObject(value).¶

Deleted: <#>Let lenValue be the result of callin

Deleted: <#>Else.¶

Deleted: <#>Let arrayLength be 0.¶

Deleted: is evaluated with parameters value

Deleted: Perform ...nded Binding Initializatio

Deleted: Evaluate ...rrayBindingPattern using

Deleted: array

Deleted:

Deleted: arrayLength, undefined

Deleted: as the obj parameter ...nd env as the

Deleted: The BoundNames of the production

Deleted: with parameters value and env as

Deleted: Return

Comment [AW98]: The destructuring wiki

Deleted: ObjectBindingPattern :¶

Deleted: The BoundNames of the production

Deleted: The production BindingPropertyList

Deleted: The BoundNames of the production

Deleted: with parameters obj and env as

Deleted: next

Deleted: Perform ...inding Initialization

Deleted: Evaluate ...indingPropertyList using

Deleted: next

Deleted: If next is an abrupt completion, return

Deleted: Perform ...inding Initialization

Deleted: Evaluate ...indingProperty using

Deleted: Perform ...yed Binding Initializatio

Deleted: Perform ...yed Binding Initializatio

Deleted: Evaluate

Runtime Semantics: Indexed Binding Initialisation

With parameters *array*, *nextIndex*, and *environment*.

NOTE When **undefined** is passed for *environment* it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

ArrayBindingPattern : [*Elision_{opt}*]

1. Return NormalCompletion(empty).

ArrayBindingPattern: [*Elision_{opt}* *BindingRestElement*]

1. Let *nextIndex* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Return the result of performing Indexed Binding Initialisation for *BindingRestElement* using *array*, *nextIndex*, and *environment* as arguments.

ArrayBindingPattern: [*BindingElementList*]

1. Return the result of performing Indexed Binding Initialisation for *BindingElementList* using *array*, *nextIndex*, and *environment* as arguments.

ArrayBindingPattern: [*BindingElementList* , *Elision_{opt}*]

1. Return the result of performing Indexed Binding Initialisation for *BindingElementList* using *array*, *nextIndex*, and *environment* as arguments.

ArrayBindingPattern: [*BindingElementList* , *Elision_{opt}* , *BindingRestElement*]

1. Let *next* be the result of performing Indexed Binding Initialisation for *BindingElementList* using *array*, *nextIndex*, and *environment* as arguments.
2. ReturnIfAbrupt(*next*).
3. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
4. Return the result of performing Indexed Binding Initialisation for *BindingRestElement* using *array*, *next+skip*, and *environment* as arguments.

BindingElementList : *Elision_{opt}* *BindingElement*

1. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
2. Let *status* be the result of performing Indexed Binding Initialisation for *BindingElement* using *array*, *nextIndex+skip*, and *environment* as arguments.
3. ReturnIfAbrupt(*status*).
4. Return *nextIndex+skip+1*.

BindingElementList : *BindingElementList* , *Elision_{opt}* *BindingElement*

1. Let *listNext* be the result of performing Indexed Binding Initialisation for *BindingElementList* using *array*, *nextIndex*, and *environment* as arguments.
2. ReturnIfAbrupt(*listNext*).
3. Let *skip* be the Elision Width of *Elision*; if *Elision* is not present, use the numeric value zero.
4. Let *status* be the result of performing Indexed Binding Initialisation for *BindingElement* using *array*, *listNext+skip*, and *environment* as arguments.
5. ReturnIfAbrupt(*status*).
6. Return *listNext+skip+1*.

BindingElement : *SingleNameBinding*

Deleted: Initialization
Deleted: <i>arrayLength</i> ,
Deleted: initialization
Deleted: the
Deleted: <i>z</i>
Deleted: Return
Deleted: If <i>Elision</i> is present, then let <i>nextIndex</i> be the result of performing Indexed Binding Initialisation for <i>Elision</i> using <i>array</i> , <i>nextIndex</i> , and <i>environment</i> .
Deleted: Perform ...ndexed Binding Initialization
Deleted: <i>arrayLength</i> ,
Deleted: Perform ...ndexed Binding Initialization
Deleted: Perform ...ndexed Binding Initialization
Deleted: 0,
Deleted: <i>index</i>
Deleted: Initialization
Deleted: ,
Deleted: 0
Deleted: <i>index</i>
Deleted: If <i>index</i> is an abrupt completion, return <i>index</i> .
Deleted: If <i>Elision</i> is present, then let <i>skip</i> be the result of performing Indexed Binding Initialisation for <i>Elision</i> using <i>array</i> , <i>nextIndex</i> , and <i>environment</i> .
Deleted: Perform ...ndexed Binding Initialization
Deleted: <i>arrayLength</i> ,
Deleted: <i>index</i>
Deleted: The BoundNames of the production
Deleted: with the parameters <i>obj</i> , <i>env</i> , and <i>index</i> as arguments.
Deleted: If <i>Elision</i> is present, then let <i>skip</i> be the result of performing Indexed Binding Initialisation for <i>Elision</i> using <i>array</i> , <i>nextIndex</i> , and <i>environment</i> .
Deleted: <i>next</i>
Deleted: Perform ...ndexed Binding Initialization
Deleted: Evaluate ...ndingElement using <i>obj...rray</i> as the <i>value</i> argument.
Deleted: <i>arrayLength</i> ,
Deleted:
Deleted: <i>env</i> as the <i>env</i> parameter, and <i>index+skip</i> as the <i>nextIndex</i> argument.
Deleted: <i>next</i>
Deleted: If <i>next</i> is an abrupt completion, return <i>next</i> .
Deleted: <i>index</i>
Deleted: The BoundNames of the production
Deleted: is evaluated with the parameters <i>obj</i> , <i>env</i> , and <i>index</i> as arguments.
Deleted: Initialization
Deleted: <i>obj</i>
Deleted: <i>arrayLength</i> ,
Deleted: as the <i>obj</i> parameter, <i>env</i> as the <i>env</i> parameter, and <i>index</i> as the <i>index</i> parameter.
Deleted: <i>next</i>
Deleted: If <i>next</i> is an abrupt completion, return <i>next</i> .
Deleted: If <i>Elision</i> is present, then let <i>skip</i> be the result of performing Indexed Binding Initialisation for <i>Elision</i> using <i>array</i> , <i>listNext+skip</i> , and <i>environment</i> as arguments.
Deleted: Evaluate
Deleted: <i>next</i>
Deleted: Perform ...ndexed Binding Initialization
Deleted: <i>obj...rray</i> as the <i>obj</i> parameter
Deleted: <i>arrayLength</i> ,
Deleted: <i>env</i> as the <i>env</i> parameter
Deleted: ,
Deleted: and ...istNext+skip , and environment as the index argument.
Deleted: <i>listNext</i>
Deleted: If <i>listNext</i> is an abrupt completion, return <i>listNext</i> .
Deleted: <i>listNext</i>
Deleted: 1

1. Return the result of performing Keyed Binding Initialisation for *SingleNameBinding* using *array*, *environment*, and *ToString(nextIndex)* as the arguments.

BindingElement : BindingPattern Initialiser_{opt}

1. Let *P* be *ToString(nextIndex)*.
2. Let *v* be the result of *Get(array, P)*.
3. ReturnIfAbrupt(*v*).
4. If *Initialiser_{opt}* is present and *v* is **undefined**, then
 - a. Let *defaultValue* be the result of evaluating *Initialiser*.
 - b. Let *v* be *ToObject(GetValue(defaultValue))*.
5. ReturnIfAbrupt(*v*).
6. Return the result of performing Binding Initialisation for *BindingPattern* passing *v* and *environment* as arguments.

BindingRestElement : ... BindingIdentifier

2. Let *A* be the result of the abstract operation *ArrayCreate* with argument 0.
3. Let *lenVal* be the result of *Get(array, "length")*.
4. Let *arrayLength* be *ToUint32(lenVal)*.
5. ReturnIfAbrupt(*arrayLength*).
6. Let *n*=0.
7. Let *index* = *nextIndex*.
8. Repeat, while *index* < *arrayLength*
 - a. Let *P* be *ToString(index)*.
 - b. Let *exists* be the result of *HasProperty(array, P)*.
 - c. ReturnIfAbrupt(*exists*).
 - d. If *exists* is **true**, then
 - i. Let *v* be the result of *Get(array, P)*.
 - ii. ReturnIfAbrupt(*v*).
 - iii. Call the *[[DefineOwnProperty]]* internal method of *A* with arguments *ToString(n)* and *PropertyDescriptor* *{[[Value]]: v, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}*.
 - e. Let *n* = *n*+1.
 - f. Let *index* = *index*+1.
9. Return the result of performing Binding Initialisation for *BindingIdentifier* using *A* and *environment* as arguments.

Runtime Semantics: Keyed Binding Initialisation

With parameters *obj*, *environment*, and *propertyName*.

NOTE When **undefined** is passed for *environment* it indicates that a *PutValue* operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

BindingElement : BindingPattern Initialiser_{opt}

1. Let *v* be the result of *Get(obj, propertyName)*.
2. ReturnIfAbrupt(*v*).
3. If *Initialiser_{opt}* is present and *v* is **undefined**, then
 - a. Let *defaultValue* be the result of evaluating *Initialiser*.
 - b. Let *v* be *ToObject(GetValue(defaultValue))*.
4. ReturnIfAbrupt(*v*).
5. Return the result of performing Binding Initialisation for *BindingPattern* passing *v* and *environment* as arguments.

SingleNameBinding : BindingIdentifier Initialiser_{opt}

1. Let *v* be the result of *Get(obj, propertyName)*.

Deleted: <#>If *nextIndex* ≥ *arrayLength*, then
Deleted: with the parameters *obj*, *env* and *in*
Deleted: Perform ...eyed Binding Initializat...
Deleted: Evaluate
Deleted: *P, obj...rray, environment*, and *ToString*
Deleted: The BoundNames of the production
Deleted: <#>If *nextIndex* ≥ *arrayLength*, then
Deleted: <#>Let *exists* be the result of calling
Deleted: with the parameters *obj*, *env* and *in*
Deleted: <#>If *exists* is **true**, then
Deleted: calling the *[[...et]]*... internal method
Deleted: *obj*
Deleted: with argument
Deleted: passing *P* as the argument
Deleted: <#>Else ¶
Deleted: <#>Let *v* be the result of evaluating
Deleted: If *v* is an abrupt completion, return *v*.
Deleted: Perform ...inding Initializat...
Deleted: Evaluate ...indingPattern passing *v* v
Deleted: ...
Deleted: ion
Deleted: (15.4)
Deleted: a new array object created as if by the
Deleted: calling the *[[...et]]*... internal method
Deleted: If *arrayLength* is an abrupt completion
Deleted: calling the *[[HasProperty]]* internal
Deleted: calling the *[[...et]]*... internal method
Deleted: If *v* is an abrupt completion, return *v*
Deleted: ,
Deleted: .[[value]]
Deleted: , and false
Deleted: Perform ...inding Initializat...
Deleted: array
Deleted: Initialization
Deleted: initialization
Deleted: the
Deleted: z
Deleted: *BindingElement: SingleNameBinding*
Deleted: <#>Let *exists* be the result of calling
Deleted: calling the *[[...et]]*... internal method
Deleted: <#>Else ¶
Deleted: *v*
Deleted: <#>Else ¶
Deleted: If *v* is an abrupt completion, return *v*.
Deleted: Perform ...inding Initializat...
Deleted: <#>Let *exists* be the result of calling
Deleted: calling the *[[...et]]* internal method of

2. ReturnIfAbrupt(*v*).
3. If *Initialiser_{opt}* is present and *v* is **undefined**, then
 - a. Let *defaultValue* be the result of evaluating *Initialiser*.
 - b. Let *v* be *GetValue(defaultValue)*.
4. ReturnIfAbrupt(*v*).
5. Return the result of performing Binding Initialisation for *BindingIdentifier* passing *v* and *environment* as arguments.

12.3 Empty Statement

Syntax

EmptyStatement :

;

Runtime Semantics

Runtime Semantics: Evaluation

EmptyStatement : ;

1. Return NormalCompletion(empty).

12.4 Expression Statement

Syntax

ExpressionStatement :

[lookahead $\notin \{\{, \text{function}, \text{class}\}\}] \text{Expression} ;$

NOTE 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** or **class** keywords because that would make it ambiguous with a *FunctionDeclaration*, a *GeneratorDeclaration*, or a *ClassDeclaration*.

Runtime Semantics

Runtime Semantics: Evaluation

ExpressionStatement : [lookahead $\notin \{\{, \text{function}, \text{class}\}\}] \text{Expression} ;$

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *value* be *GetValue(exprRef)*.
3. ReturnIfAbrupt(*value*).
4. Return NormalCompletion(*value*).

12.5 The if Statement

Syntax

IfStatement :

if (*Expression*) *Statement* **else** *Statement*
 if (*Expression*) *Statement*

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**.

Static Semantics: VarDeclaredNames

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

- Deleted:** <#>Else ¶
- Deleted:** *v*
- Deleted:** <#>Else, ¶
 <#> Let *v* be **undefined** ¶
- Deleted:** If *v* is an abrupt completion, return *v*.
- Deleted:** Perform
- Deleted:** Initialization
- Deleted:** *enviornment*
- Deleted:** The BoundNames of the production
BindingRestElement : . . . *BindingIdentifier* is determined as follows: ¶
 Return the BoundNames of *BindingIdentifier*. ¶
- Deleted:** The BoundNames of the production
BindingRestElement : . . . *Identifier* is determined as follows: ¶
 Return BoundNames of *Identifier*. ¶
- Deleted:** The production *BindingRestElement* : ...
BindingIdentifier is evaluated with the parameters *obj*,
env, and *index* as follows: ¶
 Let *lenVal* be the result of calling the [[Get]] internal
 method of *obj* with argument "length". ¶
 Let *len* be *ToInt32(lenVal)*. ¶
 Let *A* be a new array object created as if by the
 expression *new Array()* where *Array* is the
 standard built-in constructor with that name. ¶
 Let *n=0*; ¶
 Repeat, while *index* < *len* ¶
 Let *P* be *ToString(index)*. ¶
 Let *exists* be the result of calling the [[HasProperty]]
 internal method of *obj* with argument *P*. ¶
 If *exists* is true, then ¶
 Let *v* be the result of calling the [[Get]] internal
 method of *obj* passing *P* as the argument. ¶
 Call the [[DefineOwnProperty]] internal method of *A*
 with arguments *ToString(n)*, *Property Descriptor*
 {{[*Value*]: *v*, [[Writable]]: true, [[Enumerable]]: true,
 [[Configurable]]: true}, and false. ¶
 Let *n = n+1*. ¶
 Let *index = index+1*. ¶
 Perform Binding Initialization for *BindingIdentifier*
 using *A* as the *value* and *env* as the *enviornment*. ¶
 ¶
- Deleted:** Semantics ¶
 The production
- Deleted:** is evaluated as follows:
- Deleted:** (normal,
- Deleted:** , empty).
- Deleted:** might
- Deleted:** Semantics ¶
 The production
- Deleted:** is evaluated as follows:
- Deleted:** If *value* is an abrupt completion, return *value*
- Deleted:** (normal, *GetValue(exprRef)*)
- Deleted:** , empty
- Deleted:** Semantics ¶
 The VarDeclaredNames of the production
- Deleted:** is determined as follows:

1. Let *names* be VarDeclaredNames of the first *Statement*.
2. Append to *names* the elements of the VarDeclaredNames of the second *Statement*.
3. Return *names*.

IfStatement : if (Expression) Statement

1. Return the VarDeclaredNames of *Statement*.

Runtime Semantics

Runtime Semantics: Evaluation

IfStatement : if (Expression) Statement else Statement

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *exprValue* be ToBoolean(GetValue(*exprRef*)).
3. ReturnIfAbrupt(*exprValue*).
4. If *exprValue* is true, then
 - a. Let *stmtValue* be the result of evaluating the first *Statement*.
5. Else,
 - a. Let *stmtValue* be the result of evaluating the second *Statement*.
6. If *stmtValue*.[[type]] is normal and *stmtValue*.[[value]] is empty, then
 - a. Return NormalCompletion(**undefined**).
7. Return *stmtValue*.

IfStatement : if (Expression) Statement

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *exprValue* be ToBoolean(GetValue(*exprRef*)).
3. ReturnIfAbrupt(*exprValue*).
4. If *exprValue* is false, then
 - a. Return NormalCompletion(**undefined**).
5. Else,
 - a. Let *stmtValue* be the result of evaluating *Statement*.
6. If *stmtValue*.[[type]] is normal and *stmtValue*.[[value]] is empty, then
 - a. Return NormalCompletion(**undefined**).
7. Return *stmtValue*.

12.6 Iteration Statements

Syntax

IterationStatement :

```

    do Statement while ( Expression )
    while ( Expression ) Statement
    for ( ExpressionNoInopt; Expressionopt ; Expressionopt ) Statement
    for ( var VariableDeclarationListNoIn; Expressionopt ; Expressionopt ) Statement
    for ( LexicalDeclarationNoIn; Expressionopt ; Expressionopt ) Statement
    for ( LeftHandSideExpression in Expression ) Statement
    for ( var ForBindingopt in Expression ) Statement
    for ( ForDeclaration in Expression ) Statement
    for ( LeftHandSideExpression of AssignmentExpression ) Statement
    for ( var ForBinding of AssignmentExpression ) Statement
    for ( ForDeclaration of AssignmentExpression ) Statement
  
```

ForDeclaration :

LetOrConst ForBinding

NOTE 1 ForBinding is defined in 11.1.4.2.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If *exprValue* is an abrupt completion, return *exprValue*

Deleted: ToBoolean(GetValue(*exprRef*))

Deleted: Return

Deleted: Return

Comment [AWB1399]: Breaking change from ES5: completion reform

Deleted: The VarDeclaredNames of the production *IfStatement : if (Expression) Statement* is determined as follows:
 ↪ Return the VarDeclaredNames of *Statement*.
 The production

Deleted: is evaluated as follows:

Deleted: If *exprValue* is an abrupt completion, return *exprValue*

Deleted: ToBoolean(GetValue(*exprRef*))

Comment [AWB1100]: Breaking change from ES5: completion reform

Deleted: return

Deleted: (normal, empty)

Deleted: , empty).

Comment [AWB13101]: Breaking change from ES5: completion reform

Deleted: :

Comment [AWB6102]: This is breaking change from ES5 which allowed a *VariableDeclarationNoIn* to appear here. See a discuss thread "lexical for-in/for-of loose end"

Deleted: BindingIdentifier

Deleted: VariableDeclarationNoIn

Deleted: ForVarDeclaration

Deleted: Expression

Deleted: ForVarDeclaration :
 ↪ BindingPattern
 ↪ VariableDeclarationNoIn

NOTE 2 A semicolon is not required after a `do-while` statement.

Runtime Semantics

Runtime Semantics: LoopContinues Abstract Operation

The abstract operation `LoopContinues` with arguments `completion` and `labelSet` is defined by the following step:

1. If `completion.[[type]]` is `normal`, then return `true`.
2. If `completion.[[type]]` is not `continue`, then return `false`.
3. If `completion.[[target]]` is `empty`, then return `true`.
4. If `completion.[[target]]` is an element of `labelSet`, then return `true`.
5. Return `false`.

NOTE Within the `Statement` part of an `IterationStatement` a `ContinueStatement` may be used to begin a new iteration.

12.6.1 The `do-while` Statement

Static Semantics: VarDeclaredNames

IterationStatement : do Statement while (Expression)

1. Return the `VarDeclaredNames` of `Statement`.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument `labelSet`.

IterationStatement : do Statement while (Expression)

1. Let `V = undefined`.
2. Repeat
 - a. Let `stmt` be the result of evaluating `Statement`.
 - b. If `stmt.[[value]]` is not `empty`, let `V = stmt.[[value]]`.
 - c. If `stmt` is an abrupt completion and `LoopContinues (stmt,labelSet)` is `false`, return `stmt`.
 - d. Let `exprRef` be the result of evaluating `Expression`.
 - e. Let `exprValue` be `ToBoolean(GetValue(exprRef))`.
 - f. If `exprValue` is `false`, Return `NormalCompletion(V)`.
 - g. Else if `exprValue` is not `true`, then
 - i. Assert: `exprValue` is an abrupt completion.
 - ii. If `LoopContinues (exprValue,labelSet)` is `false`, return `exprValue`.

12.6.2 The `while` Statement

Static Semantics: VarDeclaredNames

IterationStatement : while (Expression) Statement

1. Return the `VarDeclaredNames` of `Statement`.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument `labelSet`.

IterationStatement : while (Expression) Statement

Comment [AWB6103]: Note that this is technically a breaking change from ES5, however it is made to match web reality.

Deleted: ForBinding :
BindingIdentifier
BindingPattern ¶

Formatted: Note

Deleted: Within the `Statement` part of an `IterationStatement` a `ContinueStatement` may be used to begin a new iteration. This semantics is defined using t

Deleted: The

Deleted: loopContinues

Deleted: be

Deleted: s

Deleted: The `VarDeclaredNames` of the production

Deleted: ;

Deleted: is determined as follows:

Deleted: Runtime Semantics: Evaluation ¶

Deleted: The production

Deleted: ;

Deleted: is evaluated as follows:

Comment [AWB6104]: Breaking change: completion reform

Deleted: empty

Deleted: <#>Let iterating be true.¶

Deleted: ,

Deleted: while iterating is true

Deleted: <#>If `stmt.type` is not `continue` or || `stmt.target` is not in the current label set, then¶
<#>If `stmt.type` is `break` and `stmt.target` is in the current label set, return (normal, `V`, empty).¶

Deleted: loopContinues

Deleted: ToBoolean(GetValue(exprRef))

Deleted: set `iterating` to false

Comment [AWB6105]: Break/continue/return in the expression works normally (future for `do {}` or block label expressions)

Deleted: a Completion Record

Deleted: loopContinues

Deleted: Return (normal, `V`, empty);¶

Deleted: The `VarDeclaredNames` of the production

Deleted: `Statement` is determined as follows:

Deleted: Runtime Semantics: Evaluation ¶

Deleted: The production

Deleted: is evaluated as follows:

1. Let $V = \text{undefined}$.
2. Repeat
 - a. Let exprRef be the result of evaluating Expression .
 - b. Let exprValue be $\text{ToBoolean}(\text{GetValue}(\text{exprRef}))$.
 - c. If exprValue is **false**, return $\text{NormalCompletion}(V)$.
 - d. If exprValue is not **true**, then
 - i. Assert: exprValue is an abrupt completion.
 - ii. If $\text{LoopContinues}(\text{exprValue}.labelSet)$ is **false**, return exprValue .
 - e. Let stmt be the result of evaluating Statement .
 - f. If $\text{stmt}[[\text{value}]]$ is not empty, let $V = \text{stmt}[[\text{value}]]$.
 - g. If $\text{LoopContinues}(\text{stmt}.labelSet)$ is **false**, return stmt .

12.6.3 The `for` Statement

Static Semantics

Static Semantics: VarDeclaredNames

IterationStatement : `for` ($\text{ExpressionNoIn}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. Return the `VarDeclaredNames` of Statement .

IterationStatement : `for` (`var` $\text{VariableDeclarationListNoIn}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. Let names be `BoundNames` of $\text{VariableDeclarationListNoIn}$.
2. Append to names the elements of the `VarDeclaredNames` of Statement .
3. Return names .

IterationStatement : `for` ($\text{LexicalDeclarationNoIn}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. Return the `VarDeclaredNames` of Statement .

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument labelSet .

IterationStatement : `for` ($\text{ExpressionNoIn}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. If ExpressionNoIn is present, then
 - a. Let exprRef be the result of evaluating ExpressionNoIn .
 - b. Let exprValue be $\text{GetValue}(\text{exprRef})$.
 - c. If $\text{LoopContinues}(\text{exprValue}.labelSet)$ is **false**, return exprValue .
2. Return the result of performing For Body Evaluation with the first Expression as the testExpr argument, the second Expression as the incrementExpr argument, Statement as the stmt argument, and with labelSet .

IterationStatement : `for` (`var` $\text{VariableDeclarationListNoIn}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. Let varDcl be the result of evaluating $\text{VariableDeclarationListNoIn}$.
2. If $\text{LoopContinues}(\text{varDcl}.labelSet)$ is **false**, return varDcl .
3. Return the result of performing For Body Evaluation with the first Expression as the testExpr argument, the second Expression as the incrementExpr argument, Statement as the stmt argument, and with labelSet .

IterationStatement : `for` ($\text{LexicalDeclarationNoIn}$; $\text{Expression}_{\text{opt}}$; $\text{Expression}_{\text{opt}}$) Statement

1. Let oldEnv be the running execution context's $\text{LexicalEnvironment}$.
2. Let loopEnv be the result of calling $\text{NewDeclarativeEnvironment}$ passing oldEnv as the argument.
3. Let isConst be the result of performing $\text{IsConstantDeclaration}$ of $\text{LexicalDeclarationNoIn}$.

Comment [AWB6106]: ES5 breaking change: completion reform
Deleted: empty
Deleted: $\text{ToBoolean}(\text{GetValue}(\text{exprRef}))$
Deleted: (normal,
Deleted: , empty
Comment [AWB6107]: Break/continue/return in the expressions works normally (future for $\{\}$ or block lambda expressions)
Deleted: Else i
Deleted: a Completion Record
Deleted: loopContinues
Deleted: <#>If stmt.type is not continue or stmt.target is not in the current label set, then <#>If stmt.type is break and stmt.target is in the current label set, then <#>Return (normal, V , empty).¶
Deleted: stmt is an abrupt completion
Deleted: loopContinues
Comment [AWB 3108]: The lexical scope of for iteration variables still needs to be taken care of
Deleted: The <code>VarDeclaredNames</code> of the production
Deleted: is determined as follows:
Deleted: Runtime Semantics: Evaluation
Deleted: The production
Deleted: is evaluated as follows:
Deleted: .
Deleted: Call
Deleted: (This value is not used but the call may have side-effects.)
Deleted: loopContinues
Deleted: increment
Deleted: testExpr
Comment [AWB6109]: ES5 breaking change: Completion reform
Deleted: The abstraction operation For Body Evaluation with arguments testExpr , incrementExpr , and labelSet is performed as follows:¶
Deleted: loopContinues
Deleted: incrementExpr
Deleted: testExpr
Comment [AWB6110]: A final decision has
Deleted: <#>Evaluate
Deleted: running
Deleted: current
Deleted: the
Deleted: d

4. For each element *dn* of the *BoundNames* of *LexicalDeclarationNoIn* do
 - a. If *isConst* is **true**, then
 - i. Call *loopEnv*'s *CreateImmutableBinding* concrete method passing *dn* as the argument.
 - b. Else,
 - i. Call *loopEnv*'s *CreateMutableBinding* concrete method passing *dn* and **false** as the arguments.
5. Set the running execution context's *LexicalEnvironment* to *loopEnv*.
6. Let *forDcl* be the result of evaluating *LexicalDeclarationNoIn*.
7. If *LoopContinues*(*forDcl*.*labelSet*) is **false**, then
 - a. Set the running execution context's *LexicalEnvironment* to *oldEnv*.
 - b. Return *forDcl*.
8. Let *bodyResult* be the result of performing For Body Evaluation with the first *Expression* as the *testExpr* argument, the second *Expression* as the *incrementExpr* argument, *Statement* as the *stmt* argument, and with *labelSet*.
9. Set the running execution context's *LexicalEnvironment* to *oldEnv*.
10. Return *bodyResult*.

Runtime Semantics: For Body Evaluation Abstract Operation

The abstract operation For Body Evaluation with arguments *testExpr*, *incrementExpr*, *stmt*, and *labelSet* is performed as follows:

1. Let *V* = **undefined**.
2. Repeat
 - a. If *testExpr* is not **[empty]**, then
 - i. Let *testExprRef* be the result of evaluating *testExpr*.
 - ii. Let *testExprValue* be *ToBoolean*(*GetValue*(*testExprRef*))
 - iii. If *testExprValue* is **false**, return *NormalCompletion*(*V*).
 - iv. Else if *LoopContinues*(*testExprValue*.*labelSet*) is **false**, return *testExprValue*.
 - b. Let *result* be the result of evaluating *stmt*.
 - c. If *result*.**[value]** is not **empty**, let *V* = *result*.**[value]**.
 - d. If *LoopContinues*(*result*.*labelSet*) is **false**, return *result*.
 - e. If *incrementExpr* is not **[empty]**, then
 - i. Let *incExprRef* be the result of evaluating *incrementExpr*.
 - ii. Let *incExprValue* be *GetValue*(*incExprRef*).
 - iii. If *LoopContinues*(*incExprValue*.*labelSet*) is **false**, return *incExprValue*.

12.6.4 The for-in and for-of Statements

Static Semantics

Static Semantics: Early Errors

IterationStatement :

for (*LeftHandSideExpression* **in** *Expression*) *Statement*
for (*LeftHandSideExpression* **of** *AssignmentExpression*) *Statement*

- It is a Syntax Error *LeftHandSideExpression* is either an *ObjectLiteral* or an *ArrayLiteral* and if the lexical token sequence matched by *LeftHandSideExpression* cannot be parsed with no tokens left over using *AssignmentPattern* as the goal symbol.
- If *LeftHandSideExpression* is either an *ObjectLiteral* or an *ArrayLiteral* and if the lexical token sequence matched by *LeftHandSideExpression* can be parsed with no tokens left over using *AssignmentPattern* as the goal symbol then the following rules are not applied. Instead, the Early Error rules for *AssignmentPattern* are used.
- It is a Syntax Error if the *LeftHandSideExpression* is an *Identifier* that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
- It is a Syntax Error if *LeftHandSideExpression* is neither an *ObjectLiteral* nor an *ArrayLiteral* and *IsValidSimpleAssignmentTarget* of *LeftHandSideExpression* is **false**.

Deleted: running
Deleted: current
Deleted: loopContinues
Deleted: varDcl
Deleted: running
Deleted: current
Deleted: varDcl
Deleted: increment
Deleted: testExpr
Deleted: running
Deleted: current

Comment [AWB6111]: ES5 breaking change:
 Completion reform
Deleted:,

- It is a Syntax Error if the *LeftHandSideExpression* is *CoverParenthesisedExpressionAndArrowParameterList* : (*Expression*) and *Expression* derived a production that would produce a Syntax Error according to these rules. This rule is recursively applied.

IterationStatement :

for (ForDeclaration in Expression) Statement
for (ForDeclaration of AssignmentExpression) Statement

- It is a Syntax Error if any element of the *BoundNames* of *ForDeclaration* also occurs in the *VarDeclaredNames* of *Statement*.

Static Semantics: BoundNames

ForDeclaration : LetOrConst ForBinding

1. Return the *BoundNames* of *ForBinding*.

Static Semantics: VarDeclaredNames

IterationStatement : for (LeftHandSideExpression in Expression) Statement

1. Return the *VarDeclaredNames* of *Statement*.

IterationStatement : for (var ForBinding in Expression) Statement

1. Let *names* be the *BoundNames* of *ForBinding*.
2. Append to *names* the elements of the *VarDeclaredNames* of *Statement*.
3. Return *names*

IterationStatement : for (ForDeclaration in Expression) Statement

1. Return the *VarDeclaredNames* of *Statement*.

IterationStatement : for (LeftHandSideExpression of AssignmentExpression) Statement

1. Return the *VarDeclaredNames* of *Statement*.

IterationStatement : for (var ForBinding of AssignmentExpression) Statement

1. Let *names* be the *BoundNames* of *ForBinding*.
2. Append to *names* the elements of the *VarDeclaredNames* of *Statement*.
3. Return *names*

IterationStatement : for (ForDeclaration of AssignmentExpression) Statement

1. Return the *VarDeclaredNames* of *Statement*.

Runtime Semantics

Runtime Semantics: Binding Instantiation

With arguments *value* and *environment*.

ForDeclaration : LetOrConst ForBinding

1. For each element *name* of the *BoundNames* of *ForBinding* do
 - a. If *IsConstantDeclaration* of *LetOrConst* is **false**, then
 - i. Call *environment*'s *CreateMutableBinding* concrete method with argument *name*.

Deleted: <#>It is a Syntax Error if the *IterationStatement* is contained in strict code and *LeftHandSideExpression* is the *Identifier eval* or the *Identifier arguments*.¶
<#>It is a Syntax Error if the *LeftHandSideExpression* is an *Identifier* that statically resolves to a declarative environment record binding and the resolved binding is an immutable binding.¶

Deleted: *z*

Deleted: <#>It is a Syntax Error if the *LeftHandSideExpression* is *PrimaryExpression* : (*Expression*) and *Expression* derived a production that would produce a Syntax Error according to these rules. This rule is recursively applied.

<#>It is a Syntax Error if *IsInvalidAssignmentPattern* of *LeftHandSideExpression* is **true**. It is a Syntax Error if the *LeftHandSideExpression* is an *ObjectLiteral* or an *ArrayLiteral* and the source code corresponding to *LeftHandSideExpression* cannot be parsed using *AssignmentPattern* as goal symbol.¶
/

Deleted: Lexically Declared Names

Deleted: Var Declared Names

Deleted: Bound Names

Deleted: *ForVarDeclaration : BindingPattern*
<#>Return the Bound Names of *BindingPattern*.
ForVarDeclaration : VariableDeclarationNoIn ¶
<#>Return the Bound Names of *VariableDeclarationNoIn*.¶

Deleted: Bound Names

Deleted: *ForBinding : BindingIdentifier* ¶
<#>Return the Bound Names of *BindingIdentifier*

Deleted: Var Declared Names

Deleted: The *VarDeclaredNames* of the production

Deleted: is determined as follows:

Deleted: Var Declared Names

Deleted: *VariableDeclarationNoIn*

Deleted: *BindingIdentifier*

Deleted: Bound Names

Deleted: *Variable*

Deleted: *BindingIdentifier*

Deleted: *DeclarationNoIn*

Deleted: Var Declared Names

Deleted: Var Declared Names

Deleted: Var Declared Names

Deleted: *ForVarDeclaration*

Deleted: Bound Names

Deleted: *ForVarDeclaration*

Deleted: Var Declared Names

Deleted: Var Declared Names

Deleted: Bound Names

- b. Else.
- Call *environment*'s `CreateImmutableBinding` concrete method with argument *name*.
2. Return the result of performing Binding Initialisation for *ForBinding* passing *value* and *environment* as the arguments.

Deleted: Perform

Runtime Semantics: Labelled Evaluation

With argument *labelSet*.

IterationStatement : for (LeftHandSideExpression in Expression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *Expression*, *enumerate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *LeftHandSideExpression*, *Statement*, *keyResult*, *assignment*, and *labelSet*.

IterationStatement : for (var ForBinding in Expression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *Expression*, *enumerate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *ForBinding*, *Statement*, *keyResult*, *varBinding*, and *labelSet*.

IterationStatement : for (ForDeclaration in Expression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *Expression*, *enumerate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *ForDeclaration*, *Statement*, *keyResult*, *lexicalBinding*, and *labelSet*.

IterationStatement : for (LeftHandSideExpression of AssignmentExpression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *AssignmentExpression*, *iterate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *LeftHandSideExpression*, *Statement*, *keyResult*, *assignment*, and *labelSet*.

IterationStatement : for (var ForBinding of AssignmentExpression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *AssignmentExpression*, *iterate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *ForBinding*, *Statement*, *keyResult*, *varBinding*, and *labelSet*.

IterationStatement : for (ForDeclaration of AssignmentExpression) Statement

- Let *keyResult* be the result of performing For In/Of Expression Evaluation with *AssignmentExpression*, *iterate*, and *labelSet*.
- ReturnIfAbrupt(*keyResult*).
- Return the result of performing For In/Of Body Evaluation with *ForDeclaration*, *Statement*, *keyResult*, *lexicalBinding*, and *labelSet*.

Deleted: Runtime Semantics: Binding Initialisation

With arguments *value* and *environment*.¶
NOTE `undefined` is passed for *environment* to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for `var` statements formal parameter lists of non-strict functions.

In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initialiser.¶
ForVarDeclaration : *BindingPattern*¶

<#>Perform Binding Initialisation for *BindingPattern* passing *value* and *env* as the arguments.¶
ForVarDeclaration : *VariableDeclarationNoIn*¶

<#>Perform Binding Initialisation for *VariableDeclarationNoIn* passing *value* and *env* as the arguments.¶
ForBinding : *BindingIdentifier*¶

<#>Perform Binding Initialisation for *BindingIdentifier* passing *value* and *env* as the arguments.¶
ForBinding : *BindingPattern*¶

<#>Perform Binding Initialisation for *BindingPattern* passing *value* and *env* as the arguments.¶
Deleted: Runtime Semantics: Evaluation¶

Deleted: The production

Deleted: is evaluated as follows:

Deleted: *Statement*

Deleted: `.[[value]]`

Deleted: *BindingIdentifier*

Deleted: *Statement*

Deleted: *BindingIdentifier*

Deleted: `.[[value]]`

Deleted: *Statement*

Deleted: `.[[value]]`

Deleted: *ForDeclaration*

Deleted: *Statement*

Deleted: `.[[value]]`

Deleted: *BindingIdentifier*

Deleted: `.[[value]]`

Deleted: *Statement*

Deleted: *BindingIdentifier*

Deleted: `.[[value]]`

Deleted: *ForDeclaration*

Runtime Semantics: For In/Of Expression Evaluation Abstract Operation

The abstract operation For In/Of Expression Evaluation is called with arguments *expr*, *iterationKind*, and *labelSet*. The value of *iterationKind* is either **enumerate** or **iterate**.

1. Let *exprRef* be the result of evaluating the production that is *expr*.
2. Let *exprValue* be GetValue(*exprRef*).
3. If *exprValue* is an abrupt completion,
 - a. If LoopContinues(*exprValue.labelSet*) is **false**, then return *exprValue*.
 - b. Else, return Completion {[[type]]: **break**, [[value]]: **empty**, [[target]]: **empty**}.
4. If *exprValue.[[value]]* is **null** or **undefined**, return Completion {[[type]]: **break**, [[value]]: **empty**, [[target]]: **empty**}.
5. Let *obj* be ToObject(*exprValue*).
6. If *iterationKind* is **enumerate**, then
 - a. Let *keys* be the result of calling the **[[Enumerate]]** internal method of *obj* with no arguments.
7. Else,
 - a. Assert *iterationKind* is **iterate**.
 - b. Let *iterator* be the result of performing **Invoke** with arguments *obj*, **@@iterator**, and an empty List.
 - c. Let *keys* be ToObject(*iterator*).
8. If *keys* is an abrupt completion, then
 - a. If LoopContinues(*exprValue.labelSet*) is **false**, then return *exprValue*.
 - b. Assert: *keys.[[type]]* is **continue**.
 - c. Return Completion {[[type]]: **break**, [[value]]: **empty**, [[target]]: **empty**}.
9. Return *keys*.

Deleted: ion

Deleted: is performed as follows:

Comment [AWB6112]: NOTE that if this a for-let, this places the evaluation of the AssignmentExpression outside the scope of its bindings. Perhaps it should be within that

Deleted: Expression

Deleted: then return

Deleted: loopContinues

Comment [AWB6113]: Note a continue in

Comment [AWB6114]: Completion value

Deleted: undefined,

Comment [AWB6115]: Completion value

Deleted: undefined,

Deleted:

Deleted:

Deleted: (normal, empty, empty)

Deleted: arguments **true** and **true**

Deleted: keys

Deleted: %

Deleted: %,

Comment [AWB6116]: Break/continue in t

Deleted: <#>Let *keys* be the result of calling t

Deleted: LoopContinues

Comment [AWB6117]: Note a continue in

Comment [AWB6118]: Completion value

Deleted: undefined,

Deleted: ion

Deleted: is performed as follows:

Deleted: running

Deleted: current

Comment [AWB6119]: Completion value

Deleted:)

Deleted: empty

Deleted: next

Deleted: performing

Deleted: with arguments

Deleted: , *keys*, and an empty arguments List

Deleted: IteratorComplete(next)

Deleted: <#>If

Deleted: <#>Let *P* be the name of the next

Deleted: the **LeftHandSideExpression**

Deleted: Call

Deleted: *P*

Comment [AWB6120]: Recent

Comment [AWB6121]: ToDo, update this

Runtime Semantics: For In/Of Body Evaluation Abstract Operation

The abstract operation For In/Of Body Evaluation is called with arguments *lhs*, *stmt*, *keys*, *lhsKind*, and *labelSet*. The value of *lhsKind* is either **assignment**, **varBinding** or **lexicalBinding**.

1. Let *oldEnv* be the running execution context's LexicalEnvironment.
2. Let *noArgs* be an empty List.
3. Let *V* = **undefined**.
4. Repeat
 - a. Let *nextResult* be the result of **Invoke(keys, "next")**.
 - b. ReturnIfAbrupt(*nextResult*).
 - c. If Type(*nextResult*) is not Object, then throw a **TypeError** exception.
 - d. Let *done* be **IteratorComplete(innerResult)**.
 - e. ReturnIfAbrupt(*done*).
 - f. If *done* is **true**, then return **NormalCompletion(V)**.
 - g. Let *nextValue* be the result of **IteratorValue(nextResult)**.
 - h. ReturnIfAbrupt(*nextValue*).
 - i. If *lhsKind* is **assignment**, then
 - i. Assert: *lhs* is a **LeftHandSideExpression**.
 - ii. If *lhs* is neither an **ObjectLiteral** nor an **ArrayLiteral** then
 1. Let *lhsRef* be the result of evaluating *lhs* (it may be evaluated repeatedly).
 2. Let *status* be the result of performing **PutValue(lhsRef, nextValue)**.
 - iii. Else
 1. Let *AssignmentPattern* be the parse of the source code corresponding to *lhs* using *AssignmentPattern* as the goal symbol.
 2. Let *rval* be **ToObject(nextValue)**.
 3. If *rval* is an abrupt completion, then let *status* be *rval*.
 4. Else, let *status* be the result of performing **Destructuring Assignment Evaluation** of *AssignmentPattern* using *rval* as the argument.
 - j. Else if *lhsKind* is **varBinding**, then
 - i. Assert: *lhs* is a **ForBinding**.
 - ii. Let *status* be the result of performing **Binding Initialisation** for *lhs* passing *nextValue* and **undefined** as the arguments.
 - k. Else,

- i. Assert *IhsKind* is `lexicalBinding`.
 - ii. Assert: *Ihs* is a `ForDeclaration`.
 - iii. Let *iterationEnv* be the result of calling `NewDeclarativeEnvironment` passing *oldEnv* as the argument.
 - iv. Perform `Binding Instantiation` for *Ihs* passing *nextValue* and *iterationEnv* as arguments.
 - v. Let *status* be `NormalCompletion(empty)`.
 - vi. Set the running execution context's LexicalEnvironment to *iterationEnv*.
1. If *status.[[type]]* is normal, then
 - i. Let *status* be the result of evaluating *stmt*.
 - ii. If *status.[[type]]* is normal and *status.[[value]]* is not empty, then
 1. Let *V* = *status.[[value]]*.
 - m. Set the running execution context's LexicalEnvironment to *oldEnv*.
 - n. If *status* is an abrupt completion and `LoopContinues(status,labelSet)` is false, then return *status*.

12.7 The continue Statement

Syntax

ContinueStatement :
 `continue` ;
 `continue` [no *LineTerminator* here] *Identifier* ;

Static Semantics

Static Semantics: Early Errors

ContinueStatement : `continue` ;

- It is a Syntax Error if this production is not nested, directly or indirectly (but not crossing function boundaries), within an *IterationStatement*.

ContinueStatement : `continue` [no *LineTerminator* here] *Identifier* ;

- It is a Syntax Error if *Identifier* does not appear in the *CurrentLabelSet* of an enclosing (but not crossing function boundaries) *IterationStatement*.

Runtime Semantics

Runtime Semantics: Evaluation

ContinueStatement : `continue` ;

1. Return `Completion{[[type]]: continue, [[value]]: empty, [[target]]: empty}`.

ContinueStatement : `continue` [no *LineTerminator* here] *Identifier* ;

1. Return `Completion{[[type]]: continue, [[value]]: empty, [[target]]: Identifier}`.

12.8 The break Statement

Syntax

BreakStatement :
 `break` ;
 `break` [no *LineTerminator* here] *Identifier* ;

Static Semantics

Static Semantics: Early Errors

Deleted: `ForDeclaration`

Comment [AWB11122]: Need to understand why result of previous step is ignored. See bug 811

Deleted: `running`

Deleted: `current`

Deleted: *stmt*

Deleted: `Statement`

Deleted: If *stmt.value* is not empty, I

Deleted: *stmt*

Deleted: `running`

Deleted: `current`

Deleted: `loopContinues`

Deleted: <#>If *stmt.type* is `break` and *stmt.target* is in the current label set, return (normal, *V*, empty).
 <#>If *stmt.type* is not `continue` or|| *stmt.target* is not in the current label set, then
 <#>If *stmt* is an abrupt completion, return *stmt*.¶

Deleted: The `VarDeclaredNames` of the production
`for (var VariableDeclarationNoIn in Expression) Statement`
Statement is determined as follows:
 Let *names* be `BoundNames` of `VariableDeclarationNoIn`.¶
 Append to *names* the elements of the `VarDeclaredNames` of *Statement*.¶
 Return *names*.¶

Deleted: The production
`IterationStatement : for (var VariableDeclarationNoIn in Expression) Statement`
Statement is evaluated as follows:
 Let *varName* be the result of evaluating `VariableDeclarationNoIn`.¶
 Let *exprRef* be the result of evaluating the `Expression`.
 Let *exprValue* be `GetValue(exprRef)`.¶
 If *exprValue* is null or undefined, return (normal, empty, empty).¶
 Let *obj* be `ToObject(exprValue)`.¶
 Let *V* = empty.¶
 Repeat¶
 Let *P* be the name of the next property of *obj* whose `[[Enumerable]]` attribute is true. If there is no such property, return (normal, *V*, empty).¶

Deleted: Semantics¶

Deleted: A program is considered syntactically incorrect if either of the following is true:
 Deleted: The program contains a `continue` statement without the optional *Identifier*, which

Deleted: The program contains a `continue` statement with the optional *Identifier*, where

Deleted: label set

Deleted: A `ContinueStatement` without an *Identifier* is evaluated as follows:
 Deleted: (

Deleted: (

Deleted: A `ContinueStatement` with the optional *Identifier* evaluated as follows:
 Deleted: (

Deleted:).

BreakStatement : break ;

- It is a Syntax Error if this production is not nested, directly or indirectly (but not crossing function boundaries), within an *IterationStatement* or a *SwitchStatement*.

BreakStatement : break [no LineTerminator here] Identifier;

- It is a Syntax Error if *Identifier* does not appear in the *CurrentLabelSet* of an enclosing (but not crossing function boundaries) Statement.

Runtime Semantics

Runtime Semantics: Evaluation

BreakStatement : break ;

1. Return Completion {[[type]]: break, [[value]]: empty, [[target]]: empty}.

BreakStatement : break [no LineTerminator here] Identifier;

1. Return Completion {[[type]]: break, [[value]]: empty, [[target]]: *Identifier*}.

12.9 The return Statement

Syntax

ReturnStatement :
 return ;
 return [no LineTerminator here] Expression ;

NOTE 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*.

Static Semantics

Static Semantics: Early Errors

- It is a Syntax Error if a *return* statement is not within a *FunctionBody* or a *GeneratorBody*.

Runtime Semantics

Runtime Semantics: Evaluation

ReturnStatement : return ;

1. Return Completion {[[type]]: return, [[value]]: **undefined**, [[target]]: empty}.

ReturnStatement : return [no LineTerminator here] Expression ;

1. Let *exprRef* be the result of evaluating *Expression*.

2. Let *exprValue* be *GetValue(exprRef)*.

3. *ReturnIfAbrupt(exprValue)*.

4. Return Completion {[[type]]: return, [[value]]: *exprValue*, [[target]]: empty}.

12.10 The with Statement

Syntax

WithStatement :
 with (*Expression*) *Statement*

Deleted: Semantics
 A program is considered syntactically incorrect if either of the following is true:
Deleted: The program contains a **break** statement without the optional *Identifier*, where
Deleted: The program contains a **break** statement with the optional *Identifier*, where
Deleted: label set

Deleted: A *BreakStatement* without an *Identifier* is evaluated as follows:
Deleted: (*Identifier*).
Deleted: ().
Deleted: A *BreakStatement* with an *Identifier* is evaluated as follows:
Deleted: (*Identifier*).
Deleted: ().
Deleted: ().

Deleted: <#>Semantics
Deleted: An ECMAScript program is considered syntactically incorrect if it contains
Deleted: that
Deleted: 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*.

Deleted: A *ReturnStatement* is evaluated as follows:
 If the *Expression* is not present, r

Deleted: (*Identifier*).
Deleted: ().

Comment [AWB9123]: TODO If *exprRef* is a Reference that invokes a getter we probably should find a way to specify that the get call is handled as a tail call.

Deleted: If *exprValue* is an abrupt completion, return *exprValue*

Deleted: (*Identifier*).

Deleted: *GetValue(exprRef)*

Deleted: ().

NOTE The `with` statement adds an object environment record for a computed object to the lexical environment of the running execution context. It then executes a statement using this augmented lexical environment. Finally, it restores the original lexical environment.

Deleted: current

Static Semantics

Static Semantics: Early Errors

WithStatement : with (Expression) Statement

- It is a Syntax Error if the code that matches this production is contained in strict code.

Deleted: Semantics¶
The static semantics of the production

Deleted: are:

Deleted: static

Static Semantics: VarDeclaredNames

WithStatement : with (Expression) Statement

1. Return the VarDeclaredNames of Statement.

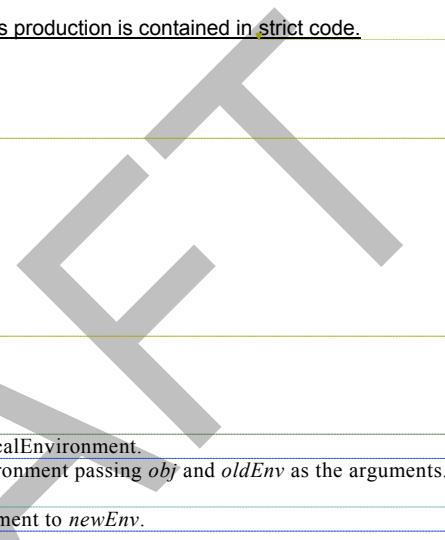
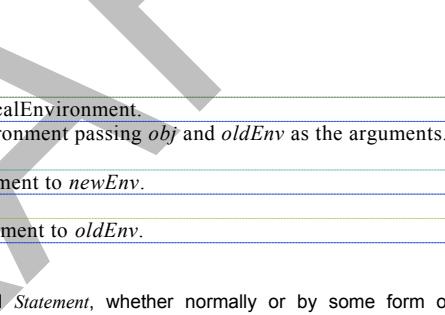
Deleted: The VarDeclaredNames of the production

Deleted: is determined as follows:

Runtime Semantics

Runtime Semantics: Evaluation

WithStatement : with (Expression) Statement

1. Let val be the result of evaluating Expression.
2. Let obj be ToObject(GetValue(val)).
3. ReturnIfAbrupt(obj).

4. Let oldEnv be the running execution context's LexicalEnvironment.
5. Let newEnv be the result of calling NewObjectEnvironment passing obj and oldEnv as the arguments.
6. Set the withEnvironment flag of newEnv to true.
7. Set the running execution context's LexicalEnvironment to newEnv.
8. Let C be the result of evaluating Statement.

9. Set the running execution context's Lexical Environment to oldEnv.
10. Return C.

NOTE No matter how control leaves the embedded Statement, whether normally or by some form of abrupt completion or exception, the LexicalEnvironment is always restored to its former state.

Deleted: The production

Deleted: is evaluated as follows:

Deleted: If obj is an abrupt completion, return obj

Deleted: j

Deleted: running

Deleted: current

Deleted: provideThis

Deleted: running

Deleted: current

Deleted: but if an exception is thrown during the evaluation
let C be (throw, V, empty), where V is the exception.
(Execution now proceeds as if no exception were thrown.)

Deleted: running

Deleted: current

Deleted: 12.10.1 Strict Mode Restrictions¶

Strict mode code may not include a WithStatement.
The occurrence of a WithStatement in such a context is treated as a SyntaxError.¶

12.11 The `switch` Statement

Syntax

SwitchStatement :
 switch (Expression) CaseBlock

CaseBlock :
 { CaseClauses_{opt} }
 { CaseClauses_{opt} DefaultClause CaseClauses_{opt} }

CaseClauses :
 CaseClause
 CaseClauses CaseClause

CaseClause :
 case Expression : StatementList_{opt}

DefaultClause :
 default : StatementList_{opt}

Static Semantics

Static Semantics: Early Errors

CaseBlock : { CaseClauses }

- It is a Syntax Error if the LexicallyDeclaredNames of *CaseClauses* contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of *CaseClauses* also occurs in the VarDeclaredNames of *CaseClauses*.

Deleted: are:

Deleted: i

Static Semantics: LexicalDeclarations

CaseBlock : {}

1. Return a new empty List.

CaseBlock : { CaseClauses_{opt} DefaultClause CaseClauses_{opt} }

1. If the first *CaseClauses* is present, let *declarations* be the LexicalDeclarations of the first *CaseClauses*.
2. Else let *declarations* be a new empty List.
3. Append to *declarations* the elements of the LexicalDeclarations of the *DefaultClause*.
4. If the second *CaseClauses* is not present, return *declarations*.
5. Else return the result of appending to *declarations* the elements of the LexicalDeclarations of the second *CaseClauses*.

Deleted: *CaseClause* : **case** Expression : StatementList ¶
 <#> It is a Syntax Error if *StatementList* includes a *StatementListItem* : *FunctionDeclaration* production and the source code matching this *CaseClause* production is not contained in extended code.¶

Deleted: *CaseBlock* : { *CaseClauses* } ¶
 <#> Return the LexicalDeclarations of *CaseClauses*

CaseClauses : CaseClauses CaseClause

1. Let *declarations* be LexicalDeclarations of *CaseClauses*.
2. Append to *declarations* the elements of the LexicalDeclarations of *CaseClause*.
3. Return *declarations*.

Deleted: LexicallyDeclaredNames

Deleted: names

Deleted: names

Deleted: the

Deleted: lyDeclaredNames

Deleted: *CaseClauses* : *CaseClause* ¶
 <#> Return the LexicalDeclarations of *CaseClause*

Deleted: names

CaseClause : case Expression : StatementList_{opt}

1. If the *StatementList* is present, return the LexicalDeclarations of *StatementList*.
2. Else return a new empty List.

DefaultClause : default : StatementList_{opt}

1. If the *StatementList* is present, return the LexicalDeclarations of *StatementList*.
2. Else return a new empty List.

Static Semantics: LexicallyDeclaredNames

CaseBlock : {}

1. Return a new empty List.

CaseBlock : { CaseClauses_{opt} DefaultClause CaseClauses_{opt} }

1. If the first *CaseClauses* is present, let *names* be the LexicallyDeclaredNames of the first *CaseClauses*.
2. Else let *names* be a new empty List.
3. Append to *names* the elements of the LexicallyDeclaredNames of the *DefaultClause*.
4. If the second *CaseClauses* is not present, return *names*.
5. Else return the result of appending to *names* the elements of the LexicallyDeclaredNames of the second *CaseClauses*.

Deleted: *CaseBlock* : { *CaseClauses* } ¶
 <#> Return the LexicallyDeclaredNames of *CaseClauses* ¶

Deleted: the

Deleted: *CaseClauses* : *CaseClause* ¶
 <#> Return the LexicallyDeclaredNames of *CaseClause* ¶

CaseClauses : CaseClauses CaseClause

1. Let *names* be LexicallyDeclaredNames of *CaseClauses*.

2. Append to *names* the elements of the LexicallyDeclaredNames of *CaseClause*.
3. Return *names*.

CaseClause : **case** *Expression* : *StatementList*_{opt}

1. If the *StatementList* is present, return the LexicallyDeclaredNames of *StatementList*.
2. Else return a new empty List.

DefaultClause : **default** : *StatementList*_{opt}

1. If the *StatementList* is present, return the LexicallyDeclaredNames of *StatementList*.
2. Else return a new empty List.

Static Semantics: VarDeclaredNames

SwitchStatement : **switch** (*Expression*) *CaseBlock*

1. Return the VarDeclaredNames of *CaseBlock*.

CaseBlock : { }

1. Return a new empty List.

CaseBlock : { *CaseClauses*_{opt} *DefaultClause* *CaseClauses*_{opt} }

1. If the first *CaseClauses* is present, let *names* be the VarDeclaredNames of the first *CaseClauses*.
2. Else let *names* be a new empty List.
3. Append to *names* the elements of the VarDeclaredNames of the *DefaultClause*.
4. If the second *CaseClauses* is not present, return *names*.
5. Else return the result of appending to *names* the elements of the VarDeclaredNames of the second *CaseClauses*.

CaseClauses : *CaseClauses* *CaseClause*

1. Let *names* be VarDeclaredNames of *CaseClauses*.
2. Append to *names* the elements of the VarDeclaredNames of *CaseClause*.
3. Return *names*.

CaseClause : **case** *Expression* : *StatementList*_{opt}

1. If the *StatementList* is present, return the VarDeclaredNames of *StatementList*.
2. Else return a new empty List.

DefaultClause : **default** : *StatementList*_{opt}

1. If the *StatementList* is present, return the VarDeclaredNames of *StatementList*.
2. Else return a new empty List.

Runtime Semantics

Runtime Semantics: Case Block Evaluation

With argument *input*.

CaseBlock : { *CaseClauses*_{opt} }

1. Let *V*=**undefined**.
2. Let *A* be the list of *CaseClause* items in source text order.
3. Let *searching* be **true**.

Deleted: Semantics¶

The VarDeclaredNames of the production

Deleted: is determined as follows:

Deleted: *CaseBlock* : { *CaseClauses* } ¶

<#>Return the VarDeclaredNames of *CaseClauses*.¶

Deleted: the

Deleted: *CaseClauses* : *CaseClause* ¶

<#>Return the VarDeclaredNames of *CaseClause*.¶

Deleted: Runtime Semantics: Evaluation¶

The production *SwitchStatement* : **switch** (*Expression*) *CaseBlock* is evaluated as follows:¶

<#>Let *exprRef* be the result of evaluating *Expression*.¶

<#>Let *oldEnv* be the running execution context's LexicalEnvironment.¶

<#>Let *blockEnv* be the result of calling

NewDeclarativeEnvironment passing *oldEnv* as the argument.¶

<#>Perform Block Declaration Instantiation using *CaseBlock* and *blockEnv*.¶

<#>Let *R* be the result of evaluating *CaseBlock*, passing it

GetValue(*exprRef*) as a parameter.¶

<#>Set the running execution context's LexicalEnvironment to *oldEnv*.¶

<#>If *R*.type is **break** and *R*.target is in the current label set (normal, *R*.value, empty).¶

<#>Return *R*.¶

NOTE No matter how control leaves the *SwitchStatement*, the LexicalEnvironment is always restored to its former state.¶

Deleted: The production

Deleted: is given an input parameter, *input*, and is evaluated as follows:

Comment [AWB6124]: ES5 breaking change: completion reform

Deleted: empty

4. Repeat, while *searching* is **true**
- Let *C* be the next *CaseClause* in *A*. If there is no such *CaseClause*, return NormalCompletion(V).
 - Let *clauseSelector* be the result of evaluating *C*.
 - ReturnIfAbrupt(clauseSelector).
 - If *input* is equal to *clauseSelector* as defined by the Strict Equality Comparison Algorithm (11.9.1), then
 - Set *searching* to **false**.
 - If *C* has a *StatementList*, then
 - Evaluate *C*'s *StatementList* and let *R* be the result.
 - ReturnIfAbrupt(R).
 - Let *V* = *R*.[[value]].
5. Repeat
- Let *C* be the next *CaseClause* in *A*. If there is no such *CaseClause*, return NormalCompletion(V).
 - If *C* has a *StatementList*, then
 - Evaluate *C*'s *StatementList* and let *R* be the result.
 - If *R*.[[value]] is not **empty**, then let *V* = *R*.[[value]].
 - If *R* is an abrupt completion, then return Completion {[[type]]: *R*.[[type]], [[value]]: *V*, [[target]]: *R*.[[target]]}.
- CaseBlock* : { *CaseClauses*_{opt} *DefaultClause* *CaseClauses*_{opt} }
- Let *V* = **undefined**.
 - Let *A* be the list of *CaseClause* items in the first *CaseClauses*, in source text order.
 - Let *found* be **false**.
 - Repeat letting *C* be in order each *CaseClause* in *A*
 - If *found* is **false**, then
 - Let *clauseSelector* be the result of Case Selector Evaluation of *C*.
 - If *clauseSelector* is an abrupt completion, then
 - If *clauseSelector*.[[value]] is **empty**, then return Completion {[[type]]: *clauseSelector*.[[type]], [[value]]: **undefined**, [[target]]: *clauseSelector*.[[target]]}.
 - Else, return *clauseSelector*.
 - If *input* is equal to *clauseSelector* as defined by the Strict Equality Comparison Algorithm (11.9.1), then set *found* to **true**.
 - If *found* is **true**, then
 - Evaluate *CaseClause C* and let *R* be the result.
 - If *R*.[[value]] is not **empty**, then let *V* = *R*.[[value]].
 - If *R* is an abrupt completion, then return Completion {[[type]]: *R*.[[type]], [[value]]: *V*, [[target]]: *R*.[[target]]}.
 - Let *foundInB* be **false**.
 - If *found* is **false**, then
 - Let *B* be a new list of the *CaseClause* items in the second *CaseClauses*, in source text order.
 - Repeat, letting *C* be in order each *CaseClause* in *B*
 - If *foundInB* is **false**, then
 - Let *clauseSelector* be the result of Case Selector Evaluation of *C*.
 - If *clauseSelector* is an abrupt completion, then
 - If *clauseSelector*.[[value]] is **empty**, then return Completion {[[type]]: *clauseSelector*.[[type]], [[value]]: **undefined**, [[target]]: *clauseSelector*.[[target]]}.
 - Else, return *clauseSelector*.
 - If *input* is equal to *clauseSelector* as defined by the Strict Equality Comparison Algorithm (11.9.1), then set *foundInB* to **true**.
 - If *foundInB* is **true**, then
 - Evaluate *CaseClause C* and let *R* be the result.
 - If *R*.[[value]] is not **empty**, then let *V* = *R*.[[value]].
 - If *R* is an abrupt completion, then return Completion {[[type]]: *R*.[[type]], [[value]]: *V*, [[target]]: *R*.[[target]]}.
 - If *foundInB* is **true**, then return NormalCompletion(V).
 - Evaluate *DefaultClause*, and let *R* be the result.
 - If *R*.[[value]] is not **empty**, then let *V* = *R*.[[value]].
 - If *R* is an abrupt completion, then return Completion {[[type]]: *R*.[[type]], [[value]]: *V*, [[target]]: *R*.[[target]]}.
 - Let *B* be a new list of the *CaseClause* items in the second *CaseClauses*, in source text order.

12. Repeat, letting C be in order each *CaseClause* in B (NOTE this is another complete iteration of the second *CaseClauses*)

- b. Evaluate *CaseClause* C , and let R be the result.
- c. If $R.[[value]]$ is not empty, then let $V = R.[[value]]$.
- d. If R is an abrupt completion, then return Completion {[[type]]: $R.[[type]]$, [[value]]: V , [[target]]: $R.[[target]]$ }.

13. Return NormalCompletion(V).

Runtime Semantics: Case Selector Evaluation

CaseClause : **case** *Expression* : *StatementList*_{opt}

1. Let *exprRef* be the result of evaluating *Expression*.
2. Return GetValue(*exprRef*).

NOTE Case Selector Evaluation 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.

Runtime Semantics: Evaluation

SwitchStatement : **switch** (*Expression*) *CaseBlock*

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *switchValue* be GetValue(*exprRef*).
3. ReturnIfAbrupt(*switchValue*).
4. Let *oldEnv* be the running execution context's LexicalEnvironment.
5. Let *blockEnv* be the result of calling NewDeclarativeEnvironment passing *oldEnv* as the argument.
6. Perform Block Declaration Instantiation using *CaseBlock* and *blockEnv*.
7. Let R be the result of performing Case Block Evaluation of *CaseBlock* with argument *switchValue*.
8. Set the running execution context's LexicalEnvironment to *oldEnv*.
9. Return R .

NOTE No matter how control leaves the *SwitchStatement* the LexicalEnvironment is always restored to its former state.

CaseClause : **case** *Expression* :

1. Return NormalCompletion(empty).

CaseClause : **case** *Expression* : *StatementList*

1. Return the result of evaluating *StatementList*.

DefaultClause : **default**:

1. Return NormalCompletion(empty).

DefaultClause : **default**: *StatementList*

1. Return the result of evaluating *StatementList*.

12.12 Labelled Statements

Syntax

LabelledStatement :
 Identifier : *Statement*

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

Deleted: Note

Deleted: that if step 7.a.i has been performed this loop does not start at the beginning of B

Deleted: <#>Let C be the next *CaseClause* in B . If there is no such *CaseClause*, return NormalCompletion((normal, V , empty)).

<#>If C has a *StatementList*, then ¶

Deleted: 's *StatementList*

Deleted: return ($R.type$, V , $R.target$)

Deleted: Evaluating

Deleted: *CaseClause*

Deleted: If *switchValue* is an abrupt completion, return *switchValue*

Deleted: running

Deleted: current

Deleted: running

Deleted: current

Deleted: <#>If $R.[[type]]$ is break and $R.[[target]]$ is in *CurrentLabelSet*, return NormalCompletion($R.[[value]]$). ¶

Deleted: [empty]

Deleted: The production

Deleted: opt

Deleted: is evaluated as follows:

Deleted: [empty]

Deleted: Let *exprRef* be the result of evaluating *Expression*. ¶

Return GetValue(*exprRef*). ¶

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. ¶

Deleted: Semantics ¶

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.

Static Semantics

Static Semantics: Early Errors

- It is a Syntax Error if a *LabelledStatement* is enclosed by a *LabelledStatement* with the same *Identifier* as the enclosed *LabelledStatement*. This does not apply to a *LabelledStatement* appearing within the body of a *FunctionDeclaration* and a *LabelledStatement* that encloses directly or indirectly the *FunctionDeclaration*.

Static Semantics: VarDeclaredNames

LabelledStatement : *Identifier* : *Statement*

1. Return the *VarDeclaredNames* of *Statement*.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument *labelSet*.

LabelledStatement : *Identifier* : *Statement*

1. Let *label* be the *StringValue* of *Identifier*.
2. Let *newLabelSet* be a new *List* containing *label* and the elements of *labelSet*.
3. If *Statement* is either *LabelledStatement* or *BreakableStatement*, then
 - a. Let *stmtResult* be the result of performing Labelled Evaluation of *Statement* with argument *newLabelSet*.
4. Else,
 - a. Let *stmtResult* be the result of evaluating *Statement*.
5. If *stmtResult*.[[type]] is **break** and *stmtResult*.[[target]] is the same value as *label*, then
 - a. Let *result* be *NormalCompletion*(*stmtResult*.[[value]]).
6. Else,
 - a. Let *result* be *stmtResult*.
7. Return *result*.

Runtime Semantics: Evaluation

LabelledStatement : *Identifier* : *Statement*

3. Let *newLabelSet* be a new empty *List*.
4. Return the result of performing Labelled Evaluation of this *LabelledStatement* with argument *newLabelSet*.

12.13 The **throw** Statement

Syntax

ThrowStatement :
 throw [no *LineTerminator* here] *Expression* ;

Runtime Semantics: Evaluation

The production *ThrowStatement* : **throw** [no *LineTerminator* here] *Expression* ; is evaluated as follows:

Deleted: An ECMAScript program is considered syntactically incorrect if it contains
Deleted: that
Deleted: label
Deleted: labels
Deleted: that
Deleted: is
Deleted: nested
Deleted: ,
Deleted: within
Deleted: a labelled statement
Deleted: The *VarDeclaredNames* of the production *DefaultCase*
Deleted: *t* is determined as follows:

Deleted:
Deleted: I

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

Deleted: Prior to the evaluation of a *LabelledStatement*, the contained *Statement* is regarded as possessing an empty label set unless it is an *IterationStatement* or a *SwitchStatement*, in which case it is regarded as possessing a label set consisting of the single element, **empty**.¶

Deleted: Semantics¶

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *exprValue* be *GetValue(exprRef)*.
3. ReturnIfAbrupt(*exprValue*).
4. Return *Completion* {[[type]]: *throw*, [[value]]: *GetValue(exprRef)*, [[target]]: empty}.

12.14 The `try` Statement

Syntax

TryStatement :

`try` *Block* *Catch*
`try` *Block* *Finally*
`try` *Block* *Catch* *Finally*

Catch :

`catch` (*CatchParameter*) *Block*

Finally :

`finally` *Block*

CatchParameter :

BindingIdentifier
BindingPattern

NOTE 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 *CatchParameter* is bound to that exception.

Deleted: *Identifier*

Formatted: Note

Deleted: *Identifier*

Static Semantics

Static Semantics: Early Errors

Catch : `catch` (*CatchParameter*) *Block*

- It is a Syntax Error if any element of the *BoundNames* of *CatchParameter* also occurs in the *LexicallyDeclaredNames* of *Block*.
- It is a Syntax Error if any element of the *BoundNames* of *CatchParameter* also occurs in the *VarDeclaredNames* of *Block*.

Deleted: the code that matches this production is contained in extended code and

Comment [AWB126]: Note that this is a new restriction that does not exist in ES5

Deleted: Static Semantics: *BoundNames*¶

CatchParameter: *BindingIdentifier* ¶
<#>Return the *BoundNames* of *BindingIdentifier*. ¶
CatchParameter: *BindingPattern* ¶
<#>Return the *BoundNames* of *BindingPattern*. ¶

Deleted: Semantics¶
The *VarDeclaredNames* of the production

Deleted: is determined as follows:

Static Semantics: VarDeclaredNames

TryStatement : `try` *Block* *Catch*

1. Let *names* be *VarDeclaredNames* of *Block*.
2. Append to *names* the elements of the *VarDeclaredNames* of *Catch*.
3. Return *names*.

TryStatement : `try` *Block* *Finally*

1. Let *names* be *VarDeclaredNames* of *Block*.
2. Append to *names* the elements of the *VarDeclaredNames* of *Finally*.
3. Return *names*.

TryStatement : `try` *Block* *Catch* *Finally*

1. Let *names* be *VarDeclaredNames* of *Block*.
2. Append to *names* the elements of the *VarDeclaredNames* of *Catch*.
3. Append to *names* the elements of the *VarDeclaredNames* of *Finally*.
4. Return *names*.

Catch : catch (CatchParameter) Block

1. Return the VarDeclaredNames of *Block*.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments *value* and *environment*.

NOTE *undefined* is passed for *environment* to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for *var* statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initialiser.

CatchParameter: BindingPattern

1. Let *exceptionObj* be ToObject(*value*).
2. ReturnIfAbrupt(*exceptionObj*).
3. Return the result of performing Binding Initialisation for *BindingPattern* passing *exceptionObj* and *environment* as the arguments.

Runtime Semantics: Catch Clause Evaluation

with parameter *thrownValue*

Catch : catch (CatchParameter) Block

1. Let *oldEnv* be the running execution context's LexicalEnvironment.
2. Let *catchEnv* be the result of calling NewDeclarativeEnvironment passing *oldEnv* as the argument.
3. For each element *argName* of the BoundNames of *CatchParameter*, do
 - a. Call the CreateMutableBinding concrete method of *catchEnv* passing *argName* as the argument.
4. Let *status* be the result of performing Binding Initialisation for *CatchParameter* passing *thrownValue* and *catchEnv* as arguments.
5. ReturnIfAbrupt(*status*).
6. Set the running execution context's LexicalEnvironment to *catchEnv*.
7. Let *B* be the result of evaluating *Block*.
8. Set the running execution context's LexicalEnvironment to *oldEnv*.
9. Return *B*.

NOTE No matter how control leaves the *Block* the LexicalEnvironment is always restored to its former state.

Runtime Semantics: Evaluation

TryStatement : try Block Catch

1. Let *B* be the result of evaluating *Block*.
2. If *B*.[[type]] is not throw, return *B*.
3. Return the result of performing Catch Clause Evaluation of *Catch* with parameter *B*.[[value]].

TryStatement : try Block Finally

1. Let *B* be the result of evaluating *Block*.
2. Let *F* be the result of evaluating *Finally*.
3. If *F*.[[type]] is normal, return *B*.
4. Return *F*.

TryStatement : try Block Catch Finally

1. Let *B* be the result of evaluating *Block*.

Deleted: Finally : finally Block ¶
Return the VarDeclaredNames of Block.¶

Deleted: Initialization

Deleted: environment

Deleted: initialization

Deleted: the

Deleted: z

Deleted: z

Deleted: CatchParameter : BindingIdentifier¶
<#>PerformReturn the result of performing BindInitializationInitialisation for *BindingIdentifier* passing *value* and *enviornmentenvironment* as the arguments.¶

Formatted: Outline numbered + Level: 1 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0.25" + Indent at: 0.25"

Comment [AWB10127]: Catching a thrown null or undefined with a destructuring parameter rethrows a TypeError. Does this make sense?

Deleted: Perform

Deleted: Initialization

Deleted: enviornment

Deleted: running

Deleted: current

Deleted: Perform

Deleted: Initialization

Deleted: g

Deleted: If an exception was thrown in the preceding step, return (throw, V, empty) where V is the exception. (Execution now proceeds as if no exception were thrown.)status is an abrupt completion, then return status

Deleted: running

Deleted: current

Deleted: running

Deleted: current

Deleted: The production

Deleted: is evaluated as follows:

Deleted: evaluating

Deleted: The production

Deleted: is evaluated as follows:

Deleted: The production

Deleted: is evaluated as follows:

2. If $B.[[type]]$ is throw, then
 - a. Let C be the result of performing Catch Clause Evaluation of $Catch$ with parameter $B.value$.
3. Else $B.[[type]]$ is not throw,
 - a. Let C be B .
4. Let F be the result of evaluating $Finally$.
5. If $F.[[type]]$ is normal, return C .
6. Return F .

12.15 The debugger statement

Syntax

DebuggerStatement :
 debugger ;

Runtime Semantics: Evaluation

NOTE Evaluating the *DebuggerStatement* production may allow an implementation to cause a breakpoint when run under a debugger. If a debugger is not present or active this statement has no observable effect.

The production *DebuggerStatement* : debugger ; is evaluated as follows:

1. If an implementation defined debugging facility is available and enabled, then
 - a. Perform an implementation defined debugging action.
 - b. Let $result$ be an implementation defined Completion value.
2. Else
 - a. Let $result$ be NormalCompletion(empty).
3. Return $result$.

13 Functions and Generators

13.1 Function Definitions

Syntax

FunctionDeclaration :
 function BindingIdentifier (FormalParameters) { *FunctionBody* }

FunctionExpression :
 function BindingIdentifier_{opt} (FormalParameters) { *FunctionBody* }

StrictFormalParameters :
FormalParameters

FormalParameters :
 [empty]
FormalParameterList

FormalParameterList :
FunctionRestParameter
FormalsList
FormalsList, FunctionRestParameter

FormalsList :
FormalParameter
FormalsList, FormalParameter

FunctionRestParameter :
 ... BindingIdentifier

Deleted: evaluating

Deleted: ,

Deleted: The production *Catch* : catch
 (IdentifierCatchParameter) Block is evaluated with parameter C as follows:
 Let C be the parameter that has been passed to this production.
 Let $oldEnv$ be the running execution context's LexicalEnvironment.

Let $catchEnv$ be the result of calling NewDeclarativeEnvironment passing $oldEnv$ as the argument.
 For each element *argName* of the BoundNames of *CatchParameter*, do

Call the CreateMutableBinding concrete method of *catchEnv* passing *argName* the *Identifier* String value as the argument.
 Call the Evaluate *CatchParameter* SetMutableBinding using concrete method of *catchEnv* passing the *Identifier*, C and *catEnv*, and false as arguments. Note that the last argument is immaterial in this situation.

If an exception was thrown in the preceding step, return (throw, V , empty) where V is the exception. (Execution now proceeds as if no exception were thrown.)
 Set the running execution context's LexicalEnvironment to *catchEnv*.
 Let B be the result of evaluating *Block*.
 Set the running execution context's LexicalEnvironment to *oldEnv*.
 Return B .

NOTE No matter how control leaves the *Block* the LexicalEnvironment is always restored to its former state.

The VarDeclaredNames of the production *Finally* : finally *Block* is determined as follows:
 Return the VarDeclaredNames of *Block*.

Deleted: The production *Finally* : finally *Block* is evaluated as follows:
 Return the result of evaluating *Block*.

Deleted: The BoundNames of the production *CatchParameter* : *BindingIdentifier* is determined as follows:
 Return the BoundNames of *BindingIdentifier*.

The production *CatchParameter* : *BindingIdentifier* is evaluated with parameters *exception* and *env* as follows:
 Deleted: Semantics

Deleted: Runtime Semantics: Evaluation

Deleted: (normal),
Deleted: , empty

Deleted: List

Deleted: opt

Deleted: List

Deleted: opt

Deleted: [empty]

Deleted: ... Identifier

Deleted: ... Identifier

Deleted: FormalParameterList

Deleted: Identifier

Deleted: FormalParameterList

Deleted: Identifier

FormalParameter :
BindingElement

FunctionBody :
FunctionStatementList

FunctionStatementList :
StatementList_{opt}

Supplemental Syntax

The following productions are used as an aid in specifying the semantics of certain ECMAScript language features. They are not used when parsing ECMAScript source code.

FunctionBody :
ThrowTypeError

ThrowTypeError :
[empty]

Static Semantics

Static Semantics: Early Errors

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

and

FunctionExpression : function BindingIdentifier_{opt} (FormalParameters) { FunctionBody }

- It is a Syntax Error if FunctionBody Contains YieldExpression is true.
- It is a Syntax Error if IsSimpleParameterList of FormalParameters is false and any element of the BoundNames of FormalParameters also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if any element of the BoundNames of FormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

NOTE The LexicallyDeclaredNames of a FunctionBody does not include identifiers bound using var or function declarations. Simple parameter lists bind identifiers as VarDeclaredNames. Parameter lists that contain destructuring patterns, default value initialisers, or a rest parameter bind identifiers as LexicallyDeclaredNames.

StrictFormalParameters : FormalParameters

- It is a Syntax Error if BoundNames of FormalParameterList contains any duplicate elements.
- It is a Syntax Error if BoundNames of FormalParameterList contains either "eval" or "arguments".

FormalParameters : FormalParameterList

- It is a Syntax Error if FormalParameters Contains YieldExpression is true.
- It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains any duplicate elements.
- It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains either "eval" or "arguments".
- It is a Syntax Error if the source code matching this production is strict code and BoundNames of FormalParameterList contains any duplicate elements.

NOTE Multiple occurrences of the same Identifier in a FormalParameterList is only allowed for non-strict functions and generator functions that have simple parameter lists.

FunctionStatementList : StatementList

- It is a Syntax Error if the LexicallyDeclaredNames of StatementList contains any duplicate entries.

Deleted: BindingIdentifier Initialiser_{opt}
Deleted: Pattern
Deleted: Initialiser_{opt}
Deleted: opt
Deleted: SourceElements_{opt}

Deleted: NOTE . The identifier of a rest parameter is specified as an Identifier rather than a BindingIdentifier because it may be the identifier arguments..¶

Deleted: Semantics¶

Deleted: List

Deleted: List

Deleted: <#>It is a Syntax Error if the source code matching this production is extended code and the BoundNames of BindingIdentifier also occurs in the VarDeclaredNames of FunctionBody.¶

<#>It is a Syntax Error if the source code matching this production is extended code and the BoundNames of BindingIdentifier also occurs in the LexicallyDeclaredNames of FunctionBody.

Deleted: <#>It is a Syntax Error if the source code matching this production is extended code and any element of the LexicallyDeclaredNames of FormalParameterList also occurs in the VarDeclaredNames of FunctionBody.¶

Deleted: List

Deleted: true

Deleted: the source code matching this production is extended code and

Deleted: List

Deleted: Lexically

Deleted: <#>It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalsParameterList contains any duplicate elements.¶

<#>It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains either "eval" or "arguments".¶

<#>It is a Syntax Error if the source code matching this production is strict code and BoundNames of FormalsParameterList contains any duplicate elements.¶

Deleted: List

Deleted: <#>It is a Syntax Error if FunctionBody Contains YieldExpression.¶

Deleted: Multiple occurrences of the same Identifier in a FormalParameterList is only allowed for non-strict functions with simple parameter lists.

Deleted: Body

Deleted: the source code matching this production is extended code and

Deleted: BoundNames

Deleted: i

- It is a Syntax Error if any element of the LexicallyDeclaredNames of *StatementList* also occurs in the VarDeclaredNames of *StatementList*.

Deleted: the source code matching this production is extended code and

FormalParameter : BindingElement

- It is a Syntax Error if *BindingElement* Contains *YieldExpression*.

Static Semantics: BoundNames

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

1. Return the BoundNames of *BindingIdentifier*.

FormalParameters : [empty]

1. Return an empty List.

FormalParameterList : FormalsList , FunctionRestParameter

1. Let *names* be BoundNames of *FormalsList*.
2. Append to *names* the BoundNames of *FunctionRestParameter*.
3. Return *names*.

FormalsList : FormalsList , FormalParameter

1. Let *names* be BoundNames of *FormalsList*.
2. Append to *names* the elements of BoundNames of *FormalParameter*.
3. Return *names*.

Static Semantics: Contains

With parameter *symbol*.

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

1. Return false.

FunctionExpression : function BindingIdentifier_{opt} (FormalParameters) { FunctionBody }

1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

Static Semantics: ExpectedArgumentCount

FormalParameters : [empty]

1. Return 0.

FormalParameterList : FunctionRestParameter

1. Return 0.

FormalParameterList : FormalsList , FunctionRestParameter

1. Return the ExpectedArgumentCount of *FormalsList*.

NOTE The ExpectedArgumentCount of a *FormalParameterList* is the number of *FormalParameters* to the left of either the rest parameter or the first *FormalParameter* with an Initialiser. A *FormalParameter* without an initialiser is allowed after the first parameter with an initializer but such parameters are considered to be optional with undefined as their default value.

Deleted: the source code matching this production is

Deleted: *FormalParameterList : FormalsList*

<#> It is a Syntax Error if *FormalParameterList* Contains *YieldExpression*.¶

<#> It is a Syntax Error if BoundNames of *FormalsList* contains any duplicate elements and either *FormalsList* Contains *BindingPattern* or *FormalsList* Contains *Initialiser*.

<#> It is a Syntax Error if BoundNames of *FormalsList* contains either "eval" or "arguments" and either *FormalsList* Contains *BindingPattern* or *FormalsList* Contains *Initialiser*.¶

FormalParameterList : FormalsList , FunctionRestParameter

<#> It is a Syntax Error if BoundNames of *FormalsList* contains any duplicate elements.¶

<#> It is a Syntax Error if BoundNames of *FormalsList* contains the any element String Value of the BoundName of *IdentifierFunctionRestParameter*.¶

FormalsList : FormalsList , FormalParameter ¶

<#> It is a Syntax Error if the source code matching this production is strict code and BoundNames of *FormalsList* contains any element which is also contained in BoundNames of *FormalParameter*.¶

FunctionRestParameter : ... BindingIdentifier ¶

<#> It is a Syntax Error if the String Value of the sole element of the BoundNames of *BindingIdentifier* is eval arguments.¶

Deleted: <#> It is a Syntax Error if the source code parsed with this production is not extended code.¶

<#> It is a Syntax Error if *Identifier* is "eval"¶

Deleted: *List*

Deleted: *List*

Deleted: *FormalParameterList : FunctionRestParameter*

<#> Return the BoundNames of *FunctionRestParameter*.¶

FormalParameterList : FormalsList ¶

<#> Return the BoundNames of *FormalsList*.¶

Deleted: *FormalParameterList : ... BindingIdentifier* ¶

<#> Return the BoundNames String Value of *BindingIdentifier*.¶

FormalParameter : BindingElement ¶

<#> Return the BoundNames of *BindingElement*.¶

Deleted: *List*

Deleted: *List*

Deleted: ¶

[empty]

Deleted: ¶

Deleted: *FormalsList*

Deleted: are

FormalsList : FormalParameter

1. If HasInitialiser of *FormalParameter* is **false** return 0
2. Return 1.

FormalsList : FormalsList , FormalParameter

1. Let *count* be the ExpectedArgumentCount of *FormalsList*.
2. If HasInitialiser of *FormalsList* is **true** or HasInitialiser of *FormalParameter* is **true**, then return *count*.
3. Return *count*+1.

Static Semantics: HasInitialiser

FormalsList : FormalsList , FormalParameter

1. If HasInitialiser of *FormalsList* is **true**, then return **true**.
2. Return HasInitialiser of *FormalParameter*.

Static Semantics: IsConstantDeclaration

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

1. Return **false**.

Static Semantics: IsSimpleParameterList

FormalParameters : [empty]

1. Return **true**.

FormalParameterList : FunctionRestParameter

1. Return **false**.

FormalParameterList : FormalsList , FunctionRestParameter

1. Return **false**.

FormalsList : FormalsList , FormalParameter

1. If IsSimpleParameterList of *FormalsList* is **false**, return **false**.
2. Return IsSimpleParameterList of *FormalParameter*.

FormalParameter : BindingElement

1. If HasInitialiser of *BindingElement* is **true**, return **false**.
2. If *FormalParameter* Contains *BindingPattern* is **true**, return **false**.
3. Return **true**.

Static Semantics: IsStrict

FunctionStatementList : StatementList_{opt}

1. If this *FunctionStatementList* is contained in strict code or if *StatementList* is strict code, then return **true**. Otherwise, return **false**.

Static Semantics: LexicallyDeclaredNames

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

Deleted: FormalsList : FormalParameter ¶
<#>Return HasInitialiser of FormalParameter ¶

Deleted: FormalParameter : BindingElement ¶
<#>Return HasInitialiser of BindingElement ¶

Deleted: List

Deleted: List

Deleted: Body

Deleted: StatementList_{opt}

Deleted: Body

Deleted:

Comment [AWB10128]: Need a better definition

Deleted: ¶

Deleted: List

1. Return the BoundNames of *BindingIdentifier*.

FunctionStatementList : [empty]

Deleted: Body

1. Return an empty List.

FunctionStatementList : *StatementList*

Deleted: Body

1. Return TopLevelLexicallyDeclaredNames of *StatementList*.

Static Semantics: VarDeclaredNames

FunctionDeclaration : **function** *BindingIdentifier* (*FormalParameters*) { *FunctionBody* }

Deleted: *FunctionBody* : *StatementList* ¶
 <#>Return the LexicallyDeclaredNames of *StatementList*. ¶

1. Return an empty List.

FunctionBody : [empty]

1. Return an empty List.

FunctionBody : *StatementList*

1. Return TopLevelVarDeclaredNames of *StatementList*.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With parameters *value* and *environment*.

NOTE When **undefined** is passed for *environment* it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

FormalParameters : [empty]

1. Return NormalCompletion(empty).

FormalParameterList : *FunctionRestParameter*

1. Return the result of performing Indexed Binding Initialisation for *FunctionRestParameter* using *value*, *0*, and *environment* as the arguments.

FormalParameterList : *FormalsList*

1. Return the result of performing Indexed Binding Initialisation for *FormalsList* using *value*, *0*, and *environment* as the arguments.

FormalParameterList : *FormalsList* , *FunctionRestParameter*

1. Let *restIndex* be the result of performing Indexed Binding Initialisation for *FormalsList* using *value*, *0*, and *environment* as the arguments.

2. ReturnIfAbrupt(*restIndex*).

3. Return the result of performing Indexed Binding Initialisation for *FunctionRestParameter* using *value*, *restIndex*, and *environment* as the arguments.

Runtime Semantics EvaluateBody

With parameter *functionObject*.

FunctionBody : FunctionStatementList_{opt}

1. The code of this *FunctionBody* is strict mode code if it is contained in strict mode code or if the Directive Prologue (14.1) of its *FunctionStatementList* contains a Use Strict Directive or if any of the conditions in 10.1.1 apply. If the code of this *FunctionBody* is strict mode code, *FunctionStatementList* is evaluated in the following steps as strict mode code. Otherwise, *StatementList* is evaluated in the following steps as non-strict mode code.
2. If *FunctionStatementList* is not present, then return NormalCompletion(**undefined**).
3. Let *result* be the result of evaluating *FunctionStatementList*.
4. If *result* [[type]] is return then return NormalCompletion(*result* [[value]])
5. ReturnIfAbrupt(*result*).
6. Return NormalCompletion(**undefined**).

FunctionBody : ThrowTypeError

1. Throw a **TypeError** exception.

Runtime Semantics: Indexed Binding Initialisation

With parameters *array*, *nextIndex*, and *environment*.

FormalsList : FormalParameter

1. Let *status* be the result of performing Indexed Binding Initialisation for *FormalParameter* using *array*, *nextIndex*, and *environment* as the arguments.
2. ReturnIfAbrupt(*status*).
3. Return *nextIndex* + 1.

FormalsList : FormalsList , FormalParameter

1. Let *lastIndex* be the result of performing Indexed Binding Initialisation for *FormalsList* using *array*, *nextIndex*, and *environment* as the arguments.
2. ReturnIfAbrupt(*lastIndex*).
3. Let *status* be the result of performing Indexed Binding Initialisation for *FormalParameter* using *array*, *lastIndex*, and *environment* as the arguments.
4. ReturnIfAbrupt(*status*).
5. Return *lastIndex* + 1.

FunctionRestParameter : . . . BindingIdentifier

1. Assert: *array* is a well formed arguments object and hence it has a valid integer valued "**length**" property.
2. Let *status* be the result of Get(*array*, "**length**").
3. Let *argumentsLength* be *status* [[value]].
4. Let *A* be the result of the abstract operation *ArrayCreate* with argument 0.
5. Let *n*=0.
6. Repeat, while *nextIndex* < *argumentsLength*.
 - a. Let *P* be *ToString*(*nextIndex*).
 - b. Assert: *array* is a well formed arguments object, hence it must have a property *P*.
 - c. Let *v* be the result of Get(*array*, *P*).
 - d. Call the [[DefineOwnProperty]] internal method of *A* with arguments *ToString*(*n*) and Property Descriptor {[[Value]]: *v* [[value]], [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}.
 - e. Let *n* = *n*+1.
 - f. Let *nextIndex* = *nextIndex* +1.
7. Return the result of performing Binding Initialisation for *BindingIdentifier* using *A* and *environment* as arguments.

Runtime Semantics: InstantiateFunctionObject

With parameter *scope*.

Deleted: <#>Return.¶
Deleted: Initialization
Deleted: <i>arrayLength</i> ,
Deleted: Perform
Deleted: Initialization
Deleted: <i>value</i>
Deleted: <i>env</i> , and
Deleted: <i>i</i>
Deleted: <i>i</i>
Deleted: Initialization
Deleted: <i>value</i>
Deleted: <i>lenValue</i> ,
Deleted: Perform
Deleted: Initialization
Deleted: <i>value</i>
Deleted: <i>lenValue</i> ,
Deleted: <i>argumentsLength</i>
Deleted: calling the [[
Deleted:]] internal method of
Deleted:
Deleted: <i>value</i>
Deleted: with argument
Deleted: <i>argumentsLength</i>
Deleted: ion
Deleted: (15.4)
Deleted: a new array object created as if by the expression new Array() where Array is the standard built-in constructor with that name
Deleted: <i>arrayLength</i>
Deleted: calling the [[
Deleted:]] internal method of
Deleted: passing
Deleted: as the argument
Deleted: ,
Deleted: , and false
Deleted: Perform
Deleted: Initialization
Deleted: <i>FormalParameter</i> : <i>BindingElement</i> ¶
<#>Return the result of performing Perform Indexed Binding Initialisation for <i>BindingElement</i> using <i>array</i> , <i>arrayLength</i> , <i>nextIndex</i> , and <i>environment</i> as the arguments.¶
Deleted: Instantiate Function Declaration

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

1. If the FunctionDeclaration is contained in strict code or if its FunctionBody is strict code, then let strict be **true**. Otherwise let strict be **false**.
2. Let F be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, scope, and strict.
3. Perform the abstract operation MakeConstructor with argument F.
4. Return F.

Runtime Semantics: Evaluation

FunctionDeclaration : function BindingIdentifier (FormalParameters) { FunctionBody }

1. Return NormalCompletion(empty).

FunctionExpression : function (FormalParameters) { FunctionBody }

1. If the FunctionExpression is contained in strict code or if its FunctionBody is strict code, then let strict be **true**. Otherwise let strict be **false**.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let closure be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, scope, and strict.
4. Perform the abstract operation MakeConstructor with argument closure.
5. Return closure.

FunctionExpression : function BindingIdentifier (FormalParameters) { FunctionBody }

1. If the FunctionExpression is contained in strict code or if its FunctionBody is strict code, then let strict be **true**. Otherwise let strict be **false**.
2. Let funcEnv be the result of calling NewDeclarativeEnvironment passing the running execution context's Lexical Environment as the argument.
3. Let envRec be funcEnv's environment record.
4. Let name be StringValue of BindingIdentifier.
5. Call the CreateImmutableBinding concrete method of envRec passing name as the argument.
6. Let closure be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, funcEnv, and strict.
7. Perform the abstract operation MakeConstructor with argument closure.
8. Call the InitializeBinding concrete method of envRec passing name and closure as the arguments.
9. Return NormalCompletion(closure).

NOTE 1 The BindingIdentifier 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 BindingIdentifier in a FunctionExpression cannot be referenced from and does not affect the scope enclosing the FunctionExpression.

NOTE 2 A prototype property is automatically created for every function defined using a FunctionDeclaration or FunctionExpression, to allow for the possibility that the function will be used as a constructor.

13.2 Arrow Function Definitions

Syntax

ArrowFunction :
 ArrowParameters => ConciseBody

ArrowParameters :
 BindingIdentifier
 CoverParenthesisedExpressionAndArrowParameterList

Deleted: List

Deleted: <#>Let scope be the LexicalEnvironment of the running current execution context.¶

Deleted: List

Deleted: ing

Deleted: The production

Deleted: List

Deleted: opt

Deleted: is instantiated as follows during Declaration Binding instantiation (10.5):

Deleted: (normal, empty, empty).

Deleted: Return the result of creating a new Function object as specified in 13.2 with parameters specified by FormalParameterList_{opt} and body specified by FunctionBody. Pass in the VariableEnvironment of the running execution context as the Scope. Pass in **true** as the Strict flag if the FunctionDeclaration is contained in strict code or if its FunctionBody is strict code.

Deleted: The production

Deleted: List

Deleted: opt

Deleted: is evaluated as follows:

Deleted: current

Deleted: List

Deleted: ing

Deleted: the result of creating 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. Pass in **true** as the Strict flag if the FunctionExpression is contained in strict code or if its FunctionBody is strict code

Deleted: List

Deleted: opt

Deleted: running

Deleted: current

Deleted:

Deleted: the String value of BindingIdentifier

Deleted: <#>Let closure be the result of creating a new Function object as specified in 13.2 with parameters specified by FormalParameterList_{opt} and body specified by FunctionBody. Pass in funcEnv as the Scope. Pass in **true** as the Strict flag if the FunctionExpression is contained in strict code or if its FunctionBody is strict code

Deleted: FormalParameterList

Deleted: ing

Deleted: Immutable

Deleted: the String value of Identifier

Deleted: Value

Deleted: The production FunctionBody:

Deleted: z

Deleted: (ArrowFormalParameterList)

ConciseBody :

 [lookahead $\notin \{ \{ \} \}$] AssignmentExpression
 { FunctionBody }

Supplemental Syntax

When processing the production ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList the following grammar is used to refine the interpretation of CoverParenthesisedExpressionAndArrowParameterList.

ArrowFormalParameters :

 (StrictFormalParameters)

Static Semantics

Static Semantics: Early Errors

ArrowFunction : ArrowParameters => ConciseBody

- It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the VarDeclaredNames of ConciseBody.
- It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the LexicallyDeclaredNames of ConciseBody.

ArrowParameters : BindingIdentifier

- It is a Syntax Error if the StringValue of the sole element of the BoundNames of BindingIdentifier is eval or arguments.

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

- It is a Syntax Error if the lexical token sequence matched by CoverParenthesisedExpressionAndArrowParameterList cannot be parsed with no tokens left over using ArrowFormalParameters as the goal symbol.
- It is a Syntax Error if any early errors are present for CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList.

ConciseBody : [lookahead $\notin \{ \{ \} \}$] AssignmentExpression

- It is a Syntax Error if AssignmentExpression Contains YieldExpression.

Static Semantics: BoundNames

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

1. Let formals be CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList.
2. Return the BoundNames of formals.

Static Semantics: Contains

With parameter symbol.

ArrowFunction : ArrowParameters => ConciseBody

1. If symbol is neither super or this, then return false.
2. If ArrowParameters Contains symbol is true, return true.
3. Return ConciseBody Contains symbol.

Deleted: ArrowFormalParameterList : [empty]
Deleted: FunctionRestParameter .
Deleted: CoverFormalsList
Deleted: CoverFormalsList , FunctionRestParameter
Deleted: z
Deleted: z
Deleted: List
Deleted: List
Deleted: CoverFormalsList : Expression
Deleted: Supplemental Syntax
When processing the production <u>CoverFormalsList : Expression</u> the <u>FormalsList</u> production is used to further restrict the source code that matches <u>Expression</u> .
Deleted: ArrowFormalParameterList : FormalParameterList
Deleted: ConciseBody
Deleted: IsSimpleParameterList of <u>ArrowParameters</u> is <u>true</u> and
Deleted: FormalParameterList
Deleted: <#>It is a Syntax Error if IsSimpleParameterList of <u>ArrowParameters</u> is false and BoundNames of <u>ArrowParameters</u> contains any duplicate elements.
<#>It is a Syntax Error if IsSimpleParameterList of <u>ArrowParameters</u> is false and BoundNames of <u>ArrowParameters</u> contains either "eval" or "arguments".
Deleted: <#>It is a Syntax Error if any
Deleted: ConciseBody
Deleted: <#>It is a Syntax Error if
Deleted:
Deleted: ArrowFormalParameterList :
Deleted: CoverFormalsList
Deleted: z
Deleted: Expression
Deleted: source code
Deleted: corresponding to
Deleted: z
Deleted: Expression
Deleted: List
Deleted: FormalsList
Deleted: <#>All Early Errors rules for
Deleted: ¶
Deleted: z
Deleted: z
Deleted: s
Deleted: ArrowParameters : BindingIdentifier
Deleted: ArrowFormalParameterList : [empty]
Deleted: ConciseBody
Deleted: s
Deleted: s

NOTE Normally, Contains does not look inside most function forms. However, Contains is used to detect `this` and `super` usage within an `ArrowFunction`.

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

1. Let `formals` be `CoveredFormalsList` of `CoverParenthesisedExpressionAndArrowParameterList`.
2. Return `formals` Contains `symbol`.

Deleted: `z`

Deleted: `z`

Static Semantics: CoveredFormalsList

ArrowParameters : BindingIdentifier

1. Return `BindingIdentifier`.

Deleted: NOTE Static semantic rules that depend upon substructure generally do not look into function definitions. This `Contains` is used to detect `yield` and `super` usage within an `ArrowFunction`. ¶

Deleted:

CoverParenthesisedExpressionAndArrowParameterList :

```
( Expression )
( )
( ... Identifier )
( Expression , ... Identifier )
```

1. Return the result of parsing the lexical token stream matched by `CoverParenthesisedExpressionAndArrowParameterList` using `ArrowFormalParameters` as the goal symbol.

Deleted: `CoverFormalsList : Expression` ¶

Deleted: source code

Deleted: corresponding to

Deleted: `z`

Deleted: `Expression`

Deleted: `List`

Deleted: `FormalsList`

Deleted: `ArrowParameters : (ArrowFormalParameterList)` ¶
 ↪ Return the ExpectedArgumentCount of `ArrowFormalParameterList`. ¶

Deleted: `ArrowFormalParameterList : [empty]`
`FunctionRestParameter` ¶
 ↪ Return 0. ¶
`ArrowFormalParameterList : []`
`CoverFormalsList`
`CoverFormalsList , FunctionRestParameter` ¶

Deleted: `z`

Deleted: `z`

Deleted: `CoveredCFormalsList of CoverFormalsList`

Deleted: `z`

Deleted: `z`

Deleted: `ConciseBody`

Static Semantics: IsSimpleParameterList

ArrowParameters : BindingIdentifier

1. Return `true`.

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

1. Let `formals` be `CoveredFormalsList` of `CoverParenthesisedExpressionAndArrowParameterList`.
2. Return the `IsSimpleParameterList` of `formals`.

Static Semantics: LexicallyDeclaredNames

ConciseBody : [lookahead $\notin \{ \} \}] AssignmentExpression$

1. Return an empty List.

Deleted: `ConciseBody : { FunctionBody }` ¶
 Return the LexicallyDeclaredNames of `FunctionBody` ¶
Static Semantics: VarDeclaredNames ¶
`ConciseBody : [lookahead $\notin \{ \} \}] AssignmentExpression$` ¶
 Return the `VarDeclaredNames` of `AssignmentExpression`. ¶
`ConciseBody : { FunctionBody }` ¶
 Return the `VarDeclaredNames` of `FunctionBody`. ¶

Deleted: and optional parameter `index`

Deleted: `z`

Runtime Semantics: Binding Initialisation

With parameters `value` and `environment`

NOTE When `undefined` is passed for `environment` it indicates that a `PutValue` operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

ArrowParameters : BindingIdentifier

1. Return the result of performing Binding Initialisation for *BindingIdentifier* using *value* and *environment* as the arguments.

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

1. Let *formals* be *CoveredFormalsList* of *CoverParenthesisedExpressionAndArrowParameterList*.
2. Return the result of performing Binding Initialisation of *formals* with arguments *value* and *environment*.

Runtime Semantics EvaluateBody

With parameter *functionObject*.

ConciseBody : [lookahead $\notin \{ \, , \} \} \mid AssignmentExpression$

1. The code of this *ConciseBody* is strict mode code if it is contained in strict mode code or if any of the conditions in 10.1.1 apply. If the code of this *ConciseBody* is strict mode code, *AssignmentExpression* is evaluated in the following steps as strict mode code. Otherwise, *AssignmentExpression* is evaluated in the following steps as non-strict mode code.
2. Let *exprRef* be the result of evaluating *AssignmentExpression*.
3. Let *exprValue* be *GetValue(exprRef)*.
4. If *exprValue.[[type]]* is *return* then return *NormalCompletion(exprValue.[[value]])*.
5. *ReturnIfAbrupt(exprValue)*.
6. Return *NormalCompletion(exprValue)*.

NOTE In the absence of extensions to this specification, the test in step 4 will never be true.

Runtime Semantics: Evaluation

ArrowFunction : ArrowParameters => ConciseBody

1. Let *strict* be *true*.
2. Let *scope* be the *LexicalEnvironment* of the running execution context.
3. Let *parameters* be *CoveredFormalsList* of *ArrowParameters*.
4. Let *closure* be the result of performing the *FunctionCreate* abstract operation with arguments *Arrow*, *parameters*, *ConciseBody*, *scope*, and *strict*.
5. Return *closure*.

NOTE Even though an *ArrowFunction* may contain references to *super*, the *FunctionCreate* call in step 3 is not passed the optional *homeObject* and *methodName* parameters. An *ArrowFunction* that references *super* is always contained within a non-*ArrowFunction* and the necessary state to implement *super* is accessible via the *scope* that is captured by the function object of the *ArrowFunction*.

13.3 Method Definitions

Syntax

MethodDefinition :

```
PropertyName ( StrictFormalParameters ) { FunctionBody }
GeneratorMethod
get PropertyName ( ) { FunctionBody }
set PropertyName ( PropertySetParameterList ) { FunctionBody }
```

PropertySetParameterList :

```
BindingIdentifier
BindingPattern
```

NOTE The single element of a *PropertySetParameterList* may not have a default value *Initialiser* because set accessors are always called with an implicitly provided argument.

Deleted: Indexed
Deleted: , <i>lenValue</i>
Deleted: ,
Deleted: 0,
Deleted: <i>z</i>
Deleted: <i>z</i>
Deleted: <i>ro</i>
Deleted: <i>i</i>
Deleted: <i>z</i>
Deleted: and optional argument <i>index</i> , if index was passed to this routine
Comment [AWB7129]: TODO, need to resolve whether or not ArrowBodies are always strict
Comment [AWB9130]: TODO If <i>exprRef</i> is Reference that invokes a getter we probably should find a way to specify that the get call is handled as a tail call
Deleted: ArrowParameters : (ArrowFormalParameterList) ¶ <#>Return the result of performing Binding Initialisation for <i>ArrowFormalParameterList</i> using <i>value</i> , <i>environment</i> as the arguments. Also pass the optional argument <i>index</i> if it is present.¶
Deleted: ArrowFormalParameterList : [empty] <#>Return <i>NormalCompletion(empty)</i> .¶ ArrowFormalParameterList : FunctionRestParameter¶ <#>Return the result of performing Indexed Binding Initialisation for <i>FunctionRestParameter</i> using <i>value</i> , <i>lenValue</i> , 0, and <i>environment</i> as the arguments.¶
Deleted: ConciseBody
Comment [AWB7131]: Confirm: concise
Deleted: current
Deleted: ArrowParameterLists
Comment [AWB7132]: TODO, need to
Comment [AWB9133]: TODO If <i>exprRef</i> is
Deleted: ConciseBodyConciseBody : [lookahe
Deleted: ConciseBody : { FunctionBody
Deleted: List
Deleted: ConciseBody
Deleted: * <i>PropertyName</i>
Deleted: (FormalParameterList) ConciseBo
Deleted: {
Deleted: ConciseBody
Deleted: FunctionBody }
Deleted:
Deleted: {
Deleted: ConciseBody
Deleted: FunctionBody }
Deleted: ed

Static Semantics

Static Semantics: Early Errors

MethodDefinition : PropertyName (StrictFormalParameters) { FunctionBody }

- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

MethodDefinition : set PropertyName (PropertySetParameterList) { FunctionBody }

- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and any element of the BoundNames of PropertySetParameterList also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and BoundNames of PropertySetParameterList contains any duplicate elements.
- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and BoundNames of PropertySetParameterList contains either "eval" or "arguments".
- It is a Syntax Error if BoundNames of PropertySetParameterList contains any duplicate elements.
- It is a Syntax Error if any element of the BoundNames of PropertySetParameterList also occurs in the LexicallyDeclaredNames of FunctionBody.
- It is a Syntax Error if PropertySetParameterList Contains YieldExpression.

Static Semantics: ExpectedArgumentCount

PropertySetParameterList : BindingIdentifier

1. Return 1.

PropertySetParameterList : BindingPattern

1. Return 1.

Static Semantics: IsSimpleParameterList

PropertySetParameterList : BindingIdentifier

1. Return true.

PropertySetParameterList : BindingPattern

1. Return false.

Static Semantics: PropName

MethodDefinition :

```
PropertyName ( FormalParameters ) { FunctionBody }
  get PropertyName ( ) { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }
```

1. Return PropName of PropertyName.

Static Semantics: ReferencesSuper

MethodDefinition : PropertyName (FormalParameters) { FunctionBody }

1. If FormalParameters Contains super is true, then return true.

Deleted: MethodDefinition : PropertyName
 (FormalParameterList) ConciseBody { FunctionBody
 and ¶

MethodDefinition : * PropertyName
 (FormalParameterList) ConciseBody { FunctionBody
 } ¶

<#>It is a Syntax Error if any element of the LexicallyDeclaredNames of FormalParameterList also occurs in the VarDeclaredNames of ConciseFunctionBody.
 <#>It is a Syntax Error if IsSimpleParameterList of FormalParameterList is true and any element of the BoundNames of FormalParameterList also occurs in the VarDeclaredNames of FunctionBody.¶

<#>It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalsParameterList contains any duplicate elements.

<#>It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains either "eval" or "arguments".¶

<#>It is a Syntax Error if the source code matching this production is strict code and BoundNames of FormalsParameterList contains any duplicate elements.

<#>It is a Syntax Error if any element of the BoundNames of FormalParameterList also occurs in the LexicallyDeclaredNames of FunctionBody.¶

Deleted: <#>It is a Syntax Error if any element of the BoundNames of FormalParameterList also occurs in the

Deleted: F

Deleted: List

Deleted: ConciseBody

Deleted:

Deleted: <#>It is a Syntax Error if ConciseBody

Deleted: ConciseBody

Deleted: FormalParameterList

Deleted: true

Deleted: FormalParameterList

Deleted: FormalParameterList

Deleted: FormalParameterList

Deleted: FormalParameterList

Deleted: ConciseBody

Deleted: <#>It is a Syntax Error if

Deleted: PropertySetParameterList : BindingPattern ¶

Deleted: Static Semantics: BoundNames¶
 PropertySetParameterList : BindingIdentifier ¶

Deleted: List

Deleted:

Deleted: MethodDefinition : PropertyName

Deleted: MethodDefinition : * PropertyName

Deleted: ¶

Deleted: List

Deleted: J

Deleted:

Deleted: List

2. Return FunctionBody Contains **super**.

MethodDefinition : **get** PropertyName () { FunctionBody }

1. Return FunctionBody Contains **super**.

MethodDefinition : **set** PropertyName (PropertySetParameterList) { FunctionBody }

1. If PropertySetParameterList Contains **super** is true, then return true.
2. Return FunctionBody Contains **super**.

Static Semantics: SpecialMethod

MethodDefinition : PropertyName (StrictFormalParameters) { FunctionBody }

1. Return false.

MethodDefinition :

```
GeneratorMethod
get PropertyName ( ) { FunctionBody }
set PropertyName ( PropertySetParameterList ) { FunctionBody }
```

1. Return true.

Runtime Semantics

Runtime Semantics: Property Definition Evaluation

With parameter *object* and optional parameter *functionPrototype*.

MethodDefinition : PropertyName (StrictFormalParameters) { FunctionBody }

1. Let *propName* be PropName of *PropertyName*.
2. Let *strict* be IsStrict of *FunctionBody*.
3. Let *scope* be the running execution context's LexicalEnvironment.
4. If ReferencesSuper of *MethodDefinition* is true, then
 - a. Let *closure* be the result of performing the FunctionCreate abstract operation with arguments *Method*, *StrictFormalParameters*, *FunctionBody*, *scope*, and *strict* and with *object* as the *homeObject* optional argument and *propName* as the *methodName* optional argument. If *functionPrototype* was passed as a parameter then also pass its value as the *functionPrototype* optional argument of FunctionCreate.
5. Else
 - a. Let *closure* be the result of performing the FunctionCreate abstract operation with arguments *Method*, *StrictFormalParameters*, *FunctionBody*, *scope*, and *strict*. If *functionPrototype* was passed as a parameter then also pass its value as the *functionPrototype* optional argument of FunctionCreate.
6. Let *desc* be the Property Descriptor{[[Value]]: *closure*, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
7. Let *status* be the result of DefinePropertyOrThrow(*object*, *propName*, *desc*).
8. ReturnIfAbrupt(*status*).
9. NormalCompletion(*closure*).

MethodDefinition : GeneratorMethod

See 13.4.

MethodDefinition : **get** PropertyName () { FunctionBody }

1. Let *propName* be PropName of *PropertyName*.
2. Let *strict* be IsStrict of *FunctionBody*.
3. Let *scope* be the running execution context's LexicalEnvironment.

Deleted: *FormalParameterList*

Deleted: *

Deleted: *PropertyName (FormalParameterList) { FunctionBody }*

Deleted: .

Deleted: *FormalParameterList*

Deleted: *ConciseBody*

Deleted: .

Deleted: true

Deleted: current

Deleted: <#>Let *needsSuperBinding* be the result of *FunctionBody* Contains **super**. ¶

<#>If *needsSuperBinding* is false, then let *needsSuperBinding* be the result of *FormalParameterList* Contains **super**. ¶

Deleted: *needsSuperBinding*

Deleted: *FormalParameterList*

Deleted: *ConciseBody*

Deleted: *FormalParameterList*

Comment [AWB10134]: At its sept 2012 meeting TC39 decided that it wants methods be enumerable.

Deleted: true,

Deleted: false

Deleted: false

Deleted: Return

Deleted: calling the [[

Deleted: Own

Deleted:]] internal method of

Deleted:

Deleted: with arguments

Deleted: ,

Deleted: and

Deleted: , and false

Deleted: *MethodDefinition*

Deleted: : * *PropertyName (FormalParameterList) ConciseBody { FunctionBody }*

Deleted:

Comment [AWB8135]: A default value expression could reference super

Deleted: <#>Let *propName* be PropName of *PropertyName*. ¶

<#>Let *strict* be IsStrict of *FunctionBody* true. ¶

<#>Let *scope* be the running current execution context's LexicalEnvironment. ¶

Deleted: *ConciseBody*

Deleted: { *FunctionBody* }

Deleted: If this *MethodDefinition* is contained in

Deleted: current

4. Let `formalParameterList` be the production `FormalParameters`: [empty]
5. If `ReferencesSuper` of `MethodDefinition` is `true`, then
 - a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `formalParameterList`, `FunctionBody`, `scope`, and `strict` and with `object` as the `homeObject` optional argument and `propName` as the `methodName` optional argument.
6. Else
 - a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `formalParameterList`, `FunctionBody`, `scope`, and `strict`.
7. Let `desc` be the Property Descriptor `{[[Get]]: closure, [[Enumerable]]: true, [[Configurable]]: true}`
8. Let `status` be the result of calling the `[[DefineOwnProperty]]` internal method of `object` with arguments `propName` and `desc`.
9. `ReturnIfAbrupt(status)`.
10. Return `NormalCompletion(closure)`.

`MethodDefinition : set PropertyName (PropertySetParameterList) { FunctionBody }`

1. Let `propName` be `PropertyName` of `PropertyName`.
2. Let `strict` be `IsStrict` of `FunctionBody`.
3. Let `scope` be the running execution context's `LexicalEnvironment`.
4. If `ReferencesSuper` of `MethodDefinition` is `true`, then
 - a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `PropertySetParameterList`, `FunctionBody`, `scope`, and `strict` and with `object` as the `homeObject` optional argument and `propName` as the `methodName` optional argument.
5. Else
 - a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `PropertySetParameterList`, `FunctionBody`, `scope`, and `strict`.
6. Let `desc` be the Property Descriptor `{[[Set]]: closure, [[Enumerable]]: true, [[Configurable]]: true}`
7. Let `status` be the result of `DefinePropertyOrThrow(object, propName, desc)`.
8. `ReturnIfAbrupt(status)`.
9. Return `NormalCompletion(closure)`.

13.4 Generator Function Definitions

Syntax

`GeneratorMethod :`
 `* PropertyName (StrictFormalParameters) { FunctionBody }`

`GeneratorDeclaration :`
 `function * BindingIdentifier (FormalParameters) { FunctionBody }`

`GeneratorExpression :`
 `function * BindingIdentifieropt (FormalParameters) { FunctionBody }`

`YieldExpression :`
 `yield YieldDelegatoropt [Lexical goal InputElementRegExp] AssignmentExpression`

`YieldDelegator :`
 `*`

Supplemental Syntax

The following productions are used as an aid in specifying the semantics of certain ECMAScript language features. They are not used when parsing ECMAScript source code.

`GeneratorBody :`
 `FunctionBody`
 `Comprehension`

- Deleted:** `List`
- Deleted:** <#>Let `needsSuperBinding` be the result of `FunctionBody Contains super`.
- Deleted:** `needsSuperBinding`
- Deleted:** <#>Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `formalParameterList`, `ConciseBody`, `scope`, and `strict` and with `object` as the `homeObject` optional argument and `propName` as the `methodName` optional argument.
- Deleted:** <#>TODO: Make closure a constructor, for ESM compat
- Deleted:** `Return`
- Deleted:** `,`
- Deleted:** `, and false`
- Deleted:** `o`
- Deleted:** `ConciseBody`
- Deleted:** `{ FunctionBody }`
- Deleted:** If this `MethodDefinition` is contained in strict code or if `FunctionBody ConciseBody` is strict code, then let `strict` be `true`. Otherwise, let `strict` be `false`.
- Deleted:** `current`
- Deleted:** <#>Let `needsSuperBinding` be the result of `FunctionBody Contains super`.
- <#>If `needsSuperBinding` is false, then let `needsSuperBinding` be the result of `PropertySetParameterList cContains super`
- Deleted:** `needsSuperBinding`
- Deleted:** `o`
- Deleted:** `o`
- Deleted:** <#>Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `PropertySetParameterList`, `ConciseBody`, `scope`, and `strict` and with `object` as the `homeObject` optional argument and `propName` as the `methodName` optional argument.
- Deleted:** <#>TODO: Make closure a constructor, for ESM compat
- Deleted:** `Return`
- Deleted:** calling the `[[`
- Deleted:** `Own`
- Deleted:** `]]` internal method of
- Deleted:** with arguments
- Deleted:** `,`
- Deleted:** `and`
- Deleted:** `, and false`
- Deleted:** NOTE The strictness and property attributes for `set` and `get` `MethodDefinition` productions differ from the other `MethodDefinition`
- Deleted:** `f`
- Deleted:** `List`
- Deleted:** `Function`
- Deleted:** `List`
- Deleted:** `Function`
- Comment [AWB10136]:** This actually doesn't

Static Semantics

Static Semantics: Early Errors

GeneratorMethod : * PropertyName (StrictFormalParameters) { FunctionBody }

and

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

and

GeneratorExpression : function * BindingIdentifier_{opt} (FormalParameters) { FunctionBody }

- It is a Syntax Error if FunctionBody Contains YieldExpression is false.

GeneratorMethod : * PropertyName (StrictFormalParameters) { FunctionBody }

- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

and

GeneratorExpression : function * BindingIdentifier_{opt} (FormalParameters) { FunctionBody }

- It is a Syntax Error if IsSimpleParameterList of FormalParameters is false and any element of the BoundNames of FormalParameters also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if any element of the BoundNames of FormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

YieldExpression : yield YieldDelegator_{opt} AssignmentExpression

- It is a Syntax Error if AssignmentExpression Contains YieldExpression.

Static Semantics: BoundNames

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return the BoundNames of BindingIdentifier.

Static Semantics: Contains

With parameter symbol.

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return false.

GeneratorExpression : function * BindingIdentifier_{opt} (FormalParameters) { FunctionBody }

1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

Static Semantics: IsConstantDeclaration

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return false.

Deleted: Function

Deleted: List

Deleted: FunctionBody

Deleted: Function

Deleted: List

Deleted: FunctionBody

Deleted: <#>It is a Syntax Error if any element of the BoundNames of FormalParameterList also occurs in the LexicallyDeclaredNames of FunctionBody.¶

Deleted: FunctionBody

Deleted:)

Deleted: any

Deleted: List

Deleted: FunctionBody

Deleted: FunctionDeclaration

Deleted: List

Deleted: FunctionBody

Deleted: Function

Deleted: List

Deleted: FunctionBody

Deleted: List

Deleted: FunctionBody

Static Semantics: LexicallyDeclaredNames

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return the BoundNames of BindingIdentifier.

Deleted: List

Deleted: FunctionBody

Static Semantics: PropName

GeneratorMethod : * PropertyName (FormalParameters) { FunctionBody }

1. Return PropName of PropertyName.

Static Semantics: ReferencesSuper

GeneratorMethod : * PropertyName (FormalParameters) { FunctionBody }

1. If FormalParameters Contains super is true, then return true.
2. Return FunctionBody Contains super.

Static Semantics: VarDeclaredNames

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return an empty List.

Deleted: List

Deleted: FunctionBody

Runtime Semantics

NOTE: Abstract operations relating to generator objects are defined in 15.19.4.3.3.

Runtime Semantics EvaluateBody

With parameter functionObject.

GeneratorBody : FunctionBody

1. Let G be the this value.
2. If Type(G) is not Object or if Type(G) is Object and G does not have a [[GeneratorState]] internal data property, then
 - a. Let G be the result of calling OrdinaryCreateFromConstructor(functionObject, "%GeneratorPrototype%", ([[GeneratorState]], [[GeneratorContext]])).
 - b. ReturnIfAbrupt(G).
3. Return the result of GeneratorStart(G, FunctionBody).

GeneratorBody : Comprehension

1. Let G be the result of ObjectCreate("%GeneratorPrototype%", ([[GeneratorState]], [[GeneratorContext]])).
2. ReturnIfAbrupt(G).
3. If the value of G's [[GeneratorState]] internal data property is not undefined, then throw a TypeError exception.
4. Let startStatus be the result of GeneratorStart(G, Comprehension).
5. ReturnIfAbrupt(startStatus).
6. Return G.

Runtime Semantics: InstantiateFunctionObject

With parameter scope.

GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }

1. If the *GeneratorDeclaration* is contained in strict code or if its *FunctionBody* is strict code, then let *strict* be **true**. Otherwise let *strict* be **false**.
2. Using *FunctionBody* from the production that is being evaluated, let *body* be the supplemental syntactic grammar production: *GeneratorBody : FunctionBody*.
3. Let *F* be the result of performing the *GeneratorFunctionCreate* abstract operation with arguments *Normal*, *FormalParameters*, *body*, *scope*, and *strict*.
4. Let *prototype* be the result of the abstract operation *ObjectCreate* with the intrinsic object %GeneratorPrototype% as its argument.
5. Perform the abstract operation *MakeConstructor* with arguments *F*, **true**, and *prototype*.
6. Return *F*.

Runtime Semantics: Property Definition Evaluation

With parameter *object* and optional parameter *functionPrototype*.

*GeneratorMethod : * PropertyName (StrictFormalParameters) { FunctionBody }*

1. Let *propName* be *PropName* of *PropertyName*.
2. Let *strict* be *IsStrict* of *FunctionBody*.
3. Let *scope* be the running execution context's *LexicalEnvironment*.
4. Using *FunctionBody* from the production that is being evaluated, let *body* be the supplemental syntactic grammar production: *GeneratorBody : FunctionBody*.
5. If *ReferencesSuper* of *GeneratorMethod* is **true**, then
 - a. Let *closure* be the result of performing the *GeneratorFunctionCreate* abstract operation with arguments *Method*, *StrictFormalParameters*, *body*, *scope*, and *strict* and with *object* as the *homeObject* optional argument and *propName* as the *methodName* optional argument.
6. Else
 - a. Let *closure* be the result of performing the *GeneratorFunctionCreate* abstract operation with arguments *Method*, *StrictFormalParameters*, *body*, *scope*, and *strict*.
7. Let *prototype* be the result of the abstract operation *ObjectCreate* with the intrinsic object %GeneratorPrototype% as its argument.
8. Perform the abstract operation *MakeConstructor* with arguments *closure*, **true**, and *prototype*.
9. Let *desc* be the Property Descriptor `{[[Value]]: closure, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
10. Let *status* be the result of *DefinePropertyOrThrow*(*object*, *propName desc*).
11. ReturnIfAbrupt(*status*).
12. Return *NormalCompletion*(*closure*).

Runtime Semantics: Evaluation

*GeneratorDeclaration : function * BindingIdentifier (FormalParameters) { FunctionBody }*

1. Return *NormalCompletion*(empty)

*GeneratorExpression : function * (FormalParameters) { FunctionBody }*

1. If the *GeneratorExpression* is contained in strict code or if its *FunctionBody* is strict code, then let *strict* be **true**. Otherwise let *strict* be **false**.
2. Using *FunctionBody* from the production that is being evaluated, let *body* be the supplemental syntactic grammar production: *GeneratorBody : FunctionBody*.
3. Let *scope* be the *LexicalEnvironment* of the running execution context.
4. Let *closure* be the result of performing the *GeneratorFunctionCreate* abstract operation with arguments *Normal*, *FormalParameters*, *body*, *scope*, and *strict*.
5. Let *prototype* be the result of the abstract operation *ObjectCreate* with the intrinsic object %GeneratorPrototype% as its argument.
6. Perform the abstract operation *MakeConstructor* with arguments *closure*, **true**, and *prototype*.
7. Return *closure*.

*GeneratorExpression : function * BindingIdentifier (FormalParameters) { FunctionBody }*

1. If the *GeneratorExpression* is contained in strict code or if its *FunctionBody* is strict code, then let *strict* be **true**. Otherwise let *strict* be **false**.
2. Using *FunctionBody* from the production that is being evaluated, let *body* be the supplemental syntactic grammar production: *GeneratorBody* : *FunctionBody*.
3. Let *funcEnv* be the result of calling *NewDeclarativeEnvironment* passing the running execution context's Lexical Environment as the argument.
4. Let *envRec* be *funcEnv*'s environment record.
5. Let *name* be StringValue of *BindingIdentifier*.
6. Call the *CreateImmutableBinding* concrete method of *envRec* passing *name* as the argument.
7. Let *closure* be the result of performing the *GeneratorFunctionCreate* abstract operation with arguments *NormalFormalParameters*, *body*, *funcEnv*, and *strict*.
8. Let *prototype* be the result of the abstract operation *ObjectCreate* with the intrinsic object %GeneratorPrototype% as its argument.
9. Perform the abstract operation *MakeConstructor* with arguments *closure*, **true**, and *prototype*.
10. Call the *InitialiseBinding* concrete method of *envRec* passing *name* and *closure* as the arguments.
11. Return *NormalCompletion*(*closure*).

NOTE 1 The *BindingIdentifier* in a *GeneratorExpression* can be referenced from inside the *GeneratorExpression*'s *FunctionBody* to allow the generator code to call itself recursively. However, unlike in a *GeneratorDeclaration*, the *BindingIdentifier* in a *GeneratorExpression* cannot be referenced from and does not affect the scope enclosing the *GeneratorExpression*.

YieldExpression : **yield** *YieldDelegator*_{opt} *AssignmentExpression*

1. Let *exprRef* be the result of evaluating *AssignmentExpression*.
2. Let *value* be *GetValue*(*exprRef*).
3. *ReturnIfAbrupt*(*value*).
4. If *YieldDelegator* is present, then
 - a. If *Type*(*value*) is not then throw a **TypeError** exception.
 - b. Let *iterator* be the result of performing *Invoke* with arguments *value*, @@*iterator* and an empty List.
 - c. *ReturnIfAbrupt*(*iterator*).
 - d. If *Type*(*iterator*) is not then throw a **TypeError** exception.
 - e. Let *received* be **undefined**.
 - f. Repeat
 - i. Let *innerResult* be the result of *Invoke*(*iterator*, "value", (*received*)).
 - ii. *ReturnIfAbrupt*(*innerResult*).
 - iii. If *Type*(*innerResult*) is not Object, then throw a **TypeError** exception.
 - iv. Let *done* be *IteratorComplete*(*innerResult*).
 - v. *ReturnIfAbrupt*(*done*).
 - vi. If *done* is **true**, then
 1. Let *innerValue* be the result of *Get*(*innerResult*, "value").
 2. *Return* *innerValue*.
 - vii. Let *yieldCompletion* be the result of *GeneratorYield*(*innerResult*).
 - viii. Let *received* be *yieldCompletion*[value].
 - ix. If *yieldCompletion*[type] is throw, then
 1. If *HasProperty*(*iterator*, "throw" is **true**, then
 - a. Let *innerResult* be the result of *Invoke*(*iterator*, "throw", (*received*)).
 - b. *ReturnIfAbrupt*(*innerResult*).
 2. *Return* *yieldCompletion*.
5. *Return* the result of *GeneratorYield*(*CreateItrResultObject*(*value*, **false**)).

13.5 Class Definitions

Syntax

ClassDeclaration :
class *BindingIdentifier* *ClassTail*

ClassExpression :
class *BindingIdentifier*_{opt} *ClassTail*

ClassTail :
ClassHeritage_{opt} { ClassBody_{opt} }

ClassHeritage :
extends AssignmentExpression

ClassBody :
ClassElementList

ClassElementList :
ClassElement
ClassElementList ClassElement

ClassElement :
MethodDefinition
static MethodDefinition
i

NOTE A ClassBody is always strict code.

Static Semantics

Static Semantics: Early Errors

ClassBody : ClassElementList

- It is a Syntax Error if PrototypePropertyNameList of ClassElementList contains any duplicate entries, unless the following condition is true for each duplicate entry: The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor MethodDefinition and the other occurrence was obtained from a set accessor MethodDefinition.
- It is a Syntax Error if StaticPropertyNameList of ClassElementList contains any duplicate entries, unless the following condition is true for each duplicate entry: The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor MethodDefinition and the other occurrence was obtained from a set accessor MethodDefinition.

ClassElement : MethodDefinition

- It is a Syntax Error if PropName of MethodDefinition is "constructor" and SpecialMethod of MethodDefinition is true.

ClassElement : static MethodDefinition

- It is a Syntax Error if PropName of MethodDefinition is "prototype".

Static Semantics: BoundNames

ClassDeclaration: class BindingIdentifier ClassTail

- Return the BoundNames of BindingIdentifier.

Static Semantics: ConstructorMethod

ClassBody : ClassElementList

- Let list be PrototypeMethodDefinitions of ClassElementList.
- For each MethodDefinition m in list, do
 - If PropName of m is "constructor", return m.
- Return empty.

Deleted: ClassDeclaration : class BindingIdentifier ClassTail
 and
ClassExpression : class BindingIdentifier ClassTail
 <#> It is a Syntax Error if BoundNames of BindingIdentifier contains either "eval" or "arguments"!
Deleted: {
Deleted: }
Deleted: Method
Deleted: ClassHeritage : extends AssignmentExpression
 <#> It is a Syntax Error if AssignmentExpression Contains YieldExpression.

NOTE Early Error rules ensure that there is only one method definition named "**constructor**" and that it isn't an accessor property or generator definition.

Static Semantics: Contains

With parameter *symbol*.

ClassTail : *ClassHeritage*_{opt} { *ClassBody* }

1. If *symbol* is *ClassBody*, return **true**.
2. If *ClassHeritage* is not present, return **false**.
3. If *symbol* is *ClassHeritage*, return **true**.
4. Return the result of Contains for *ClassHeritage* with argument *symbol*.

NOTE Static semantic rules that depend upon substructure generally do not look into class bodies.

Static Semantics: IsConstantDeclaration

ClassDeclaration: **class** *BindingIdentifier* *ClassTail*

1. Return **false**.

Deleted: true

Static Semantics: IsStatic

ClassElement : *MethodDefinition*

1. Return **false**.

ClassElement : **static** *MethodDefinition*

1. Return **true**.

ClassElement : ;

1. Return **false**.

Static Semantics: LexicallyDeclaredNames

ClassDeclaration: **class** *BindingIdentifier* *ClassTail*

1. Return the BoundNames of *BindingIdentifier*.

Static Semantics: PrototypeMethodDefinitions

ClassElementList : *ClassElement*

1. If PropName of *ClassElement* is empty or "**constructor**", return a new empty List.
2. If IsStatic of *ClassElement* is **true**, return a new empty List.
3. Return a List containing *ClassElement*.

ClassElementList : *ClassElementList* *ClassElement*

1. Let *list* be PrototypeMethodDefinitions of *ClassElementList*.
2. If PropName of *ClassElement* is empty or "**constructor**", return *list*.
3. If IsStatic of *ClassElement* is **true**, return *list*.
4. Append *ClassElement* to the end of *list*.
5. Return *list*.

Static Semantics: PrototypePropertyNameList

ClassElementList : ClassElement

1. If PropName of *ClassElement* is empty, return a new empty List.
2. If IsStatic of *ClassElement* is true, return a new empty List.
3. Return a List containing PropName of *ClassElement*.

ClassElementList : ClassElementList ClassElement

1. Let *list* be PrototypePropertyNameList of *ClassElementList*.
2. If PropName of *ClassElement* is empty, return *list*.
3. If IsStatic of *ClassElement* is true, return *list*.
4. Append PropName of *ClassElement* to the end of *list*.
5. Return *list*.

Static Semantics: PropName

ClassElement : ;

1. Return empty.

Static Semantics: StaticPropertyNameList

ClassElementList : ClassElement

1. If PropName of *ClassElement* is empty, return a new empty List.
2. If IsStatic of *ClassElement* is false, return a new empty List.
3. Return a List containing PropName of *ClassElement*.

ClassElementList : ClassElementList ClassElement

1. Let *list* be StaticPropertyNameList of *ClassElementList*.
2. If PropName of *ClassElement* is empty, return *list*.
3. If IsStatic of *ClassElement* is false, return *list*.
4. Append PropName of *ClassElement* to the end of *list*.
5. Return *list*.

Static Semantics: StaticMethodDefinitions

ClassElementList : ClassElement

1. If PropName of *ClassElement* is empty, return a new empty List.
2. If IsStatic of *ClassElement* is false, return a new empty List.
3. Return a List containing *ClassElement*.

ClassElementList : ClassElementList ClassElement

1. Let *list* be StaticMethodDefinitions of *ClassElementList*.
2. If PropName of *ClassElement* is empty, return *list*.
3. If IsStatic of *ClassElement* is false, return *list*.
4. Append *ClassElement* to the end of *list*.
5. Return *list*.

Static Semantics: VarDeclaredNames

ClassDeclaration: class BindingIdentifier ClassTail

1. Return an empty List.

Runtime Semantics

Runtime Semantics: ClassDefinitionEvaluation

With parameter *className*.

ClassTail : *ClassHeritage_{opt}* { *ClassBody* }

1. If *ClassHeritage_{opt}* is not present, then
 - a. Let *protoParent* be the intrinsic object %ObjectPrototype%.
 - b. Let *constructorParent* be the intrinsic object %FunctionPrototype%.
2. Else
 - a. Let *superclass* be the result of evaluating *ClassHeritage*.
 - b. ReturnIfAbrupt(*superclass*).
 - c. If *superclass* is **null**, then
 - i. Let *protoParent* be **null**.
 - ii. Let *constructorParent* be the intrinsic object %FunctionPrototype%.
 - d. Else if Type(*superclass*) is not Object, throw a **TypeError** exception.
 - e. Else if IsConstructor(*superclass*) is **false**, then throw a **TypeError** exception.
 - f. Else
 - i. Let *protoParent* be the result of Get(*superclass*, "prototype").
 - ii. ReturnIfAbrupt(*protoParent*).
 - iii. If Type(*protoParent*) is neither Object or Null, throw a **TypeError** exception.
 - iv. Let *constructorParent* be *superclass*.
3. Let *proto* be the result of the abstract operation ObjectCreate with argument *protoParent*.
4. Let *lex* be the LexicalEnvironment of the running execution context.
5. If *className* is not **undefined**, then
 - a. Let *scope* be the result of calling NewDeclarativeEnvironment passing *lex* as the argument.
 - b. Let *envRec* be *scope*'s environment record.
 - c. Call the CreateImmutableBinding concrete method of *envRec* passing *className* as the argument.
 - d. Set the running execution context's LexicalEnvironment to *scope*.
6. Let *constructor* be ConstructorMethod of *ClassBody*.
7. If *constructor* is empty, then
 - a. If *ClassHeritage_{opt}* is present, then
 - i. Let *constructor* be the result of parsing the String "constructor(... args){super(... args);}" using the syntactic grammar with the goal symbol *MethodDefinition*.
 - b. Else,
 - i. Let *constructor* be the result of parsing the String "constructor(){ }" using the syntactic grammar with the goal symbol *MethodDefinition*.
8. Let *strict* be **true**.
9. Let *F* be the result of performing Property Definition Evaluation for *constructor* with argument *proto* and *constructorParent* as the optional *functionPrototype* argument.
10. Perform the abstract operation MakeConstructor with argument *F* and **false** as the optional *writablePrototype* argument and *proto* as the optional *prototype* argument.
11. If *className* is not **undefined**, then
 - a. Call the InitialiseBinding concrete method of *envRec* passing *className* and *F* as the arguments.
12. Let *desc* be the Property Descriptor{[[Enumerable]]: **false**, [[Writable]]: **true**, [[Configurable]]: **true**}.
13. Call the [[DefineOwnProperty]] internal method of *proto* with arguments "constructor" and *desc*.
14. Let *protoMethods* be PrototypeMethodDefinitions of *ClassBody*.
15. For each *MethodDefinition m* in order from *protoMethods*
 - a. Perform Property Definition Evaluation for *m* with argument *proto*.
16. Let *staticMethods* be StaticMethodDefinitions of *ClassBody*.
17. For each *MethodDefinition s* in order from *staticMethods*
 - a. Perform Property Definition Evaluation for *s* with argument *F*.
18. Set the running execution context's LexicalEnvironment to *lex*.
19. Return *F*.

Deleted:

Deleted: does not have a [[Construct]] internal property method

Deleted: ¶

Deleted: Let *protoParent* be *superclass*.

Deleted: <#> Let *constructorParent* be the intrinsic object %FunctionPrototype%. ¶

Deleted: calling the [[

Deleted:] internal method of

Deleted:

Deleted: passing

Deleted: as the argument

Deleted: *proto*

Deleted: <#> If the *ClassTail* is contained in strict code or its *FunctionBody* is strict code, then let *strict* be **true**. Otherwise let *strict* be **false**. ¶

Deleted: *ClassHeritage_{opt}* is present and

Deleted: .constructor

Comment [AWB9137]: Note that this variable currently isn't used in this algorithm

Deleted: If the *ClassTail* is contained in strict code or if *constructor* is strict code, then 1

Deleted: Otherwise let *strict* be **false**.

Comment [AWB8138]: As it now stands, this will never be an abrupt completion

Deleted: ing

Deleted: false

Deleted: false

Deleted: object

Deleted: ,

Deleted: , and false.

Deleted: m

Deleted: m

Runtime Semantics: Evaluation

ClassDeclaration: class BindingIdentifier ClassTail

1. Let value be the result of ClassDefinitionEvaluation of ClassTail with argument undefined.
2. ReturnIfAbrupt(value).
3. Let env be the running execution context's LexicalEnvironment.
4. Let status be the result of performing Binding Initialisation for BindingIdentifier passing value and env as the arguments.
5. ReturnIfAbrupt(status).
6. Return NormalCompletion(empty).

NOTE The argument to ClassDefinitionEvaluation controls whether or not the class that is defined with a BindingIdentifier has a local binding to the identifier. Only a ClassExpression gets a local name binding of its name. A ClassDeclaration never has such a binding. This maintains the parallel with FunctionExpression and FunctionDeclaration.

ClassExpression: class BindingIdentifier_{opt} ClassTail

1. If BindingIdentifier_{opt} is not present, then let className be undefined.
2. Else, let className be StringValue of BindingIdentifier.
3. Let value be the result of ClassDefinitionEvaluation of ClassTail with argument className.
4. ReturnIfAbrupt(value).
5. Return NormalCompletion(value).

13.6 Tail Position Calls

The wiki proposal has a preliminary attempt at defining tail position. See http://wiki.ecmascript.org/doku.php?id=harmony:proper_tail_calls.

This material still needs to be reviewed and updated for incorporation here.

14 Scripts and Modules

14.1 Script

Syntax

Script :
 ScriptBody_{opt}

ScriptBody :
 OuterStatementList

OuterStatementList :
 OuterItem
 OuterStatementList OuterItem

OuterItem :
 ModuleDeclaration
 ImportDeclaration
 StatementListItem

Static Semantics

Static Semantics: Early Errors

ScriptBody : OuterStatementList

Deleted: <#>Let className be String Value of BindingIdentifier.¶

Deleted: className

Deleted: If value is an abrupt completion, return value

Deleted:

Deleted: Value

Comment [AWB9139]: TODO: Need to define tail positions.

Deleted: 13.1 Strict Mode Restrictions¶

It is a SyntaxError if any Identifier value occurs more than once within a

FormalParameterList of a strict mode

FunctionDeclaration or FunctionExpression.¶

It is a SyntaxError if the Identifier "eval" or

the Identifier "arguments" occurs within a

FormalParameterList of a strict mode

FunctionDeclaration or FunctionExpression.¶

It is a SyntaxError if the Identifier "eval" or

the Identifier "arguments" occurs as the

Identifier of a strict mode FunctionDeclaration

or FunctionExpression.¶

Deleted: 13.21.156 Creating Function Objects and Constructors¶

Runtime Semantics: FunctionCreate Abstract Operation¶

The abstract operation FunctionCreate requires the arguments: kind which is one of (Normal, Method, Arrow), A Function object is constructed as follows Given given an optional parameter list specified by FormalParameterList, a body specified by FunctionBody, a Lexical Environment specified by Scope, and a Boolean flag Strict, and optionally, an object functionPrototype, an object homeObject and a string methodName. FunctionCreate performs the following steps a Function object is constructed as follows:¶

<#>Create a new native ECMAScript object and F be that object.¶

<#>Set F's essential internal methods except for [[GetP]] and [[GetOwnProperty]] to the default ordinary object definitions specified in 8.3.¶

<#>Set F's essential internal methods for [[Call]] [[GetP]] and [[GetOwnProperty]] to the default ordinary object definitions specified in 8.3.19.¶

<#>Set all the internal methods, except for [[GetProperty]], of F as described in 8.12.¶

Deleted: 7

Deleted: 13.2 Generator Definitions¶

Syntax¶

GeneratorDeclaration :¶

Deleted: Programs

Deleted: Program

Deleted: SourceElements_{opt}

Deleted: Program

Deleted: SourceElements

Deleted: Program

Deleted: SourceElement
SourceElements SourceElement

Deleted: Program

- It is a Syntax Error if the LexicallyDeclaredNames of *OuterStatementList* contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of *OuterStatementList* also occurs in the VarDeclaredNames of *OuterStatementList*.
- It is a Syntax Error if *OuterStatementList* Contains *ReturnStatement*.
- It is a Syntax Error if *OuterStatementList* Contains *super*.
- It is a Syntax Error if *OuterStatementList* Contains *YieldExpression*.

NOTE Additional error conditions relating to conflicting or duplicate declarations are checked during module linking prior to evaluation of a *Script*. If any such errors are detected the *Script* is not evaluated.

Static Semantics: IsStrict

ScriptBody : *OuterStatementList*

1. If this *ScriptBody* is contained in strict code or if *OuterStatementList* is strict code, then return **true**. Otherwise, return **false**.

Comment [AWB10140]: Need a better definition

Static Semantics: LexicallyDeclaredNames

OuterStatementList : *OuterStatementList OuterItem*

1. Let *names* be LexicallyDeclaredNames of *OuterStatementList*.
2. Append to *names* the elements of the LexicallyDeclaredNames of *OuterItem*.
3. Return *names*.

OuterItem : *ModuleDeclaration*

1. Return the BoundNames of *ModuleDeclaration*.

Deleted: Import

OuterItem : *ImportDeclaration*

1. Return the BoundNames of *ImportDeclaration*.

OuterItem : *StatementListItem*

1. Return TopLevelLexicallyDeclaredNames of *StatementListItem*.

NOTE At the top level of a *Script*, function declarations are treated like var declarations rather than like lexical declarations.

Static Semantics: LexicallyScopedDeclarations

OuterStatementList : *OuterStatementList OuterItem*

1. Let *declarations* be LexicallyScopedDeclarations of *OuterStatementList*.
2. Append to *declarations* the elements of the LexicallyScopedDeclarations of *OuterItem*.
3. Return *declarations*.

OuterItem : *ModuleDeclaration*

1. Return a new List containing *ModuleDeclaration*.

OuterItem : *ImportDeclaration*

1. Return a new List containing *ImportDeclaration*.

OuterItem : *StatementListItem*

1. Return TopLevelLexicallyScopedDeclarations of *StatementListItem*.

Static Semantics: VarDeclaredNames

OuterStatementList : OuterStatementList OuterItem

1. Let *names* be VarDeclaredNames of *OuterStatementList*.
2. Append to *names* the elements of the VarDeclaredNames of *OuterItem*.
3. Return *names*.

OuterItem : ModuleDeclaration

2. Return an empty List.

OuterItem : ImportDeclaration

2. Return an empty List.

OuterItem : StatementListItem

2. Return TopLevelVarDeclaredNames of *StatementListItem*.

Static Semantics: VarScopedDeclarations

OuterStatementList : OuterStatementList OuterItem

1. Let *declarations* be VarScopedDeclarations of *OuterStatementList*.
2. Append to *declarations* the elements of the VarScopedDeclarations of *OuterItem*.
3. Return *declarations*.

OuterItem : ModuleDeclaration

1. Return a new empty List.

OuterItem : ImportDeclaration

1. Return a new empty List.

OuterItem : StatementListItem

1. Return the TopLevelVarScopedDeclarations of *StatementListItem*.

Runtime Semantics

Runtime Semantics: Script Evaluation

With argument *realm* and *deletableBindings*.

Script : ScriptBody_{opt}

1. The code of this *Script* is strict mode code if the Directive Prologue (14.1) of its *ScriptBody* contains a Use Strict Directive or if any of the conditions of 10.1.1 apply. If the code of this *Script* is strict mode code, *ScriptBody* is evaluated in the following steps as strict mode code. Otherwise *ScriptBody* is evaluated in the following steps as non-strict mode code.
2. If *ScriptBody* is not present, return *NormalCompletion(empty)*.
3. Let *globalEnv* be *realm*.*[[globalEnv]]*.
4. Let *status* be the result of performing Global Declaration Instantiation as described in 10.5.1 using *ScriptBody*, *globalEnv*, and *deletableBindings* as arguments.
5. ReturnIfAbrupt(*status*).
6. Let *progCxt* be a new ECMAScript code execution context.
7. Set the *progCxt*'s Realm to *realm*.
8. Set the *progCxt*'s VariableEnvironment to *globalEnv*.

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Deleted: <#>Set the <i>progCxt</i> 's PreviousContext to empty.
Deleted: <i>realm</i> 's .[[Global Environment]]

9. Set the *progCxt*'s LexicalEnvironment to *globalEnv*.
10. If there is a currently running execution context, suspend it.
11. Push *progCxt* on to the execution context stack; *progCxt* is now the running execution context.
12. Let *result* be the result of evaluating *ScriptBody*.
13. Suspend *progCxt* and remove it from the execution context stack.
14. If the execution context stack is not empty, resume the context that is now on the top of the execution context stack as the running execution context. Otherwise, the execution context stack is now empty and there is no running execution context.
15. Return *result*.

NOTE The processes for initiating the evaluation of a *Script* and for dealing with the result of such an evaluation are defined by an ECMAScript implementation and not by this specification.

Runtime Semantics: Evaluation

OuterStatementList : *OuterStatementList OuterItem*

1. Let *s1* be the result of evaluating *OuterStatementList*.
2. ReturnIfAbrupt(*s1*).
3. Let *s* be the result of evaluating *OuterItem*.
4. If *s*.[[type]] is throw, return *s*.
5. If *s*.[[value]] is empty, let *V* = *s*.[[value]], otherwise let *V* = *s*.[[value]].
6. Return Completion {[[type]]: *s*.[[type]], [[value]]: *V*, [[target]]: *s*.[[target]]}.

NOTE See the 12.1 NOTE regarding evaluation of *StatementList* : *StatementList StatementListItem*.

14.1.1 Directive Prologues and the Use Strict Directive

A Directive Prologue is the longest sequence of *ExpressionStatement* productions occurring as the initial *StatementListItem* productions of a *ScriptBody* or *FunctionBody* and where each *ExpressionStatement* in the sequence consists entirely of a *StringLiteral* token followed by a semicolon. The semicolon may appear explicitly or may be inserted by automatic semicolon insertion. A Directive Prologue may be an empty sequence.

A Use Strict Directive is an *ExpressionStatement* in a Directive Prologue whose *StringLiteral* is either the exact character sequences "use strict" or 'use strict'. A Use Strict Directive may not contain an *EscapeSequence* or *LineContinuation*.

A Directive Prologue may contain more than one Use Strict Directive. However, an implementation may issue a warning if this occurs.

NOTE The *ExpressionStatement* productions of a Directive Prologue are evaluated normally during evaluation of the containing production. Implementations may define implementation specific meanings for *ExpressionStatement* productions which are not a Use Strict Directive and which occur in a Directive Prologue. If an appropriate notification mechanism exists, an implementation should issue a warning if it encounters in a Directive Prologue an *ExpressionStatement* that is not a Use Strict Directive or which does not have a meaning defined by the implementation.

14.2 Modules

15 Standard Built-in 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, a built-in object that is callable as a function is a Build-in Function object with the characteristics described in 8.4.7. Unless specified otherwise, the [[Extensible]] internal data property of a built-in object initially has the value true.

- Deleted:** realm.[[globalEnv]]
- Deleted:** 's Global Environment
- Deleted:** <#>If ProgramBody is present, then<#>Perform Global Binding Instantiation as described in 10.5.x using the global code.||
- Deleted:** *SourceElements*
- Deleted:** *ProgramBody*
- Deleted:**
- Comment [AWB6141]:** This is a place where we could put something about what to do with unhandled exceptions
- Deleted:** Exit the execution context *progCxt*.
- Deleted:** T
- Deleted:** running current execution context to empty
- Deleted:** *Program*
- Comment [AWB11142]:** Not strictly true any longer. Will need to update.
- Deleted:** The production *SourceElements ProgramBody* *SourceElements SourceElementStatementList* is evaluated as follows:|| Let *headResult* be the result of evaluating *SourceElements*.|| If *headResult* is an abrupt completion, return *headResult*.|| Let *tailResult* be result of evaluating *SourceElementStatementList*.|| If *tailResult.value* is empty, let *V* = *headResult.value*, otherwise let *V* = *tailResult.value*.|| Return (tailResult.type, *V*, tailResult.target)the result of evaluating *StatementList*.||
- Deleted:** The production *SourceElement* : *Statement* is evaluated as follows:|| Return the result of evaluating *Statement*.|| The production *SourceElement* : *FunctionDeclaration* is evaluated as follows:|| Return (normal, empty, empty).||
- Deleted:** 1
- Deleted:** as the initial *SourceElement* productions of a *Program* or
- Comment [AWB15143]:** TODO: need to update
- Deleted:** *Program*
- Deleted:** *SourceElements*

- Deleted:** the
- Deleted:** [[Class]] internal property of
- Deleted:** is "Function"
- Deleted:** has the [[IsFunctionNativeBrandBuiltInBrand] internal data property with value NativeFunctionBuiltInFunction if that built-in object has [[Call]] internal property method
- Deleted:** , or "Object" if that built-in object does not have a [[Call]] internal property

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 clause 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 clause is given more arguments than the function is specified to allow, the extra arguments are evaluated by the call and then ignored by the function. However, an implementation may define implementation specific behaviour relating to such arguments as long as the behaviour is not the throwing of a **TypeError** exception that is predicated simply on the presence of an extra argument.

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` (15.3.3), as the value of its `[[Prototype]]` internal `data` property.

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Unless otherwise specified every built-in prototype object has the Object prototype object, which is the initial value of the expression `Object.prototype` (15.2.4), as the value of its `[[Prototype]]` internal `data` property, except the Object prototype object itself.

None of the built-in functions described in this clause that are not constructors shall implement the `[[Construct]]` internal method unless otherwise specified in the description of a particular function. The behaviour specified in this clause for each built-in function is the specification of the `[[Call]]` internal method behaviour for that function with `[[Call]] thisArgument` providing the `this` value and `[[Call]] argumentList` providing the named parameters for each built-in function. None of the built-in functions described in this clause shall have a `prototype` property unless otherwise specified in the description of a particular function.

Comment [AW144]: https://bugs.ecmascript.org/show_bug.cgi?id=155

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This clause generally describes distinct behaviours for when a constructor is “called as a function” and for when it is “called as part of a `new` expression”. The “called as a function” behaviour corresponds to the invocation of the constructor’s `[[Call]]` internal method and the “called as part of a new expression” behaviour corresponds to the invocation of the constructor’s `[[Construct]]` internal method.

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Every built-in Function object, F , described in this clause—whether as a constructor, an ordinary function, or both—has the properties that are defined by performing the following step when the function object is created:

1. Perform the `AddRestrictedFunctionProperties` (13.6.3) abstract operation with argument F .

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Every built-in Function object described in this clause—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 subclause 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 subclause 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 clause has the attributes { `[[Writable]]: false`, `[[Enumerable]]: false`, `[[Configurable]]: false` }.

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Every other `data` property described in this clause has the attributes { `[[Writable]]: true`, `[[Enumerable]]: false`, `[[Configurable]]: true` } unless otherwise specified.

Every accessor property described in this clause has the attributes {`[[Enumerable]]: false, [[Configurable]]: true`} unless otherwise specified. If only a `get` accessor function is described, the `set` accessor function is the default value, `undefined`. If only a `set` accessor is function is described the `get` accessor is the default value, `undefined`.

15.1 The Global Object

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

Unless otherwise specified, the standard built-in properties of the global object have attributes {`[[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true`}.

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

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

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The value of the `[[Prototype]]` internal data property of the global object is 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.

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15.1.1 Value Properties of the Global Object

15.1.1.1 `NaN`

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

15.1.1.2 `Infinity`

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

15.1.1.3 `undefined`

The value of `undefined` is `undefined` (see 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 `Type(x)` is not `String`, return `x`.
2. Let `script` be the ECMAScript code that is the result of parsing `x`, interpreted as UTF-16 encoded Unicode text as described in 8.4, for the goal symbol `Script`. If the parse fails or any early errors are detected, throw a `SyntaxError` exception (but see also clause 16).
3. If `script` Contains `ScriptBody` is `false`, return `undefined`.
4. Let `strictScript` be `IsStrict` of `script`.
5. If this is a direct call to `eval` (15.1.2.1.1), let `direct` be `true`, otherwise let `direct` be `false`.
6. If `direct` is `true` and the code that made the direct call to `eval` is strict code, then let `strictCaller` be `true`. Otherwise, let `strictCaller` be `false`.

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7. Let *ctx* be the running execution context. If *direct* is **true** *ctx* will be the execution context that performed the direct eval. If *direct* is **false** *ctx* will be the execution context for the invocation of the eval function.
8. Let *evalRealm* be *ctx*'s Realm.
9. If *direct* is **false** and *strictScript* is **false**, then
 - a. Return the result of Script Evaluation for *script* with arguments *evalRealm* and **true**.
10. If *direct* is **true**, *strictScript* is **false**, *strictCaller* is **false**, and *ctx*'s LexicalEnvironment is the same as *evalRealm*.[[globalEnv]], then
 - a. Return the result of Script Evaluation for *script* with arguments *evalRealm* and **true**.
11. If *direct* is **true**, then
 - a. If the code that made the direct call to eval is **function code** and *ValidInFunction* of *script* is **false**, then throw a **SyntaxError** exception.
 - b. If the code that made the direct call to eval is **module code** and *ValidInModule* of *script* is **false**, then throw a **SyntaxError** exception.
12. If *direct* is **true**, then
 - a. Let *lexEnv* be *ctx*'s LexicalEnvironment.
 - b. Let *varEnv* be *ctx*'s VariableEnvironment.
13. Else,
 - a. Let *lexEnv* be *evalRealm*.[[globalEnv]].
 - b. Let *varEnv* be *evalRealm*.[[globalEnv]].
14. If *strictScript* is **true** or if *direct* is **true** and *strictCaller* is **true**, then
 - a. Let *strictVarEnv* be the result of calling **NewDeclarativeEnvironment** passing the *lexEnv* as the argument.
 - b. Let *lexEnv* be *strictVarEnv*.
 - c. Let *varEnv* be *strictVarEnv*.
15. Let *status* be the result of performing **Eval Declaration Instantiation** as described in 10.5.5 with *script*, *varEnv*, and *lexEnv*.
16. ReturnIfAbrupt(*status*).
17. Let *evalCxt* be a new ECMAScript code execution context.
18. Set the *evalCxt*'s Realm to *evalRealm*.
19. Set the *evalCxt*'s VariableEnvironment to *varEnv*.
20. Set the *evalCxt*'s LexicalEnvironment to *lexEnv*.
21. If there is a currently running execution context, suspend it.
22. Push *evalCxt* on to the execution context stack; *evalCxt* is now the running execution context.
23. Let *result* be the result of evaluating *script*.
24. Suspend *evalCxt* and remove it from the execution context stack.
25. Resume the context that is now on the top of the execution context stack as the running execution context.
26. Return *result*.

NOTE The eval code cannot instantiate variable or function bindings in the variable environment of the calling context that invoked the eval if either the code of the calling context or the eval code is strict code. Instead such bindings are instantiated in a new VariableEnvironment that is only accessible to the eval code.

15.1.2.1.1 Direct Call to Eval

A direct call to the eval function is one that is expressed as a *CallExpression* that meets the following two conditions:

The Reference that is the result of evaluating the *MemberExpression* in the *CallExpression* has an environment record as its base value and its reference name is "**eval**".

The result of calling the abstract operation **GetValue** with that Reference as the argument is the standard built-in function defined in 15.1.2.1.

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 *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. If *radix* is 16, the number may also optionally begin with the character pairs **0x** or **0X**.

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

1. Let `inputString` be `ToString(string)`.
2. ReturnIfAbrupt(`string`).
3. Let `S` be a newly created substring of `inputString` consisting of the first character that is not a `StrWhiteSpaceChar` and all characters following that character. (In other words, remove leading white space.) If `inputString` does not contain any such characters, let `S` be the empty string.
4. Let `sign` be 1.
5. If `S` is not empty and the first character of `S` is a minus sign `-`, let `sign` be `-1`.
6. 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`.
7. Let `R` be `ToInt32(radix)`.
8. ReturnIfAbrupt(`R`).
9. Let `stripPrefix` be `true`.
10. If `R` $\neq 0$, then
 - a. If `R < 2` or `R > 36`, then return `NaN`.
 - b. If `R \neq 16`, let `stripPrefix` be `false`.
11. Else, `R = 0`
 - a. Let `R = 10`.
12. If `stripPrefix` is `true`, then
 - a. 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`.
13. 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`.
14. If `Z` is empty, return `NaN`.
15. Let `mathInt` be 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 `mathInt` may be an implementation-dependent approximation to the mathematical integer value that is represented by `Z` in radix-`R` notation.)
16. Let `number` be the Number value for `mathInt`.
17. Return `sign \times number`.

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

15.1.2.3 `parseFloat`(`string`)

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

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

1. Let `inputString` be `ToString(string)`.
2. ReturnIfAbrupt(`string`).
3. Let `trimmedString` be a substring of `inputString` 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.) If `inputString` does not contain any such characters, let `trimmedString` be the empty string.
4. If neither `trimmedString` nor any prefix of `trimmedString` satisfies the syntax of a `StrDecimalLiteral` (see 9.3.1), return `NaN`.
5. Let `numberString` be the longest prefix of `trimmedString`, which might be `trimmedString` itself, that satisfies the syntax of a `StrDecimalLiteral`.
6. Return the Number value for the MV of `numberString`.

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

15.1.2.4 isNaN (number)

Returns **true** if the argument coerces to **NaN**, and otherwise returns **false**.

1. Let *num* be `ToNumber(number)`.
2. ReturnIfAbrupt(*num*).
3. If *num* is **NaN**, return **true**.
4. Otherwise, return **false**.

Deleted: `ToNumber(number)`

NOTE A reliable way for ECMAScript code to test if a value *x* is a **NaN** is an expression of the form *x* `!==` *x*. The result will be **true** if and only if *x* is a **NaN**.

15.1.2.5 isFinite (number)

Returns **false** if the argument coerces to **NaN**, $+\infty$, or $-\infty$, and otherwise returns **true**.

1. Let *num* be `ToNumber(number)`.
2. ReturnIfAbrupt(*num*).
3. If `ToNumber(num)` is **NaN**, $+\infty$, or $-\infty$, return **false**.
4. Otherwise, return **true**.

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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:

Scheme : *First* / *Second* ; *Third* ? *Fourth*

where the italicised names represent components and “:”, “/”, “;” 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.

Syntax

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

uriMark ::: one of

 - _ . ! ~ * ' ()

NOTE The above syntax is based upon RFC 2396 and does not reflect changes introduced by the more recent RFC 3986.

Runtime Semantics

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 transformed into its UTF-8 encoding, with surrogate pairs first converted from UTF-16 to the corresponding code point value. (Note that for code units 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 "%xx".

Runtime Semantics: Encode Abstract Operation

The encoding and escaping process is described by the abstract operation `Encode` taking two String arguments *string* and *unescapeSet*.

1. Let *strLen* be the number of characters in *string*.
2. Let *R* be the empty String.
3. Let *k* be 0.
4. Repeat
 - a. If *k* equals *strLen*, return *R*.
 - b. Let *C* be the character at position *k* within *string*.
 - c. If *C* is in *unescapeSet*, then
 - i. Let *S* be a String containing only the character *C*.
 - ii. Let *R* be a new String value computed by concatenating the previous value of *R* and *S*.
 - d. Else, *C* is not in *unescapeSet*.
 - i. If the code unit value of *C* is not less than 0xDC00 and not greater than 0xDFFF, throw a **URIError** exception.
 - ii. If the code unit value of *C* is less than 0xD800 or greater than 0xDBFF, then
 1. Let *V* be the code unit value of *C*.
 - iii. Else,
 1. Increase *k* by 1.
 2. If *k* equals *strLen*, throw a **URIError** exception.
 3. Let *kChar* be the code unit value of the character at position *k* within *string*.
 4. If *kChar* is less than 0xDC00 or greater than 0xDFFF, throw a **URIError** exception.
 5. Let *V* be (((the code unit value of *C*) - 0xD800) × 0x400 + (*kChar* - 0xDC00) + 0x10000).
 - iv. Let *Octets* be the array of octets resulting by applying the UTF-8 transformation to *V*, and let *L* be the array size.
 - v. Let *j* be 0.
 - vi. Repeat, while *j* < *L*
 1. Let *jOctet* be the value at position *j* within *Octets*.

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2. Let S be a String containing three characters “% XY ” where XY are two uppercase hexadecimal digits encoding the value of $jOctet$.
 3. Let R be a new String value computed by concatenating the previous value of R and S .
 4. Increase j by 1.

e. Increase k by 1.

Runtime Semantics: Decode Abstract Operation

The unescaping and decoding process is described by the abstract operation `Decode` taking two String arguments `string` and `reservedSet`.

- Let $strLen$ be the number of characters in $string$.
 - Let R be the empty String.
 - Let k be 0.
 - Repeat
 - If k equals $strLen$, return R .
 - Let C be the character at position k within $string$.
 - If C is not '`%`', then
 - Let S be the String containing only the character C .
 - Else C is '`%`',
 - Let $start$ be k .
 - If $k + 2$ is greater than or equal to $strLen$, throw a **URIError** exception.
 - If the characters at position $(k+1)$ and $(k + 2)$ within $string$ do not represent hexadecimal digits, throw a **URIError** exception.
 - Let B be the 8-bit value represented by the two hexadecimal digits at position $(k + 1)$ and $(k + 2)$.
 - Increment k by 2.
 - If the most significant bit in B is 0, then
 - Let C be the character with code unit value B .
 - If C is not in $reservedSet$, then
 - Let S be the String containing only the character C .
 - Else C is in $reservedSet$,
 - Let S be the substring of $string$ from position $start$ to position k included.
 - Else the most significant bit in B is 1,
 - Let n be the smallest non-negative number such that $(B \ll n) \& 0x80$ is equal to 0.
 - If n equals 1 or n is greater than 4, throw a **URIError** exception.
 - Let $Octets$ be an array of 8-bit integers of size n .
 - Put B into $Octets$ at position 0.
 - If $k + (3 \times (n - 1))$ is greater than or equal to $strLen$, throw a **URIError** exception.
 - Let j be 1.
 - Repeat, while $j < n$
 - Increment k by 1.
 - If the character at position k within $string$ is not '`%`', throw a **URIError** exception.
 - If the characters at position $(k + 1)$ and $(k + 2)$ within $string$ do not represent hexadecimal digits, throw a **URIError** exception.
 - Let B be the 8-bit value represented by the two hexadecimal digits at position $(k + 1)$ and $(k + 2)$.
 - If the two most significant bits in B are not 10, throw a **URIError** exception.
 - Increment k by 2.
 - Put B into $Octets$ at position j .
 - Increment j by 1.
 - Let V be the value obtained by applying the UTF-8 transformation to $Octets$, that is, from an array of octets into a 21-bit value. If $Octets$ does not contain a valid UTF-8 encoding of a Unicode code point throw an **URIError** exception.
 - If $V \leq 0x10000$, then
 - Let C be the character with code unit value V .
 - If C is not in $reservedSet$, then

- i. Let S be the String containing only the character C .
- c Else, C is in *reservedSet*.
 - i. Let S be the substring of *string* from position *start* to position *k* included.
- 10. Else, $V \geq 0x10000$.
 - a Let L be $((V - 0x10000) \& 0x3FF) + 0xDC00)$.
 - b Let H be $((((V - 0x10000) \gg 10) \& 0x3FF) + 0xD800)$.
 - c Let S be the String containing the two characters with code unit values H and L .
- e. Let R be a new String value computed by concatenating the previous value of R and S .
- f. Increase k by 1.

NOTE This syntax of Uniform Resource Identifiers is based upon RFC 2396 and does not reflect the more recent RFC 3986 which replaces RFC 2396. A formal description and implementation of UTF-8 is given in RFC 3629.

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, $n > 1$, 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 specified in [Table 32](#).

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Table 32 — UTF-8 Encodings

Code Unit Value	Representation	1 st Octet	2 nd Octet	3 rd Octet	4 th Octet
0x0000 – 0x007F	00000000 0zzzzzzz	0zzzzzzz			
0x0080 – 0x07FF	00000yyy yyzzzzzz	110yyyyy	10zzzzzz		
0x0800 – 0xD7FF	xxxxyyyy yyzzzzzz	1110xxxx	10yyyyyy	10zzzzzz	
0xD800 – 0xDBFF followed by 0xDC00 – 0xDFFF	110110vv vvvwwwxx followed by 110111yy yyzzzzzz	11110uuu	10uuwwww	10xxyyyy	10zzzzzz
0xD800 – 0xDBFF not followed by 0xDC00 – 0xDFFF	causes URIError				
0xDC00 – 0xDFFF	causes URIError				
0xE000 – 0xFFFF	xxxxyyyy yyzzzzzz	1110xxxx	10yyyyyy	10zzzzzz	

Where

$$uuuuu = vvvv + 1$$

to account for the addition of 0x10000 as in Surrogates, section 3.7, of the Unicode Standard.

The range of code unit values 0xD800-0xFFFF is used to encode surrogate pairs; the above transformation combines a UTF-16 surrogate pair into a UTF-32 representation and encodes the resulting 21-bit value in UTF-8. Decoding reconstructs the surrogate pair.

RFC 3629 prohibits the decoding of invalid UTF-8 octet sequences. For example, the invalid sequence C0 80 must not decode into the character U+0000. Implementations of the Decode algorithm are required to throw a **URIError** when encountering such invalid sequences.

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. Let *uriString* be *ToString(encodedURI)*.
2. ReturnIfAbrupt(*uriString*).

3. Let *reservedURISet* be a String containing one instance of each character valid in *uriReserved* plus “#”.
4. Return the result of calling *Decode(uriString, reservedURISet)*

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. Let *componentString* be *ToString(encodedURIComponent)*.
2. ReturnIfAbrupt(componentString).
3. Let *reservedURIComponentSet* be the empty String.
4. Return the result of calling *Decode(componentString, reservedURIComponentSet)*

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, three, or four 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. Let *uriString* be *ToString(uri)*.
2. ReturnIfAbrupt(uriString).
3. Let *unescapeURISet* be a String containing one instance of each character valid in *uriReserved* and *uriUnescaped* plus “#”.
4. Return the result of calling *Encode(uriString, unescapeURISet)*

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, three, or four 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. Let *componentString* be *ToString(uriComponent)*.
2. ReturnIfAbrupt(componentString).
3. Let *unescapeURIComponentSet* be a String containing one instance of each character valid in *uriUnescaped*.
4. Return the result of calling *Encode(componentString, unescapeURIComponentSet)*

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.

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15.1.4.3 Array (. . .)

See 15.4.1.

Deleted: 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.

15.1.4.16 Map (. . .)

See 15.14.3.

15.1.4.17 WeakMap (. . .)

See 15.15.3.

15.1.4.18 Set (. . .)

See 15.16.3.

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, return the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
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 supplied, then
 - a. If `Type(value)` is `Object`, then return `value`.
 - b. If `Type(value)` is `String`, return `ToObject(value)`.
 - c. If `Type(value)` is `Boolean`, return `ToObject(value)`.
 - d. If `Type(value)` is `Number`, return `ToObject(value)`.
2. Assert: The argument `value` was not supplied or its type was `Null` or `Undefined`.
3. Return the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.

15.2.3 Properties of the Object Constructor

The value of the `[[Prototype]]` internal `data` property of the `Object` constructor is the standard built-in `Function` prototype object.

Besides 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 standard built-in `Object` prototype object (15.2.4).

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The abstract operation `ObjectCreate` with optional argument `proto` (an object or `null`) is used to specify the creation of new `Object` objects. It performs the following steps:
 <#> If `proto` was not provided, let `proto` be the intrinsic `%ObjectPrototype%`.
 <#> Let `obj` be a newly created ECMAScript object.
 <#> Set the `[[Prototype]]` internal property of `obj` to `proto`.
 <#> Set `obj`'s common internal methods to the default definitions specified in 8.12.
 <#> Set the `[[Extensible]]` internal property of `obj` to `true`.
 <#> Return `obj`.

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Deleted: a new `Object` object exactly as if the standard built-in `Object` constructor had been called with the same arguments (15.2.2.1)

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If the `value` is a native ECMAScript object, do not create a new object but simply

Deleted: <#> 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.

Deleted: <#> Let `obj` be a newly created native ECMAScript object.

<#> Set the `[[Prototype]]` internal property of `obj` to the standard built-in `Object` prototype object (15.2.4).

<#> Set the `[[Class]]` internal property of `obj` to `"Object"`.

<#> Set the `[[Extensible]]` internal property of `obj` to `true`.

<#> Set all the internal methods of `obj` as specified in 8.12.

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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 result of calling the `[[GetInheritance]]` internal method of `O`.

15.2.3.3 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. Let `key` be `ToPropertyKey(P)`.
3. ReturnIfAbrupt(key).
4. Let `desc` be the result of calling the `[[GetOwnProperty]]` internal method of `O` with argument `key`.
5. ReturnIfAbrupt(desc).
6. Return the result of calling `FromPropertyDescriptor(desc)` (8.2.5.4).

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. Let `keys` be the result of calling the `[[OwnPropertyKeys]]` internal method of `O`.
3. ReturnIfAbrupt(keys).
4. Let `nameList` be a new empty List.
5. Let `gotAllNames` be `false`.
6. Repeat while `gotAllNames` is `false`.
 - a. Let `next` be the result of `Invoke(keys, "next")`.
 - b. ReturnIfAbrupt(next).
 - c. If `Type(next)` is not `Object`, then throw a `TypeError` exception.
 - d. Let `done` be `IteratorComplete(next)`.
 - e. ReturnIfAbrupt(done).
 - f. If `done` is `true`, then let `gotAllNames` be `true`.
 - g. Else,
 - i. Let `nextKey` be `IteratorValue(next)`.
 - ii. ReturnIfAbrupt(nextKey).
 - iii. If `Type(nextKey)` is `String`, then
 1. Append `nextKey` as the last element of `nameList`.
7. Return `CreateArrayFromList(keys)`.

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` or `Null` throw a `TypeError` exception.
2. Let `obj` be the result of the abstract operation `ObjectCreate` with argument `O`.
3. If the argument `Properties` is present and not `undefined`, then
 - a. Return the result of the abstract operation `ObjectDefineProperties` with arguments `obj` and `Properties`.
4. Return `obj`.

15.2.3.6 Object.defineProperty (O, P, Attributes)

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

1. If `Type(O)` is not `Object` throw a `TypeError` exception.

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- Deleted:** IteratorComplete(next)
- Deleted:** <#>If `next` is an abrupt completion, then return `next`.
<#>Assert `next.[[type]]` is normal.
<#>Let `nextKey` be `next.[[value]]`.
- Deleted:** <#>If `Type(O)` is not `Object` throw a `TypeError` exception.
<#>Let `keys` be the result of calling the `[[OwnPropertyKeys]]` internal method of `O`.
<#>ReturnIfAbrupt(keys).
<#>Let `array` be the result of the abstraction operation `ArrayCreate` (15.4) with argument `0` the result of creating a new object as if by the expression `new Array` where `Array` is the standard built-in constructor with that name.
<#>Let `n` be `0`.
<#>For each named own property `P` of `O`.
<#>Let `name` be the String value that is the name of `P`.
<#>Call the `[[DefineOwnProperty]]` internal method of `array` with arguments `Tostring(n)`, the `PropertyDescriptor` `{[[Value]]: name, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true, and false}`.
<#>Increment `n` by 1.
<#>Return `arrayCreateArrayFromList(keys)`.
- Deleted:** NOTE If `O` is a String instance, the set of own properties processed in step 4 includes the implicit properties defined in 15.5.2 that correspond to character positions within the object's `[[PrimitiveValue]]` String.
- Deleted:** abstraction operation
- Deleted:** the result of creating a new object as if by the expression `new Object()` where `Object` is the standard built-in constructor with that name
- Deleted:** <#>Set the `[[Prototype]]` internal property of `O`.
- Deleted:** add own properties to `obj` as if by calling the standard built-in function
- Deleted:** `Object.defineProperties`

2. Let *name* be *ToPropertyKey(P)*.
3. ReturnIfAbrupt(name).
4. Let *desc* be the result of calling *ToPropertyDescriptor* with *Attributes* as the argument.
5. ReturnIfAbrupt(desc).
6. Let *success* be the result of *DefinePropertyOrThrow(O, name, desc)*.
7. ReturnIfAbrupt(success).
8. 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:

1. Return the result of the abstract operation *ObjectDefineProperties* with arguments *O* and *Properties*.

Runtime Semantics: ObjectDefineProperties Abstract Operation

The abstract operation *ObjectDefineProperties* with arguments *O* and *Properties* performs the following steps:

1. If *Type(O)* is not *Object* throw a **TypeError** exception.
2. Let *props* be *ToObject(Properties)*.
3. Let *names* be an internal list containing the keys of each enumerable own property of *props*.
4. Let *descriptors* be an empty internal List.
5. For each element *P* of *names* in list order,
 - a. Let *descObj* be the result of *Get(props, P)*.
 - b. ReturnIfAbrupt(descObj).
 - c. Let *desc* be the result of calling *ToPropertyDescriptor* with *descObj* as the argument.
 - d. ReturnIfAbrupt(desc).
 - e. Append the pair (a two element List) consisting of *P* and *desc* to the end of *descriptors*.
6. Let *pendingException* be **undefined**.
7. For each *pair* from *descriptors* in list order,
 - a. Let *P* be the first element of *pair*.
 - b. Let *desc* be the second element of *pair*.
 - c. Let *status* be the result of *DefinePropertyOrThrow(O, P, desc)*.
 - d. If *status* is an Abrupt Completion then,
 - i. If *pendingException* is **undefined**, then set *pendingException* to *status*.
8. ReturnIfAbrupt(pendingException).
9. Return *O*.

If an implementation defines a specific order of enumeration for the *for-in* statement, that same enumeration order must be used to order the list elements in step 3 of this algorithm.

NOTE An exception in defining an individual property in step 7 does not terminate the process of defining other properties. All valid property definitions are processed.

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. Let *status* be the result of calling the *[[SetIntegrity]* internal methods of *O* with argument "sealed".
3. ReturnIfAbrupt(status).
4. If *status* is **false**, throw a **TypeError** exception.
5. Return *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. Let *status* be the result of calling the *[[SetIntegrity]* internal methods of *O* with argument "frozen".

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Deleted: <#>For each named own property named <i>P</i> of <i>O</i> ,
<#>Let <i>desc</i> be the result of calling the <i>[[GetOwnProperty]]</i> internal method of <i>O</i> with <i>P</i> .
<#>If <i>desc</i> .[[Configurable]] is true, set <i>desc</i> .[[Configurable]] to false.¶
Call
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Deleted: <#>Set the <i>[[Extensible]]</i> internal property of <i>O</i> to false.¶
Deleted: <#>For each named own property named <i>P</i> of <i>O</i> ,
<#>Let <i>desc</i> be the result of calling the <i>[[GetOwnProperty]]</i> internal method of <i>O</i> with <i>P</i> .
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3. ReturnIfAbrupt(status).
4. If status is false, throw a **TypeError** exception.
5. Return O.

15.2.3.10 Object.preventExtensions (O)

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

1. If Type(O) is not Object throw a **TypeError** exception.
2. Let status be the result of calling the **[[SetIntegrity]]** internal method of O with argument **"nonextensible"**.
3. ReturnIfAbrupt(status).
4. If status is false, throw a **TypeError** exception.
5. 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. Return the result of calling the **[[HasIntegrity]]** internal methods of O with argument "sealed".

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. Return the result of calling the **[[HasIntegrity]]** internal methods of O with argument "frozen".

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 result of IsExtensible(O).

15.2.3.14 Object.keys (O)

When the **keys** function is called with argument O, the following steps are taken:

1. If Type(O) is not Object, throw a **TypeError** exception.
2. Let keys be the result of calling the **[[OwnPropertyKeys]]** internal method of O.
3. ReturnIfAbrupt(keys).
4. Let nameList be a new empty List.
5. Let gotAllNames be **false**.
6. Repeat while gotAllNames is **false**.
 - a. Let next be the result of **Invoke(keys, "next")**.
 - b. ReturnIfAbrupt(next).
 - c. If **Type(next)** is not Object, then throw a **TypeError** exception.
 - d. Let done be **IteratorComplete(next)**.
 - e. ReturnIfAbrupt(done).
 - f. If done is **true**, then let gotAllNames be **true**.
 - g. Else.
 - i. Let nextKey be **IteratorValue(next)**.
 - ii. ReturnIfAbrupt(nextKey).
 - iii. If **Type(nextKey)** is String, then
 1. Let desc be the result of calling the **[[GetOwnProperty]]** internal method of O with argument nextKey.
 2. ReturnIfAbrupt(desc).
 3. If desc is not **undefined** and desc.[[Enumerable]] is **true**, then
 - a. Append nextKey as the last element of nameList.

Deleted: <#>Set the [[Extensible]] internal property of O to false.¶

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Deleted: <#>For each named own property name P of O, <#>Let desc be the result of calling the **[[GetOwnProperty]]** internal method of O with P.¶ <#>If desc.[[Configurable]] is **true**, then return **false**.¶ <#>Let extensible be the result of calling the **[[IsExtensible]]** internal property of O.¶ <#>ReturnIfAbrupt(extensible).¶ <#>If the [[Extensible]] internal property of O is **false**, then return **true**.¶ Otherwise, r

Deleted: TestIfSecureObject(O, false)

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Deleted: <#>For each named own property name P of O, <#>Let desc be the result of calling the **[[GetOwnProperty]]** internal method of O with P.¶ <#>ReturnIfAbrupt(desc).¶ <#>If IsDataDescriptor(desc) is **true** then¶ <#>If desc.[[Writable]] is **true**, return **false**.¶ <#>If desc.[[Configurable]] is **true**, then return **false**.¶ <#>Let extensible be the result of calling the **[[IsExtensible]]** internal property of O.¶ <#>ReturnIfAbrupt(extensible).¶ <#>If the [[Extensible]] internal property of O is **false**, then return **true**.¶ Otherwise, r

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<#>Assert next.[[type]] is normal.¶

<#>Let nextKey be next.[[value]].¶

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7. Return CreateArrayFromList(*keys*).

If an implementation defines a specific order of enumeration for the for-in statement, the same order must be used for the elements of the array returned in step 7.

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15.2.3.15 Object.getOwnPropertyKeys (O)

When the **getOwnPropertyKeys** function is called with argument *O*, the following steps are taken:

1. If Type(*O*) is not Object, throw a **TypeError** exception.
2. Let *keys* be the result of calling the **[[OwnPropertyKeys]]** internal method of *O*.
3. Return *keys*.

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TODO :

- May need to say something about order of enumeration and post call property additions and deletions

15.2.3.16 Object.is (value1, value2)

When the **is** function is called with arguments *value1* and *value2* the following steps are taken:

1. Return **SameValue**(*value1*, *value2*).

15.2.3.17 Object.assign (target, source)

TODO :

- Only enumerable own properties of source
- Invoke **[[Get]]** on property list derived from source, for each property in list **[[Put]]** on target
- private names are not copied
- unique names are copied
- super mechanism (rebind super)
- Returns modified "target"

Deleted: <#>Let *n* be the number of own enumerable properties of *O*.
<#>Let *array* be the result of the abstraction operation abstract operation **ArrayCreate** (15.4) with argument *n* the result of creating a new Object as is by the expression **new Array(n)** where **Array** is the standard built-in constructor with that name.
<#>Let *index* be 0.
<#>For each own enumerable property of *O* whose name String is *P*.
<#>Let *P* be the key of the property.
<#>Call the **[[DefineOwnProperty]]** internal method of *array* with arguments **Tostring(index)**, **PropertyDescriptor** {[[Value]]: *P*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}, and **false**.
<#>Increment *index* by 1.
<#>Return *array*.

If an implementation defines a specific order of enumeration for the for-in statement, that same enumeration order must be used in step 5 of this algorithm.

Deleted: 15

Comment [AWB11149]: TODO need an algorithm

Because **[[Get]]/[[Put]]** are invoked we need to figure out something to say about the order in which properties are accessed.

Deleted: ¶

15.2.3.18 Object.mixin (target, source)

Don't have TC39 concensus on including this or its name. However, there appears to be strong interest both within TC39 and on es-discuss and reasonable use cases. "mixin" seems to be the favorite name from es-discuss, although concerns have been raised that it might clash with some existing libraries.

TODO :

- All non-private properties of source
- Uses **[[GetOwnProperty]]/[[DefineOwnProperty]]**
- private symbols are not copied
- non-symbols are copied

- super mechanism (rebind super)
- Returns modified "target"

15.2.3.2 Object.setPrototypeOf (O, proto)

When the `setPrototypeOf` function is called with arguments *O* and *proto*, the following steps are taken:

1. If `Type(O)` is not `Object`, then throw a `TypeError` exception.
2. If `Type(proto)` is neither `Object` or `Null`, then throw a `TypeError` exception.
3. Let *status* be the result of calling the `[[SetInheritance]]` internal method of *O* with argument *proto*.
4. `ReturnIfAbrupt(status)`.
5. If *status* is `false`, then throw a `TypeError` exception.
6. `Return O`.

15.2.4 Properties of the Object Prototype Object

The `Object.prototype` object is an ordinary object.

The value of the `[[Prototype]]` internal `data` property of the `Object prototype` object is `null`, and the initial value of the `[[Extensible]]` internal `data` property is `true`.

15.2.4.1 Object.prototype.constructor

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

15.2.4.2 Object.prototype.toString ()

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

1. If the `this` value is `undefined`, return "`[object Undefined]`".
2. If the `this` value is `null`, return "`[object Null]`".
3. If `Type(the this value)` is `Symbol`, then return "`[object Symbol]`".
4. Let *O* be the result of calling `ToObject` passing the `this` value as the argument.
5. If *O* is an exotic `Array` object, then let `builtinTag` be "`Array`".
6. Else, if *O* is an exotic `String` object, then let `builtinTag` be "`String`".
7. Else, if *O* is an exotic `arguments` object, then let `builtinTag` be "`Arguments`".
8. Else, if *O* is an ordinary `function` object, a built-in `function` object, or a bound `function` exotic object, then let `builtinTag` be "`Function`".
9. Else, if *O* has a `[[ErrorData]]` internal `data` property, then let `builtinTag` be "`Error`".
10. Else, if *O* has a `[[BooleanData]]` internal `data` property, then let `builtinTag` be "`Boolean`".
11. Else, if *O* has a `[[NumberData]]` internal `data` property, then let `builtinTag` be "`Number`".
12. Else, if *O* has a `[[DateValue]]` internal `data` property, then let `builtinTag` be "`Date`".
13. Else, if *O* has a `[[RegExpMatcher]]` internal `data` property, then let `builtinTag` be "`RegExp`".
14. Else, if *O* has a `[[MathTag]]` internal `data` property, then let `builtinTag` be "`Math`".
15. Else, if *O* has a `[[JSONTag]]` internal `data` property, then let `builtinTag` be "`JSON`".
16. Else, let `builtinTag` be "`Object`".
17. Let `hasTag` be the result of `HasProperty(O, @@toStringTag)`.
18. `ReturnIfAbrupt(hasTag)`.
19. If `hasTag` is `false`, then let `tag` be `builtinTag`.
20. Else,
 - a. Let `tag` be the result of `Get(O, @@toStringTag)`.
 - b. If `tag` is an abrupt completion, let `tag` be `NormalCompletion("???"`).
 - c. Let `tag` be `tag [[value]]`.
 - d. If `Type(tag)` is not `String`, let `tag` be "`???"`.

Deleted: 15.2.3.15 `Object.isObject (O)`
 When the `isObject` function is called with argument
 the following steps are taken:
 If `Type(O)` is `Object` return true.
 Return false.

Deleted: , the value of the `[[Class]]` internal property is
 "Object".

Deleted: <#>If *O* is an exotic `Symbol` object, then return
 " [object let tag be "Symbol"] ".

Comment [AWB14150]: Need to decide how to tag
 Math object

Comment [AWB14151]: Need to decide how to tag
 JSON object

Deleted: <#>Else if *O* has a `[[NativeBrandBuiltInBrand]]`
 internal data property, let `tag` be the corresponding value from
 Table 32Table 30Table 28.
 <#>Else ¶

Deleted: calling the `[[HasProperty]]` internal method of

Deleted: with argument

Deleted: "Object"

Deleted: calling the `[[`

Deleted: `]]` internal method of

Deleted: with argument

- e. If `tag` is any of `"Arguments"`, `"Array"`, `"Boolean"`, `"Date"`, `"Error"`, `"Function"`, `"JSON"`, `"Math"`, `"Number"`, `"RegExp"`, or `"String"` and `SameValue(tag, builtinTag)` is `false`, then let `tag` be the string value `"~"` concatenated with the current value of `tag`.

21. Return the String value that is the result of concatenating the three Strings `"[object "`, `tag`, and `"]"`.

NOTE Historically, this function was occasionally used to access the string value of the `[[Class]]` internal data property that was used in previous editions of this specification as a nominal type tag for various built-in objects. The above definition of `toString` preserves the ability to use it as a reliable test for those specific kinds of built-in objects but it does not provide a reliable type testing mechanism for other kinds of built-in or program defined objects.

15.2.4.3 Object.prototype.toLocaleString ()

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

1. Let `O` be the `this` value.
2. ReturnIfAbrupt(`O`)
3. Return the result of `Invoke(O, "toString")`.

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 ()

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

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. Return `O`.

15.2.4.5 Object.prototype.hasOwnProperty (V)

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

1. Let `P` be `ToPropertyKey(V)`.
2. ReturnIfAbrupt(`P`).
3. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
4. ReturnIfAbrupt(`O`).
5. Return the result of calling the `[[HasOwnProperty]]` internal method of `O` passing `P` as the argument.

NOTE The ordering of steps 1 and 3 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the `this` value is `undefined` or `null`.

15.2.4.6 Object.prototype.isPrototypeOf (V)

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

1. If `V` is not an object, return `false`.
2. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
3. ReturnIfAbrupt(`O`).
4. Repeat
 - a. Let `V` be the result of calling the `[[GetInheritance]]` internal method of `V` with no arguments.
 - b. If `V` is `null`, return `false`.
 - c. If `O` and `V` refer to the same object, return `true`.

NOTE The ordering of steps 1 and 2 is chosen to preserve the behaviour specified by previous editions of this specification for the case where `V` is not an object and the `this` value is `undefined` or `null`.

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Deleted: O
Deleted: a host object, let <code>tag</code> be an implementation defined string value. This value must not be <code>undefined</code>
Deleted: "Object",
Deleted: As
Deleted: .
Deleted: <#>Else, Let let class tag be the string value "Object" of the <code>[[Class]]</code> internal property of
Deleted: class
Deleted: 1
Deleted: Table 323028 — <code>[[BuiltInBrand]]</code> Tag Values [[NativeBrandBuiltInBrand]] Value
Deleted: This
Deleted: result of calling <code>ToObject</code> passing the
Deleted: as the argument
Deleted: <#>Let <code>toString</code> be the result of calling the <code>[[Get]]</code> internal method of <code>O</code> passing <code>"toString"</code> as the argument. <#>If <code>IsCallable(toString)</code> is <code>false</code> , throw a <code>TypeError</code> exception.
Deleted: calling
Deleted: the abstract operation
Deleted: the
Deleted: with arguments
Deleted: <code>[[Call]]</code> internal method of
Deleted: <code>toString</code> passing <code>O</code> ,
Deleted: as the <code>this</code> value
Deleted: and
Deleted: no
Deleted: an empty arguments List
Deleted: <#>If <code>O</code> is the result of calling the <code>Object</code> constructor with a host object (15.2.2.1), then <#>Return either <code>O</code> or another value such as the host object originally passed to the constructor. The specific result that is returned is implementation-defined.
Deleted: ToString
Deleted: Let <code>desc</code> be
Deleted: GetOwnProperty
Deleted: <#>If <code>desc</code> is <code>undefined</code> , return <code>false</code> . <#>Return <code>true</code> .
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Deleted: Prototype
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Deleted: property

15.2.4.7 Object.prototype.propertyIsEnumerable (V)

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

1. Let P be `ToString(V)`.
2. `ReturnIfAbrupt(P)`.
3. Let O be the result of calling `ToObject` passing the `this` value as the argument.
4. `ReturnIfAbrupt(O)`.
5. Let $desc$ be the result of calling the `[[GetOwnProperty]]` internal method of O passing P as the argument.
6. If $desc$ is `undefined`, return `false`.
7. Return the value of $desc.[[Enumerable]]$.

NOTE 1 This method does not consider objects in the prototype chain.

NOTE 2 The ordering of steps 1 and 2 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the `this` value is `undefined` or `null`.

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

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The `Function` constructor is the `%Function%` intrinsic object and the initial value of the `Function` property of the global object. 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. However, if the `this` value passed in the call is an `Object` with an `[[Code]]` internal data property whose value is `undefined`, it initializes the `this` value using the argument values. This permits `Function` to be used both as factory method and to perform constructor instance initialization.

`Function` may be subclassed and subclass constructors may perform a `super` invocation of the `Function` constructor to initialize subclass instances. However, all syntactic forms for defining function objects create instances of `Function`. There is no syntactic means to create instances of `Function` subclasses except for the built-in Generator Function subclass.

15.3.1.1 Function ($p_1, p_2, \dots, p_n, body$)

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

When the `Function` function is called with some arguments $p_1, p_2, \dots, p_n, body$ (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 $argCount$ be the total number of arguments passed to this function invocation.
2. Let P be the empty String.
3. If $argCount = 0$, let $bodyText$ be the empty String.
4. Else if $argCount = 1$, let $bodyText$ be that argument.
5. Else $argCount > 1$.
 - a. Let $firstArg$ be the first argument.
 - b. Let P be `ToString(firstArg)`.
 - c. `ReturnIfAbrupt(P)`.
 - d. Let k be 2.
 - e. Repeat, while $k < argCount$
 - i. Let $nextArg$ be the k 'th argument.
 - ii. Let $nextArgString$ be `ToString(nextArg)`.
 - iii. `ReturnIfAbrupt(nextArgString)`.

Deleted: When the `Function` function is called with some arguments $p_1, p_2, \dots, p_n, body$ (where n might be that is, there are no " p " arguments, and where $body$ might also not be provided), the following steps are taken:
 <#> 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 ($p_1, p_2, \dots, p_n, body$)¶

Deleted: constructor

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- iv. Let P be the result of concatenating the previous value of P , the String `,` (a comma), and nextArgString .
- v. Increase k by 1.
- f. Let bodyText be the k^{th} argument.
- 6. Let bodyText be `ToString(bodyText)`.
- 7. $\text{ReturnIfAbrupt}(\text{bodyText})$.
- 8. Let parameters be the result of parsing P , interpreted as UTF-16 encoded Unicode text as described in 8.4, using FormalParameters as the goal symbol. Throw a **SyntaxError** exception if the parse fails.
- 9. Let body be the result of parsing bodyText , interpreted as UTF-16 encoded Unicode text as described in 8.4, using FunctionBody as the goal symbol. Throw a **SyntaxError** exception if the parse fails or if any static semantics errors are detected.
- 10. If funcBody Contains YieldExpression is **true**, then throw a **SyntaxError** exception.
- 11. If $\text{IsSimpleParameterList}$ of parameters is **false** and any element of the BoundNames of parameters also occurs in the VarDeclaredNames of body , then throw a **SyntaxError** exception.
- 12. If any element of the BoundNames of parameters also occurs in the $\text{LexicallyDeclaredNames}$ of body , then throw a **SyntaxError** exception.
- 13. If bodyText is strict mode code (see 10.1.1) then let strict be **true**, else let strict be **false**.
- 14. Let scope be the Global Environment.
- 15. Let F be the **this** value.
- 16. If $\text{Type}(F)$ is not **Object** or if F does not have a [[Code]] internal data property or if the value of [[Code]] is not **undefined**, then
 - a. Let F be the result of calling `FunctionAllocate` with argument `%FunctionPrototype%`.
- 17. If the value of F 's [[FunctionKind]] internal data property is not "**normal**", then throw a **TypeError** exception.
- 18. Perform the `FunctionInitialize` abstract operation with arguments F , Normal , parameters , body , scope , and strict .
- 19. Perform the abstract operation `MakeConstructor` with argument F .
- 20. Return F .

A **prototype** property is automatically created for every function created using the **Function** constructor, 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:

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

15.3.1.2 new Function (... argumentsList)

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

1. Let F be the **Function** function object on which the `new` operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct` (F , argumentsList).

If **Function** is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.3.2 Properties of the Function Constructor

The **Function** constructor is itself a built-in **Function** object. The value of the [[Prototype]] internal data property of the **Function** constructor is `%FunctionPrototype%`, the intrinsic **Function** prototype object (15.3.3).

The value of the [[Extensible]] internal data property of the **Function** constructor is **true**.

The **Function** constructor has the following properties:

Deleted: `ToString()`
Deleted: `)`

Deleted: `If`
Deleted: `is not parsable as a`
Deleted: `List`
Deleted: `opt`
Deleted: `then t`

Deleted: `<#>If body is not parsable as`
`FunctionBody then throw a SyntaxError exception`

Deleted: `<#>If strict is true, throw any`
`exceptions specified in 13.1 that apply.` ¶

Deleted: `<#>Return a new Function object`
`created as specified 13.2.6 passing P parameters`
`as the FormalParameterListopt and body as the`
`FunctionBody. Pass in the Global Environment as`
`the Scope parameter and strict as the Strict flag.` ¶

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Deleted: `Constructor`

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Deleted: `and its has a`
`[[ClassIsFunctionNativeBrandBuiltInBrand]] is`
`"Function"internal data property whose value`
`is NativeFunctionBuiltInFunction`

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15.3.2.1 Function.prototype

The value of `Function.prototype` is the `%FunctionPrototype%`, the intrinsic `Function` prototype object (15.3.3).

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

15.3.2.2 Function.length

This is a data property with a value of 1. This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false` }.

15.3.2.3 Function @@create()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `proto` be the result of `GetPrototypeOfFromConstructor(F, "%FunctionPrototype%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `FunctionAllocate` with argument `proto`.
5. Return `obj`.

This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true` }.

NOTE The `Function @@create` function is intentionally generic; it does not require that its `this` value be the `Function` constructor object. It can be transferred to other constructor functions for use as a `@@create` method. When used with other constructors, this function will create a exotic function object whose `[[Prototype]]` value is obtained from the associated constructor.

15.3.3 Properties of the Function Prototype Object

The `Function` prototype object is itself a Built-in Function object. When invoked, it accepts any arguments and returns `undefined`.

NOTE The `Function` prototype object is specified to be a function object to ensure compatibility with ECMAScript code that was created prior to the 6th Edition of this specification.

The value of the `[[Prototype]]` internal data property of the `Function` prototype object is the intrinsic object %ObjectPrototype% (15.2.4). The initial value of the `[[Extensible]]` internal data property of the `Function` prototype object is `true`.

The `function` prototype object does not have a `prototype` property.

The `length` property of the `Function` prototype object is `0`.

15.3.3.1 Function.prototype.constructor

The initial value of `Function.prototype.constructor` is the intrinsic object %Function%.

15.3.3.2 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.

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

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15.3.3.3 Function.prototype.apply (thisArg, argArray)

When the `apply` method is called on an object `func` with arguments `thisArg` and `argArray`, the following steps are taken:

1. If `IsCallable(func)` is `false`, then throw a `TypeError` exception.
2. If `argArray` is `null` or `undefined`, then
 - a. Return the result of calling the `[[Call]]` internal method of `func`, providing `thisArg` as `thisArgument` and an empty `List` of arguments as `argumentsList`.
3. If `Type(argArray)` is not `Object`, then throw a `TypeError` exception.
4. Let `len` be the result of `Get(argArray, "length")`.
5. Let `n` be `ToUint32(len)`.
6. ReturnIfAbrupt(n).
7. Let `argList` be an empty `List`.
8. Let `index` be `0`.
9. Repeat while `index < n`
 - a. Let `indexName` be `ToString(index)`.
 - b. Let `nextArg` be the result of `Get(argArray, indexName)`.
 - c. ReturnIfAbrupt(nextArg).
 - d. Append `nextArg` as the last element of `argList`.
 - e. Set `index` to `index + 1`.
10. Return the result of calling the `[[Call]]` internal method of `func`, providing `thisArg` as `thisArgument` and `argList` as `argumentsList`.

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

NOTE The `thisArg` value is passed without modification as the `this` value. This is a change from Edition 3, where a `undefined` or `null` `thisArg` is replaced with the global object and `ToObject` is applied to all other values and that result is passed as the `this` value.

15.3.3.4 Function.prototype.call (thisArg [, arg1 [, arg2, ...]])

When the `call` method is called on an object `func` with argument `thisArg` and optional arguments `arg1`, `arg2` etc, the following steps are taken:

1. If `IsCallable(func)` is `false`, then throw a `TypeError` exception.
2. Let `argList` be an empty `List`.
3. If this method was called with more than one argument then in left to right order starting with `arg1` append each argument as the last element of `argList`.
4. Return the result of calling the `[[Call]]` internal method of `func`, providing `thisArg` as `thisArgument` and `argList` as `argumentsList`.

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

NOTE The `thisArg` value is passed without modification as the `this` value. This is a change from Edition 3, where a `undefined` or `null` `thisArg` is replaced with the global object and `ToObject` is applied to all other values and that result is passed as the `this` value.

15.3.3.5 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 `Target` be the `this` value.
2. If `IsCallable(Target)` is `false`, throw a `TypeError` exception.
3. Let `A` be a new (possibly empty) internal list consisting of all of the argument values provided after `thisArg` (`arg1`, `arg2` etc), in order.
4. Let `F` be the result of the abstract operation `BindFunctionCreate` with arguments `Target`, `thisArg`, and `A`.
5. If `Target` has a `[[BoundTargetFunction]]` internal data property, then
 - a. Let `targetLen` be the result of `Get(Target, "length")`.

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Deleted: <#>Set all the internal methods, except for `[[Get]]`, of `F` as specified in 8.12.¶

<#>Set the `[[Get]]` internal property of `F` as specified in 15.3.5.4.¶

<#> of `F` to `true`.¶

<#>Set the `[[TargetFunction]]` internal property of `F` to `Target`.¶

<#>Set the `[[BoundThis]]` internal property of `F` the value of `thisArg`.¶

<#>Set the `[[BoundArgs]]` internal property of `F` `A`.¶

<#>Set Add the `[[ClassIsFunctionNativeBrand]]` internal property with value `NativeFunction` of `F` to `"Function"`.¶

<#>Set the `[[Prototype]]` internal property of `F` to the intrinsic `FunctionPrototype` standard built-in Function prototype object as specified in 15.3.1.¶

<#>Set the `[[Call]]` internal property of `F` as described in 15.3.4.5.1.¶

<#>Set the `[[Construct]]` internal property of `F` as described in 15.3.4.5.2.¶

<#>Set the `[[HasInstance]]` internal property of `F` described in 15.3.4.5.3.¶

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Deleted: `[[IsFunctionNativeBrandBuiltInBrand]`

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`NativeFunctionBuiltInFunction`

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Deleted:

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- b. `ReturnIfAbrupt(targetLen)`.
 c. Let L be the larger of 0 and the result of `targetLen` minus the number of elements of A .
 6. Else let L be 0.
 7. Call the `[[DefineOwnProperty]]` internal method of F with arguments `"length"` and `PropertyDescriptor` `{[[value]]: L , [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}`.
 8. Perform the `AddRestrictedFunctionProperties` abstract operation with argument F .
 9. Return F .

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

NOTE Function objects created using `Function.prototype.bind` are exotic objects. They also do not have a `prototype` property.

15.3.3.6 Function.prototype[@@create](V)

The `@@create` method of an object F performs the following steps:

1. Return the result of calling `OrdinaryCreateFromConstructor(F , "%ObjectPrototype%")`.

NOTE This is default `@@create` method that is inherited by all ordinary constructor functions that do not explicitly over-ride it.

15.3.3.7 Function.prototype[@@hasInstance](V)

When the `@@hasInstance` method of an object F is called with value V , the following steps are taken:

1. Let F be the `this` value.
2. Return the result of `OrdinaryHasInstance(F , V)`.

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

NOTE This is the default implementation of `@@hasInstance` that most functions inherit. `@@hasInstance` is called by the `instanceof` operator to determine whether a value is an instance of a specific constructor. An expression such as

`v instanceof F`
 evaluates as
`F[@@hasInstance](v)`

A constructor function can control which objects are recognize as its instances by `instanceof` by exposing a different `@@hasInstance` method on the function.

This property is non-writable and non-configurable to prevent tampering that could be used to globally expose the target function of a bound function.

15.3.4 Function Instances

Every function instance is an ordinary function object and has the internal data properties listed in Table 13.

Function instances that correspond to strict mode functions and function instances created using the `Function.prototype.bind` method (15.3.3.5) have properties named `caller` and `arguments` that throw a `TypeError` exception. An ECMAScript implementation must not associate any implementation specific behaviour with accesses of these properties from strict mode function code.

The Function instances have the following properties:

15.3.4.1 length

The value of the `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

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<#> Call the <code>[[DefineOwnProperty]]</code> internal method of F with arguments <code>"caller"</code> , <code>PropertyDescriptor</code> <code>{[[Get]]: thrower, [[Set]]: thrower, [[Enumerable]]: false, [[Configurable]]: false}</code> , and <code>false</code> . ¶
<#> Call the <code>[[DefineOwnProperty]]</code> internal method of F with arguments <code>"arguments"</code> , <code>PropertyDescriptor</code> <code>{[[Get]]: thrower, [[Set]]: thrower, [[Enumerable]]: false, [[Configurable]]: false, and <code>false</code>. ¶</code>
Deleted: or the <code>[[Code]]</code> , <code>[[FormalParameters]]</code> , and <code>[[Scope]]</code> internal properties
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Deleted: a <code>[[Call]]</code> internal property method and in most implementations, a <code>[[HasInstance]]</code> internal property method
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`length` property depends on the function. This property has the attributes { `[[Writable]]: false`, `[[Enumerable]]: false`, `[[Configurable]]: false` }.

15.3.4.2 `prototype`

Function instances that can be used as a constructor have a `prototype` property. Whenever such a function instance is created another ordinary object is also created and is the initial value of the function's `prototype` property. Unless otherwise specified, the value of the `prototype` property is used to initialise the `[[Prototype]]` internal data property of a newly created `ordinary` object before the Function object is invoked as a constructor for that newly created object.

This property has the attributes { `[[Writable]]: true`, `[[Enumerable]]: false`, `[[Configurable]]: false` }.

NOTE Function objects created using `Function.prototype.bind` or by evaluating a `MethodDefinition` (that is not a `GeneratorMethod`) or an `ArrowFunction` grammar production do not have a `prototype` property.

15.4 Array Objects

Array objects are exotic objects that give special treatment to a certain class of property names. See 8.4.3 for a definition of this special treatment.

An Array object, O , is said to be sparse if the following algorithm returns `true`:

1. Let len be the result of `Get(O , "length")`.
2. For each integer i in the range $0 \leq i < \text{ToUint32}(len)$
 - a. Let $elem$ be the result of calling the `[[GetOwnProperty]]` internal method of O with argument `Tostring(i)`.
 - b. If $elem$ is `undefined`, return `true`.
3. Return `false`.

15.4.1 The Array Constructor

The `Array` constructor is the `%Array%` intrinsic object and the initial value of the `Array` property of the global object. 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(..)` is equivalent to the object creation expression `new Array(..)` with the same arguments. However, if the `this` value passed in the call is an `Object` with an `[[ArrayInitialisationState]]` internal data property whose value is `undefined`, it initializes the `this` value using the argument values. This permits `Array` to be used both as factory method and to perform constructor instance initialization.

`Array` may be subclassed and subclass constructors may perform a super invocation of the `Array` constructor to initialize subclass instances.

15.4.1.1 `Array ([item1 [, item2 [, ...]]])`

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

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

1. Let `numberOfArgs` be the number of arguments passed to this constructor call.
2. Assert: `numberOfArgs ≠ 1`.
3. Let O be the `this` value.
4. If `Type(O)` is `Object` and O has a `[[ArrayInitialisationState]]` internal data property and the value of `[[ArrayInitialisationState]]` is `false`, then
 - a. Set the value of O 's `[[ArrayInitialisationState]]` internal data property to `true`.
 - b. Let $array$ be O .
5. Else,
 - a. Let F be this function.
 - b. Let $proto$ be the result of `GetPrototypeOfFromConstructor(F , "%ArrayPrototype%")`.

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Deleted: 15.3.5.3 `[[HasInstance]](V)`

Assume F is a Function object.¶ When the `[[HasInstance]]` internal method of F is called with value V , the following steps are taken:¶

<#> If V is not an object, return `false`.¶

<#> Let O be the result of calling the `[[Get]]` internal method of F with property name "`prototype`".¶

<#> Return `IsAbrupt(O)`.¶

<#> If `Type(O)` is not `Object`, throw a `TypeError` exception.¶

<#> Repeat¶

<#> Let V be the value of the `[[Prototype]]` internal property of V .¶

<#> If V is `null`, return `false`.¶

<#> If O and V refer to the same object, return `true`.¶

NOTE Function objects created using `Function.prototype.bind` have a different implementation of `[[HasInstance]]` defined in 15.3.4.5.3.¶

Deleted: 15.3.5.4 `[[Get]](P)`

Function objects use a variation of the `[[Get]]` internal method used for other native ECMAScript objects (8.12.3).¶

Assume F is a Function object. When the `[[Get]]` internal method of F is called with property name P , the following steps are taken:¶

<#> Let v be the result of calling the default `[[Get]]` internal method (8.12.3) on F passing P as the property name argument.¶

<#> If P is "`caller`" and v is a strict mode Function object, throw a `TypeError` exception.¶

<#> Return v .¶

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- c. ReturnIfAbrupt(proto).
- d. Let array be the result of the abstract operation ArrayCreate with arguments numberOArgs and proto.
- 6. ReturnIfAbrupt(array).
- 7. Let k be 0.
- 8. Let items be a zero-origin List contain the argument items in order.
- 9. Repeat, while k < numberOArgs.
 - a. Let Pk be ToString(k).
 - b. Let itemK be kth element of items.
 - c. Let defineStatus be the result of DefinePropertyOrThrow(array, Pk, Property Descriptor {[[Value]]: itemK, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}).
 - d. ReturnIfAbrupt(defineStatus).
 - e. Increase k by 1.
- 10. Let putStatus be the result of Put(array, "length", numberOArgs, true).
- 11. ReturnIfAbrupt(putStatus).
- 12. Return array.

15.4.1.2 Array (len)

This description applies if and only if the Array constructor is given exactly one argument.

- 1. Let numberOArgs be the number of arguments passed to this constructor call.
- 2. Assert: numberOArgs = 1.
- 3. Let O be the this value.
- 4. If Type(O) is Object and O has an [[ArrayInitialisationState]] internal data property and the value of [[ArrayInitialisationState]] is false, then
 - a. Set the value of O's [[ArrayInitialisationState]] internal data property to true.
 - b. Let array be O.
- 5. Else,
 - a. Let F be this function.
 - b. Let proto be the result of GetPrototypeOfFromConstructor(F, "%ArrayPrototype%").
 - c. ReturnIfAbrupt(proto).
 - d. Let array be the result of the abstract operation ArrayCreate with argument 0 and proto.
- 6. ReturnIfAbrupt(array).
- 7. If Type(len) is not Number, then
 - a. Let defineStatus be the result of DefinePropertyOrThrow(array, "0", Property Descriptor {[[Value]]: len, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}).
 - b. ReturnIfAbrupt(defineStatus).
 - c. Let intLen be 1.
- 8. Else,
 - a. Let intLen be ToUint32(len).
 - b. If intLen ≠ len, then throw a RangeError exception.
- 9. Let putStatus be the result of Put(array, "length", intLen, true).
- 10. ReturnIfAbrupt(putStatus).
- 11. Return array.

15.4.1.3 new Array (... argumentsList)

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

- 1. Let F be the Array function object on which the new operator was applied.
- 2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
- 3. Return the result of OrdinaryConstruct (F, argumentsList).

If Array is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

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15.4.2 Properties of the Array Constructor

The value of the `[[Prototype]]` internal `data` property of the `Array` constructor is the Function prototype object (15.3.3).

Besides and the `length` property (whose value is `1`), the `Array` constructor has the following properties:

15.4.2.1 `Array.prototype`

The value of `Array.prototype` is `%ArrayPrototype%` the intrinsic `Array` prototype object (15.4.3).

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

15.4.2.2 `Array.isArray (arg)`

The `isArray` function takes one argument `arg`, and performs the following steps are taken:

1. If `Type(arg)` is not `Object`, return `false`.
2. If `arg` is an exotic `Array` object, then return `true`.
3. Return `false`.

15.4.2.3 `Array.of (...items)`

When the `of` method is called with any number of arguments, the following steps are taken:

1. Let `lenValue` be the result of `Get(items, "length")`.
2. Let `len` be `ToInteger(lenValue)`.
3. Let `C` be the `this` value.
4. If `IsConstructor(C)` is `true`, then
 - a. Let `newObj` be the result of calling the `[[Construct]]` internal method of `C` with an argument list containing the single item `len`.
 - b. Let `A` be `ToObject(newObj)`.
5. Else,
 - a. Let `A` be the result of the abstract operation `ArrayCreate` with argument `len`.
6. `ReturnIfAbrupt(A)`.
7. Let `k` be `0`.
8. Repeat, while `k < len`
 - a. Let `Pk` be `ToString(k)`.
 - b. Let `kValue` be the result of `Get(items, Pk)`.
 - c. Let `defineStatus` be the result of `DefinePropertyOrThrow(A, Pk, Property Descriptor {[[Value]]: kValue, [[value]]: kValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true})`.
 - d. `ReturnIfAbrupt(defineStatus)`.
 - e. Increase `k` by `1`.
9. Let `putStatus` be the result of `Put(A, "length", len, true)`.
10. `ReturnIfAbrupt(putStatus)`.
11. Return `A`.

The `length` property of the `of` method is `0`.

NOTE 1 The `items` argument is assume to be a well-formed rest argument value.

NOTE 2 The `of` function is an intentionally generic factory method; it does not require that its `this` value be the `Array` constructor. Therefore it can be transferred to or inherited by other constructors that may be called with a single numeric argument.

15.4.2.4 `Array.from (arrayLike , mapfn=undefined, thisArg=undefined)`

When the `from` method is called with argument `arrayLike`, the following steps are taken:

1. Let `items` be `ToObject(arrayLike)`.

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Deleted: the value of the `[[Class]]` internal property of

Deleted: is `"Array"`

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2. ReturnIfAbrupt(items).
3. Let lenValue be the result of Get(items, "length").
4. Let len be ToInteger(lenValue).
5. ReturnIfAbrupt(len).
6. Let C be the this value.
7. If IsConstructor(C) is true, then
 - a. Let newObj be the result of calling the [[Construct]] internal method of C with an argument list containing the single item len.
 - b. Let A be ToObject(newObj).
8. Else,
 - a. Let A be the result of the abstract operation ArrayCreate with argument len.
9. ReturnIfAbrupt(A).
10. Let k be 0.
11. Repeat, while k < len
 - a. Let Pk be ToString(k).
 - b. Let kPresent be the result of HasProperty(items, Pk).
 - c. ReturnIfAbrupt(kPresent).
 - d. If kPresent is true, then
 - i. Let kValue be the result of Get(items, Pk).
 - ii. ReturnIfAbrupt(kValue).
 - iii. Let defineStatus be the result of DefinePropertyOrThrow(A, Pk, Property Descriptor {[[Value]]: kValue, [[value]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}).
 - iv. ReturnIfAbrupt(defineStatus).
 - e. Increase k by 1.
12. Let putStatus be the result of Put(A, "length", len, true).
13. ReturnIfAbrupt(putStatus).
14. Return A.

NOTE The from function is an intentionally generic factory method; it does not require that its this value be the Array constructor. Therefore it can be transferred to or inherited by any other constructors that may be called with a single numeric argument.

15.4.2.5 Array[@@create]()

The @@create method of an object F performs the following steps:

1. Let F be the this value.
2. Let proto be the result of GetPrototypeOfFromConstructor(F, "%ArrayPrototype%").
3. ReturnIfAbrupt(proto).
4. Let obj be the result of calling ArrayCreate with arguments undefined and proto.
5. Return obj.

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

NOTE 1 Passing undefined as the first argument to ArrayCreate causes the [[ArrayInitialisationState]] internal data property of the array to be initially assigned the value false. This is a flag used to indicate that the instance has not yet been initialized by the Array constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in any unobservable manner.

NOTE 2 The Array @@create function is intentionally generic; it does not require that its this value be the Array constructor object. It can be transferred to other constructor functions for use as a @@create method. When used with other constructors, this function will create an exotic Array object whose [[Prototype]] value is obtained from the associated constructor.

15.4.3 Properties of the Array Prototype Object

The value of the [[Prototype]] internal data property of the Array prototype object is the intrinsic object %ObjectPrototype%.

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The Array prototype object is itself an ordinary object. It is not an Array instance and does not have a length property.

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 object to be an object which is not an exotic Array object.

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

15.4.3.1 Array.prototype.constructor

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

15.4.3.2 Array.prototype.toString ()

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

1. Let array be the result of calling ToObject on the this value.
2. ReturnIfAbrupt(array).
3. Let func be the result of Get(array, "join").
4. ReturnIfAbrupt(func).
5. If IsCallable(func) is false, then let func be the standard built-in method Object.prototype.toString (15.2.4.2).
6. Return the result of calling the [[Call]] internal method of func providing array as thisArgument and an empty List as argumentsList.

NOTE The toString 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 toString function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.3 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. Let array be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(array).
3. Let arrayLen be the result of Get(array, "length").
4. Let len be ToUint32(arrayLen).
5. ReturnIfAbrupt(len).
6. Let separator be the String value for the list-separator String appropriate for the host environment’s current locale (this is derived in an implementation-defined way).
7. If len is zero, return the empty String.
8. Let firstElement be the result of Get(array, "0").
9. Let noArgs be an empty List.
10. ReturnIfAbrupt(firstElement).
11. If firstElement is undefined or null, then
 - a. Let R be the empty String.
12. Else
 - a. Let R be the result of Invoke(firstElement, "toLocaleString").
 - b. Let R be ToString(R).
 - c. ReturnIfAbrupt(R).
13. Let k be 1.
14. Repeat, while k < len
 - a. Let S be a String value produced by concatenating R and separator.

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- Deleted:**; its [[Class]] is "Array" it has an [[NativeBrandBuiltinBrandIsArray]] internal data property with value NativeArrayBuiltinArray
- Deleted:** and it has
- Deleted:** (whose initial value is +0) and the special [[DefineOwnProperty]] internal method described in 15.4.5.1
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- Deleted:** the value of the [[Class]] internal property is not "Array"
- Deleted:** does not have an [[IsArrayNativeBrandBuiltinBrand]] internal data property with value NativeArrayBuiltinArray
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<#>Let func be the result of calling the [[Get]] internal method of elementObj with argument "toLocaleString".¶
<#>If IsCallable(func) is false, throw a TypeError exception.¶
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- Comment [AWB7156]:** This step was missing in ES<=5.1
- Deleted:** If R is an abrupt completion, return R.
- Deleted:** Let R be the result of calling the [[Call]] internal method of func providing elementObj as args

- b. Let `nextElement` be the result of `Get(array.ToString(k))`.
- c. `ReturnIfAbrupt(nextElement)`.
- d. If `nextElement` is `undefined` or `null`, then
 - i. Let `R` be the empty String.
- e. Else
 - i. Let `R` be the result of `Invoke(nextElement, "toLocaleString")`.
 - ii. Let `R` be `ToString(R)`.
 - iii. `ReturnIfAbrupt(R)`.
- f. Let `R` be a String value produced by concatenating `S` and `R`.
- g. Increase `k` by 1.

15. Return `R`.

NOTE 1 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.

NOTE 2 The `toLocaleString` 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 `toLocaleString` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.4 Array.prototype.concat ([item1 [, item2 [, ...]]])

When the `concat` method is called with zero or more arguments `item1`, `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 `O` be the result of calling `ToObject` passing the `this` value as the argument.
- 2. `ReturnIfAbrupt(O)`.
- 3. Let `A` be the result of the abstract operation `ArrayCreate` with argument `0`.
- 4. Let `n` be `0`.
- 5. Let `items` be an internal List whose first element is `O` and whose subsequent elements are, in left to right order, the arguments that were passed to this function invocation.
- 6. Repeat, while `items` is not empty
 - a. Remove the first element from `items` and let `E` be the value of the element.
 - b. If `E` is an exotic Array object, then
 - i. Let `k` be `0`.
 - ii. Let `len` be the result of `Get(E, "length")`.
 - iii. `ReturnIfAbrupt(len)`.
 - iv. Repeat, while `k < len`
 - 1. Let `P` be `ToString(k)`.
 - 2. Let `exists` be the result of `HasProperty(E, P)`.
 - 3. `ReturnIfAbrupt(exists)`.
 - 4. If `exists` is `true`, then
 - a. Let `subElement` be the result of `Get(E, P)`.
 - b. Call the `[[DefineOwnProperty]]` internal method of `A` with arguments `ToString(n)` and Property Descriptor `{[[Value]]: E, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - 5. Increase `n` by 1.
 - 6. Increase `k` by 1.
 - c. Else, `E` is not an Array
 - i. Call the `[[DefineOwnProperty]]` internal method of `A` with arguments `ToString(n)` and Property Descriptor `{[[Value]]: E, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - ii. Increase `n` by 1.
- 7. Let `putStatus` be the result of `Put(A, "length", n, true)`.
- 8. `ReturnIfAbrupt(putStatus)`.
- 9. Return `A`.

The `length` property of the `concat` method is **1**.

- Deleted:** calling the `[[Delete]]` internal method of `A`.
- Deleted:** `]` internal method of `A`.
- Deleted:**
- Deleted:** with argument
- Deleted:** `<#>Let elementObj be ToObject(nextElement).`
- Deleted:** calling
- Deleted:** with arguments
- Deleted:** , `nextElement`,
- Deleted:** and an empty arguments List
- Comment [AWB7157]:** This step was missing in ES<=5.1
- Deleted:** If `R` is an abrupt completion, return `R`.
- Deleted:** `<#>Let func be the result of calling the [[Get]] internal method of elementObj with argument "toLocaleString".`
- Deleted:** `<#>If IsCallable(func) is false, throw a TypeError exception.`
- Deleted:** `<#>Let R be the result of calling the [[Call]] internal method of func providing elementObj as the this value and an empty arguments list. ¶`
- Deleted:** host
- Deleted:** 15.4.4
- Deleted:** abstraction operation
- Deleted:** (15.4)
- Deleted:** a new array created as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name
- Deleted:** the value of the `[[Class]]` internal property of `A`
- Deleted:** is `"Array"`
- Deleted:** has
- Deleted:** the `[[IsArrayNativeBrandBuiltinBrand]]` internal data property with value `NativeArrayBuiltinArray`
- Deleted:** calling the `[[Get]]` internal method of `E` with argument `"length"`
- Deleted:** calling the `[[HasProperty]]` internal method of `E`
- Deleted:** with
- Deleted:** calling the `[[`
- Deleted:** `]]` internal method of `E`
- Deleted:**
- Deleted:** with argument
- Deleted:** ,
- Deleted:** , and `false`
- Deleted:** ,
- Deleted:** , and `false`
- Deleted:** Call
- Deleted:** calling the `[[Put]]` internal method of `A` with arguments `"length"`, `n`, and `true`
- Deleted:** If `putStatus` is an abrupt completion, return `putStatus`.

NOTE 1 The explicit setting of the `length` property in step 7 is necessary to ensure that its value is correct in situations where the trailing elements of the result Array are not present.

NOTE 2 The `concat` 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 `concat` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.5 Array.prototype.join (separator)

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

The `join` method takes one argument, `separator`, and performs the following steps:

1. Let O be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let $lenVal$ be the result of `Get(O , "length")`.
4. Let len be `ToInt32(lenVal)`.
5. ReturnIfAbrupt(len).
6. If `separator` is `undefined`, let `separator` be the single-character String `,`.
7. Let sep be `ToString(separator)`.
8. If len is zero, return the empty String.
9. Let $element0$ be the result of `Get(O , "0")`.
10. If $element0$ is `undefined` or `null`, let R be the empty String; otherwise, let R be `ToString(element0).`
11. ReturnIfAbrupt(R).
12. Let k be 1 .
13. Repeat, while $k < len$
 - a. Let S be the String value produced by concatenating R and sep .
 - b. Let $element$ be the result of `Get(O , ToString(k))`.
 - c. If $element$ is `undefined` or `null`, then let $next$ be the empty String; otherwise, let $next$ be `ToString(element)`.
 - d. ReturnIfAbrupt($next$).
 - e. Let R be a String value produced by concatenating S and $next$.
 - f. Increase k by 1 .
14. Return R .

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.6 Array.prototype.pop ()

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

1. Let O be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let $lenVal$ be the result of `Get(O , "length")`.
4. Let len be `ToInt32(lenVal)`.
5. ReturnIfAbrupt(len).
6. If len is zero,
 - a. Let `putStatus` be the result of `Put(O , "length", 0, true)`.
 - b. ReturnIfAbrupt(`putStatus`).
 - c. Return `undefined`.
7. Else, $len > 0$,
 - a. Let $newLen$ be $len - 1$.
 - b. Let $indx$ be `ToString(newLen)`.
 - c. Let $element$ be the result of `Get(O , $indx$)`.

Deleted: host

Deleted: 15.4.4

Deleted: calling the [[Get]] internal method of O with argument "length"

Deleted: calling the [[

Deleted:]] internal method of O

Deleted:

Deleted: with argument

Deleted: Let

Deleted: If R is an abrupt completion, return R

Deleted: calling the [[

Deleted:]] internal method of O

Deleted:

Deleted: with argument

Deleted: L

Deleted: If $next$ is an abrupt completion, return $next$.

Deleted: host

Deleted: 15.4.4

Deleted: calling the [[Get]] internal method of O with argument "length"

Deleted: Call

Deleted: calling the [[Put]] internal method of O with arguments "length", 0 , and `true`

Deleted: If `putStatus` is an abrupt completion, return `putStatus`.

Deleted: ,

Deleted: `indx`

Deleted: `ToString(`

Deleted: `)`

Deleted: calling the [[

Deleted:]] internal method of O

Deleted:

Deleted: with argument

- d. ReturnIfAbrupt(element).
- e. Let deleteStatus be the result of DeletePropertyOrThrow(O, idx).
- f. ReturnIfAbrupt(deleteStatus).
- g. Let putStatus be the result of Put(O, "length", newLen, true).
- h. ReturnIfAbrupt(putStatus).
- i. Return element.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.7 `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. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let `lenVal` be the result of Get(O, "length").
4. Let `n` be `ToUint32(lenVal)`.
5. ReturnIfAbrupt(n).
6. Let `items` be an internal List whose elements are, in left to right order, the arguments that were passed to this function invocation.
7. Repeat, while `items` is not empty
 - a. Remove the first element from `items` and let `E` be the value of the element.
 - b. Let putStatus be the result of Put(O, ToString(n), E, true).
 - c. ReturnIfAbrupt(putStatus).
 - d. Increase `n` by 1.
8. Let putStatus be the result of Put(O, "length", n, true).
9. ReturnIfAbrupt(putStatus).
10. 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 an exotic object that is not an Array is implementation-dependent.

15.4.3.8 `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. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let `lenVal` be the result of Get(O, "length").
4. Let `len` be `ToUint32(lenVal)`.
5. ReturnIfAbrupt(len).
6. Let `middle` be `floor(len/2)`.
7. Let `lower` be 0.
8. Repeat, while `lower ≠ middle`
 - a. Let `upper` be `len - lower - 1`.
 - b. Let `upperP` be `ToString(upper)`.
 - c. Let `lowerP` be `ToString(lower)`.
 - d. Let `lowerValue` be the result of Get(O, lowerP).
 - e. ReturnIfAbrupt(lowerValue).
 - f. Let `upperValue` be the result of Get(O, upper).

- Deleted:** If `element` is an abrupt completion, return `element`.
- Deleted:** of calling Call the `[[Delete]]` internal method of `O`.
- Deleted:** with arguments
- Deleted:** and `true`
- Deleted:** If `deleteStatus` is an abrupt completion, return `deleteStatus`.
- Deleted:** calling Call the `[[Put]]` internal method of `O` with arguments `"length"`, `idxnewLen`, and `true`
- Deleted:** If `putStatus` is an abrupt completion, return `putStatus`.
- Deleted:** host
- Deleted:** 15.4.4

- Deleted:** calling the `[[Get]]` internal method of `O` with argument `"length"`
- Deleted:** `len`

- Deleted:** calling Call the `[[Put]]` internal method of `O` with arguments `"length"`, `n`, and `true`
- Deleted:** If `putStatus` is an abrupt completion, return `putStatus`.
- Deleted:** host
- Deleted:** 15.4.4

- Deleted:** calling the `[[Get]]` internal method of `O` with argument `"length"`
- Deleted:** calling the `[[Delete]]` internal method of `O`.
- Deleted:** with argument
- Deleted:** If `lowerValue` is an abrupt completion, return `lowerValue`
- Deleted:** calling the `[[Put]]` internal method of `O` with arguments `"length"`, `lowerP`, and `true`
- Deleted:** If `putStatus` is an abrupt completion, return `putStatus`.
- Deleted:** with argument
- Deleted:** `upperP`

- g. [ReturnIfAbrupt\(*upperValue*\)](#).

h. Let *lowerExists* be the result of [HasProperty\(*O*, *lowerP*\)](#).

i. [ReturnIfAbrupt\(*lowerExists*\)](#).

j. Let *upperExists* be the result of [HasProperty\(*O*, *upperP*\)](#).

k. [ReturnIfAbrupt\(*upperExists*\)](#).

l. If *lowerExists* is **true** and *upperExists* is **true**, then

 - [Let *putStatus* be the result of Put\(*O*, *lowerP*, *upperValue*, **true**\)](#).
 - [ReturnIfAbrupt\(*putStatus*\)](#).
 - [Let *putStatus* be the result of Put\(*O*, *upperP*, *lowerValue*, **true**\)](#).
 - [ReturnIfAbrupt\(*putStatus*\)](#).

m. Else if *lowerExists* is **false** and *upperExists* is **true**, then

 - [Let *putStatus* be the result of Put\(*O*, *lowerP*, *upperValue*, **true**\)](#).
 - [ReturnIfAbrupt\(*putStatus*\)](#).
 - [Let *deleteStatus* be the result of DeletePropertyOrThrow \(*O*, *upperP*\)](#).
 - [ReturnIfAbrupt\(*deleteStatus*\)](#).

n. Else if *lowerExists* is **true** and *upperExists* is **false**, then

 - [Let *deleteStatus* be the result of DeletePropertyOrThrow \(*O*, *lowerP*\)](#).
 - [ReturnIfAbrupt\(*deleteStatus*\)](#).
 - [Let *putStatus* be the result of Put\(*O*, *upperP*, *lowerValue*, **true**\)](#).
 - [ReturnIfAbrupt\(*putStatus*\)](#).

o. Else both *lowerExists* and *upperExists* are **false**.

 - No action is required.

p. Increase *lower* by 1.

9. Return *O*.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.9 Array.prototype.shift ()

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

- Let O be the result of calling `ToObject` passing the `this` value as the argument.
 - ReturnIfAbrupt(O).
 - Let $lenVal$ be the result of `Get(O , "length")`.
 - Let len be `ToUint32(lenVal)`.
 - ReturnIfAbrupt(len).
 - If len is zero, then
 - Let $putStatus$ be the result of `Put(O , "length", 0, true)`.
 - ReturnIfAbrupt($putStatus$).
 - Return `undefined`.
 - Let $first$ be the result of `Get(O , "0")`.
 - ReturnIfAbrupt($first$).
 - Let k be 1.
 - Repeat, while $k < len$
 - Let $from$ be `ToString(k)`.
 - Let to be `ToString($k-1$)`.
 - Let $fromPresent$ be the result of `HasProperty(O , $from$)`.
 - ReturnIfAbrupt($fromPresent$).
 - If $fromPresent$ is `true`, then
 - Let $fromVal$ be the result of `Get(O , $from$)`.
 - ReturnIfAbrupt($fromVal$).
 - Let $putStatus$ be the result of `Put(O , to , $fromVal$, true)`.
 - ReturnIfAbrupt($putStatus$).
 - Else $fromPresent$ is `false`,
 - Let $deleteStatus$ be the result of `DeletePropertyOrThrow(O , to)`.
 - ReturnIfAbrupt($deleteStatus$).
 - Increase k by 1.
 - Let $deleteStatus$ be the result of `DeletePropertyOrThrow(O , ToString(len-1))`.

12. ReturnIfAbrupt(deleteStatus).
13. Let putStatus be the result of Put(O, "length", len-1, true).
14. ReturnIfAbrupt(putStatus).
15. Return first.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.10 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 *O* be the result of calling **ToObject** passing the **this** value as the argument.
2. ReturnIfAbrupt(*O*).
3. Let *A* be the result of the abstract operation **ArrayCreate** with argument 0.
4. Let *lenVal* be the result of Get(*O, "length*).
5. Let *len* be UInt32(lenVal).
6. ReturnIfAbrupt(*len*).
7. Let *relativeStart* be ToInteger(start).
8. ReturnIfAbrupt(*relativeStart*).
9. If *relativeStart* is negative, let *k* be max((*len* + *relativeStart*), 0); else let *k* be min(*relativeStart*, *len*).
10. If *end* is **undefined**, let *relativeEnd* be *len*; else let *relativeEnd* be ToInteger(end).
11. ReturnIfAbrupt(*relativeEnd*).
12. If *relativeEnd* is negative, let *final* be max((*len* + *relativeEnd*), 0); else let *final* be min(*relativeEnd*, *len*).
13. Let *n* be 0.
14. Repeat, while *k < final*
 - a. Let *Pk* be ToString(*k*).
 - b. Let *kPresent* be the result of HasProperty(*O, Pk*).
 - c. ReturnIfAbrupt(*kPresent*).
 - d. If *kPresent* is **true**, then
 - i. Let *kValue* be the result of Get(*O, Pk*).
 - ii. ReturnIfAbrupt(*kValue*).
 - iii. Let *status* be the result of CreateOwnProperty(*A, ToString(*n*), kValue*).
 - iv. ReturnIfAbrupt(*status*).
 - v. If *status* is **false**, throw a **TypeError** exception.
 - e. Increase *k* by 1.
 - f. Increase *n* by 1.
15. Let *putStatus* be the result of Put(*A, "length", n, true*).
16. ReturnIfAbrupt(*putStatus*).
17. Return *A*.

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

NOTE 1 The explicit setting of the **length** property of the result Array in step 15 is necessary to ensure that its value is correct in situations where the trailing elements of the result Array are not present.

NOTE 2 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 an exotic object that is not an Array is implementation-dependent.

15.4.3.11 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*.

- Deleted:** If *deleteStatus* is an abrupt completion, return *deleteStatus*
- Deleted:** calling Call the [[Delete]] internal method of
- Deleted:**
- Deleted:** with arguments
- Deleted:** (
- Deleted:**)
- Deleted:** and
- Deleted:** If *putStatus* is an abrupt completion, return *putStatus*
- Deleted:** host
- Deleted:** 15.4.4
- Deleted:** abstraction operation
- Deleted:** (15.4)
- Deleted:** a new array created as if by the expression **new Array()** where **Array** is the standard built-in constructor with that name
- Deleted:** calling the [[Get]] internal method of *O* with argument "**length**"
- Deleted:** If *relativeStart* is an abrupt completion, return *relativeStart*
- Deleted:** If *relativeEnd* is an abrupt completion, return *relativeEnd*
- Deleted:** calling the [[HasProperty]] internal method of
- Deleted:** with argument
- Deleted:** calling the [[Delete]] internal method of
- Deleted:**
- Deleted:**
- Deleted:** with argument
- Deleted:** If *kValue* is an abrupt completion, return *kValue*
- Deleted:** Call the [[DefineOwnProperty]] internal method
- Deleted:** with arguments
- Deleted:** :)
- Deleted:** Property Descriptor {[[Value]]:}
- Deleted:** ,
- Deleted:** [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**
- Deleted:**
- Deleted:** , and false
- Comment [AWB9158]:** Fix for ES5 bug
https://bugs.ecmascript.org/show_bug.cgi?id=417
- Deleted:** *final*
- Deleted:** calling the [[Put]] internal method of *A* with arguments "**length**", *final*, and **true**
- Deleted:** host
- Deleted:** 15.4.4

Let *obj* be the result of calling `ToObject` passing the `this` value as the argument.

Let *len* be the result of applying `Uint32` to the result of `Get(obj, "length")`.

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 *proto* be the result of calling the `[[GetInheritance]]` internal method of *obj*. If *proto* is not `null` and there exists an integer *j* such that all of the conditions below are satisfied then the behaviour of `sort` is implementation-defined:

- *obj* is sparse (15.4)
- $0 \leq j < len$
- The result of `HasProperty(proto, ToString(j))` is `true`.

The behaviour of `sort` is also implementation defined if *obj* is sparse and any of the following conditions are true:

- The result of the predicate `IsExtensible(obj)` is `false`.
- Any array index property of *obj* whose name is a nonnegative integer less than *len* is a data property whose `[[Configurable]]` attribute is `false`.

The behaviour of `sort` is also implementation defined if any array index property of *obj* whose name is a nonnegative integer less than *len* is an accessor property or is a data property whose `[[Writable]]` attribute is `false`.

Otherwise, the following steps are taken.

1. Perform an implementation-dependent sequence of calls to the `[[Get]]` and `[[Set]]` internal methods of *obj*, to the `DeletePropertyOrThrow` abstract operation with *obj* as the first argument, and to `SortCompare` (described below), where the `property key` argument for each call to `[[Get]]`, `[[Set]]`, or `DeletePropertyOrThrow` is the string representation of a nonnegative integer less than *len* and where the arguments for calls to `SortCompare` are results of previous calls to the `[[Get]]` internal method. If *obj* is not sparse then `DeletePropertyOrThrow` must not be called. If any `[[Set]]` call returns `false` a `TypeError` exception is thrown. If an abrupt completion is returned from any of these operations, it is immediately returned as the value of this function.
2. Return *obj*.

The returned object must have the following two properties.

- There must be some mathematical permutation π of the nonnegative integers less than *len*, such that for every nonnegative integer *j* less than *len*, if property $old[j]$ existed, then $new[\pi(j)]$ is exactly the same value as $old[j]$. But if property $old[j]$ did not exist, then $new[\pi(j)]$ does not exist.
- Then for all nonnegative integers *j* and *k*, each less than *len*, if $SortCompare(j,k) < 0$ (see `SortCompare` below), then $\pi(j) < \pi(k)$.

Here the notation $old[j]$ is used to refer to the hypothetical result of calling the `[[Get]]` internal method of *obj* with argument *j* before this function is executed, and the notation $new[j]$ to refer to the hypothetical result of calling the `[[Get]]` internal method of *obj* 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 $a <_{CF} b$ means $comparefn(a,b) < 0$; $a =_{CF} b$ means $comparefn(a,b) = 0$ (of either sign); and $a >_{CF} b$ means $comparefn(a,b) > 0$.

- 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, $Type(v)$ is `Number`, and *v* is not `Nan`. Note that this implies that exactly one of $a <_{CF} b$, $a =_{CF} b$, and $a >_{CF} b$ will be true for a given pair of *a* and *b*.
- Calling $comparefn(a,b)$ does not modify the `this` object.

Comment [AWB7159]: TODO: take completion values into account.

Deleted: *O*

Deleted: calling the `[[Get]]` internal method of *obj* with argument "`length`"

Deleted: value

Deleted: Prototype

Deleted: *e*

Deleted: property

Deleted: calling the `[[`

Deleted: `]]` internal method of

Deleted:

Deleted: with argument

Deleted: calling

Deleted: `[[`

Deleted: `]]` internal property method of

Deleted:

Deleted: *P*

Deleted: ,

Deleted: Put

Deleted: *P*

Deleted: and

Deleted: `[[`

Deleted: `]]`

Deleted: internal methods

Deleted: of

Deleted: first

Deleted: *P*

Deleted: *P*

Deleted: Put

Deleted: `[[Delete]`

Deleted: `]`

Deleted: *P*

Deleted: The throw argument to the `[[Put]]` and `[[Delete]]` internal methods will be the value `true`

Deleted: `[[`

Deleted: `]]`

Deleted: *P*

Deleted: *P*

Deleted: *P*

- $a =_{CF} a$ (reflexivity)
- If $a =_{CF} b$, then $b =_{CF} a$ (symmetry)
- If $a =_{CF} b$ and $b =_{CF} c$, then $a =_{CF} c$ (transitivity of $=_{CF}$)
- If $a <_{CF} b$ and $b <_{CF} c$, then $a <_{CF} c$ (transitivity of $<_{CF}$)
- If $a >_{CF} b$ and $b >_{CF} c$, then $a >_{CF} c$ (transitivity of $>_{CF}$)

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.

Runtime Semantics: SortCompare Abstract Operation

When the SortCompare abstract operation is called with two arguments j and k , the following steps are taken:

1. Let $jString$ be `ToString(j)`.
2. Let $kString$ be `ToString(k)`.
3. Let $hasj$ be the result of `HasProperty(obj, jString)`.
4. ReturnIfAbrupt(hasj).
5. Let $hask$ be the result of `HasProperty(obj, kString)`.
6. ReturnIfAbrupt(hask).
7. If $hasj$ and $hask$ are both **false**, then return **+0**.
8. If $hasj$ is **false**, then return **1**.
9. If $hask$ is **false**, then return **-1**.
10. Let x be the result of `Get(obj, jString)`.
11. ReturnIfAbrupt(x).
12. Let y be the result of `Get(obj, kString)`.
13. ReturnIfAbrupt(y).
14. If x and y are both **undefined**, return **+0**.
15. If x is **undefined**, return **1**.
16. If y is **undefined**, return **-1**.
17. If the argument *comparefn* is not **undefined**, then
 - a. If `IsCallable(comparefn)` is **false**, throw a **TypeError** exception.
 - b. Return the result of calling the `[[Call]]` internal method of *comparefn* passing **undefined** as `thisArgument` and with a `List` containing the values of x and y as the `argumentsList`.
18. Let $xString$ be `ToString(x).`
19. ReturnIfAbrupt(xString).
20. Let $yString$ be `ToString(y).`
21. ReturnIfAbrupt(yString).
22. If $xString < yString$, return **-1**.
23. If $xString > yString$, return **1**.
24. 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 an exotic object that is not an Array is implementation-dependent.

15.4.3.12 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. An Array object containing the deleted elements (if any) is returned. The following steps are taken:

1. Let O be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let A be the result of the abstract operation `ArrayCreate` with argument **0**.
4. Let $lenVal$ be the result of `Get(O, "length")`.
5. Let len be `ToUint32(lenVal)`.

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- Deleted:** calling the `[[HasProperty]]` internal method of
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- Deleted:** with argument
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- Deleted:** arguments

- Deleted:** abstraction operation
- Deleted:** (15.4)
- Deleted:** a new array created as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name
- Deleted:** calling the `[[Get]]` internal method of O with argument `"length"`.

6. `ReturnIfAbrupt(len).`
7. Let `relativeStart` be `ToInteger(start)`.
8. `ReturnIfAbrupt(relativeStart).`
9. If `relativeStart` is negative, let `actualStart` be `max((len + relativeStart), 0)`; else let `actualStart` be `min(relativeStart, len)`.
10. Let `actualDeleteCount` be `min(max(ToInteger(deleteCount), 0), len - actualStart)`.
11. Let `k` be 0.
12. Repeat, while `k < actualDeleteCount`
 - a. Let `from` be `ToString(actualStart + k)`.
 - b. Let `fromPresent` be the result of `HasProperty(O, from)`.
 - c. `ReturnIfAbrupt(fromPresent).`
 - d. If `fromPresent` is `true`, then
 - i. Let `fromValue` be the result of `Get(O, from)`.
 - ii. `ReturnIfAbrupt(fromValue).`
 - iii. Call the `[[DefineOwnProperty]]` internal method of `A` with arguments `ToString(k)` and Property Descriptor `{[[Value]]: fromValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - e. Increment `k` by 1.
13. Let `putStatus` be the result of `Put(A, "length", actualDeleteCount, true)`.
14. `ReturnIfAbrupt(putStatus).`
15. Let `items` be an internal List whose elements are, in left to right order, the portion of the actual argument list starting with `item1`. The list will be empty if no such items are present.
16. Let `itemCount` be the number of elements in `items`.
17. If `itemCount < actualDeleteCount`, then
 - a. Let `k` be `actualStart`.
 - b. Repeat, while `k < (len - actualDeleteCount)`
 - i. Let `from` be `ToString(k + actualDeleteCount)`.
 - ii. Let `to` be `ToString(k + itemCount)`.
 - iii. Let `fromPresent` be the result of `HasProperty(O, from)`.
 - iv. `ReturnIfAbrupt(fromPresent).`
 - v. If `fromPresent` is `true`, then
 1. Let `fromValue` be the result of `Get(O, from)`.
 2. `ReturnIfAbrupt(fromValue).`
 3. `Let putStatus be the result of Put(O, to, fromValue, true).`
 4. `ReturnIfAbrupt(putStatus).`
 - vi. Else `fromPresent is false.`
 1. `Let deleteStatus be the result of DeletePropertyOrThrow(O, to).`
 2. `ReturnIfAbrupt(deleteStatus).`
 - vii. Increase `k` by 1.
 - c. Let `k` be `len`.
 - d. Repeat, while `k > (len - actualDeleteCount + itemCount)`
 - i. `Let deleteStatus be the result of DeletePropertyOrThrow(O, ToString(k - 1)).`
 - ii. `ReturnIfAbrupt(deleteStatus).`
 - iii. Decrease `k` by 1.
18. Else if `itemCount > actualDeleteCount`, then
 - a. Let `k` be `(len - actualDeleteCount)`.
 - b. Repeat, while `k > actualStart`
 - i. Let `from` be `ToString(k + actualDeleteCount - 1)`.
 - ii. Let `to` be `ToString(k + itemCount - 1)`.
 - iii. Let `fromPresent` be the result of `HasProperty(O, from)`.
 - iv. `ReturnIfAbrupt(fromPresent).`
 - v. If `fromPresent` is `true`, then
 1. Let `fromValue` be the result of `Get(O, from)`.
 2. `ReturnIfAbrupt(fromValue).`
 3. `Let putStatus be the result of Put(O, to, fromValue, true).`
 4. `ReturnIfAbrupt(putStatus).`
 - vi. Else `fromPresent is false.`
 1. `Let deleteStatus be the result of DeletePropertyOrThrow(O, to).`
 2. `ReturnIfAbrupt(deleteStatus).`
 - vii. Decrease `k` by 1.

19. Let k be $actualStart$.
20. Repeat, while $items$ is not empty
 - a. Remove the first element from $items$ and let E be the value of that element.
 - b. Let $putStatus$ be the result of $\text{Put}(O, \text{ToString}(k), E, \text{true})$.
 - c. $\text{ReturnIfAbrupt}(putStatus)$.
 - d. Increase k by 1.

21. Let $putStatus$ be the result of $\text{Put}(O, "length", len - actualDeleteCount + itemCount, \text{true})$.
22. $\text{ReturnIfAbrupt}(putStatus)$.
23. Return A .

The **length** property of the **splice** method is **2**.

NOTE 1 The explicit setting of the **length** property of the result Array in step 13 is necessary to ensure that its value is correct in situations where its trailing elements are not present.

NOTE 2 The **splice** 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 **splice** function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.13 Array.prototype.unshift ([item1 [, 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 **unshift** method is called with zero or more arguments $item1$, $item2$, etc., the following steps are taken:

1. Let O be the result of calling **ToObject** passing the **this** value as the argument.
2. $\text{ReturnIfAbrupt}(O)$.
3. Let $lenVal$ be the result of $\text{Get}(O, "length")$.
4. Let len be $\text{ToUint32}(lenVal)$.
5. $\text{ReturnIfAbrupt}(len)$.
6. Let $argCount$ be the number of actual arguments.
7. Let k be len .
8. Repeat, while $k > 0$,
 - a. Let $from$ be $\text{ToString}(k-1)$.
 - b. Let to be $\text{ToString}(k+argCount-1)$.
 - c. Let $fromPresent$ be the result of $\text{HasProperty}(O, from)$.
 - d. $\text{ReturnIfAbrupt}(fromPresent)$.
 - e. If $fromPresent$ is **true**, then
 - i. Let $fromValue$ be the result of $\text{Get}(O, from)$.
 - ii. $\text{ReturnIfAbrupt}(fromValue)$.
 - iii. Let $putStatus$ be the result of $\text{Put}(O, to, fromValue, \text{true})$.
 - iv. $\text{ReturnIfAbrupt}(putStatus)$.
 - f. Else $fromPresent$ is **false**,
 - i. Let $deleteStatus$ be the result of $\text{DeletePropertyOrThrow}(O, to)$.
 - ii. $\text{ReturnIfAbrupt}(deleteStatus)$.
 - g. Decrease k by 1.
9. Let j be 0.
10. Let $items$ be an internal List whose elements are, in left to right order, the arguments that were passed to this function invocation.
11. Repeat, while $items$ is not empty
 - a. Remove the first element from $items$ and let E be the value of that element.
 - b. Let $putStatus$ be the result of $\text{Put}(O, \text{ToString}(j), E, \text{true})$.
 - c. $\text{ReturnIfAbrupt}(putStatus)$.
 - d. Increase j by 1.
12. Let $putStatus$ be the result of $\text{Put}(O, "length", len+argCount, \text{true})$.
13. $\text{ReturnIfAbrupt}(putStatus)$.
14. Return $len+argCount$.

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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 an exotic object that is not an Array is implementation-dependent.

15.4.3.14 Array.prototype.indexOf (searchElement [, fromIndex])

`indexOf` compares `searchElement` to the elements of the array, in ascending order, using the internal Strict Equality Comparison Algorithm (11.9.1), 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 O be the result of calling `ToObject` passing the `this` value as the argument.
 2. ReturnIfAbrupt(O).
 3. Let $lenValue$ be the result of `Get(O , "length")`.
 4. Let len be `ToUint32(lenValue)`.
 5. ReturnIfAbrupt(len).
 6. If len is 0, return -1.
 7. If argument `fromIndex` was passed let n be `ToInteger(fromIndex)`; else let n be 0.
 8. ReturnIfAbrupt(n).
 9. If $n \geq len$, return -1.
 10. If $n \geq 0$, then
 - a. Let k be n .
 11. Else $n < 0$
 - a. Let k be $len - \text{abs}(n)$.
 - b. If $k \leq 0$, then let k be 0.
 12. Repeat, while $k < len$
 - a. Let $kPresent$ be the result of `HasProperty(O , ToString(k))`.
 - b. ReturnIfAbrupt($kPresent$).
 - c. If $kPresent$ is `true`, then
 - i. Let $elementK$ be the result of `Get(O , ToString(k))`.
 - ii. ReturnIfAbrupt($elementK$).
 - iii. Let $same$ be the result of performing the Strict Equality Comparison Algorithm $searchElement \equiv\equiv elementK$.
 - iv. If $same$ is `true`, return k .
 - d. Increase k by 1.
13. Return -1.

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 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 an exotic object that is not an Array is implementation-dependent.

15.4.3.15 Array.prototype.lastIndexOf (searchElement [, fromIndex])

`lastIndexOf` compares `searchElement` to the elements of the array in descending order using the internal Strict Equality Comparison Algorithm (11.9.1), 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 minus one (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

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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 *O* be the result of calling `ToObject` passing the **this** value as the argument.
2. `ReturnIfAbrupt(O)`.
3. Let *lenValue* be the result of `Get(O, "length")`.
4. Let *len* be `ToInt32(lenValue)`.
5. `ReturnIfAbrupt(len)`.
6. If *len* is 0, return -1.
7. If argument *fromIndex* was passed let *n* be `ToInteger(fromIndex)`; else let *n* be *len*-1.
8. `ReturnIfAbrupt(n)`.
9. If *n* \geq 0, then let *k* be $\min(n, len - 1)$.
10. Else, *n* < 0 .
 - a. Let *k* be *len* - $\text{abs}(n)$.
11. Repeat, while *k* \geq 0
 - a. Let *kPresent* be the result of `HasProperty(O, ToString(k))`.
 - b. `ReturnIfAbrupt(kPresent)`.
 - c. If *kPresent* is **true**, then
 - i. Let *elementK* be the result of `Get(O, ToString(k))`.
 - ii. `ReturnIfAbrupt(elementK)`.
 - iii. Let *same* be the result of performing Strict Equality Comparison Algorithm `searchElement === elementK`.
 - iv. If *same* is **true**, return *k*.
 - d. Decrease *k* by 1.
12. Return -1.

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 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 an exotic object that is not an Array is implementation-dependent.

15.4.3.16 Array.prototype.every (callbackfn [, thisArg])

callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value **true** or **false**. **every** calls *callbackfn* 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 elements of the array which actually exist; it is not called for missing elements of the array.

If a *thisArg* parameter is provided, it will be used as the **this** value for each invocation of *callbackfn*. 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 object being traversed.

every does not directly mutate the object on which it is called but the object may be mutated by the calls to *callbackfn*.

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 after the call to **every** begins and before being visited 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 *O* be the result of calling `ToObject` passing the **this** value as the argument.

Deleted: calling the [[Get]] internal method of *O* with the argument "**length**".

Deleted: If *n* is an abrupt completion, return *n*.

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2. `ReturnIfAbrupt(O)`.
3. Let *lenValue* be the result of `Get(O, "length")`.
4. Let *len* be `ToInt32(lenValue)`.
5. `ReturnIfAbrupt(len)`.
6. If `IsCallable(callbackfn)` is **false**, throw a **TypeError** exception.
7. If *thisArg* was supplied, let *T* be *thisArg*; else let *T* be **undefined**.
8. Let *k* be 0.
9. Repeat, while *k* < *len*
 - a. Let *Pk* be `ToString(k)`.
 - b. Let *kPresent* be the result of `HasProperty(O, Pk)`.
 - c. If *kPresent* is **true**, then
 - i. Let *kValue* be the result of `Get(O, Pk)`.
 - ii. `ReturnIfAbrupt(kValue)`.
 - iii. Let *testResult* be the result of calling the `[[Call]]` internal method of *callbackfn* with *T* as `thisArgument` and a `List` containing *kValue*, *k*, and *O* as `argumentsList`.
 - iv. `ReturnIfAbrupt(testResult)`.
 - v. If `ToBoolean(testResult)` is **false**, return **false**.
 - d. Increase *k* by 1.
10. Return **true**.

The **length** property of the **every** method is **1**.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.17 Array.prototype.some (callbackfn [, thisArg])

callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value **true** or **false**. **some** calls *callbackfn* 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 elements of the array which actually exist; it is not called for missing elements of the array.

If a *thisArg* parameter is provided, it will be used as the **this** value for each invocation of *callbackfn*. 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 object being traversed.

some does not directly mutate the object on which it is called but the object may be mutated by the calls to *callbackfn*.

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 existing elements of the array are changed, their value as passed to *callbackfn* will be the value at the time that **some** visits them; elements that are deleted after the call to **some** begins and before being visited are not visited. **some** acts like the "exists" quantifier in mathematics. In particular, for an empty array, it returns **false**.

When the **some** method is called with one or two arguments, the following steps are taken:

1. Let *O* be the result of calling `ToObject` passing the **this** value as the argument.
2. `ReturnIfAbrupt(O)`.
3. Let *lenValue* be the result of `Get(O, "length")`.
4. Let *len* be `ToInt32(lenValue)`.
5. `ReturnIfAbrupt(len)`.
6. If `IsCallable(callbackfn)` is **false**, throw a **TypeError** exception.
7. If *thisArg* was supplied, let *T* be *thisArg*; else let *T* be **undefined**.
8. Let *k* be 0.
9. Repeat, while *k* < *len*

Deleted: calling the `[[Get]]` internal method of *O* with the argument "**length**".

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- a. Let P_k be $\text{ToString}(k)$.
- b. Let $k\text{Present}$ be the result of $\text{HasProperty}(O, P_k)$.
- c. $\text{ReturnIfAbrupt}(k\text{Present})$.
- d. If $k\text{Present}$ is **true**, then
 - i. Let $k\text{Value}$ be the result of $\text{Get}(O, P_k)$.
 - ii. $\text{ReturnIfAbrupt}(k\text{Value})$.
 - iii. Let testResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing $k\text{Value}$, k , and O as argumentsList .
 - iv. $\text{ReturnIfAbrupt}(\text{testResult})$.
 - v. If $\text{ToBoolean}(\text{testResult})$ is **true**, return **true**.
- e. Increase k by 1.

10. Return **false**.

The **length** property of the **some** method is **1**.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.18 Array.prototype.forEach (callbackfn [, thisArg])

callbackfn should be a function that accepts three arguments. **forEach** calls *callbackfn* once for each element present in the array, in ascending order. *callbackfn* is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a *thisArg* parameter is provided, it will be used as the **this** value for each invocation of *callbackfn*. 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 object being traversed.

forEach does not directly mutate the object on which it is called but the object may be mutated by the calls to *callbackfn*.

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, their value as passed to *callbackfn* will be the value at the time **forEach** visits them; elements that are deleted after the call to **forEach** begins and before being visited are not visited.

When the **forEach** method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling **ToObject** passing the **this** value as the argument.
2. $\text{ReturnIfAbrupt}(O)$.
3. Let lenValue be the result of $\text{Get}(O, \text{"length"})$.
4. Let len be $\text{ToUint32}(\text{lenValue})$.
5. $\text{ReturnIfAbrupt}(\text{len})$.
6. If $\text{IsCallable}(\text{callbackfn})$ is **false**, throw a **TypeError** exception.
7. If *thisArg* was supplied, let T be *thisArg*; else let T be **undefined**.
8. Let k be 0.
9. Repeat, while $k < \text{len}$
 - a. Let P_k be $\text{ToString}(k)$.
 - b. Let $k\text{Present}$ be the result of $\text{HasProperty}(O, P_k)$.
 - c. $\text{ReturnIfAbrupt}(k\text{Present})$.
 - d. If $k\text{Present}$ is **true**, then
 - i. Let $k\text{Value}$ be the result of $\text{Get}(O, P_k)$.
 - ii. $\text{ReturnIfAbrupt}(k\text{Value})$.
 - iii. Let funcResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing $k\text{Value}$, k , and O as argumentsList .
 - iv. $\text{ReturnIfAbrupt}(\text{funcResult})$.
 - e. Increase k by 1.

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- Deleted:** with argument
- Deleted:** If $k\text{Value}$ is an abrupt completion, return $k\text{Value}$.
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- Deleted:** argument
- Deleted:** list
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10. Return **`undefined`**.

The **`length`** property of the **`forEach`** method is **1**.

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 an exotic object that is not an Array is implementation-dependent.

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15.4.3.19 Array.prototype.map (callbackfn [, thisArg])

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`callbackfn` should be a function that accepts three arguments. **`map`** calls **`callbackfn`** once for each element in the array, in ascending order, and constructs a new Array from the results. **`callbackfn`** is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a **`thisArg`** parameter is provided, it will be used as the **`this`** value for each invocation of **`callbackfn`**. 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 object being traversed.

`map` does not directly mutate the object on which it is called but the object may be mutated by the calls to **`callbackfn`**.

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, their value as passed to **`callbackfn`** will be the value at the time **`map`** visits them; elements that are deleted after the call to **`map`** begins and before being visited are not visited.

When the **`map`** method is called with one or two arguments, the following steps are taken:

1. Let **`O`** be the result of calling **`ToObject`** passing the **`this`** value as the argument.

Deleted: calling the [[Get]] internal method of **`O`** with the argument "**`length`**".

2. **ReturnIfAbrupt(O)**

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3. Let **`lenValue`** be the result of **`Get(O, "length")`**.

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4. Let **`len`** be **`ToInt32(lenValue)`**.

Deleted: calling the [[**`HasProperty`**]] internal method of **`O`** with argument

5. **ReturnIfAbrupt(len)**

Deleted: calling the [[`[[Call]]`**]] internal method of **`O`****

6. If **`IsCallable(callbackfn)`** is **false**, throw a **`TypeError`** exception.

Deleted:]] internal method of

7. If **`thisArg`** was supplied, let **`T`** be **`thisArg`**; else let **`T`** be **`undefined`**.

Deleted:

8. Let **`A`** be the result of the abstract operation **`ArrayCreate`** with argument **`len`**.

Deleted: with argument

9. Let **`k`** be **0**.

Deleted: the **`this`** value

10. Repeat, while **`k < len`**

Deleted: argument

a. Let **`Pk`** be **`ToString(k)`**.

Deleted: list

b. Let **`kPresent`** be the result of **`HasProperty(O, Pk)`**.

Deleted: ,

c. **ReturnIfAbrupt(kPresent)**

Deleted: , and **false**

d. If **`kPresent`** is **true**, then

Deleted: host

i. Let **`kValue`** be the result of **`Get(O, Pk)`**.

e. Increase **`k`** by **1**.

ii. **ReturnIfAbrupt(kValue)**

iii. Let **`mappedValue`** be the result of calling the [[**`Call`**]] internal method of **`callbackfn`** with **`T`** as **`thisArgument`** and a List containing **`kValue`**, **`k`**, and **`O`** as **`argumentsList`**.

iv. **ReturnIfAbrupt(mappedValue)**

v. Call the [[**`DefineOwnProperty`**]] internal method of **`A`** with arguments **`Pk`** and **`Property Descriptor`** {[[**`Value`**]]: **`mappedValue`**, [[**`Writable`**]]: **true**, [[**`Enumerable`**]]: **true**, [[**`Configurable`**]]: **true**}

11. Return **`A`**.

The **`length`** property of the **`map`** method is **1**.

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 an exotic object that is not an Array is implementation-dependent.

15.4.3.20 Array.prototype.filter (callbackfn [, thisArg])

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callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value **true** or **false**. **filter** calls *callbackfn* 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 elements of the array which actually exist; it is not called for missing elements of the array.

If a *thisArg* parameter is provided, it will be used as the **this** value for each invocation of *callbackfn*. 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 object being traversed.

filter does not directly mutate the object on which it is called but the object may be mutated by the calls to *callbackfn*.

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 their value as passed to *callbackfn* will be the value at the time **filter** visits them; elements that are deleted after the call to **filter** begins and before being visited are not visited.

When the **filter** method is called with one or two arguments, the following steps are taken:

1. Let *O* be the result of calling **ToObject** passing the **this** value as the argument.
2. **ReturnIfAbrupt(*O*)**.
3. Let *lenValue* be the result of **Get(*O*, "length")**.
4. Let *len* be **ToInt32(*lenValue*)**.
5. **ReturnIfAbrupt(*len*)**.
6. If **IsCallable(callbackfn)** is **false**, throw a **TypeError** exception.
7. If *thisArg* was supplied, let *T* be *thisArg*; else let *T* be **undefined**.
8. Let *A* be the result of the abstract operation **ArrayCreate** with argument *0*.
9. Let *k* be *0*.
10. Let *to* be *0*.
11. Repeat, while *k* < *len*
 - a. Let *Pk* be **ToString(*k*)**.
 - b. Let *kPresent* be the result of **HasProperty(*O*, *Pk*)**.
 - c. **ReturnIfAbrupt(*kPresent*)**.
 - d. If *kPresent* is **true**, then
 - i. Let *kValue* be the result of **Get(*O*, *Pk*)**.
 - ii. **ReturnIfAbrupt(*kValue*)**.
 - iii. Let *selected* be the result of calling the **[[Call]]** internal method of *callbackfn* with *T* as **thisArgument** and a List containing *kValue*, *k*, and *O* as **argumentsList**.
 - iv. **ReturnIfAbrupt(*selected*)**.
 - v. If **ToBoolean(selected)** is **true**, then
 1. Call the **[[DefineOwnProperty]]** internal method of *A* with arguments **ToString(*to*)** and **Property Descriptor** **{[[Value]]: *kValue*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}**.
 2. Increase *to* by 1.
 - e. Increase *k* by 1.
12. Return *A*.

The **length** property of the **filter** method is **1**.

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 an exotic object that is not an **Array** is implementation-dependent.

Deleted: calling the **[[Get]]** internal method of *O* with the argument "**length**"

Deleted: abstraction operation

Deleted: (15.4)

Deleted: a new array created as if by the expression **new Array()** where **Array** is the standard built-in constructor with that name

Deleted: calling the **[[HasProperty]]** internal method of *O* with argument

Deleted: calling the **[[**

Deleted: **]]** internal method of

Deleted:

Deleted: with argument

Deleted: If *kValue* is an abrupt completion, return *kValue*

Deleted: the **this** value

Deleted: argument

Deleted: list

Deleted: If *selected* is an abrupt completion, return *selected*

Deleted: **),**

Deleted: , and **false**

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15.4.3.21 Array.prototype.reduce (callbackfn [, initialValue])

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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 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. It is a **TypeError** if the array contains no elements and *initialValue* is not provided.

reduce does not directly mutate the object on which it is called but the object may be mutated by the calls to *callbackfn*.

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 existing elements of the array are changed, their value as passed to *callbackfn* will be the value at the time **reduce** visits them; elements that are deleted after the call to **reduce** begins and before being visited are not visited.

When the **reduce** method is called with one or two arguments, the following steps are taken:

1. Let *O* be the result of calling **ToObject** passing the **this** value as the argument.
2. **ReturnIfAbrupt(*O*)**
3. Let *lenValue* be the result of Get(*O*, "length").
4. Let *len* be **ToInt32**(*lenValue*).
5. **ReturnIfAbrupt(*len*)**
6. If **IsCallable(callbackfn)** is **false**, throw a **TypeError** exception.
7. If *len* is 0 and *initialValue* is not present, throw a **TypeError** exception.
8. Let *k* be 0.
9. If *initialValue* is present, then
 - a. Set *accumulator* to *initialValue*.
10. Else, *initialValue* is not present,
 - a. Let *kPresent* be **false**.
 - b. Repeat, while *kPresent* is **false** and *k* < *len*
 - i. Let *Pk* be **ToString**(*k*).
 - ii. Let *kPresent* be the result of GetProperty(*O*, *Pk*).
 - iii. **ReturnIfAbrupt(*kPresent*)**.
 - iv. If *kPresent* is **true**, then
 1. Let *accumulator* be the result of Get(*O*, *Pk*).
 2. **ReturnIfAbrupt(*accumulator*)**.
 - v. Increase *k* by 1.
 - c. If *kPresent* is **false**, throw a **TypeError** exception.
11. Repeat, while *k* < *len*
 - a. Let *Pk* be **ToString**(*k*).
 - b. Let *kPresent* be the result of GetProperty(*O*, *Pk*).
 - c. **ReturnIfAbrupt(*kPresent*)**.
 - d. If *kPresent* is **true**, then
 - i. Let *kValue* be the result of Get(*O*, *Pk*).
 - ii. **ReturnIfAbrupt(*kValue*)**.
 - iii. Let *accumulator* be the result of calling the **[[Call]]** internal method of *callbackfn* with **undefined** as *thisArgument* and a *List* containing *accumulator*, *kValue*, *k*, and *O* as *argumentsList*.
 - iv. **ReturnIfAbrupt(*accumulator*)**.
 - e. Increase *k* by 1.
12. Return *accumulator*.

The **length** property of the **reduce** method is 1.

Deleted: calling the **[[Get]]** internal method of *O* with the argument "length"

Deleted: ,

Deleted: calling the **[[HasProperty]]** internal method of *O* with argument

Deleted: calling the **[[**

Deleted: **]]** internal method of

Deleted:

Deleted: with argument

Deleted: If *accumulator* is an abrupt completion return *accumulator*.

Deleted: calling the **[[HasProperty]]** internal method of *O* with argument

Deleted: calling the **[[**

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Deleted:

Deleted: with argument

Deleted: If *kValue* is an abrupt completion, return *kValue*

Deleted: the **this** value

Deleted: argument

Deleted: list

Deleted: If *accumulator* is an abrupt completion return *accumulator*

NOTE The `reduce` 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 `reduce` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.22 Array.prototype.reduceRight (callbackfn [, initialValue])

`callbackfn` should be a function that takes four arguments. `reduceRight` calls the callback, as a function, once for each element present in the array, in descending 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 object being traversed. The first time the function is called, the `previousValue` and `currentValue` can be one of two values. If an `initialValue` was provided in the call to `reduceRight`, then `previousValue` will be equal to `initialValue` and `currentValue` will be equal to the last value in the array. If no `initialValue` was provided, then `previousValue` will be equal to the last value in the array and `currentValue` will be equal to the second-to-last value. It is a `TypeError` if the array contains no elements and `initialValue` is not provided.

`reduceRight` does not directly mutate the object on which it is called but the object may be mutated by the calls to `callbackfn`.

The range of elements processed by `reduceRight` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `reduceRight` begins will not be visited by `callbackfn`. If existing elements of the array are changed by `callbackfn`, their value as passed to `callbackfn` will be the value at the time `reduceRight` visits them; elements that are deleted after the call to `reduceRight` begins and before being visited are not visited.

When the `reduceRight` method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(O).
3. Let $lenValue$ be the result of `Get(O , "length")`.
4. Let len be `ToInt32(lenValue)`.
5. ReturnIfAbrupt(len).
6. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
7. If len is 0 and `initialValue` is not present, throw a `TypeError` exception.
8. Let k be $len - 1$.
9. If `initialValue` is present, then
 - a. Set `accumulator` to `initialValue`.
10. Else, `initialValue` is not present,
 - a. Let $kPresent$ be `false`.
 - b. Repeat, while $kPresent$ is `false` and $k \geq 0$
 - i. Let Pk be `ToString(k)`.
 - ii. Let $kPresent$ be the result of `HasProperty(O , Pk)`.
 - iii. ReturnIfAbrupt($kPresent$).
 - iv. If $kPresent$ is `true`, then
 1. Let `accumulator` be the result of `Get(O , Pk)`.
 2. ReturnIfAbrupt(`accumulator`).
 - v. Decrease k by 1.
 - c. If $kPresent$ is `false`, throw a `TypeError` exception.
11. Repeat, while $k \geq 0$
 - a. Let Pk be `ToString(k)`.
 - b. Let $kPresent$ be the result of `HasProperty(O , Pk)`.
 - c. ReturnIfAbrupt($kPresent$).
 - d. If $kPresent$ is `true`, then
 - i. Let $kValue$ be the result of `Get(O , Pk)`.
 - ii. ReturnIfAbrupt($kValue$).
 - iii. Let `accumulator` be the result of calling the `[[Call]]` internal method of `callbackfn` with `undefined` as `thisArgument` and a `List` containing `accumulator`, `kValue`, `k`, and O as `argumentsList`.

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- Deleted:** calling the `[[Get]]` internal method of O with the argument `"length"`
- Deleted:**,
- Deleted:** calling the `[[HasProperty]]` internal method of O with argument
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- Deleted:** `]]` internal method of
- Deleted:**
- Deleted:** with argument
- Deleted:** If `accumulator` is an abrupt completion, return `accumulator`
- Deleted:** calling the `[[HasProperty]]` internal method of O with argument
- Deleted:** calling the `[[`
- Deleted:** `]]` internal method of
- Deleted:**
- Deleted:** with argument
- Deleted:** If `kValue` is an abrupt completion, return `kValue`
- Deleted:** the `this` value
- Deleted:** argument
- Deleted:** list

- iv. ReturnIfAbrupt(accumulator)
- e. Decrease k by 1.

12. Return $accumulator$.

Deleted: If $accumulator$ is an abrupt completion
return $accumulator$

The **length** property of the **reduceRight** method is 1.

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 an exotic object that is not an Array is implementation-dependent.

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15.4.3.23 Array.prototype.find (predicate , thisArg = undefined)

predicate should be a function that accepts three arguments and returns a value that is coercible to the Boolean value **true** or **false**. **find** calls **predicate** once for each element present in the array, in ascending order, until it finds one where **predicate** returns **true**. If such an element is found, **find** immediately returns that element value. Otherwise, **find** returns **undefined**. **predicate** is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a **thisArg** parameter is provided, it will be used as the **this** value for each invocation of **predicate**. If it is not provided, **undefined** is used instead.

predicate is called with three arguments: the value of the element, the index of the element, and the object being traversed.

find does not directly mutate the object on which it is called but the object may be mutated by the calls to **predicate**.

The range of elements processed by **find** is set before the first call to **callbackfn**. Elements that are appended to the array after the call to **find** begins will not be visited by **callbackfn**. If existing elements of the array are changed, their value as passed to **predicate** will be the value at the time that **find** visits them; elements that are deleted after the call to **find** begins and before being visited are not visited.

When the **find** method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling **ToObject** passing the **this** value as the argument.
2. ReturnIfAbrupt(O).
3. Let $lenValue$ be the result of **Get(O , "length")**.
4. Let len be **ToInteger($lenValue$)**.
5. ReturnIfAbrupt(len).
6. If **IsCallable($predicate$)** is **false**, throw a **TypeError** exception.
7. If **thisArg** was supplied, let T be **thisArg**; else let T be **undefined**.
8. Let k be 0.
9. Repeat, while $k < len$
 - a. Let Pk be **ToString(k)**.
 - b. Let $kPresent$ be the result of **HasProperty(O , Pk)**.
 - c. ReturnIfAbrupt($kPresent$).
 - d. If $kPresent$ is **true**, then
 - i. Let $kValue$ be the result of **Get(O , Pk)**.
 - ii. ReturnIfAbrupt($kValue$).
 - iii. Let $testResult$ be the result of calling the **[[Call]]** internal method of **predicate** with T as **thisArgument** and a List containing $kValue$, k , and O as **argumentsList**.
 - iv. ReturnIfAbrupt($testResult$).
 - v. If **ToBoolean($testResult$)** is **true**, return $kValue$.
 - e. Increase k by 1.
10. Return **undefined**.

The **length** property of the **find** method is 1.

NOTE The **find** 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 **find** function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.24 Array.prototype.findIndex (predicate , thisArg = undefined)

predicate should be a function that accepts three arguments and returns a value that is coercible to the Boolean value **true** or **false**. **findIndex** calls *predicate* once for each element present in the array, in ascending order, until it finds one where *predicate* returns **true**. If such an element is found, **findIndex** immediately returns the index of that element value. Otherwise, **findIndex** returns -1. *predicate* is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a *thisArg* parameter is provided, it will be used as the **this** value for each invocation of *predicate*. If it is not provided, **undefined** is used instead.

predicate is called with three arguments: the value of the element, the index of the element, and the object being traversed.

findIndex does not directly mutate the object on which it is called but the object may be mutated by the calls to *predicate*.

The range of elements processed by **findIndex** is set before the first call to *callbackfn*. Elements that are appended to the array after the call to **find** begins will not be visited by *callbackfn*. If existing elements of the array are changed, their value as passed to *predicate* will be the value at the time that **findIndex** visits them; elements that are deleted after the call to **findIndex** begins and before being visited are not visited.

When the **findIndex** method is called with one or two arguments, the following steps are taken:

1. Let *O* be the result of calling **ToObject** passing the **this** value as the argument.
2. ReturnIfAbrupt(*O*).
3. Let *lenValue* be the result of **Get**(*O*, "**length**").
4. Let *len* be **ToInteger**(*lenValue*).
5. ReturnIfAbrupt(*len*).
6. If **IsCallable**(*predicate*) is **false**, throw a **TypeError** exception.
7. If *thisArg* was supplied, let *T* be *thisArg*; else let *T* be **undefined**.
8. Let *k* be 0.
9. Repeat, while *k* < *len*
 - a. Let *Pk* be **ToString**(*k*).
 - b. Let *kPresent* be the result of **HasProperty**(*O*, *Pk*).
 - c. ReturnIfAbrupt(*kPresent*).
 - d. If *kPresent* is **true**, then
 - i. Let *kValue* be the result of **Get**(*O*, *Pk*).
 - ii. ReturnIfAbrupt(*kValue*).
 - iii. Let *testResult* be the result of calling the **[[Call]]** internal method of *predicate* with *T* as **thisArgument** and a List containing *kValue*, *k*, and *O* as **argumentsList**.
 - iv. ReturnIfAbrupt(*testResult*).
 - v. If **ToBoolean**(*testResult*) is **true**, return *k*.
 - e. Increase *k* by 1.
10. Return -1.

The **length** property of the **findIndex** method is 1.

NOTE The **findIndex** 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 **findIndex** function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.25 Array.prototype.entries ()

The following steps are taken:

1. Let *O* be the result of calling **ToObject** with the **this** value as its argument.
2. ReturnIfAbrupt(*O*).
3. Return the result of calling the **CreateArrayIterator** abstract operation with arguments *O* and "**key+value**".

Comment [AWB11160]: Need to decide whether to allow an argument that requests sparse iteration

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15.4.3.26 Array.prototype.keys()

The following steps are taken:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. Return the result of calling the `CreateArrayIterator` abstract operation with arguments O and `"key"`.

Comment [AWB11161]: Need to decide whether to allow an argument that requests sparse iteration

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15.4.3.27 Array.prototype.values()

The following steps are taken:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. Return the result of calling the `CreateArrayIterator` abstract operation with arguments O and `"value"`.

Comment [AWB11162]: Need to decide whether to allow an argument that requests sparse iteration

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Comment [AWB10163]: This is how we identify a property whose key is a built-in Symbol

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Comment [AWB10164]: Do we really want do this sort of method sharing. It has a bad smell.

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Deleted: 15.4.5.1 [[DefineOwnProperty]] Desc, Throw)¶

Array objects use a variation of the `[[DefineOwnProperty]]` internal method used by other native ECMAScript objects (8.12.9). Assume A is an Array object, $Desc$ is a Property Descriptor, and $Throw$ is a Boolean flag. In the following algorithm, the term "Reject" means "If $Throw$ is true, then throw a `TypeError` exception, otherwise return `false`."

When the `[[DefineOwnProperty]]` internal method of A is called with property P , Property Descriptor $Desc$, and Boolean flag $Throw$, the following steps are taken:
 <#> `ReturnIfAbrupt(A)`

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15.4.4 Properties of Array Instances

Array instances are exotic Array objects and have the internal methods specified for such objects. Array instances inherit properties from the Array prototype object. Array instances also have a `[ArrayInitializationState]` internal data property.

Array instances have a `length` property, and a set of enumerable properties with array index names.

15.4.4.1 length

The `length` property of this Array object is a data property whose value is always numerically greater than the name of every deletable property whose name is an array index.

The `length` property initially has the attributes `{ [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }`.

NOTE Attempting to set the `length` property of an Array object to a value that is numerically less than or equal to the largest numeric property name of an existing array indexed non-deletable property of the array will result in the `length` being set to a numeric value that is one greater than that largest numeric property name. See 8.4.2.1.

15.4.5 Array Iterator Object Structure

An Array Iterator is an object, with the structure defined below, that represent a specific iteration over some specific Array instance object. There is not a named constructor for Array Iterator objects. Instead, Array iterator objects are created by calling certain methods of Array instance objects.

15.4.5.1 CreateArrayIterator Abstract Operation

Several methods of Array objects return `Iterator` objects. The abstract operation `CreateArrayIterator` with arguments `array` and `kind` is used to create and such iterator objects. It performs the following steps:

1. Let O be the result of calling `ToObject(array)`.
2. ReturnIfAbrupt(O).
3. Let itr be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ArrayIteratorPrototype%` as its argument.
4. Add a `[[IteratedObject]]` internal data property to itr with value O .
5. Add a `[[ArrayIteratorNextIndex]]` internal data property to itr with value `0`.
6. Add a `[[ArrayIterationKind]]` internal data property of itr with value `kind`.
7. Return itr .

15.4.5.2 The Array Iterator Prototype

All Array Iterator Objects inherit properties from a common Array Iterator Prototype object. The `[[Prototype]]` internal data property of the Array Iterator Prototype is the `%ObjectPrototype%` intrinsic object. In addition, the Array Iterator Prototype has the following properties:

15.4.5.2.1 ArrayIterator.prototype.constructor

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15.4.5.2.2 ArrayIterator.prototype.next()

1. Let O be the `this` value.
2. If $\text{Type}(O)$ is not `Object`, throw a `TypeError` exception.
3. If O does not have all of the internal properties of a Array Iterator Instance (15.4.5.1.2), throw a `TypeError` exception.
4. Let a be the value of the `[[IteratedObject]]` internal data property of O .
5. Let $index$ be the value of the `[[ArrayIteratorNextIndex]]` internal data property of O .
6. Let $itemKind$ be the value of the `[[ArrayIterationKind]]` internal data property of O .
7. Let $lenValue$ be the result of `Get(a, "length")`.
8. Let len be `ToUint32(lenValue)`.
9. `ReturnIfAbrupt(len)`.
10. If $itemKind$ contains the substring `"sparse"`, then
 - a. Let $found$ be `false`.
 - b. Repeat, while $found$ is `false` and $index < len$
 - i. Let $elementKey$ be `ToString(index)`.
 - ii. Let $found$ be the result of `HasProperty(a, elementKey)`.
 - iii. `ReturnIfAbrupt(found)`.
 - iv. If $found$ is `false`, then
 1. Increase $index$ by 1.
11. If $index \geq len$, then
 - a. Set the value of the `[[ArrayIteratorNextIndex]]` internal data property of O to $+\infty$.
 - b. `Return CreateItrResultObject(undefined, true)`.
12. Let $elementKey$ be `ToString(index)`.
13. Set the value of the `[[ArrayIteratorNextIndex]]` internal data property of O to $index+1$.
14. If $itemKind$ contains the substring `"value"`, then
 - a. Let $elementValue$ be the result of `Get(a, elementKey)`.
 - b. `ReturnIfAbrupt(elementValue)`.
15. If $itemKind$ contains the substring `"key+value"`, then
 - a. Let $result$ be the result of the abstract operation `ArrayCreate` with argument 2.
 - b. Assert: $result$ is a new, well-formed `Array` object so the following operations will never fail.
 - c. Call the `[[DefineOwnProperty]]` internal method of $result$ with arguments `"0"` and `Property Descriptor {[[Value]]: elementKey, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - d. Call the `[[DefineOwnProperty]]` internal method of $result$ with arguments `"1"` and `Property Descriptor {[[Value]]: elementValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - e. `Return CreateItrResultObject(result, false)`.
16. Else If $itemKind$ contains the substring `"key"` then, `return CreateItrResultObject(elementKey, false)`.
17. Assert: $itemKind$ contains the substring `"value"`.
18. `Return CreateItrResultObject(elementValue, false)`.

15.4.5.2.3 ArrayIterator.prototype.[@@iterator]()

The following steps are taken:

1. `Return the this value.`

Comment [AWB10165]: TODO: need to decide what to use for a constructor for these sort of objects.

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Deleted: calling the `[[Get]]` internal method of a with the argument `"length"`

Deleted: calling the `[[HasProperty]]` internal method of a with argument

Comment [AWB15166]: We don't currently have a public API for requesting a sparse iteration. If that remains the case we can delete this clause.

Deleted: `Infinity`

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Deleted: `{[[type]]: throw, [[value]]: %StopIteration%, [[target]]: empty}`

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Comment [AWB11167]: This is a string. Should be return the numeric value of `index` instead?

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Deleted: `result`

Comment [AWB11168]: This is a string. Should be return the numeric value of `index` instead?

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Comment [AWB10169]: This is how we identify a property whose key is a built-in `Symbol`

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15.4.5.2.4 ArrayIterator.prototype.@@toStringTag

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The initial value of the @@toStringTag property is the string value "Array Iterator".

15.4.5.3 Properties of Array Iterator Instances

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Array Iterator instances inherit properties from the Array Iterator prototype (the intrinsic, %ArrayIteratorPrototype%). Array Iterator instances are initially created with the internal properties listed in Table 33.

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Table 33 — Internal Data Properties of Array Iterator Instances

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Internal Data Property Name	Description
[[IteratedObject]]	The object whose array elements are being iterated.
[[ArrayIteratorNextIndex]]	The integer index of the next array index to be examined by this iteration.
[[ArrayIterationKind]]	A string value that identifies what is to be returned for each element of the iteration. The possible values are: "key", "value", "key+value", "sparse:key", "sparse:value", "sparse:key+value".

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. However, if the `this` value value passed in the call is an Object with an uninitialized `[[StringData]]` internal data property, it initializes the `this` value using the argument value. This permits `String` to be used both to perform type conversion and to perform constructor instance initialization.

`String` may be subclassed and subclass constructors may perform a super invocation of the `String` constructor to initialize the `[[StringData]]` state of subclass instances.

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.

When `String` is called with argument `value`, the following steps are taken:

1. Let `O` be the `this` value.
2. If no arguments were passed to this function invocation, then let `s` be "".
3. Else, let `s` be `ToString(value)`.
4. ReturnIfAbrupt(`s`).
5. If `Type(O)` is Object and `O` has a `[[StringData]]` internal data property and the value of `[[StringData]]` is `undefined`, then
 - a. Let `length` be the number of code unit elements in `s`.
 - b. Let `status` be the result of `DefinePropertyOrThrow(O, "length", Property Descriptor{[[Value]]: length, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false })`.
 - c. ReturnIfAbrupt(`status`).
 - d. Set the value of `O`'s `[[StringData]]` internal data property to `s`.
 - e. Return `O`.
6. Return `s`.

Deleted: `value` is `undefined`

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 exotic `String` object.

15.5.2.1 `new String (value)`

`String` called as part of a new expression with optional argument `value` performs the following steps:

1. Let `F` be the `String` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct (F, argumentsList)`.

If `String` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.5.3 Properties of the String Constructor

The value of the `[[Prototype]]` internal `data` property of the `String` constructor is the standard built-in Function prototype object (15.3.3).

Besides 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 standard built-in String prototype object (15.5.4).

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

15.5.3.2 `String.fromCharCode (...codeUnits)`

The `String.fromCharCode` function may be called with a variable number of arguments which form the rest parameter `codeUnits`. The following steps are taken:

1. Assert: `codeUnits` is a well-formed rest parameter object.
2. Let `length` be the result of `Get(codeUnits, "length")`.
3. Let `elements` be a new List.
4. Let `nextIndex` be 0.
5. Repeat while `nextIndex < length`
 - a. Let `next` be the result of `Get(codeUnits, ToString(nextIndex))`.
 - b. Let `nextCU` be `ToUint16(next)`.
 - c. `ReturnIfAbrupt(nextCU)`.
 - d. Append `nextCU` to the end of `elements`.
 - e. Let `nextIndex` be `nextIndex + 1`.
6. Return the `String` value whose elements are, in order, the elements in the List `elements`. If `length` is 0, the empty string is returned.

The `length` property of the `fromCharCode` function is 1.

15.5.3.3 `String.fromCodePoint (...codePoints)`

The `String.fromCodePoint` function may be called with a variable number of arguments which form the rest parameter `codePoints`. The following steps are taken:

1. Assert: `codePoints` is a well-formed rest parameter object.
2. Let `length` be the result of `Get(codePoints, "length")`.
3. Let `elements` be a new List.

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Deleted: The `[[Prototype]]` internal data property of the newly constructed object is set to the standard built-in `String` prototype object that is the initial value of `String.prototype` (15.5.3.1).
The `[[Class]]` internal property of the newly constructed object is set to "string" has the `[[IsStringNativeBranch]]` internal property with value `StringWrapper`.
The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.
The `[[PrimitiveValueStringData]]` internal data property of the newly constructed object is set to `ToString(value)`, or the empty `String` if `value` is not supplied.
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Comment [AWB9170]: Should we provide `fromCodeUnit` as an alias for this property and label `fromCharCode` as obsolete.
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Deleted: 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 unit value of a character. If no arguments are supplied, the result is the empty `String`.
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4. Let `nextIndex` be 0.
5. Repeat while `nextIndex < length`
 - a. Let `next` be the result of `Get(codePoints, ToString(nextIndex))`.
 - b. Let `nextCP` be `ToNumber(next)`.
 - c. ReturnIfAbrupt(`nextCP`).
 - d. If `SameValue(nextCP, ToInteger(nextCP))` is `false`, then throw a **RangeError** exception.
 - e. If `nextCP < 0` or `nextCP > 0x10FFFF`, then throw a **RangeError** exception.
 - f. Append the elements of the UTF-16 Encoding (clause 6) of `nextCP` to the end of `elements`.
 - g. Let `nextIndex` be `nextIndex + 1`.
6. Return the `String` value whose elements are, in order, the elements in the List `elements`. If `length` is 0, the empty string is returned.

The `length` property of the `fromCodePoint` function is **0**.

15.5.3.4 String.raw (callSite, ...substitutions)

The `String.raw` function may be called with a variable number of arguments. The first argument is `callSite` and the remainder of the arguments form the rest parameter `substitutions`. The following steps are taken:

1. Assert: `substitutions` is a well-formed rest parameter object.
2. Let `cooked` be `ToObject(callSite)`.
3. ReturnIfAbrupt(`cooked`).
4. Let `rawValue` be the result of `Get(cooked, "raw")`.
5. Let `raw` be `ToObject(rawValue)`.
6. ReturnIfAbrupt(`raw`).
7. Let `len` be the result of `Get(raw, "length")`.
8. Let `literalSegments` be `ToUint(len)`.
9. ReturnIfAbrupt(`literalSegments`).
10. If `literalSegments = 0`, then return the empty string.
11. Let `stringElements` be a new List.
12. Let `nextIndex` be 0.
13. Repeat
 - a. Let `nextKey` be `ToString(nextIndex)`.
 - b. Let `next` be the result of `Get(raw, nextKey)`.
 - c. Let `nextSeg` be `ToString(next)`.
 - d. ReturnIfAbrupt(`nextSeg`).
 - e. Append in order the code unit elements of `nextSeg` to the end of `stringElements`.
 - f. If `nextIndex + 1 = literalSegments`, then
 - i. Return the `String` value whose elements are, in order, the elements in the List `stringElements`. If `length` is 0, the empty string is returned.
 - g. Let `next` be the result of `Get(substitutions, nextKey)`.
 - h. Let `nextSub` be `ToString(next)`.
 - i. ReturnIfAbrupt(`nextSub`).
 - j. Append in order the code unit elements of `nextSub` to the end of `stringElements`.
 - k. Let `nextIndex` be `nextIndex + 1`.

The `length` property of the `raw` function is **1**.

NOTE `String.raw` is intended for use as a tag function of a Tagged Template String (11.2.6). When called as such the first argument will be a well formed template call site object and the rest parameter will contain the substitution values.

15.5.3.5 String[@@create]()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `proto` be the result of `GetPrototypeOfConstructor(F, "%StringPrototype%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `StringCreate(proto)`.

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Comment [AWB9171]: Note this follows the ES6 convention for rest parameters rather than the precedent established by `fromCharCode`
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Comment [AWB10172]: TODO: this is something we probably need if we are going to eliminate array usage of `ToUint32`
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5. Return *obj*.

This property has the attributes { [[Writable]]: **false**, [[Enumerable]]: **false**, [[Configurable]]: **true** }.

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NOTE [[StringData]] is initially assigned the value **undefined** as a flag to indicate that the instance has not yet been initialized by the String constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.5.4 Properties of the String Prototype Object

The String prototype object is itself an ordinary object. It is not a String instance and does not have a [[StringData]] internal data property.

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Deleted: whose value is an empty String

Deleted: The String prototype object has the [[IsStringNativeBrandBuiltinBrand]] internal data property with value StringWrapperBuiltinStringWrapper.

The value of the [[Prototype]] internal data property of the String prototype object is the standard built-in Object prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the String prototype object defined below are not generic and the this value passed to them must be either a String value or an object that has a [[StringData]] internal data property that has been initialized to a String value.

The abstract operation `thisStringValue(value)` performs the following steps:

1. If `Type(value)` is String, return `value`.
2. If `Type(value)` is Object and `value` has a [[StringData]] internal data property, then
 - a. Let `s` be the value of `value`'s [[StringData]] internal data property.
 - b. If `s` is not **undefined**, then return `s`.
3. Throw a `TypeError` exception.

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The phrase “this String value” within the specification of a method refers to the result returned by calling the abstract operation `thisStringValue` with the `this` value of the method invocation passed as the argument.

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()

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

1. Let `s` be `thisStringValue(this value)`.
2. Return `s`.

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NOTE For a String object, the `toString` method happens to return the same thing as the `valueOf` method.

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Comment [AWB9173]: Perhaps BMPCharAt should be provided as an alias for this method and charAt should be marked as obsolete.

Deleted: Returns this String value.¶ The `valueOf` function is not generic; it throws a `TypeError` exception if its `this` value is not a String or a String object. Therefore, it cannot be transferred to other kinds of objects for use as a method.¶

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15.5.4.3 String.prototype.valueOf()

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

1. Let `s` be `thisStringValue(this value)`.
2. Return `s`.

15.5.4.4 String.prototype.charAt(pos)

NOTE Returns a single element String containing the code unit at element position `pos` in the String value resulting from converting this object to a String. If there is no element at that position, the result is the empty String. The result is a String value, not a String object.

If `pos` is a value of Number type 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. Let O be `CheckObjectCoercible(this value)`.
 2. Let S be `ToString(O)`.
 3. ReturnIfAbrupt(S).
 4. Let $position$ be `ToInteger(pos)`.
 5. ReturnIfAbrupt($position$).
 6. Let $size$ be the number of `elements` in S .
 7. If $position < 0$ or $position \geq size$, return the empty String.
 8. Return a String of length 1, containing one `code unit` from S , namely the `code unit` at position $position$, where the first (leftmost) `code unit` in S 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)

NOTE Returns a Number (a nonnegative integer less than 2^{16}) that is the code unit value of the string element at position *pos* in the String resulting from converting this object to a String. If there is no element at that position, the result is NaN.

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

1. Let O be CheckObjectCoercible(this value).
 2. Let S be ToString(O).
 3. ReturnIfAbrupt(S).
 4. Let $position$ be ToInteger(pos).
 5. ReturnIfAbrupt($position$).
 6. Let $size$ be the number of elements in S .
 7. If $position < 0$ or $position \geq size$, return NaN.
 8. Return a value of Number type, whose value is the code unit value of the element at position $position$ in the String S , where the first (leftmost) element in S 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 (...args)

NOTE When the `concat` method is called with zero or more arguments, it returns a String consisting of the string elements of this object (converted to a String) followed by the string elements of each of the arguments converted to a String. The result is a String value, not a String object.

The following steps are taken:

1. Assert: *args* is a well-formed rest parameter object.
 2. Let *O* be CheckObjectCoercible(**this** value).
 3. Let *S* be *ToString(O)*.
 4. ReturnIfAbrupt(*S*).
 5. Let *args* be an internal list that is a copy of the argument list passed to this function.
 6. Let *R* be *S*.
 7. Repeat, while *args* is not empty
 - a. Remove the first element from *args* and let *next* be the value of that element.
 - b. Let *nextString* be *ToString(next)*.
 - c. ReturnIfAbrupt(*nextString*).
 - d. Let *R* be the String value consisting of the string elements in the previous value of *R* followed by the string elements of *nextString*.
 8. 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 (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 greater than or equal to `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. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. `ReturnIfAbrupt(S)`.
4. Let `searchStr` be `ToString(searchString)`.
5. `ReturnIfAbrupt(searchString)`.
6. Let `pos` be `ToInteger(position)`. (If `position` is `undefined`, this step produces the value 0).
7. `ReturnIfAbrupt(pos)`.
8. Let `len` be the number of elements in `S`.
9. Let `start` be `min(max(pos, 0), len)`.
10. Let `searchLen` be the number of elements in `searchStr`.
11. Return the smallest possible integer `k` not smaller than `start` such that `k + searchLen` is not greater than `len`, and for all nonnegative integers `j` less than `searchLen`, the code unit at position `k+j` of `S` is the same as the code unit at position `j` of `searchStr`; but if there is no such integer `k`, then return the value -1.

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. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. `ReturnIfAbrupt(S)`.
4. Let `searchStr` be `ToString(searchString)`.
5. `ReturnIfAbrupt(searchString)`.
6. Let `numPos` be `ToNumber(position)`. (If `position` is `undefined`, this step produces the value `NaN`).
7. `ReturnIfAbrupt(numPos)`.
8. If `numPos` is `NaN`, let `pos` be `+∞`; otherwise, let `pos` be `ToInteger(numPos)`.
9. Let `len` be the number of elements in `S`.
10. Let `start` be `min(max(pos, 0), len)`.
11. Let `searchLen` be the number of elements in `searchStr`.
12. Return the largest possible nonnegative integer `k` not larger than `start` such that `k + searchLen` is not greater than `len`, and for all nonnegative integers `j` less than `searchLen`, the code unit at position `k+j` of `S` is the same as the code unit at position `j` of `searchStr`; but if there is no such integer `k`, then return the value -1.

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

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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 the `this` value (converted to a String) with `that` (converted to a String). The two Strings are `S` and `That`. The two Strings are compared in an implementation-defined fashion. The result is intended to order String values in the sort order specified by the system default locale, and will be negative, zero, or positive, depending on whether `S` comes before `That` in the sort order, the Strings are equal, or `S` comes after `That` in the sort order, respectively.

Before perform the comparisons the following steps are performed to prepare the Strings:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(S).
4. Let `That` be `ToString(that)`.
5. ReturnIfAbrupt(That).

The `localeCompare` method, if considered as a function of two arguments `this` and `that`, is a consistent comparison function (as defined in 15.4.3.11) on the set of all Strings.

The actual return values are implementation-defined to permit implementers to encode additional information in the value, but the function is required to define a total ordering on all Strings and to return 0 when comparing Strings that are considered canonically equivalent by the Unicode standard.

If no language-sensitive comparison at all is available from the host environment, this function may perform a bitwise comparison.

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.

NOTE 3 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.

NOTE 4 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.

15.5.4.10 `String.prototype.match (regexp)`

When the `match` method is called with argument `regexp`, the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(S).
4. If `Type(regexp)` is `Object` and `HasProperty(regexp, @@isRegExp)` is `true`, then let `rx` be `regexp`;
5. Else, let `rx` be the result of the abstract operation `RegExpCreate` (15.10.4.1) with arguments `regexp` and `undefined`.
6. ReturnIfAbrupt(rx).
7. Let `args` be a new List with `S` as its sole element.
8. Return the result of `Invoke(rx, "match", args)`.

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Deleted: abstraction operation
Deleted: a new <code>RegExp</code> object created as if by the expression <code>new RegExp (regexp)</code> where <code>RegExp</code> is the standard built-in constructor with that name
Deleted: <#>Let <code>global</code> be the result of calling the <code>[[Get]]</code> internal method of <code>rx</code> with argument, <code>"global"</code> . <#>ReturnIfAbrupt(<code>global</code>). <#>Let <code>exec</code> be the standard built-in function <code>RegExp.prototype.exec</code> (see 15.10.6.2) <#>If <code>global</code> is not <code>true</code> , then <#>Return the result of calling the <code>[[Call]]</code> internal method of <code>exec</code> abstract operation <code>RegExpExec</code> (see 15.10.6.2) with arguments <code>rx</code> as and the <code>this</code> value and argument list containing <code>S</code> . <#>Else, <code>global</code> is <code>true</code> , <#>Let <code>putStatus</code> be the result of calling <code>Call</code> the <code>[[Put]]</code> internal method of <code>rx</code> with arguments, <code>"lastIndex"</code> , and 0, and <code>true</code> . <#>ReturnIfAbrupt(<code>putStatus</code>). <#>Let <code>A</code> be a new array created as if by the expression <code>new Array ()</code> where <code>Array</code> is the standard built-in constructor with that name the result of the abstraction operation abstract operation <code>ArrayCreate</code> (15.4) with argument 0. <#>Let <code>previousLastIndex</code> be 0. <#>Let <code>n</code> be 0. <#>Let <code>lastMatch</code> be <code>true</code> . <#>Repeat, while <code>lastMatch</code> is <code>true</code> <#>Let <code>result</code> be the result of calling the abstract operation <code>RegExpExec</code> (see 15.10.6.2) <code>[[Call]]</code> internal method of <code>exec</code> with arguments <code>rx</code> as the <code>this</code> value and argument list containing and <code>S</code> . <#>ReturnIfAbrupt(<code>result</code>). <#>If <code>result</code> is <code>null</code> , then set <code>lastMatch</code> to <code>false</code> . <#>Else, <code>result</code> is not <code>null</code> . Deleted: Deleted: <code>regexp</code> Deleted: <code>A</code>

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)`

When the `replace` method is called with arguments `searchValue` and `replaceValue` the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `string` be `ToString(O)`.
3. ReturnIfAbrupt(`string`).
4. If `Type(searchValue)` is Object and `HasProperty(searchValue, @@isRegExp)` is true, then
 - a. Let `args` be a new List with elements `string` and `replaceValue`.
 - b. Return the result of `Invoke(searchValue, "replace", args)`.
5. Let `searchString` be `ToString(searchValue)`.
6. ReturnIfAbrupt(`searchString`).
7. Search `string` for the first occurrence of `searchString` and let `pos` be the index position within `string` of the first code unit of the matched substring and let `matched` be `searchString`. If no occurrences of `searchString` were found, return `string`.
8. If `IsCallable(replaceValue)` is true, then
 - a. Let `repValue` be the result of calling the `[[Call]]` internal methods of `replaceValue` passing `undefined` as the `this` value and a List containing `matched`, `pos`, and `string` as the argument list.
 - b. Let `repStr` be `ToString(repValue)`.
 - c. ReturnIfAbrupt(`repStr`).
9. Else,
 - a. Let `captures` be an empty List.
 - b. Let `repStr` be the result of the abstract operation `GetReplaceSubstitution(matched, string, pos, captures)`.
10. Let `tailPos` be `pos + the number of code units in matched`.
11. Let `newString` be the String formed by concatenating the first `pos` code units of `string`, `repStr`, and the trailing substring of `string` starting at index `tailPos`. If `pos` is 0, the first element of the concatenation will be the empty String.
12. Return `newString`.

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.

Runtime Semantics: `GetReplaceSubstitution Abstract Operation`

The abstract operation `GetReplaceSubstitution(matched, string, position, captures)` performs the following steps:

1. Assert: `Type(matched)` is String.
2. Let `matchLength` be the number of code units in `matched`.
3. Assert: `Type(string)` is String.
4. Let `stringLength` be the number of code units in `string`.
5. Assert: `position` is a non-negative integer.
6. Assert: `position < stringLength`.
7. Assert: `captures` is a possibly empty List of Strings.
8. Let `tailPos` be `position + matchLength`.
9. Let `m` be the number of elements in `captures`.
10. Let `result` be a String value derived from `matched` by replacing code unit elements in `matched` by replacement text as specified in Table 34. These \$ replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements.
11. Return `result`.

- Deleted:** First set `string` according to the following step
Deleted: ReturnIfAbrupt()
Deleted:)
Deleted: Call `CheckObjectCoercible` passing the `this` value of its argument.
Deleted: the result of calling
Deleted: , giving it the `this` value as its argument
Deleted: `regexp`
Deleted: <#>If `searchValue` is a regular expression (an object whose `[[Class]]` has the value `[[IsRegExpNativeBrandBuiltinBrand]]`) internal data property whose value is `NativeRegExpBuiltinRegEx` is "RegEx"
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` (using `NcapturingParens` as specified in 15.10.2.1).
Deleted: <#>Assert: If `searchValue` is not a regular expression, ¶
Deleted: 1
Deleted: and
Deleted: search `string` for the first occurrence of `searchString`. Let `m` be 0.
Deleted: let `pos` be 0 and let `matched` be the empty String
Deleted: Let `m` be 0.
Deleted:
Deleted: is a function
Deleted: then
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Deleted: for

Deleted: each matched substring, call the function with the following `m + 3` arguments. Argument 1 is the substring `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.

Deleted: Let `result` be a String value derived from `matched` by replacing code unit elements in `matched` by replacement text as specified in ¶
<#>Table 33. These \$ replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements.¶

Deleted: If `Type(value)` is Object and `value` has a `[[StringData]]` internal data property, then ¶

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 elements in `newString` by replacement text as specified in Table 34Table 30. 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(/(\$(\d))/g, "$$1-`

Table 34 — Replacement Text Symbol Substitutions

Code unit	Unicode Characters	Replacement text
0x0024, 0x0024	\$\$	\$
0x0024, 0x0026	\$&	matched
0x0024, 0x0060	\$`	If <i>position</i> is 0, the replacement is the empty String. Otherwise the replacement is the substring of <i>string</i> that starts at index 0 and whose last code point is at index <i>position</i> -1.
0x0024, 0x0027	\$`	If <i>tailPos</i> ≥ <i>stringLength</i> , the replacement is the empty String. Otherwise the replacement is the substring of <i>string</i> that starts at index <i>tailPos</i> and continues to the end of <i>string</i> .
0x0024, N where 0x0031 < N < 0x0039	\$n where n is one of 1 2 3 4 5 6 7 8 9 and \$n is not followed by a decimal digit	The <i>n</i> th element of <i>captures</i> , where <i>n</i> is a single digit in the range 1 to 9. If <i>n</i> ≤ <i>m</i> and the <i>n</i> th element of <i>captures</i> is undefined, use the empty String instead. If <i>n</i> > <i>m</i> , the result is implementation-defined.
0x0024, N, N where 0x0030 < N < 0x0039	\$nn where n is one of 0 1 2 3 4 5 6 7 8 9	The <i>nn</i> th element of <i>captures</i> , where <i>nn</i> is a two-digit decimal number in the range 01 to 99. If <i>nn</i> ≤ <i>m</i> and the <i>nn</i> th element of <i>captures</i> is undefined, use the empty String instead. If <i>nn</i> is 00 or <i>nn</i> > <i>m</i> , the result is implementation-defined.
0x0024	\$ in any context that does not match on of the above.	\$

15.5.4.12 String.prototype.search (regexp)

When the search method is called with argument *regexp*, the following steps are taken:

1. Let *O* be CheckObjectCoercible(*this* value).
2. Let *string* be ToString(*O*).
3. ReturnIfAbrupt(*string*).
4. If Type(*regexp*) is Object and HasProperty(*regexp*, @@isRegExp) is true, then,
 - a. Let *rx* be *regexp*;
5. Else,
 - a. Let *rx* be the result of the abstract operation RegExpCreate (15.10.3.1) with arguments *regexp* and undefined.
6. ReturnIfAbrupt(*rx*).
7. Let *args* be a new List with the single element *string*.
8. Return the result of Invoke(*regexp*, "search", *args*).

NOTE 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 element position *start* and running to, but not including, element 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 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. Let *O* be CheckObjectCoercible(*this* value).
2. Let *S* be ToString(*O*).
3. ReturnIfAbrupt(*S*).
4. Let *len* be the number of elements in *S*.
5. Let *intStart* be ToInteger(*start*).
6. If *end* is undefined, let *intEnd* be *len*; else let *intEnd* be ToInteger(*end*).
7. If *intStart* is negative, let *from* be max(*len* + *intStart*, 0); else let *from* be min(*intStart*, *len*).
8. If *intEnd* is negative, let *to* be max(*len* + *intEnd*, 0); else let *to* be min(*intEnd*, *len*).

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Deleted: The
Deleted: substring.
Deleted: \$`
Deleted: r
Deleted: The
Deleted: portion of
Deleted: that precedes the matched substring
Deleted: '
Deleted: r
Deleted: .
Deleted: The portion of <i>string</i> that follows the matched substring.
Deleted: and \$n is not followed by a decimal digit
Deleted: 0
Deleted: 0
Comment [AWB14174]: Why is this impl defined? Can we specify this??
Comment [AWB14175]: "12345".replace()
Deleted: NOTE The replace function is
Deleted: ReturnIfAbrupt()
Deleted:)
Deleted: Call CheckObjectCoercible passing the
Deleted: the result of calling
Deleted: , giving it the this value as its argument
Deleted: S
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Deleted: regexp has the
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Deleted: a new RegExp object created as if by the
Deleted: <#>Search the value string from its
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Deleted: ReturnIfAbrupt()
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Deleted: Call CheckObjectCoercible passing the
Deleted: the result of calling
Deleted: , giving it the this value as its argument
Deleted: characters

9. Let *span* be $\max(to - from, 0)$.
10. Return a String value containing *span* consecutive elements from *S* beginning with the element at position *from*.

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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.

Deleted: (i.e., an object with the `[[IsRegExpNativeBrandBuiltinBrand]]` internal data property whose value is `NativeRegExpBuiltinRegExp` whose `[[Class]]` internal property is "`RegExp`"; see 15.10)

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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 `code unit` elements; the length of the result array equals the length of the String, and each substring contains one `code unit`.) 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,

```
"A<B>bold</B>and<CODE>coded</CODE>".split(/<(\w)/?([^\w]+)>/)
```

evaluates to the array

```
["A", undefined, "B", "bold", "/", "B", "and", undefined,  
"CODE", "coded", "/", "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 *O* be `CheckObjectCoercible(this value)`.
2. `ReturnIfAbrupt(O)`.
3. If `Type(separator)` is Object and `HasProperty(separator, @@isRegExp)` is **true**, then,
 - a. Let *args* be a new List with elements *O* and *limit*.
 - b. Return the result of `Invoke(separator, "split", args)`
4. Let *S* be `ToString(O)`.
5. `ReturnIfAbrupt(S)`.
6. Let *A* be the result of the abstract operation `ArrayCreate` with argument *0*.
7. Let *lengthA* be 0.
8. If *limit* is **undefined**, let *lim* = $2^{32}-1$; else let *lim* = `ToUint32(limit)`.
9. Let *s* be the number of elements in *S*.
10. Let *p* = 0.
11. Let *R* be `ToString(separator)`.
12. `ReturnIfAbrupt(R)`.
13. If *lim* = 0, return *A*.

Deleted: `ReturnIfAbrupt()`

Deleted: `)`

Deleted: Call `CheckObjectCoercible` passing the **this** value as its argument.

Deleted: `<#>Let S be the result of calling ToString, giving the this value as its argument.`

Deleted: *S*

Deleted: *e*

Deleted: *S*

Deleted: *e*

Deleted: a new array created as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name

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Deleted: If *separator* has the `[[IsRegExpNativeBrandBuiltinBrand]]` internal data property whose value is `NativeRegExpBuiltinRegExp` is a `RegExp` object (its `[[Class]]` is "`RegExp`"), let *R* be *separator* let *R* = *separator*; otherwise l

Deleted: =

Deleted: *sepearator*

14. If *separator* is **undefined**, then
- Call the **[[DefineOwnProperty]]** internal method of *A* with arguments **"0"** and **Property Descriptor** **{[[Value]]: *S*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}**.
 - Assert: **the previous step will never result in an abrupt completion.**
 - Return *A*.
15. If *s* = 0, then
- Let *z* be the result of *SplitMatch(S, 0, R)*.**
 - If *z* is not **false**, return *A*.
 - Call the **[[DefineOwnProperty]]** internal method of *A* with arguments **"0"** and **Property Descriptor** **{[[Value]]: *S*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}**.
 - Assert: **the previous step will never result in an abrupt completion.**
 - Return *A*.
16. Let *q* = *p*.
17. Repeat, while *q* ≠ *s*
- Let *e* be the result of *SplitMatch(S, q, R)*.**
 - If *e* is **false**, then let *q* = *q*+1.
 - Else, *e* is an integer index into *S*.
 - If *e* = *p*, then let *q* = *q*+1.
 - Else, *e* ≠ *p*
 - Let *T* be a String value equal to the substring of *S* consisting of the **code units at** positions *p* (inclusive) through *q* (exclusive).
 - Call the **[[DefineOwnProperty]]** internal method of *A* with arguments **ToString(*lengthA*)** and **Property Descriptor** **{[[Value]]: *T*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}**.
 - Assert: **the previous step will never result in an abrupt completion.**
 - Increment *lengthA* by 1.
 - If *lengthA* = *lim*, return *A*.
 - Let *p* = *e*.
 - Let *q* = *p*.
18. Let *T* be a String value equal to the substring of *S* consisting of the **code units at** positions *p* (inclusive) through *s* (exclusive).
19. Call the **[[DefineOwnProperty]]** internal method of *A* with arguments **ToString(*lengthA*)** and **Property Descriptor** **{[[Value]]: *T*, [[Writable]]: **true**, [[Enumerable]]: **true**, [[Configurable]]: **true**}**.
20. Assert: **the previous step will never result in an abrupt completion.**
21. Return *A*.

Runtime Semantics: *SplitMatch* Abstract Operation

The abstract operation *SplitMatch* takes three parameters, a String *S*, an integer *q*, and a String *R*, and performs the following in order to return either **false** or the end index of a match:

- Type(*R*) must be String. Let *r* be the number of **code units** in *R*.
- Let *s* be the number of **code units** in *S*.
- If *q+r* > *s* then return **false**.
- If there exists an integer *i* between 0 (inclusive) and *r* (exclusive) such that the **code unit** at position *q+i* of *S* is different from the **code unit** at position *i* of *R*, then return **false**.
- Return *q+r*.

The **length** property of the **split** method is 2.

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

15.5.4.15 *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 **element position** *start* and running to, but not including, **element 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:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(`S`).
4. Let `len` be the number of elements in `S`.
5. Let `intStart` be `ToInteger(start)`.
6. If `end` is **`undefined`**, let `intEnd` be `len`; else let `intEnd` be `ToInteger(end)`.
7. Let `finalStart` be `min(max(intStart, 0), len)`.
8. Let `finalEnd` be `min(max(intEnd, 0), len)`.
9. Let `from` be `min(finalStart, finalEnd)`.
10. Let `to` be `max(finalStart, finalEnd)`.
11. Return a String whose length is `to - from`, containing **code units** from `S`, namely the **code units** with indices `from` through `to - 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 ()

This function interprets a string value as a sequence of code points, as described in 8.4. The following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(`S`).
4. Let `cpList` be a List containing in order the code points as defined in 8.4 of `S`, starting at the first element of `S`.
5. For each code point `c` in `cpList`, if the Unicode Character Database provides a language insensitive lower case equivalent of `c` then replace `c` in `cpList` with that equivalent code point(s).
6. Let `cuList` be a new List.
7. For each code point `c` in `cpList`, in order, append to `cuList` the elements of the UTF-16 Encoding (clause 6) of `c`.
8. Let `L` be a String whose elements are, in order, the elements of `cuList`.
9. Return `L`.

The result must 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).

NOTE 1 The case mapping of some **code points** may produce multiple **code points**. In this case the result String may not be the same length as the source String. 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 `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 interprets a string value as a sequence of code points, as described in 8.4.

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 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.

NOTE 2 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.

15.5.4.18 String.prototype.toUpperCase ()

This function interprets a string value as a sequence of code points, as described in 8.4.

This function behaves in exactly the same way as `String.prototype.toLowerCase`, except that code points are mapped to their *uppercase* equivalents as specified in the Unicode Character Database.

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

15.5.4.19 String.prototype.toLocaleUpperCase ()

This function interprets a string value as a sequence of code points, as described in 8.4.

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 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.

NOTE 2 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.

15.5.4.20 String.prototype.trim ()

This function interprets a string value as a sequence of code points, as described in 8.4.

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let T be a String value that is a copy of S with both leading and trailing white space removed. The definition of white space is the union of *WhiteSpace* and *LineTerminator*. When determining whether a Unicode character is in Unicode general category “Zs”, code unit sequences are interpreted as UTF-16 encoded code point sequences as specified in 8.4.
5. Return T .

Deleted: ReturnIfAbrupt()

Deleted:)

Deleted: Call CheckObjectCoercible passing the `this` value as its argument.

Deleted: the result of calling

Deleted: , giving it the `this` value as its argument

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.

15.5.4.21 String.prototype.repeat (count)

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let n be the result of calling ToInteger(count).

Deleted: ReturnIfAbrupt()

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Deleted: the result of calling

Deleted: , giving it the `this` value as its argument

5. ReturnIfAbrupt(*n*).
6. If *n* < 0, then throw a **RangeError** exception.
7. If *n* is $+\infty$, then throw a **RangeError** exception.
8. Let *T* be a String value that is made from *n* copies of *S* appended together. If *n* is 0, *T* is the empty String.
9. Return *T*.

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NOTE 1 This method creates a String consisting of the string elements of this object (converted to String) repeated *count* time.

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NOTE 2 The `repeat` 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.

15.5.4.22 String.prototype.startsWith (searchString [, position])

The following steps are taken:

1. Let *O* be `CheckObjectCoercible(this value)`.
2. Let *S* be `ToString(O)`.
3. ReturnIfAbrupt(*S*).
4. Let *searchStr* be `ToString(searchString)`.
5. ReturnIfAbrupt(*searchStr*).
6. Let *pos* be `ToInteger(position)`. (If *position* is `undefined`, this step produces the value `0`).
7. ReturnIfAbrupt(*pos*).
8. Let *len* be the number of elements in *S*.
9. Let *start* be `min(max(pos, 0), len)`.
10. Let *searchLength* be the number of elements in *searchString*.
11. If *searchLength*+*start* is greater than *len*, return `false`.
12. If the *searchLength* sequence of elements of *S* starting at *start* is the same as the full element sequence of *searchString*, return `true`.
13. Otherwise, return `false`.

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

NOTE 1 This method returns `true` if the sequence of elements of *searchString* converted to a String is the same as the corresponding elements of this object (converted to a String) starting at *position*. Otherwise returns `false`.

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NOTE 2 The `startsWith` 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.

15.5.4.23 String.prototype.endsWith (searchString [, endPosition])

The following steps are taken:

1. Let *O* be `CheckObjectCoercible(this value)`.
2. Let *S* be `ToString(O)`.
3. ReturnIfAbrupt(*S*).
4. Let *searchStr* be `ToString(searchString)`.
5. ReturnIfAbrupt(*searchStr*).
6. Let *len* be the number of elements in *S*.
7. If *endPosition* is `undefined`, let *pos* be *len*, else let *pos* be `ToInteger(endPosition)`.
8. ReturnIfAbrupt(*pos*).
9. Let *end* be `min(max(pos, 0), len)`.
10. Let *searchLength* be the number of elements in *searchString*.
11. Let *start* be *end* - *searchLength*.
12. If *start* is less than 0, return `false`.
13. If the *searchLength* sequence of elements of *S* starting at *start* is the same as the full element sequence of *searchString*, return `true`.
14. Otherwise, return `false`.

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

NOTE 1 Returns **true** if the sequence of elements of *searchString* converted to a String is the same as the corresponding elements of this object (converted to a String) starting at *endPosition* – *length(this)*. Otherwise returns **false**.

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NOTE 2 The **endsWith** 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.

15.5.4.24 String.prototype.contains (searchString, position = 0.)

The **contains** method takes two arguments, *searchString* and *position*, and performs the following steps:

1. Let *O* be **CheckObjectCoercible(this value)**.
2. Let *S* be **ToString(*O*)**.
3. ReturnIfAbrupt(*S*).
4. Let *searchStr* be **ToString(searchString)**.
5. ReturnIfAbrupt(*searchStr*).
6. Let *pos* be **ToInteger(position)**. (If *position* is **undefined**, this step produces the value **0**).
7. ReturnIfAbrupt(*pos*).
8. Let *len* be the number of elements in *S*.
9. Let *start* be **min(max(*pos*, 0), *len*)**.
10. Let *searchLen* be the number of characters in *searchStr*.
11. If there exists any integer *k* not smaller than *start* such that *k + searchLen* is not greater than *len*, and for all nonnegative integers *j* less than *searchLen*, the character at position *k+j* of *S* is the same as the character at position *j* of *searchStr*, return **true**; but if there is no such integer *k*, return **false**.

The **length** property of the **contains** method is **1**.

NOTE 1 If *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 *position*, then return **true**; otherwise, return **false**. If *position* is **undefined**, **0** is assumed, so as to search all of the String.

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NOTE 2 The **contains** 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.

15.5.4.25 String.prototype.codePointAt (pos)

NOTE Returns a Number (a nonnegative integer less than 1114112) that is the UTF-16 encoded code point value starting at the string element at position *pos* in the String resulting from converting this object to a String. If there is no element at that position, the result is **NaN**. If a valid UTF-16 surrogate pair does not begin at *pos*, the result is the code unit at *pos*.

Comment [AWB9176]: Do we also need **UnicodeCharAt** that returns a string of length 0 or 2?

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

1. Let *O* be **CheckObjectCoercible(this value)**.
2. Let *S* be **ToString(*O*)**.
3. ReturnIfAbrupt(*S*).
4. Let *position* be **ToInteger(*pos*)**.
5. ReturnIfAbrupt(*position*).
6. Let *size* be the number of elements in *S*.
7. If *position* < 0 or *position* > *size*, return **undefined**.
8. Let *first* be the code unit value of the element at index *position* in the String *S*.
9. If *first* < 0xD800 or *first* > 0xDBFF or *position*+1 = *size*, then return *first*.
10. Let *second* be the code unit value of the element at index *position*+1 in the String *S*.
11. If *second* < 0xDC00 or *second* > 0xDFFF, then return *first*.
12. Return $((first - 0xD800) \times 1024) + (second - 0xDC00) + 0x10000$.

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Comment [AWB9177]: Note that this is inconsistent with the pre-existing behaviour of **charCodeAt** which returns **NaN** for out of bounds positions

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NOTE The **codePointAt** 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.

15.5.4.26 String.prototype.normalize (form = "NFC")

When the `normalize` method is called with one argument `form`, the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(`S`).
4. If `form` is not provided or `undefined` let `form` be "NFC".
5. Let `f` be `ToString(form)`.
6. ReturnIfAbrupt(`f`).
7. If `f` is not one of "NFC", "NFD", "NFKC", or "NFKD", then throw a **RangeError** Exception.
8. Let `ns` be the String value is the result of normalizing `S` into the normalization form named by `f` as specified in UTR 15, Unicode Normalization Forms.
9. Return `ns`.

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

15.5.5 Properties of String Instances

String instances are String exotic objects and have the internal methods specified for such objects. String instances inherit properties from the String prototype object. String instances also have a `[[StringData]]` internal data property.

String instances have a `length` property, and a set of enumerable properties with array index names.

15.5.5.1 length

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

Once a String object is initialized, this property is unchanging. It has the attributes { `[[Writable]]: false`, `[[Enumerable]]: 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. However, if the `this` value passed in the call is an Object with an uninitialized `[[BooleanData]]` internal data property, it initializes the `this` value using the argument value. This permits `Boolean` to be used both to perform type conversion and to perform constructor instance initialization.

`Boolean` may be subclassed and subclass constructors may perform a super invocation of the `Boolean` constructor to initialize the `[[BooleanData]]` state of subclass instances.

15.6.1.1 Boolean (value)

When `Boolean` is called with argument `value`, the following steps are taken:

1. Let `O` be the `this` value.
2. Let `b` be `ToBoolean(value)`.
3. If `Type(O)` is `Object` and `O` has a `[[BooleanData]]` internal data property and the value of `[[BooleanData]]` is `undefined`, then
 - a. Set the value of `O`'s `[[BooleanData]]` internal data property to `b`.
 - b. Return `O`.
4. Return `b`.

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Deleted: 15.5.4.25 String.prototype.toArray()

The following steps are taken:
ReturnIfAbrupt(`CheckObjectCoercible(this value)`).
Let `S` be the result of calling `ToString`, giving it the `this` value as its argument.
ReturnIfAbrupt(`S`).

Let `len` be the number of characters in `S`.
Let `array` be the result of the abstraction operation `ArrayCreate (15.4)` with argument `len`.
Let `n` be 0.

Repeat, while `n < len`:
Let `c` be the character at position `n` in `S`.
Call the `[[DefineOwnProperty]]` internal method of `array` with arguments `ToString(n)`, the `PropertyDescriptor` { `[[Value]]: c`, `[[Writable]]: true`, `[[Enumerable]]: true`, `[[Configurable]]: true` }, and `false`.
Increment `n` by 1.
Return `array`.

The length property of the `toArray` method is 0.
NOTE 1 Returns an Array object with elements corresponding to the characters of this object (converted to a String).
NOTE 2 The `toArray` 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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Deleted: The `[[PrimitiveValue]]` internal property is the String value represented by this String object. The array index named properties correspond to the individual characters elements of the String value. A special `[[GetOwnProperty]]` internal method is used to specify the number, values, and attributes of the array index named properties. ¶

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Deleted: 15.5.5.2 `[[GetOwnProperty]] (P)`
String objects use a variation of the `[[GetOwnProperty]]` internal method used for other native ECMAScript objects (8.12.1). This special internal method provides access to named properties corresponding to the individual characters elements of String objects. ¶ Assume `S` is a String object and `P` is a String. ¶ When the `[[GetOwnProperty]]` internal method of `S` is called with property name `P`, the following steps are taken: ¶

<#> Let `desc` be the result of calling the default `[[GetOwnProperty]]` internal method (8.12.1) on `S` with argument `P`. ¶

<#> If `desc` is not `undefined` return `desc`. ¶

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 ordinary object.

15.6.2.1 new Boolean (value)

`Boolean` called as part of a new expression with optional argument `value` performs the following steps:

1. Let `F` be the `Boolean` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct (F, argumentsList)`.

If `Boolean` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.6.3 Properties of the Boolean Constructor

The value of the `[[Prototype]]` internal data property of the Boolean constructor is the Function prototype object (15.3.3).

Besides 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 }`.

15.6.3.2 Boolean[@@create]()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%BooleanPrototype%", ([[BooleanData]]))`.
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

NOTE `[[BooleanData]]` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the Boolean constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.6.4 Properties of the Boolean Prototype Object

The Boolean prototype object is an ordinary object. It is not a Boolean instance and does not have a `[[BooleanData]]` internal data property.

The value of the `[[Prototype]]` internal data property of the Boolean prototype object is the standard built-in Object prototype object (15.2.4).

The abstract operation `thisBooleanValue(value)` performs the following steps:

1. If `Type(value)` is Boolean, return `value`.
2. If `Type(value)` is Object and `value` has a `[[BooleanData]]` internal data property, then
 - a. Let `b` be the value of `value`'s `[[BooleanData]]` internal data property.
 - b. If `b` is not `undefined`, then return `b`.
3. Throw a `TypeError` exception.

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

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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 ()

The following steps are taken:

1. Let `b` be `thisBooleanValue(this value)`.
2. `ReturnIfAbrupt(b)`.
3. If `b` is `true`, then return `"true"`; else return `"false"`.

15.6.4.3 Boolean.prototype.valueOf ()

The following steps are taken:

1. `Return thisBooleanValue(this value)`.

15.6.5 Properties of Boolean Instances

Boolean instances are ordinary objects that inherit properties from the Boolean prototype object. Boolean instances have a `[[BooleanData]]` internal data property. The `[[BooleanData]]` internal data property is the Boolean value represented by this Boolean 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. However, if the `this` value passed in the call is an Object with an uninitialized `[[NumberData]]` internal data property, it initializes the `this` value using the argument value. This permits `Number` to be used both to perform type conversion and to perform constructor instance initialization.

`Number` may be subclassed and subclass constructors may perform a super invocation of the `Number` constructor to initialize the `[[NumberData]]` state of subclass instances.

15.7.1.1 Number ([value])

When `Number` is called with argument `number`, the following steps are taken:

1. Let `O` be the `this` value.
2. If no arguments were passed to this function invocation, then let `n` be `+0`.
3. Else, let `n` be `ToNumber(value)`.
4. `ReturnIfAbrupt(n)`.
5. If `Type(O)` is Object and `O` has a `[[NumberData]]` internal data property and the value of `[[NumberData]]` is `undefined`, then
 - a. Set the value of `O`'s `[[NumberData]]` internal data property to `n`.
 - b. `Return O`.
6. `Return n`.

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 ordinary object.

15.7.2.1 new Number (...args)

`Number` called as part of a `new` expression with argument list `args` it performs the following steps:

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**Deleted: <#>If `Type(B)` is Boolean, then let `b` be `B`.
 <#>Else if `Type(B)` is Object and the value of the `[[Class]]` internal property of `B` is `"Boolean"` as a `[[IsBooleanNativeWrapperBooleanData]]` internal data property whose value is BooleanWrapper, then let `b` be the value of the `[[BooleanDataPrimitiveValue]]` internal data property of `B`.
 <#>Else throw a `TypeError` exception.**
**Deleted: <#>Let `B` be the `this` value.
 <#>If `Type(B)` is Boolean, then let `b` be `B`.
 <#>Else if `Type(B)` is Object and the value of the `[[Class]]` internal property of `B` is `"Boolean"` as a `[[IsBooleanNativeWrapperBooleanData]]` internal data property whose value is BooleanWrapper, then let `b` be the value of the `[[BooleanDataPrimitiveValue]]` internal data property of `B`.
 <#>Else throw a `TypeError` exception.**
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Deleted: Returns a Number value (not a Number object computed by `ToNumber(value)`) if `value` was supplied, else returns `+0`.
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**Deleted: The `[[Prototype]]` internal data 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]]` internal property of the newly constructed object is set to `"Number"` as a `[[IsNumberNativeBrandBuiltInBrand]]` internal data property whose value is `NumberWrapperBuiltInNumberWrapper`.
 The `[[PrimitiveValueNumberData]]` internal data property of the newly constructed object is set to `ToNumber(value)` if `value` was supplied, else to `+0`.
 The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.**

1. Let F be the **Number** function object on which the **new** operator was applied.
2. Let $argumentsList$ be the *argumentsList* argument of the **[[Construct]]** internal method that was invoked by the **new** operator.
3. Return the result of **OrdinaryConstruct** (F , $argumentsList$).

If **Number** is implemented as an ordinary function object, its **[[Construct]]** internal method will perform the above steps.

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15.7.3 Properties of the Number Constructor

The value of the **[[Prototype]]** internal **data** property of the Number constructor is the Function prototype object (15.3.3).

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Besides the **length** property (whose value is **1**), the Number constructor has the following properties:

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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 5×10^{-324} .

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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** }.

15.7.3.7 Number.EPSILON

The value of `Number.EPSILON` is the difference between 1 and the smallest value greater than 1 that is representable as a `Number` value, which is approximately $2.2204460492503130808472633361816 \times 10^{-16}$.

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

15.7.3.8 Number.MAX_INTEGER

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The value of `Number.MAX_INTEGER` is the largest integer value that can be represented as a `Number` value without losing precision, which is 9007199254740991.

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

15.7.3.9 Number.parseInt (string, radix)

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Same as 15.1.2.2.

Comment [AWB7178]: Same specification or same value?

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15.7.3.10 Number.parseFloat (string)

Same as 15.1.2.3.

Comment [AWB7179]: Same specification or same value?

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15.7.3.11 Number.isNaN (number)

When the `Number.isNaN` is called with one argument `number`, the following steps are taken:

1. If `Type(number)` is not `Number`, return `false`.
2. If `number` is `Nan`, return `true`.
3. Otherwise, return `false`.

NOTE This function differs from the global `isNaN` function (15.1.2.4) is that it does not convert its argument to a `Number` before determining whether it is `NaN`.

15.7.3.12 Number.isFinite (number)

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When the `Number.isFinite` is called with one argument `number`, the following steps are taken:

1. If `Type(number)` is not `Number`, return `false`.
2. If `number` is `Nan`, $+\infty$, or $-\infty$, return `false`.
3. Otherwise, return `true`.

15.7.3.13 Number.isInteger (number)

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When the `Number.isInteger` is called with one argument `number`, the following steps are taken:

1. If `Type(number)` is not `Number`, return `false`.
2. Let `integer` be `ToInteger(number)`.
3. If `integer` is not equal to `number`, return `false`.
4. Otherwise, return `true`.

15.7.3.14 Number.toInteger (number)

Comment [AWB7180]: Name changed from `tolInteg` to `tolInt` at Marcdh 29 TC39 meeting. And changed back to `toInteger` at the Jan 29, 2013 meeting.

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When the `Number.toInteger` is called with one argument `number`, the following steps are taken:

1. Return `ToInteger(number)`.

15.7.3.15 Number[@@create]()

The `@@create` method of an object `F` performs the following steps:

1. Let F be the **this** value.
2. Let obj be the result of calling OrdinaryCreateFromConstructor(F , "%NumberPrototype%", ([[NumberData]])).
3. Return obj .

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

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NOTE [[NumberData]] is initially assigned the value **undefined** as a flag to indicate that the instance has not yet been initialized by the Number constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.7.4 Properties of the Number Prototype Object

The Number prototype object is an ordinary object. It is not a Number instance and does not have a [[NumberData]] internal data property.

The value of the [[Prototype]] internal data property of the Number prototype object is the standard built-in Object prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the Number prototype object defined below are not generic and the **this** value passed to them must be either a Number value or an object that has a [[NumberData]] internal data property that has been initialized to a Number value.

The abstract operation **thisNumberValue(value)** performs the following steps:

1. If **Type(value)** is Number, return **value**.
2. If **Type(value)** is Object and **value** has a [[NumberData]] internal data property, then
 - a. Let n be the value of **value**'s [[NumberData]] internal data property.
 - b. If n is not **undefined**, then return n .
3. Throw a **TypeError** exception.

The phrase "this Number value" within the specification of a method refers to the result returned by calling the abstract operation **thisNumberValue** with the **this** value of the method invocation passed as the argument.

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])

The optional **radix** should be an integer value in the inclusive range 2 to 36. If **radix** not present or is **undefined** the Number 10 is used as the value of **radix**. If **ToInteger(radix)** is the Number 10 then this Number value is given as an argument to the **ToString** abstract operation; the resulting String value is returned.

If **ToInteger(radix)** is not an integer between 2 and 36 inclusive throw a **RangeError** exception. If **ToInteger(radix)** is an integer from 2 to 36, but not 10, the result is a String representation of this Number value using the specified radix. Letters a-z are used for digits with values 10 through 35. The precise algorithm is implementation-dependent if the radix is not 10, however the algorithm should be a generalisation of that specified in 9.1.8.1.

The **toString** function is not generic; it throws a **TypeError** exception if its **this** value is not a Number or 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 this Number value 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**.

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Deleted: In the following descriptions of functions that are properties of the Number prototype object, the phrase "this Number object" refers to either the object that is the **this** value for the invocation of the function or, if **Type(this value)** is Number, an object that is created as if by the expression **new Number(this value)** where **Number** is the standard built-in constructor with that name. Also, t

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Deleted: Number value represented by this Number object, that is, the value of the [[PrimitiveValueNumberData]] internal data property of this Number object or the **this** value if its type is Number. A **TypeError** exception is thrown if the **this** value is neither an object for which the value of the **hasOwnProperty** method has an [[ClassIsNumberNativeBrandNumberData]] internal data property is "Number" or a value whose type is Number.

Comment [AWB7181]: TODO: need to provide algorithm that orders abnormal completion detection

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 ()

1. Let x be `thisNumberValue(this value)`.
2. Return x .

15.7.4.5 Number.prototype.toFixed (fractionDigits)

Note `toFixed` returns a String containing this Number value represented in decimal fixed-point notation with fractionDigits digits after the decimal point. If fractionDigits is `undefined`, 0 is assumed.

The following steps are performed:

1. Let x be `thisNumberValue(this value)`.
2. ReturnIfAbrupt(x).
3. Let f be `ToInteger(fractionDigits)`. (If fractionDigits is `undefined`, this step produces the value 0).
4. ReturnIfAbrupt(f).
5. If $f < 0$ or $f > 20$, throw a **RangeError** exception.
6. If x is `NaN`, return the String "`NaN`".
7. Let s be the empty String.
8. If $x < 0$, then
 - a. Let s be `"-"`.
 - b. Let $x = -x$.
9. If $x \geq 10^{21}$, then
 - a. Let m be `ToString(x)`.
10. Else $x < 10^{21}$
 - a. Let n be an integer for which the exact mathematical value of $n \div 10^f - x$ is as close to zero as possible. If there are two such n , pick the larger n .
 - b. 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).
 - c. If $f \neq 0$, then
 - i. Let k be the number of `elements` in m .
 - ii. If $k \leq f$, then
 1. Let z be the String consisting of $f+1-k$ occurrences of the code unit 0x0030.
 2. Let m be the concatenation of Strings z and m .
 3. Let $k = f + 1$.
 - iii. Let a be the first $k-f$ `elements` of m , and let b be the remaining f `elements` of m .
 - iv. Let m be the concatenation of the three Strings a , `"."`, and b .
11. 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 this Number value represented in decimal exponential notation with one digit before the significand's decimal point and fractionDigits digits after the significand's decimal point. If fractionDigits is

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Deleted: Returns this Number value.¶

Deleted: The `valueOf` function is not generic; it throws a **TypeError** exception if its `this` value is not a Number or a Number object. Therefore, it cannot be transferred to other kinds of objects for use as a method.¶

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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 `thisNumberValue(this value)`.
2. **ReturnIfAbrupt(x).**
3. Let f be `ToInteger(fractionDigits)`.
4. **ReturnIfAbrupt(f).**
5. If x is **`NaN`**, return the String "**`NaN`**".
6. Let s be the empty String.
7. If $x < 0$, then
 - a. Let s be `"-"`.
 - b. Let $x = -x$.
8. If $x = +\infty$, then
 - a. Return the concatenation of the Strings s and "**`Infinity`**".
9. If `fractionDigits` is not **`undefined`** and ($f < 0$ or $f > 20$), throw a **RangeError** exception.
10. If $x = 0$, then
 - a. **If `fractionDigits` is `undefined`, then let $f = 0$.**
 - b. Let m be the String consisting of $f+1$ occurrences of the code unit `0x0030`.
 - c. Let $e = 0$.
11. Else $x \neq 0$
 - a. If `fractionDigits` is not **`undefined`**, then
 - i. Let e and n be integers such that $10^f \leq n < 10^{f+1}$ and for which the exact mathematical value of $n \times 10^{e-f} - x$ is as close to zero as possible. If there are two such sets of e and n , pick the e and n for which $n \times 10^{e-f}$ is larger.
 - b. Else **`fractionDigits` is `undefined`**.
 - i. Let e , n , and f be integers such that $f \geq 0$, $10^f \leq n < 10^{f+1}$, the number value for $n \times 10^{e-f}$ 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.
 - c. Let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes).
12. If $f \neq 0$, then
 - a. Let a be the first **`element`** of m , and let b be the remaining **`elements`** of m .
 - b. Let m be the concatenation of the three Strings a , `"."`, and b .
13. If $e = 0$, then
 - a. Let $c = "+"$.
 - b. Let $d = "0"$.
14. Else
 - a. If $e > 0$, then let $c = "+"$.
 - b. Else $e \leq 0$
 - i. Let $c = "-"$.
 - ii. Let $e = -e$.
 - c. Let d be the String consisting of the digits of the decimal representation of e (in order, with no leading zeroes).
15. Let m be the concatenation of the four Strings m , `"e"`, c , and d .
16. Return the concatenation of the Strings s and m .

The `length` property of the `toExponential` method is **1**.

If the `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 `toExponential` for values of `fractionDigits` less than 0 or greater than 20. In this case `toExponential` would not necessarily throw **RangeError** for such values.

NOTE For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 9.b.i be used as a guideline:

- i. Let e , n , and f be integers such that $f \geq 0$, $10^f \leq n < 10^{f+1}$, the number value for $n \times 10^{e-f}$ is x , and f is as small as possible. If there are multiple possibilities for n , choose the value of n for which $n \times 10^{e-f}$ is closest in value to x . If there are two such possible values of n , choose the one that is even.

15.7.4.7 Number.prototype.toPrecision (precision)

Return a String containing this Number value represented either in decimal exponential notation with one digit before the significand's decimal point and $precision - 1$ digits after the significand's decimal point or in decimal fixed notation with $precision$ significant digits. If $precision$ is **undefined**, call `ToString` (9.8.1) instead. Specifically, perform the following steps:

1. Let x be `thisNumberValue(this value)`.
2. ReturnIfAbrupt(x).
3. If $precision$ is **undefined**, return `ToString(x)`.
4. Let p be `ToInteger(precision)`.
5. ReturnIfAbrupt(p).
6. If x is **NaN**, return the String "**NaN**".
7. Let s be the empty String.
8. If $x < 0$, then
 - a. Let s be `"-"`.
 - b. Let $x = -x$.
9. If $x = +\infty$, then
 - a. Return the concatenation of the Strings s and "**Infinity**".
10. If $p < 1$ or $p > 21$, throw a **RangeError** exception.
11. If $x = 0$, then
 - a. Let m be the String consisting of p occurrences of the code unit `0x0030` (the Unicode character '`0`').
12. Else $x \neq 0$,
 - a. Let e and n be integers such that $10^{p-1} \leq n < 10^p$ and for which the exact mathematical value of $n \times 10^{e-p+1} - x$ is as close to zero as possible. If there are two such sets of e and n , pick the e and n for which $n \times 10^{e-p+1}$ is larger.
 - b. Let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes).
 - c. If $e < -6$ or $e \geq p$, then
 - i. Let a be the first element of m , and let b be the remaining $p-1$ elements of m .
 - ii. Let m be the concatenation of the three Strings a , `"."`, and b .
 - iii. If $e = 0$, then
 1. Let $c = "+"$ and $d = "0"$.
 - iv. Else $e \neq 0$,
 1. If $e > 0$, then
 - a. Let $c = "+"$.
 2. Else $e < 0$,
 - a. Let $c = "-"$.
 - b. Let $e = -e$.
 3. Let d be the String consisting of the digits of the decimal representation of e (in order, with no leading zeroes).
 - v. Let m be the concatenation of the five Strings s , m , `"e"`, c , and d .
 13. If $e = p-1$, then return the concatenation of the Strings s and m .
 14. If $e \geq 0$, then
 - a. Let m be the concatenation of the first $e+1$ elements of m , the code unit `0x002E` (Unicode character `"."`), and the remaining $p-(e+1)$ elements of m .
 15. Else $e < 0$,
 - a. Let m be the concatenation of the String `"0."`, $-(e+1)$ occurrences of code unit `0x0030` (the Unicode character '`0`'), and the String m .
 16. Return the concatenation of the Strings s and m .

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The `length` property of the `toPrecision` method is **1**.

If the `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 `toPrecision` for values of *precision* less than 1 or greater than 21. In this case `toPrecision` would not necessarily throw `RangeError` for such values.

15.7.4.8 Number.prototype.clz()

When the `Number.prototype.clz` is called with one argument *number*, the following steps are taken:

1. Let *x* be thisNumberValue(*this* value).
2. Let *n* be `ToUint32(x)`.
3. ReturnIfAbrupt(*n*).
4. Let *p* be the number of leading zero bits in the 32-bit binary representation of *n*.
5. Return *p*.

NOTE If *n* is 0, *p* will be 32. If the most significant bit of the 32-bit binary encoding of *n* is 1, *p* will be 0.

15.7.5 Properties of Number Instances

Number instances are ordinary objects that inherit properties from the Number prototype object. Number instances also have a `[[NumberData]]` internal data property. The `[[NumberData]]` internal data property is the Number value represented by this Number object.

15.8 The Math Object

The Math object is a single ordinary object.

The value of the `[[Prototype]]` internal data property of the Math object is the standard built-in Object prototype object (15.2.4). The Math object has a `[[MathTag]]` internal data property whose value is `true`.

The Math is not a function object. It does not have a `[[Construct]]` internal method; it is not possible to use the Math object as a constructor with the `new` operator. The Math object also does not have a `[[Call]]` internal method; 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 Math.E

The Number value for *e*, 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 Math.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 Math.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` }.

Comment [AWB7182]: Added at March 2012 TC39 meeting

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Comment [AWB7183]: Unsigned seems most general, signed values could be converted in a previous step.

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15.8.1.4 **Math.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.LOG2E** is approximately the reciprocal of the value of **Math.LN2**.

15.8.1.5 **Math.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.LOG10E** is approximately the reciprocal of the value of **Math.LN10**.

15.8.1.6 **Math.PI**

The Number value for π , 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 **Math.SQRT1_2**

The Number value for the square root of $\frac{1}{2}$, 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 **Math.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

Each of the following **Math** object functions applies the ToNumber abstract operation to each of its arguments (in left-to-right order if there is more than one). If ToNumber returns an abrupt completion, that completion record is immediately returned. Otherwise, function performs a computation on the resulting Number value(s).

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In the function descriptions below, the symbols **Nan**, **-0**, **+0**, **$-\infty$** and **$+\infty$** refer to the Number values described in 8.5.

NOTE The behaviour of the functions **acos**, **asin**, **atan**, **atan2**, **cos**, **exp**, **log**, **pow**, **sin**, **sqrt**, and **tan** 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 (<http://www.netlib.org/fdlibm>).

15.8.2.1 Math.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 $-\infty$, the result is $+\infty$.

15.8.2.2 Math.acos (*x*)

Returns an implementation-dependent approximation to the arc cosine of *x*. The result is expressed in radians and ranges from +0 to $+\pi$.

- 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 exactly 1, the result is +0.

15.8.2.3 Math.asin (*x*)

Returns an implementation-dependent approximation to the arc sine of *x*. The result is expressed in radians and ranges from $-\pi/2$ to $+\pi/2$.

- 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 Math.atan (*x*)

Returns an implementation-dependent approximation to the arc tangent of *x*. The result is expressed in radians and ranges from $-\pi/2$ to $+\pi/2$.

- 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 $+\infty$, the result is an implementation-dependent approximation to $+\pi/2$.
- If *x* is $-\infty$, the result is an implementation-dependent approximation to $-\pi/2$.

15.8.2.5 Math.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 an implementation-dependent approximation to $-\pi$.

- If y is -0 and $x < 0$, the result is an implementation-dependent approximation to $-\pi$.
- If $y < 0$ and x is $+0$, the result is an implementation-dependent approximation to $-\pi/2$.
- If $y < 0$ and x is -0 , the result is an implementation-dependent approximation to $-\pi/2$.
- If $y > 0$ and y is finite and x is $+\infty$, the result is $+0$.
- If $y > 0$ and y is finite and x is $-\infty$, the result is an implementation-dependent approximation to $+\pi$.
- If $y < 0$ and y is finite and x is $+\infty$, the result is -0 .
- If $y < 0$ and y is finite and x is $-\infty$, the result is an implementation-dependent approximation to $-\pi$.
- If y is $+\infty$ and x is finite, the result is an implementation-dependent approximation to $+\pi/2$.
- If y is $-\infty$ and x is finite, the result is an implementation-dependent approximation to $-\pi/2$.
- If y is $+\infty$ and x is $+\infty$, the result is an implementation-dependent approximation to $+\pi/4$.
- If y is $+\infty$ and x is $-\infty$, the result is an implementation-dependent approximation to $+3\pi/4$.
- If y is $-\infty$ and x is $+\infty$, the result is an implementation-dependent approximation to $-\pi/4$.
- If y is $-\infty$ and x is $-\infty$, the result is an implementation-dependent approximation to $-3\pi/4$.

15.8.2.6 **Math.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 **Math.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 **Math.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 **Math.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 $+0$.

NOTE The value of `Math.floor(x)` is the same as the value of `-Math.ceil(-x)`.

15.8.2.10 `Math.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 `Math.max([value1[, value2[, ...]]])`

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 using the Abstract Relational Comparison Algorithm (11.8.1) except that $+0$ is considered to be larger than -0 .

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

15.8.2.12 `Math.min([value1[, value2[, ...]]])`

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 using the Abstract Relational Comparison Algorithm (11.8.1) except that $+0$ is considered to be larger than -0 .

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

15.8.2.13 `Math.pow(x, y)`

Returns an implementation-dependent approximation to the result of raising x to the power y .

- If y is NaN, the result is NaN.
- If y is $+0$, the result is 1, even if x is NaN.
- If y is -0 , the result is 1, even if x is NaN.
- If x is NaN and y is nonzero, the result is NaN.
- If $\text{abs}(x)>1$ and y is $+\infty$, the result is $+\infty$.
- If $\text{abs}(x)>1$ and y is $-\infty$, the result is $+0$.
- If $\text{abs}(x)<1$ and y is $+\infty$, the result is NaN.
- If $\text{abs}(x)<1$ and y is $-\infty$, the result is NaN.
- If $\text{abs}(x)<1$ and y is $+\infty$, the result is $+0$.
- If $\text{abs}(x)<1$ and y is $-\infty$, the result is $+\infty$.
- If x is $+\infty$ and $y>0$, the result is $+\infty$.
- If x is $+\infty$ and $y<0$, the result is $+0$.
- If x is $-\infty$ and $y>0$ and y is an odd integer, the result is $-\infty$.
- If x is $-\infty$ and $y>0$ and y is not an odd integer, the result is $+\infty$.

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- If x is $-\infty$ and $y < 0$ and y is an odd integer, the result is -0 .
- If x is $-\infty$ and $y < 0$ and y is not an odd integer, the result is $+0$.
- If x is $+0$ and $y > 0$, the result is $+0$.
- If x is $+0$ and $y < 0$, the result is $+\infty$.
- If x is -0 and $y > 0$ and y is an odd integer, the result is -0 .
- If x is -0 and $y > 0$ and y is not an odd integer, the result is $+0$.
- If x is -0 and $y < 0$ and y is an odd integer, the result is $-\infty$.
- If x is -0 and $y < 0$ and y is not an odd integer, the result is $+\infty$.
- If $x < 0$ and x is finite and y is finite and y is not an integer, the result is NaN .

15.8.2.14 Math.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 Math.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 Math.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 .
- If x is $+\infty$ or $-\infty$, the result is NaN .

15.8.2.17 Math.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 Math.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.

15.8.2.19 Math.log10 (x)

Returns an implementation-dependent approximation to the base 10 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, the result is $-\infty$.
- If x is -0, the result is $-\infty$.
- If x is 1, the result is +0.
- If x is $+\infty$, the result is $+\infty$.

15.8.2.20 Math.log2 (x)

Returns an implementation-dependent approximation to the base 2 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, the result is $-\infty$.
- If x is -0, the result is $-\infty$.
- If x is 1, the result is +0.
- If x is $+\infty$, the result is $+\infty$.

15.8.2.21 Math.log1p (x)

Returns an implementation-dependent approximation to the natural logarithm of $1 + x$. The result is computed in a way that is accurate even when the value of x is close to zero.

- If x is NaN, the result is NaN.
- If x is less than -1, the result is NaN.
- If x is -1, the result is $-\infty$.
- If x is +0, the result is +0.
- If x is -0, the result is -0.
- If x is $+\infty$, the result is $+\infty$.

15.8.2.22 Math.expm1 (x)

Returns an implementation-dependent approximation to subtracting 1 from the exponential function of x (raised to the power of x , where e is the base of the natural logarithms). The result is computed in a way that is accurate even when the value of x is close 0.

- 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 -1.

15.8.2.23 Math.cosh(x)

Returns an implementation-dependent approximation to the hyperbolic cosine of x .

- 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 $+\infty$.

NOTE The value of $\cosh(x)$ is the same as $(\exp(x) + \exp(-x))/2$.

15.8.2.24 Math.sinh(x)

Returns an implementation-dependent approximation to the hyperbolic sine of 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 $-\infty$.

NOTE The value of $\cosh(x)$ is the same as $(\exp(x) - \exp(-x))/2$.

15.8.2.25 Math.tanh(x)

Returns an implementation-dependent approximation to the hyperbolic tangent of 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 +1.
- If x is $-\infty$, the result is -1.

NOTE The value of $\tanh(x)$ is the same as $(\exp(x) - \exp(-x))/(\exp(x) + \exp(-x))$.

15.8.2.26 Math.acosh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic cosine of x .

- If x is NaN, the result is NaN.
- If x is less than 1, the result is NaN.
- If x is 1, the result is +0.
- If x is $+\infty$, the result is $+\infty$.

15.8.2.27 Math.asinh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic sine of 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 $-\infty$.

15.8.2.28 Math.atanh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic tangent of x .

- If x is NaN, the result is NaN.
- If x is less than -1, the result is NaN.
- If x is greater than 1, the result is NaN.
- If x is -1, the result is $-\infty$.
- If x is +1, the result is $+\infty$.
- If x is +0, the result is +0.
- If x is -0, the result is -0.

15.8.2.29 Math.hypot(value1 , value2 , value3 = 0)

Given two or three arguments, hypot returns an implementation-dependent approximation of the square root of the sum of squares of up to three arguments.

- If any argument is $+\infty$, the result is $+\infty$.
- If any argument is $-\infty$, the result is $+\infty$.
- If no argument is $+\infty$ or $-\infty$, and any argument is NaN, the result is NaN.
- If all arguments are either +0 or -0, the result is +0.

The length property of the `hypot` function is 2.

15.8.2.30 Math.trunc(x)

Returns the integral part of the number x , removing any fractional digits. 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 $-\infty$.

15.8.2.31 Math.sign(x)

Returns the sign of the x , indicating whether x is positive, negative or zero.

- 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 negative and not -0, the result is -1.
- If x is positive and not +0, the result is +1.

15.8.2.32 Math.cbrt(x)

Returns an implementation-dependent approximation to the cube root of 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 $-\infty$.

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Comment [AWB7184]: Concensus at March29 TC39 meeting was to drop this function. See March29 meeting notes

Deleted: 15.8.2.30 hypot2(value1 , value2 , value3) ¶

Given two or three arguments, hypot2 returns an implementation-dependent approximation of the square root of the sum of squares of its arguments. ¶
 <#> If no arguments are given, the result is +0. ¶
 <#> If any argument is $+\infty$, the result is $+\infty$. ¶
 <#> If any argument is $-\infty$, the result is $+\infty$. ¶
 <#> If no argument is $+\infty$ or $-\infty$, and any argument is NaN, the result is NaN. ¶
 <#> If all arguments are either +0 or -0, the result is +0. ¶

15.8.2.33 Math.imul(x, y)

15.7.4.8 Math. imul ()

When the `Math.imul` is called with arguments `x` and `y` the following steps are taken:

1. Let `a` be `ToUint32(x)`.
2. ReturnIfAbrupt(`a`).
3. Let `a` be `ToUint32(y)`.
4. ReturnIfAbrupt(`b`).
5. Let `product` be $(a \times b)$ modulo 2^{32} .
6. If `product > 2^{31}`, return $product - 2^{32}$, otherwise return `product`.

15.9 Date Objects

15.9.1 Overview of Date Objects and Definitions of Abstract Operations

Deleted: Operators

The following functions are abstract operations that operate on time values (defined in 15.9.1.1). Note that, in every case, if any argument to one of these functions is `NaN`, the result will be `NaN`.

15.9.1.1 Time Values and Time Range

A Date object contains a Number indicating a particular instant in time to within a millisecond. Such a Number is called a *time value*. A time value may also be `NaN`, indicating that the Date object does not represent a specific instant of time.

Time is measured in ECMAScript in milliseconds since 01 January, 1970 UTC. In time values 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 $-9,007,199,254,740,992$ to $9,007,199,254,740,992$; 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:

$$\text{TimeWithinDay}(t) = t \bmod \text{msPerDay}$$

15.9.1.3 Year Number

ECMAScript uses an extrapolated Gregorian system to map a day number to a year number and to determine the month and date within that year. In this system, leap years are precisely those which are (divisible by 4) and ((not divisible by 100) or (divisible by 400)). The number of days in year number y is therefore defined by

$$\begin{aligned} \text{DaysInYear}(y) &= 365 \text{ if } (y \bmod 4) \neq 0 \\ &= 366 \text{ if } (y \bmod 4) = 0 \text{ and } ((y \bmod 100) \neq 0) \\ &= 365 \text{ if } ((y \bmod 100) = 0 \text{ and } ((y \bmod 400) \neq 0)) \\ &= 366 \text{ if } ((y \bmod 100) = 0 \text{ and } ((y \bmod 400) = 0)) \end{aligned}$$

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:

$$\text{DayFromYear}(y) = 365 \times (y-1970) + \text{floor}((y-1969)/4) - \text{floor}((y-1901)/100) + \text{floor}((y-1601)/400)$$

The time value of the start of a year is:

$$\text{TimeFromYear}(y) = \text{msPerDay} \times \text{DayFromYear}(y)$$

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:

$$\begin{aligned} \text{InLeapYear}(t) &= 0 \text{ if } \text{DaysInYear}(\text{YearFromTime}(t)) = 365 \\ &= 1 \text{ if } \text{DaysInYear}(\text{YearFromTime}(t)) = 366 \end{aligned}$$

15.9.1.4 Month Number

Months are identified by an integer in the range 0 to 11, inclusive. The mapping $\text{MonthFromTime}(t)$ from a time value t to a month number is defined by:

$\text{MonthFromTime}(t) = 0$	if	0	$\leq \text{DayWithinYear}(t) < 31$
= 1	if	31	$\leq \text{DayWithinYear}(t) < 59+\text{InLeapYear}(t)$
= 2	if	$59+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 90+\text{InLeapYear}(t)$
= 3	if	$90+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 120+\text{InLeapYear}(t)$
= 4	if	$120+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 151-\text{InLeapYear}(t)$
= 5	if	$151+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 181+\text{InLeapYear}(t)$
= 6	if	$181+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 212+\text{InLeapYear}(t)$
= 7	if	$212+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 243+\text{InLeapYear}(t)$
= 8	if	$243+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 273+\text{InLeapYear}(t)$
= 9	if	$273+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 304+\text{InLeapYear}(t)$
= 10	if	$304+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 334-\text{InLeapYear}(t)$
= 11	if	$334+\text{InLeapYear}(t)$	$\leq \text{DayWithinYear}(t) < 365+\text{InLeapYear}(t)$

where

$$\text{DayWithinYear}(t) = \text{Day}(t) - \text{DayFromYear}(\text{YearFromTime}(t))$$

A month value of 0 specifies January; 1 specifies February; 2 specifies March; 3 specifies April; 4 specifies May; 5 specifies June; 6 specifies July; 7 specifies August; 8 specifies September; 9 specifies October; 10 specifies November; and 11 specifies December. Note that $\text{MonthFromTime}(0) = 0$, corresponding to Thursday, 01 January, 1970.

15.9.1.5 Date Number

A date number is identified by an integer in the range 1 through 31, inclusive. The mapping $\text{DateFromTime}(t)$ from a time value t to a month number is defined by:

$\text{DateFromTime}(t) = \text{DayWithinYear}(t)+1$	if $\text{MonthFromTime}(t)=0$
= $\text{DayWithinYear}(t)-30$	if $\text{MonthFromTime}(t)=1$
= $\text{DayWithinYear}(t)-58-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=2$
= $\text{DayWithinYear}(t)-89-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=3$
= $\text{DayWithinYear}(t)-119-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=4$
= $\text{DayWithinYear}(t)-150-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=5$
= $\text{DayWithinYear}(t)-180-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=6$
= $\text{DayWithinYear}(t)-211-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=7$
= $\text{DayWithinYear}(t)-242-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=8$
= $\text{DayWithinYear}(t)-272-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=9$
= $\text{DayWithinYear}(t)-303-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=10$
= $\text{DayWithinYear}(t)-333-\text{InLeapYear}(t)$	if $\text{MonthFromTime}(t)=11$

15.9.1.6 Week Day

The weekday for a particular time value t is defined as

$$\text{WeekDay}(t) = (\text{Day}(t) + 4) \text{ modulo } 7$$

A weekday value of 0 specifies Sunday; 1 specifies Monday; 2 specifies Tuesday; 3 specifies Wednesday; 4 specifies Thursday; 5 specifies Friday; and 6 specifies Saturday. Note that $\text{WeekDay}(0) = 4$, corresponding to Thursday, 01 January, 1970.

15.9.1.7 Local Time Zone Adjustment

An implementation of ECMAScript is expected to determine the local time zone adjustment. 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 .

NOTE It is recommended that implementations use the time zone information of the IANA Time Zone Database.

Deleted: The value LocalTZA does not vary with time but depends only on the geographic location.

Comment [AWB8185]: Need a reference

15.9.1.8 Daylight Saving Time Adjustment

An implementation of ECMAScript is expected to make its best effort to determine the local daylight saving time adjustment. An implementation dependent algorithm using best available information on time zones to determine the local daylight saving time adjustment $\text{DaylightSavingTA}(t)$, measured in milliseconds.

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 (1) the time since the beginning of the year
 $t - \text{TimeFromYear}(\text{YearFromTime}(t))$
 (2) whether t is in a leap year
 $\text{InLeapYear}(t)$
 (3) the week day of the beginning of the year
 $\text{WeekDay}(\text{TimeFromYear}(\text{YearFromTime}(t)))$
 and (4) the geographic location.
 The implementation of ECMAScript should not try to determine whether the exact time was subject to daylight saving time, but just whether daylight saving time would have been in effect if the current daylight saving time algorithm had been used at the time. This avoids complications such as taking into account the years that the 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 $\text{UTC}(\text{LocalTime}(t))$ is not necessarily always equal to t .

15.9.1.10 Hours, Minutes, Second, and Milliseconds

The following functions are useful in decomposing time values:

$$\begin{aligned} \text{HourFromTime}(t) &= \text{floor}(t / \text{msPerHour}) \text{ modulo HoursPerDay} \\ \text{MinFromTime}(t) &= \text{floor}(t / \text{msPerMinute}) \text{ modulo MinutesPerHour} \\ \text{SecFromTime}(t) &= \text{floor}(t / \text{msPerSecond}) \text{ modulo SecondsPerMinute} \\ \text{msFromTime}(t) &= t \text{ modulo msPerSecond} \end{aligned}$$

where

$$\begin{aligned} \text{HoursPerDay} &= 24 \\ \text{MinutesPerHour} &= 60 \\ \text{SecondsPerMinute} &= 60 \\ \text{msPerSecond} &= 1000 \\ \text{msPerMinute} &= 60000 = \text{msPerSecond} \times \text{SecondsPerMinute} \\ \text{msPerHour} &= 3600000 = \text{msPerMinute} \times \text{MinutesPerHour} \end{aligned}$$

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:

- If `hour` is not finite or `min` is not finite or `sec` is not finite or `ms` is not finite, return `Nan`.

2. Let h be $\text{ToInteger}(hour)$.
3. Let m be $\text{ToInteger}(min)$.
4. Let s be $\text{ToInteger}(sec)$.
5. Let $milli$ be $\text{ToInteger}(ms)$.
6. Let t be $h * \text{msPerHour} + m * \text{msPerMinute} + s * \text{msPerSecond} + milli$, performing the arithmetic according to IEEE 754 rules (that is, as if using the ECMAScript operators $*$ and $+$).
7. Return t .

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. Let y be $\text{ToInteger}(year)$.
3. Let m be $\text{ToInteger}(month)$.
4. Let dt be $\text{ToInteger}(date)$.
5. Let ym be $y + \text{floor}(m / 12)$.
6. Let mn be m modulo 12.
7. Find a value t such that `YearFromTime(t)` is ym and `MonthFromTime(t)` is mn and `DateFromTime(t)` is 1; but if this is not possible (because some argument is out of range), return `NaN`.
8. Return `Day(t) + dt - 1`.

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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. Return $day \times \text{msPerDay} + time$.

15.9.1.14 TimeClip (time)

The operator `TimeClip` calculates a number of milliseconds from its argument, which must be an ECMAScript Number value. This operator functions as follows:

1. If `time` is not finite, return `NaN`.
2. If $\text{abs}(time) > 8.64 \times 10^{15}$, return `NaN`.
3. Return $\text{ToInteger}(time) + (+0)$. (Adding a positive zero converts `-0` to `+0`.)

Deleted: an implementation-dependent choice of either `ToInteger(time)` or

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

ECMAScript defines a string interchange format for date-times based upon a simplification of the ISO 8601 Extended Format. The format is as follows: `YYYY-MM-DDTHH:mm:ss.sssZ`

Where the fields are as follows:

- YYYY** is the decimal digits of the year 0000 to 9999 in the Gregorian calendar.
- “–” (hyphen) appears literally twice in the string.
- MM** is the month of the year from 01 (January) to 12 (December).
- DD** is the day of the month from 01 to 31.
- T** “T” appears literally in the string, to indicate the beginning of the time element.
- HH** is the number of complete hours that have passed since midnight as two decimal digits from 00 to 24.

- : “:” (colon) appears literally twice in the string.
- mm** is the number of complete minutes since the start of the hour as two decimal digits from 00 to 59.
- ss** is the number of complete seconds since the start of the minute as two decimal digits from 00 to 59.
- . “.” (dot) appears literally in the string.
- sss** is the number of complete milliseconds since the start of the second as three decimal digits.
- z** is the time zone offset specified as “z” (for UTC) or either “+” or “-” followed by a time expression **HH:mm**

This format includes date-only forms:

YYYY
YYYY-MM
YYYY-MM-DD

It also includes “date-time” forms that consist of one of the above date-only forms immediately followed by one of the following time forms with an optional time zone offset appended:

THH:mm
THH:mm:ss
THH:mm:ss.sss

All numbers must be base 10. If the **MM** or **DD** fields are absent “01” is used as the value. If the **HH**, **mm**, or **ss** fields are absent “00” is used as the value and the value of an absent **sss** field is “000”. If the time zone offset is absent, the date-time is interpreted as a local time.

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.

NOTE 1 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

NOTE 2 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.

15.9.1.15.1 Extended years

ECMAScript requires the ability to specify 6 digit years (extended years); approximately 285,426 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. The year 0 is considered positive and hence prefixed with a + sign.

NOTE Examples of extended years:

-283457-03-21T15:00:59.008Z	283458 B.C.
-000001-01-01T00:00:00Z	2 B.C.
+000000-01-01T00:00:00Z	1 B.C.
+000001-01-01T00:00:00Z	1 A.D.
+001970-01-01T00:00:00Z	1970 A.D.
+002009-12-15T00:00:00Z	2009 A.D.
+287396-10-12T08:59:00.992Z	287396 A.D.

- Deleted:** The value of an
- Deleted:** absent
- Deleted:** in
- Deleted:** is “z”

15.9.2 The Date Constructor Called as a Function

When `Date` is called as a function rather than as a constructor, it returns a String representing the current time (UTC). However, if the `this` value passed in the call is an Object with an uninitialized `[[DateValue]]` internal data property, `Date` initializes the `this` object using the argument value. This permits `Date` to be used both as a function for creating date strings and to perform constructor instance initialization.

`Date` may be subclassed and subclass constructors may perform a super invocation of the `Date` constructor to initialize the `[[DateValue]]` state of subclass instances.

15.9.2.1 Date (year, month [, date [, hours [, minutes [, seconds [, ms]]]]])

This description applies only if the `Date` constructor is called with at least two arguments.

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

1. Let `numberOfArgs` be the number of arguments passed to this constructor call.
2. Assert: `numberOfArgs ≥ 2`.
3. Let `O` be the `this` value.
4. If `Type(O)` is Object and `O` has a `[[DateValue]]` internal data property and the value of `[[DateValue]]` is `undefined`, then
 - a. Let `y` be `ToNumber(year)`.
 - b. ReturnIfAbrupt(`y`).
 - c. Let `m` be `ToNumber(month)`.
 - d. ReturnIfAbrupt(`m`).
 - e. If `date` is supplied then let `dt` be `ToNumber(date)`; else let `dt` be `1`.
 - f. ReturnIfAbrupt(`dt`).
 - g. If `hours` is supplied then let `h` be `ToNumber(hours)`; else let `h` be `0`.
 - h. ReturnIfAbrupt(`h`).
 - i. If `minutes` is supplied then let `min` be `ToNumber(minutes)`; else let `min` be `0`.
 - j. ReturnIfAbrupt(`min`).
 - k. If `seconds` is supplied then let `s` be `ToNumber(seconds)`; else let `s` be `0`.
 - l. ReturnIfAbrupt(`s`).
 - m. If `ms` is supplied then let `milli` be `ToNumber(ms)`; else let `milli` be `0`.
 - n. ReturnIfAbrupt(`milli`).
 - o. If `y` is not `NaN` and $0 \leq \text{ToInteger}(y) \leq 99$, then let `yr` be $1900 + \text{ToInteger}(y)$; otherwise, let `yr` be `y`.
 - p. Let `finalDate` be `MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli))`.
 - q. Set the `[[DateValue]]` internal data property of `O` to `TimeClip(UTC(finalDate))`.
 - r. Return `O`.
5. Else,
 - a. Return the result computed as if by the expression `(new Date()) .toString()` where `Date` is this function and `toString` is the standard built-in method `Date.prototype.toString`.

15.9.2.2 Date (value)

This description applies only if the `Date` constructor is called with exactly one argument.

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

1. Let `numberOfArgs` be the number of arguments passed to this constructor call.
2. Assert: `numberOfArgs = 1`.
3. Let `O` be the `this` value.
4. If `Type(O)` is Object and `O` has a `[[DateValue]]` internal data property and the value of `[[DateValue]]` is `undefined`, then
 - a. If `Type(value)` is Object and `value` has a `[[DateValue]]` internal data property, then
 - i. Let `tv` be `thisTimeValue(value)`.
 - b. Else,
 - i. Let `v` be `ToPrimitive(value)`.
 - ii. If `Type(v)` is String, then

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NOTE The function call `Date(...)` is not equivalent to the object creation expression `new Date(...)` with the same arguments.¶

15.9.2.1 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 `(new Date()) .toString()` where `Date` is the standard built-in constructor with that name and `toString` is the standard built-in method `Date.prototype.toString`.¶

15.9.3 The Date Constructor ¶

When `Date` is called as part of a `new` expression, it is a constructor: it initialises the newly created ordinary object.¶

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Deleted: When `Date` is called with two to seven arguments, it computes the date from `year`, `month`, and (optionally) `date`, `hours`, `minutes`, `seconds` and `ms`.¶

Deleted: The `[[Prototype]]` internal data 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]]` internal property of the newly constructed object is set to "Date" has a `[[IsDateNativeBrandBuiltinBrand]]` internal data property whose value is NativeDateBuiltinDate. The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.¶

The `[[PrimitiveValueDateValue]]` internal data property of the newly constructed object is set as follows.¶

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Deleted: <#> The `[[Prototype]]` internal data 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 newly constructed object has a `[[IsDateNativeBrandBuiltinBrand]]` internal data property whose value is NativeDateBuiltinDate. The `[[Class]]` internal property of the newly constructed object is set to "Date".¶

<#> The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.¶

<#> The `[[PrimitiveValueDateValue]]` internal data property of the newly constructed object is set as follows.¶

1. Let v be the result of parsing y as a date, in exactly the same manner as for the `parse` method (15.9.4.2). If the parse resulted in an abrupt completion, v is the Completion Record.
- iii. Else
 1. Let v be `ToNumber`(v).
 - c. `ReturnIfAbrupt`(v).
 - d. Set the `[[DateValue]]` internal data property of O to `TimeClip`(v).
 - e. `Return` O .
5. Else
 - a. Return the result computed as if by the expression `(new Date()).toString()` where `Date` is this function and `toString` is the standard built-in method `Date.prototype.toString`.

15.9.2.3 Date ()

This description applies only if the Date constructor is called with no arguments.

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

1. Let `numberOfArgs` be the number of arguments passed to this constructor call.
2. Assert: `numberOfArgs = 0`.
3. Let O be the `this` value.
4. If `Type(O)` is Object and O has a `[[DateValue]]` internal data property and the value of `[[DateValue]]` is `undefined`, then
 - a. Set the `[[DateValue]]` internal data property of O to the time value (UTC) identifying the current time.
 - b. `Return` O .
5. Else,
 - a. Return the result computed as if by the expression `(new Date()).toString()` where `Date` is this function and `toString` is the standard built-in method `Date.prototype.toString`.

15.9.3 The Date Constructor

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

15.9.3.1 new Date (...args)

`Date` called as part of a `new` expression with argument list `args` performs the following steps:

1. Let F be the `Date` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct`(F , `argumentsList`).

If `Date` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.9.4 Properties of the Date Constructor

The value of the `[[Prototype]]` internal `data` property of the Date constructor is the Function prototype object (15.3.3).

Besides 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).

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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. If `ToString` results in an abrupt completion the Completion Record is immediately returned. Otherwise, `parse` interprets the resulting String as a date and time; it returns a Number, the UTC time value corresponding to the date and time. 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. Unrecognisable Strings or dates containing illegal element values in the format String shall cause `Date.parse` to return **NaN**.

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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:

```
x.valueOf()
Date.parse(x.toString())
Date.parse(x.toUTCString())
Date.parse(x.toISOString())
```

However, the expression

```
Date.parse(x.toLocaleString())
```

is not required to produce the same Number value as the preceding three expressions and, in general, the value produced by `Date.parse` is implementation-dependent when given any String value that does not conform to the Date Time String Format (15.9.1.15) and 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. Let *y* be `ToNumber(year)`.
2. ReturnIfAbrupt(v).
3. Let *m* be `ToNumber(month)`.
4. ReturnIfAbrupt(m).
5. If *date* is supplied then let *dt* be `ToNumber(date)`; else let *dt* be **1**.
6. ReturnIfAbrupt(dt).
7. If *hours* is supplied then let *h* be `ToNumber(hours)`; else let *h* be **0**.
8. ReturnIfAbrupt(h).
9. If *minutes* is supplied then let *min* be `ToNumber(minutes)`; else let *min* be **0**.
10. ReturnIfAbrupt(min).
11. If *seconds* is supplied then let *s* be `ToNumber(seconds)`; else let *s* be **0**.
12. ReturnIfAbrupt(s).
13. If *ms* is supplied then let *milli* be `ToNumber(ms)`; else let *milli* be **0**.
14. ReturnIfAbrupt(milli).
15. If *y* is not **NaN** and $0 \leq \text{ToInteger}(y) \leq 99$, then let *yr* be $1900 + \text{ToInteger}(y)$; otherwise, let *yr* be *y*.
16. Return `TimeClip(MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli)))`.

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The `length` property of the `UTC` function is **7**.

NOTE The `UTC` function differs from the `Date` constructor in two ways: it returns a time value as a Number, rather than creating a Date object, and it interprets the arguments in UTC rather than as local time.

15.9.4.4 Date.now()

The `now` function return a Number value that is the time value designating the UTC date and time of the occurrence of the call to `now`.

15.9.4.5 Date[@@create]()

The `[@@create]` method of an object `F` performs the following steps:

1. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%DatePrototype%", ([[DateValue]])).`
2. ReturnIfAbrupt(`obj`).
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

NOTE `[[DateValue]]` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the `Date` constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.9.5 Properties of the Date Prototype Object

The `Date` prototype object is itself an ordinary object. It is not a `Date` instance and does not have a `[[DateValue]]` internal data property.

The value of the `[[Prototype]]` internal data property of the `Date` prototype object is the standard built-in `Object` prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the `Date` prototype object defined below are not generic and the `this` value passed to them must be an object that has a `[[DateValue]]` internal data property that has been initialized to a time value.

The abstract operation `thisTimeValue(value)` performs the following steps:

1. If `Type(value)` is `Object` and `value` has a `[[DateValue]]` internal data property, then
 - a. Let `n` be the Number that is the value of `value`'s `[[NumberData]]` internal data property.
 - b. If `n` is not `undefined`, then return `n`.
2. Throw a `TypeError` exception.

In following descriptions of functions that are properties of the `Date` prototype object, the phrase "this `Date` object" refers to the object that is the `this` value for the invocation of the function. The phrase "this time value" within the specification of a method refers to the result returned by calling the abstract operation `thisTimeValue` with the `this` value of the method invocation passed as the argument.

15.9.5.1 Date.prototype.constructor

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

15.9.5.2 Date.prototype.toString()

This function returns a String value. If this time value is `NaN`, the String value is "`Invalid Date`", otherwise 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.

NOTE For any Date value `d` whose milliseconds amount is zero, the result of `Date.parse(d.toString())` is equal to `d.valueOf()`. See 15.9.4.2.

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 <#>Add a `[[NativeBrand]]` internal data property to `obj`.
 <#>Set the `[[NativeBrand]]` internal data property of `obj` to `BuiltinDate`.
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Deleted: and has a `[[IsDateNativeBrandBuiltinBrand]]` internal data property whose value is `NativeDateBuiltinDate`.

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Deleted: Unless explicitly noted otherwise, none of the functions are generic; a `TypeError` exception is thrown if the `this` value is not an object for which the value of the `[[Class]]` with a `[[IsDateNativeBrandDateValue]]` internal data property is "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 `[[PrimitiveValueDateValue]]` internal data property of the `Date` object.
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15.9.5.3 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 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 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.

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 Date.prototype.toLocaleDateString ()

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 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.

15.9.5.7 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. Return this time value.

15.9.5.10 Date.prototype.getFullYear ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is NaN, return NaN.
4. Return YearFromTime(LocalTime(t)).

15.9.5.11 Date.prototype.getUTCFullYear ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is NaN, return NaN.
4. Return YearFromTime(t).

15.9.5.12 Date.prototype.getMonth ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return MonthFromTime(LocalTime(t)).

15.9.5.13 Date.prototype.getUTCMonth ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return MonthFromTime(t).

15.9.5.14 Date.prototype.getDate ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return DateFromTime(LocalTime(t)).

15.9.5.15 Date.prototype.getUTCDate ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return DateFromTime(t).

15.9.5.16 Date.prototype.getDay ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return WeekDay(LocalTime(t)).

15.9.5.17 Date.prototype.getUTCDay ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return WeekDay(t).

15.9.5.18 Date.prototype.getHours ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return HourFromTime(LocalTime(t)).

15.9.5.19 Date.prototype.getUTCHours ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is **NAN**, return **NAN**.
4. Return HourFromTime(t).

15.9.5.20 Date.prototype.getMinutes ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).

3. If t is `NAN`, return `NAN`.
4. Return `MinFromTime(LocalTime(t))`.

15.9.5.21 Date.prototype.getUTCMilliseconds ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return `MinFromTime(t)`.

15.9.5.22 Date.prototype.getSeconds ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return `SecFromTime(LocalTime(t))`.

15.9.5.23 Date.prototype.getUTCSeconds ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return `SecFromTime(t)`.

15.9.5.24 Date.prototype.getMilliseconds ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return `msFromTime(LocalTime(t))`.

15.9.5.25 Date.prototype.getUTCMilliseconds ()

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return `msFromTime(t)`.

15.9.5.26 Date.prototype.getTimezoneOffset ()

Returns the difference between local time and UTC time in minutes.

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. If t is `NAN`, return `NAN`.
4. Return $(t - \text{LocalTime}(t)) / \text{msPerMinute}$.

15.9.5.27 Date.prototype.setTime (time)

1. Let v be `TimeClip(ToNumber(time))`.
2. ReturnIfAbrupt(v).
3. Set the `[[DateValue]]` internal `data` property of this Date object to v .
4. Return v .

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15.9.5.28 Date.prototype.setMilliseconds (ms)

1. Let t be the result of `LocalTime(this time value)`.
2. Let $time$ be `MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), ToNumber(ms))`.
3. Let u be `TimeClip(UTC(MakeDate(Day(t), time)))`.
4. Set the `[[DateValue]]` internal `data` property of this Date object to u .

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5. Return u .

15.9.5.29 Date.prototype.setUTCMilliseconds (ms)

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let $time$ be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), ToNumber(ms)).
4. Let v be TimeClip(MakeDate(Day(t), $time$)).
5. Set the `[[DateValue]]` internal data property of this Date object to v .
6. Return v .

Deleted: PrimitiveValue

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. Let s be ToNumber(sec).
3. If ms is not specified, then let $milli$ be $msFromTime(t)$; otherwise, let $milli$ be ToNumber(ms).
4. Let $date$ be MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s , $milli$)).
5. Let u be TimeClip(UTC($date$)).
6. Set the `[[DateValue]]` internal data property of this Date object to u .
7. Return u .

Deleted: PrimitiveValue

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

15.9.5.31 Date.prototype.setUTCMilliseconds (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. ReturnIfAbrupt(t).
3. Let s be ToNumber(sec).
4. If ms is not specified, then let $milli$ be $msFromTime(t)$; otherwise, let $milli$ be ToNumber(ms).
5. Let $date$ be MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s , $milli$)).
6. Let v be TimeClip($date$).
7. Set the `[[DateValue]]` internal data property of this Date object to v .
8. Return v .

Deleted: PrimitiveValue

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

15.9.5.32 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. Let m be ToNumber(min).
3. If sec is not specified, then let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
4. If ms is not specified, then let $milli$ be $msFromTime(t)$; otherwise, let $milli$ be ToNumber(ms).
5. Let $date$ be MakeDate(Day(t), MakeTime(HourFromTime(t), m , s , $milli$)).
6. Let u be TimeClip(UTC($date$)).
7. Set the `[[DateValue]]` internal data property of this Date object to u .
8. Return u .

Deleted: PrimitiveValue

The `length` property of the `setMinutes` method is 3.

15.9.5.33 Date.prototype.setUTCMinutes (min [, sec [, ms]])

If *sec* is not specified, this behaves as if *sec* were specified with the value `getUTCSeconds()`.

If *ms* is not specified, this function behaves as if *ms* were specified with the value return by `getUTCMilliseconds()`.

1. Let *t* be this time value.
2. ReturnIfAbrupt(*t*).
3. Let *m* be `ToNumber(min)`.
4. If *sec* is not specified, then let *s* be `SecFromTime(t)`; otherwise, let *s* be `ToNumber(sec)`.
5. If *ms* is not specified, then let *milli* be `msFromTime(t)`; otherwise, let *milli* be `ToNumber(ms)`.
6. Let *date* be `MakeDate(Day(t), MakeTime(HourFromTime(t), m, s, milli))`.
7. Let *v* be `TimeClip(date)`.
8. Set the `[[DateValue]]` internal data property of this Date object to *v*.
9. Return *v*.

Deleted: PrimitiveValue

The `length` property of the `setUTCMinutes` method is 3.

15.9.5.34 Date.prototype.setHours (hour [, min [, sec [, ms]]])

If *min* is not specified, this behaves as if *min* were specified with the value `getMinutes()`.

If *sec* is not specified, this behaves as if *sec* were specified with the value `getSeconds()`.

If *ms* is not specified, this behaves as if *ms* were specified with the value `getMilliseconds()`.

1. Let *t* be the result of `LocalTime(this time value)`.
2. Let *h* be `ToNumber(hour)`.
3. If *min* is not specified, then let *m* be `MinFromTime(t)`; otherwise, let *m* be `ToNumber(min)`.
4. If *sec* is not specified, then let *s* be `SecFromTime(t)`; otherwise, let *s* be `ToNumber(sec)`.
5. If *ms* is not specified, then let *milli* be `msFromTime(t)`; otherwise, let *milli* be `ToNumber(ms)`.
6. Let *date* be `MakeDate(Day(t), MakeTime(h, m, s, milli))`.
7. Let *u* be `TimeClip(UTC(date))`.
8. Set the `[[DateValue]]` internal data property of this Date object to *u*.
9. Return *u*.

Deleted: PrimitiveValue

The `length` property of the `setHours` method is 4.

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 `getUTCSeconds()`.

If *ms* is not specified, this behaves as if *ms* were specified with the value `getUTCMilliseconds()`.

1. Let *t* be this time value.
2. ReturnIfAbrupt(*t*).
3. Let *h* be `ToNumber(hour)`.
4. If *min* is not specified, then let *m* be `MinFromTime(t)`; otherwise, let *m* be `ToNumber(min)`.
5. If *sec* is not specified, then let *s* be `SecFromTime(t)`; otherwise, let *s* be `ToNumber(sec)`.
6. If *ms* is not specified, then let *milli* be `msFromTime(t)`; otherwise, let *milli* be `ToNumber(ms)`.
7. Let *newDate* be `MakeDate(Day(t), MakeTime(h, m, s, milli))`.
8. Let *v* be `TimeClip(newDate)`.
9. Set the `[[DateValue]]` internal data property of this Date object to *v*.
10. Return *v*.

Deleted: PrimitiveValue

The `length` property of the `setUTCHours` method is 4.

15.9.5.36 Date.prototype.setDate (date)

1. Let t be the result of LocalTime(this time value).
2. Let dt be ToNumber($date$).
3. Let $newDate$ be MakeDate(MakeDay(YearFromTime(t), MonthFromTime(t), dt), TimeWithinDay(t)).
4. Let u be TimeClip(UTC($newDate$)).
5. Set the `[[DateValue]]` internal data property of this Date object to u .
6. Return u .

Deleted: PrimitiveValue

15.9.5.37 Date.prototype.setUTCDate (date)

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let dt be ToNumber($date$).
4. Let $newDate$ be MakeDate(MakeDay(YearFromTime(t), MonthFromTime(t), dt), TimeWithinDay(t)).
5. Let v be TimeClip($newDate$).
6. Set the `[[DateValue]]` internal data property of this Date object to v .
7. Return v .

Deleted: PrimitiveValue

15.9.5.38 Date.prototype.setMonth (month [, date])

If $date$ is not specified, this behaves as if $date$ were specified with the value `getDATE()`.

1. Let t be the result of LocalTime(this time value).
2. Let m be ToNumber($month$).
3. If $date$ is not specified, then let dt be DateFromTime(t); otherwise, let dt be ToNumber($date$).
4. Let $newDate$ be MakeDate(MakeDay(YearFromTime(t), m , dt), TimeWithinDay(t)).
5. Let u be TimeClip(UTC($newDate$)).
6. Set the `[[DateValue]]` internal data property of this Date object to u .
7. Return u .

Deleted: PrimitiveValue

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

15.9.5.39 Date.prototype.setUTCMonth (month [, date])

If $date$ is not specified, this behaves as if $date$ were specified with the value `getUTCDate()`.

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let m be ToNumber($month$).
4. If $date$ is not specified, then let dt be DateFromTime(t); otherwise, let dt be ToNumber($date$).
5. Let $newDate$ be MakeDate(MakeDay(YearFromTime(t), m , dt), TimeWithinDay(t)).
6. Let v be TimeClip($newDate$).
7. Set the `[[DateValue]]` internal data property of this Date object to v .
8. Return v .

Deleted: PrimitiveValue

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

15.9.5.40 Date.prototype.setFullYear (year [, month [, date]])

If $month$ is not specified, this behaves as if $month$ were specified with the value `getMonth()`.

If $date$ is not specified, this behaves as if $date$ were specified with the value `getDATE()`.

1. Let t be the result of LocalTime(this time value); but if this time value is `NaN`, let t be `+0`.
2. Let y be ToNumber($year$).
3. If $month$ is not specified, then let m be MonthFromTime(t); otherwise, let m be ToNumber($month$).
4. If $date$ is not specified, then let dt be DateFromTime(t); otherwise, let dt be ToNumber($date$).
5. Let $newDate$ be MakeDate(MakeDay(y , m , dt), TimeWithinDay(t)).

6. Let u be TimeClip(UTC($newDate$)).
7. Set the `[[DateValue]]` internal data property of this Date object to u .
8. Return u .

Deleted: PrimitiveValue

The `length` property of the `setFullYear` method is 3.

15.9.5.41 Date.prototype.setUTCFullYear (year [, month [, date]])

If `month` is not specified, this behaves as if `month` were specified with the value `getUTCMonth()`.

If `date` is not specified, this behaves as if `date` were specified with the value `getUTCDate()`.

1. Let t be this time value; but if this time value is `NaN`, let t be `+0`.
2. ReturnIfAbrupt(t).
3. Let y be `ToNumber(year)`.
4. If `month` is not specified, then let m be `MonthFromTime(t)`; otherwise, let m be `ToNumber(month)`.
5. If `date` is not specified, then let dt be `DateFromTime(t)`; otherwise, let dt be `ToNumber(date)`.
6. Let $newDate$ be `MakeDate(MakeDay(y, m, dt), TimeWithinDay(t))`.
7. Let v be `TimeClip(newDate)`.
8. Set the `[[DateValue]]` internal data property of this Date object to v .
9. Return v .

Deleted: PrimitiveValue

The `length` property of the `setUTCFullYear` method is 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 to produce a String representation of a date that is more readable than the format specified in 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 defined in 15.9.1.15 but with a space rather than a “`T`” used to separate the date and time elements.

15.9.5.43 Date.prototype.toISOString ()

This function returns a String value represent the instance in time represented by this Date object. The format of the String is the Date Time string format defined in 15.9.1.15. All fields are present in the String. The time zone is always UTC, denoted by the suffix Z. If the time value of this object is not a finite Number a `RangeError` exception is thrown.

15.9.5.44 Date.prototype.toJSON (key)

This function provides a String representation of a Date object for use by `JSON.stringify` (15.12.3).

When the `toJSON` method is called with argument `key`, the following steps are taken:

1. Let O be the result of calling `ToObject`, giving it the `this` value as its argument.
2. Let tv be `ToPrimitive(O , hint Number)`.
3. If tv is a Number and is not finite, return `null`.
4. Let `toISO` be the result of Get(O , "toISOString").
5. ReturnIfAbrupt(`toISO`).
6. If `IsCallable(toISO)` is `false`, throw a `TypeError` exception.
7. Return the result of calling the `[[Call]]` internal method of `toISO` with O as `thisArgument` and an empty `List` as `argumentsList`.

Deleted: calling the `[[`
Deleted: `]]` internal method of
Deleted:
Deleted: with argument
Deleted: the `this` value
Deleted: argument l

NOTE 1 The argument is ignored.

NOTE 2 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. However, it does require that any such object have a `toISOString` method. An object is free to use the argument `key` to filter its stringification.

15.9.5.45 Date.prototype.`@@ToPrimitive` (hint)

This function is called by ECMAScript language operators to convert an object to a primitive value. The allowed values for `hint` are `"default"`, `"number"`, and `"string"`. Date objects are unique among built-in ECMAScript objects in that they treat `"default"` as being equivalent to `"string"`. All other built-in ECMAScript objects treat `"default"` as being equivalent to `"number"`.

When the `@@ToPrimitive` method is called with argument `hint`, the following steps are taken:

1. Let `O` be this Date object.
2. If `Type(O)` is not `Object`, then throw a `TypeError` exception.
3. If `hint` is the string value `"string"` or the string value `"default"`, then
 - a. Let `tryFirst` be `"string"`.
4. Else if `hint` is the string value `"number"`, then
 - a. Let `tryFirst` be `"number"`.
5. Else, throw a `TypeError` exception.
6. Return the result of `OrdinaryToPrimitive(O, tryFirst)`.

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Deleted: and their have a `[[ClassIsDateNativeBrandBuiltinBrand]]` internal whose value is `NativeDateBuiltinDate`

Deleted: property value is `"Date"`

Deleted: PrimitiveValue

Deleted: ¶

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15.9.6 Properties of Date Instances

Date instances are ordinary objects that inherit properties from the Date prototype object. Date instances also have a `[[DateValue]]` internal data property. The `[[DateValue]]` internal data property is the time value represented by this Date 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`

Assertion ::

```

^
$ 
\ b
\ B
( ? = Disjunction )
( ? ! Disjunction )

```

Quantifier ::

```

QuantifierPrefix
QuantifierPrefix ?

```

QuantifierPrefix ::

```

*
+
?
{ DecimalDigits }
{ DecimalDigits , }
{ DecimalDigits , DecimalDigits }

```

Atom ::

```

PatternCharacter
.
\ AtomEscape
CharacterClass
( Disjunction )
( ? : Disjunction )

```

PatternCharacter ::

```

SourceCharacter but not one 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
<ZWJ>
<ZWNJ>

```

DecimalEscape ::

```

DecimalIntegerLiteral [lookahead ≠ DecimalDigit]

```

CharacterClassEscape :: **one of**
d D s S w W

CharacterClass ::
 [[lookahead $\notin \{\wedge\}$] *ClassRanges*]
 [\wedge *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 \ or] or -
\ ClassEscape

ClassEscape ::
DecimalEscape
b
CharacterEscape
CharacterClassEscape

15.10.2 Pattern Semantics

A regular expression pattern is converted into an internal procedure 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. The internal procedure is used as the value of a *RegExp* object's *[[RegExpMatcher]]* internal *data* property.

Deleted: *[[Match]]*

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 from 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* procedure is an internal closure (i.e. an internal procedure 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* procedure is an internal closure that takes two arguments -- a *State* and a *Continuation* -- and returns a *MatchResult* result. A *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 new *State* to test if the rest of the pattern can match as well. If it can, the *Matcher* returns the *State* returned by *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* procedure 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 *nth* 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 algorithms in 15.10.2.
 2. Let *InputLength* be the length of *Input*. This variable will be used throughout the algorithms 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.

NOTE A Pattern evaluates ("compiles") to an internal procedure value. `RegExp.prototype.exec` can then apply this procedure 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 internal procedure 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*.
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 **failure**, return *r*.
 3. Call *m2(x, c)* and return its result.

NOTE 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 **undefined** values instead of Strings. Thus, for example,

```
/a|ab/.exec("abc")
```

returns the result "a" and not "ab". Moreover,

```
/((a)|(ab))((c)|(bc))/.exec("abc")
```

returns the array

```
["abc", "a", "a", undefined, "bc", undefined, "bc"]
```

and not

```
["abc", "ab", undefined, "ab", "c", "c", undefined]
```

15.10.2.4 Alternative

The production *Alternative :: [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 *Alternative :: Alternative Term* evaluates as follows:

1. Evaluate *Alternative* to obtain a Matcher *m1*.
2. Evaluate *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.

NOTE 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 *Term :: 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 *Assertion* to obtain an AssertionTester *t*.
2. Call *t(x)* and let *r* be the resulting Boolean value.
3. If *r* is **false**, return **failure**.
4. Call *c(x)* and return its result.

The production *Term :: Atom* evaluates by evaluating *Atom* to obtain a Matcher and returning that Matcher.

The production *Term :: Atom Quantifier* evaluates as follows:

1. Evaluate *Atom* to obtain a Matcher *m*.
2. Evaluate *Quantifier* to obtain the three results: an integer *min*, an integer (or ∞) *max*, and Boolean *greedy*.
3. If *max* is finite and less than *min*, then throw a **SyntaxError** exception.
4. Let *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 *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.

Runtime Semantics: RepeatMatcher Abstract Operation

The abstract operation *RepeatMatcher* takes eight parameters, a Matcher *m*, an integer *min*, an integer (or ∞) *max*, a Boolean *greedy*, a State *x*, a Continuation *c*, an integer *parenIndex*, and an integer *parenCount*, and performs the following:

1. If *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:
 1. If *min* is zero and *y*'s *endIndex* is equal to *x*'s *endIndex*, then return **failure**.
 2. If *min* is zero then let *min2* be zero; otherwise let *min2* be *min*-1.
 3. If *max* is ∞ , then let *max2* be ∞ ; otherwise let *max2* be *max*-1.
 4. Call *RepeatMatcher(m, min2, max2, greedy, y, c, parenIndex, parenCount)* and return its result.
3. Let *cap* be a fresh copy of *x*'s *captures* internal array.
4. For every integer *k* that satisfies *parenIndex* < *k* and *k* ≤ *parenIndex+parenCount*, set *cap[k]* to **undefined**.
5. Let *e* be *x*'s *endIndex*.
6. Let *xr* be the State (*e*, *cap*).
7. If *min* is not zero, then call *m(xr, d)* and return its result.
8. If *greedy* is **false**, then
 - a. Call *c(x)* and let *z* be its result.
 - b. If *z* is not **failure**, return *z*.
 - c. Call *m(xr, d)* and return its result.
9. Call *m(xr, d)* and let *z* be its result.
10. If *z* is not **failure**, return *z*.
11. Call *c(x)* and return its result.

NOTE 1 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.

NOTE 2 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 ($(n-1)^{st}$) 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 ($n-1$)st repetition of *Atom* and so on.

Compare

```
/a[a-z]{2,4}/.exec("abcdefghijkl")
```

which returns "abcde" with

```
/a[a-z]{2,4}?/.exec("abcdefghijkl")
```

which returns "abc".

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:

```
"aaaaaaaaaaaaaaa".replace(/^(a+)\1*/,"$1")
```

which returns the gcd in unary notation "aaaaa".

NOTE 3 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", "ac", "a", undefined, "c"]
```

and not

```
["zaacbbbcac", "z", "ac", "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, 4, and 5.

NOTE 4 Step 1 of the RepeatMatcher's *d* closure 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

```
["b", ""]
```

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**.
5. Return **false**.

Deleted: multiline

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 production *Assertion* :: (? = *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 steps:
 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 **failure**, return **failure**.
 4. Let *y* be *r*'s State.
 5. Let *cap* be *y*'s *captures* internal array.
 6. Let *xe* be *x*'s *endIndex*.
 7. Let *z* be the State (*xe*, *cap*).
 8. Call *c*(*z*) and return its result.

The production *Assertion* :: (? ! *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 steps:
 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.

Runtime Semantics: IsWordChar Abstract Operation

The abstract operation *IsWordChar* takes an integer parameter *e* and performs the following:

1. If *e* is -1 or *e* is *InputLength*, return **false**.
2. Let *c* be the character *Input*[*e*].
3. If *c* is one of the sixty-three characters 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
0	1	2	3	4	5	6	7	8	9	_															
4. Return **false**.

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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 ∞) *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 ∞) *max*.
2. Return the three results *min*, *max*, and **false**.

The production *QuantifierPrefix* :: * evaluates by returning the two results 0 and ∞ .

The production *QuantifierPrefix* :: + evaluates by returning the two results 1 and ∞ .

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 ∞ .

The production *QuantifierPrefix* :: { *DecimalDigits* , *DecimalDigits* } evaluates as follows:

1. Let *i* be the MV of the first *DecimalDigits*.
2. Let *j* be the MV of the second *DecimalDigits*.
3. Return the two results *i* and *j*.

15.10.2.8 Atom

The production *Atom* :: *PatternCharacter* evaluates as follows:

1. Let *ch* be the character represented by *PatternCharacter*.
2. Let *A* be a one-element CharSet containing the character *ch*.
3. Call *CharacterSetMatcher*(*A*, **false**) and return its Matcher result.

The production *Atom* :: . evaluates as follows:

1. Let *A* be the set of all characters except *LineTerminator*.
2. Call *CharacterSetMatcher*(*A*, **false**) and return its Matcher result.

The production *Atom* :: \ *AtomEscape* evaluates by evaluating *AtomEscape* to obtain a Matcher and returning that Matcher.

The production *Atom* :: *CharacterClass* evaluates as follows:

1. Evaluate *CharacterClass* to obtain a CharSet *A* and a Boolean *invert*.
2. Call *CharacterSetMatcher*(*A*, *invert*) and return its Matcher result.

The production *Atom* :: (*Disjunction*) evaluates as follows:

1. Evaluate *Disjunction* to obtain a Matcher *m*.
2. Let *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 *Atom* :: (*Disjunction*) production is expanded prior to this production's *Atom* plus the total number of *Atom* :: (*Disjunction*) productions enclosing this *Atom*.
3. Return an internal Matcher closure that takes two arguments, a State *x* and a Continuation *c*, and performs the following steps:
 1. Create an internal Continuation closure *d* that takes one State argument *y* and performs the following steps:
 1. Let *cap* be a fresh copy of *y*'s *captures* internal array.
 2. Let *xe* be *x*'s *endIndex*.

3. Let ye be y 's *endIndex*.
 4. Let s be a fresh String whose characters are the characters of *Input* at positions xe (inclusive) through ye (exclusive).
 5. Set $cap[parenIndex+1]$ to s .
 6. Let z be the State (ye, cap).
 7. Call $c(z)$ and return its result.
2. Call $m(x, d)$ and return its result.

The production $Atom :: (\ ? : Disjunction)$ evaluates by evaluating *Disjunction* to obtain a Matcher and returning that Matcher.

Runtime Semantics: CharacterSetMatcher Abstract Operation

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 steps:
 1. Let e be x 's *endIndex*.
 2. If e is *InputLength*, return **failure**.
 3. Let ch be the character $Input[e]$.
 4. Let cc be the result of *Canonicalize(ch)*.
 5. If *invert* is **false**, then
 - a. If there does not exist a member a of set A such that *Canonicalize(a)* is cc , return **failure**.
 6. Else *invert* is **true**,
 - a. If there exists a member a of set A such that *Canonicalize(a)* is cc , return **failure**.
 7. Let cap be x 's *captures* internal array.
 8. Let y be the State ($e+1, cap$).
 9. Call $c(y)$ and return its result.

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Runtime Semantics: Canonicalize Abstract Operation

The abstract operation *Canonicalize* takes a character parameter ch and performs the following steps:

1. If *IgnoreCase* is **false**, return ch .
2. Let u 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 u does not consist of a single character, return ch .
4. Let cu be u 's character.
5. If ch 's code unit value is greater than or equal to decimal 128 and cu 's code unit value is less than decimal 128, then return ch .
6. Return cu .

NOTE 1 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 internal procedure. To inhibit the capturing behaviour of parentheses, use the form $(?: \ Disjunction)$ instead.

NOTE 2 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,

```
/(?=(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:

```
/(?=(a+))a*b\1/.exec("baaabac")
```

This expression returns

```
["aba", "a"]
```

and not:

```
["aaaba", "a"]
```

NOTE 3 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)\2(.*)/.exec("baaabac")
```

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:

```
["baaabac", "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 "**a**" (\u000Df) 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 \u0131 and \u017F 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 a character, then
 - a. Let *ch* be *E*'s character.
 - b. Let *A* be a one-element CharSet containing the character *ch*.
 - c. Call *CharacterSetMatcher*(*A*, **false**) and return its Matcher result.
3. *E* must be an integer. Let *n* be that integer.
4. If *n*=0 or *n*>NCapturingParens then throw a **SyntaxError** exception.
5. 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(x)* and return its result.
4. Let *e* be *x*'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.

Deleted: *NCapturingParens*

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.

NOTE An escape sequence of the form `\` followed by a nonzero decimal number *n* matches the result of the *n*th 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 *n*th one is **undefined** because it has not captured anything, then the backreference always succeeds.

15.10.2.10 CharacterEscape

The production *CharacterEscape* :: *ControlEscape* evaluates by returning the character according to [Table 35](#).

Table 35.— ControlEscape Character Values

ControlEscape	Code Unit	Name	Symbol
t	\u0009	horizontal tab	<HT>
n	\u000A	line feed (new line)	<LF>
v	\u000B	vertical tab	<VT>
f	\u000C	form feed	<FF>
r	\u000D	carriage return	<CR>

The production *CharacterEscape* :: *c ControlLetter* evaluates as follows:

1. Let *ch* be the character represented by *ControlLetter*.
2. Let *i* be *ch*'s code unit value.
3. Let *j* be the remainder of dividing *i* by 32.
4. Return the character whose code unit value is *j*.

The production *CharacterEscape* :: *HexEscapeSequence* evaluates by evaluating the CV of the *HexEscapeSequence* (see 7.8.6) and returning its character result.

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The production *CharacterEscape* :: *UnicodeEscapeSequence* evaluates by evaluating the CV of the *UnicodeEscapeSequence* (see 7.8.6) and returning its character result.

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The production *CharacterEscape* :: *IdentityEscape* evaluates by returning the character represented by *IdentityEscape*.

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15.10.2.11 DecimalEscape

The production *DecimalEscape* :: *DecimalIntegerLiteral* [lookahead \notin *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.

NOTE If `\` is 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 :: s* 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.

The production *CharacterClassEscape :: s* evaluates by returning the set of all characters not included in the set returned by *CharacterClassEscape :: s*.

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
0	1	2	3	4	5	6	7	8	9	–															

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 $\notin \{^{\wedge}\}$ 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 :: [empty]* 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 *NonemptyClassRanges :: 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*.

Runtime Semantics: CharacterRange Abstract Operation

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 unit value of character a .
5. Let j be the code unit 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 .

NOTE 1 *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 unit value is greater than the second *ClassAtom*'s code unit value.

NOTE 2 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 `.

NOTE 3 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 \ or] or -* 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.

NOTE 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 the backspace character, while \B and backreferences raise errors. Using a backreference inside a *ClassAtom* causes an error.

15.10.3 The RegExp Constructor Called as a Function

When `RegExp` is called as a function rather than as a constructor, it creates and initialises a new `RegExp` object. Thus the function call `RegExp(...)` is equivalent to the object creation expression `new RegExp(...)` with the same arguments. However, if the `this` value passed in the call is an Object with an `[[RegExpMatcher]]` internal data property whose value is `undefined`, it initializes the `this` value using the argument values. This permits `RegExp` to be used both as factory method and to perform constructor instance initialization.

`RegExp` may be subclassed and subclass constructors may perform a super invocation of the `RegExp` constructor to initialize subclass instances.

15.10.3.1 RegExp(pattern, flags)

The following steps are taken:

1. Let *func* be this `RegExp` function object.
2. Let *O* be the `this` value.
3. If `Type(O)` is not Object or `Type(O)` is Object and *O* does not have a `[[RegExpMatcher]]` internal data property or `Type(O)` is Object and *O* has a `[[RegExpMatcher]]` internal data property and the value of `[[RegExpMatcher]]` is not `undefined`, then
 - a. If `Type(pattern)` is Object and *O* has a `[[RegExpMatcher]]` internal data property and *flags* is `undefined`, then
 - i. Return *pattern*;
 - b. Let *O* be the result of calling the abstract operation `RegExpAlloc` with argument *func*.
 - c. ReturnIfAbrupt(*O*).
4. If `Type(pattern)` is Object and *pattern* has a `[[RegExpMatcher]]` internal data property, then
 - a. If the value of *pattern*'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a `TypeError` exception.
 - b. If *flags* is not `undefined`, then throw a `TypeError` exception.
 - c. Let *P* be the value of *pattern*'s `[[OriginalSource]]` internal data property.
 - d. Let *F* be the value of *pattern*'s `[[OriginalFlags]]` internal data property.
5. Else
 - a. let *P* be *pattern*.
 - b. let *F* be *flags*.
6. Return the result of the abstract operation `RegExpInitialize` with arguments *O*, *P*, and *F*.

NOTE If *pattern* is supplied using a *StringLiteral*, the usual escape sequence substitutions are performed before the String is processed by `RegExp`. If *pattern* must contain an escape sequence to be recognised by `RegExp`, any backslash \ characters must be escaped within the *StringLiteral* to prevent them being removed when the contents of the *StringLiteral* are formed.

Comment [AWB14189]: This then clause corresponds to the "called as a function" case the ES5 spec.

Deleted: <#>If *pattern* is `undefined`, then let *P* be the empty String.
<#>Else, let *P* be `ToString(pattern)`.
<#>ReturnIfAbrupt(*P*).
<#>If *flags* is `undefined`, then let *F* be the empty String.
<#>Else, let *F* be `ToString(flags)`.
<#>ReturnIfAbrupt(*F*).
Deleted: `obj`

Deleted: <#>If `Type(pattern)` is `Object` and *pattern* has `[[NativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` and *flags* is `undefined` then return *pattern*.
Deleted: the result of the abstraction operation abstract operation `RegExpCreate` with arguments *pattern* and *flags*

Runtime Semantics: `RegExpAlloc` Abstract Operation

When the abstract operation `RegExpAlloc` with argument `constructor` is called, the following steps are taken:

1. Assert: `constructor` is a constructable function.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(constructor, "%RegExpPrototype%", (|[RegExpMatcher]|, |[OriginalSource]|, |[OriginalFlags]|)).`
3. Let `status` be the result of `DefinePropertyOrThrow(obj, "lastIndex", PropertyDescriptor {[[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false}).`
4. `ReturnIfAbrupt(status).`
5. `Return obj.`

NOTE `[[RegExpMatcher]]` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the `RegExp` constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

Runtime Semantics: `RegExpInitialize` Abstract Operation

When the abstract operation `RegExpInitialize` with arguments `obj`, `pattern`, and `flags` is called, the following steps are taken:

1. If `pattern` is `undefined`, then let `P` be the empty String.
2. Else, let `P` be `ToString(pattern)`.
3. `ReturnIfAbrupt(P).`
4. If `flags` is `undefined`, then let `F` be the empty String.
5. Else, let `F` be `ToString(flags)`.
6. `ReturnIfAbrupt(F).`
7. If `F` contains any character other than "`g`", "`i`", "`m`", "`u`", or "`y`" or if it contains the same character more than once, then throw a `SyntaxError` exception.
8. Parse `P` interpreted as UTF-16 encoded Unicode characters using the grammars in 15.10.1 for the goal symbol `Pattern`. Throw a `SyntaxError` exception if `P` did not conform to the grammar or if all characters of `P` where not matched by the parse.
9. Set `obj`'s `[[RegExpMatcher]]` internal data property to the internal procedure obtained by evaluating ("compiling") the step 3's parse of `P` and applying the semantics provided in 15.10.2.
10. Set the value of `obj`'s `[[OriginalSource]]` internal data property to `P`.
11. Set the value of `obj`'s `[[OriginalFlags]]` internal data property to `F`.
12. Let `putStatus` be the result of `Put(obj, "lastIndex", 0, true)`.
13. `ReturnIfAbrupt(putStatus).`
14. `Return obj.`

Deleted: i

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Deleted: Create

Deleted: P

Deleted:

Deleted: F

Deleted: does the following:

Deleted: <#>Assert: `P` and `F` are both Strings.

Deleted: <#>Let `escapedSource` be the result of calling the abstract operation `EscapeRegExpPattern` with arguments `P` and `F`. ¶

Deleted: Initialize

Deleted: <#>Assert: `P` and `F` are both Strings.

Deleted: If `pattern` is an object `R` that has an `[[IsRegExpNativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` whose `[[Class]]` internal 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` that has an `[[IsRegExpNativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` whose `[[Class]]` internal property is "`RegExp`" and `flags` is `undefined`, then throw a `TypeError` exception. Otherwise, let `P` be the empty String if `pattern` is `undefined` and `ToString(pattern)` otherwise, and let `F` be the empty String if `flags` is `undefined` and `ToString(flags)` otherwise. ¶

If the characters of `P` do not have the syntactic form `Pattern`, then throw a `SyntaxError` exception. Otherwise let the newly constructed object have a `[[Match]]` internal data property obtained by evaluating ("compiling") the characters of `P` as a `Pattern` as described in 15.10.2. ¶

If `F` contains any character other than "`g`", "`i`", "`m`", or "`u`", or if it contains the same character more than once, then throw a `SyntaxError` exception. If a `SyntaxError` exception is not thrown, then the

Deleted: `[[Match]]`

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Runtime Semantics: `RegExpCreate` Abstract Operation

When the abstract operation `RegExpCreate` with arguments `P` and `F` is called, the following steps are taken:

1. Let `obj` be the result of calling the abstract operation `RegExpAlloc` with argument `%RegExp%`.
2. `ReturnIfAbrupt(obj).`
3. Return the result of the abstract operation `RegExpInitialize` with arguments `obj`, `P`, and `F`.

Runtime Semantics: `EscapeRegExpPattern` Abstract Operation

When the abstract operation `EscapeRegExpPattern` with arguments `P` and `F` is called, the following occurs:

Let `S` be a String in the form of a `Pattern` equivalent to `P` interpreted as UTF-16 encoded Unicode characters, in which certain characters are escaped as described below. `S` may or may not be identical to `P` or `pattern`; however, the internal procedure that would result from evaluating `S` as a `Pattern` must behave identically to the internal procedure given by the constructed object's `[[RegExpMatcher]]` internal data property. Separate calls to this abstract operation using the same values for `P` and `F` must produce identical results.

The characters / occurring in the pattern shall be escaped in `S` as necessary to ensure that the String value formed by concatenating the Strings "/" , `S` , "/" , and `F` can be parsed (in an appropriate lexical context) as a `RegularExpressionLiteral` that behaves identically to the constructed regular expression. For example, if `P` is

"/", then S could be "\/" or "\u002F", among other possibilities, but not "/", because /// followed by F would be parsed as a *SingleLineComment* rather than a *RegularExpressionLiteral*. If P is the empty String, this specification can be met by letting S be "(?:)".

Comment [AWB14190]: Why is this underspecified?
Why not specify an required escaping? Do different implementation differ in their results?

Return S .

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(...args)

`RegExp` called as part of a `new` expression with argument list `args` it performs the following steps:

1. Let F be the `RegExp` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct`(F , `argumentsList`).

If `RegExp` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.10.5 Properties of the RegExp Constructor

The value of the `[[Prototype]]` internal `data` property of the `RegExp` constructor is the standard built-in Function prototype object (15.3.3).

Besides 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` }.

15.10.5.2 RegExp@@create()

The `@@create` method of an object F performs the following:

1. Return the result of calling the abstract operation `RegExpAlloc` with argument F .

This property has the attributes { `[[Writable]]: false`, `[[Enumerable]]: false`, `[[Configurable]]: true` }.

15.10.6 Properties of the RegExp Prototype Object

The `RegExp` prototype object is an ordinary object. It is not a `RegExp` instance and does not have a `[[RegExpMatcher]]` internal data property or any of the other internal data properties of `RegExp` instance objects.

The value of the `[[Prototype]]` internal `data` property of the `RegExp` prototype object is the standard built-in Object prototype object (15.2.4).

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

15.10.6.1 RegExp.prototype.constructor

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

Deleted: The following properties of the newly constructed object are data properties with the attributes that are specified in 15.10.7. The `[[Value]]` of each property is set as follows:
The `source` property of the newly constructed object is set to S .
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 `[[Prototype]]` internal data property of the newly constructed object is set to the standard built-in `RegExp` prototype object as specified in 15.10.6.

The `[[Class]]` internal property of the newly constructed object has an `[[IsRegExpNativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` is set to "`RegExp`".
NOTE If pattern is a `StringLiteral`, the usual escape sequence substitutions are performed before the String is processed by `RegExp`. If pattern must contain an escape sequence to be recognised by `RegExp`, any backslash \ characters must be escaped within the `StringLiteral` to prevent them being removed when the contents of the `StringLiteral` are formed.

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Deleted: The `RegExp` prototype object is itself a regular expression object; it has an `[[IsRegExpNativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` `[[Class]]` is "`RegExp`". The initial values of the `RegExp` prototype object's data properties (15.10.7) are set as if the object was created by the expression `new RegExp`, where `RegExp` is that standard built-in constructor with that name.

Deleted: 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 object for which the value of the `hasOwnProperty` method has an `[[ClassIsRegExpNativeBrandBuiltInBrand]]` internal data property whose value is `NativeRegExpBuiltInRegExp` is not "`RegExp`".

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 *string* did not match.

The String `ToString(string)` is searched for an occurrence of the regular expression pattern as follows:

1. Let *R* be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If *R* does not have a `[[RegExpMatcher]]` internal data property, then throw a `TypeError` exception.
4. If the value of *R*'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let *S* be the value of `ToString(string)`.
6. `ReturnIfAbrupt(S)`.
7. Return the result of the `RegExpExec` abstract operation with arguments *R* and *S*.

Runtime Semantics: `RegExpExec` Abstract Operation

The abstract operation `RegExpExec` with arguments *R* (an object) and *S* (a string) performs the following steps:

1. Assert: *R* is an initialized `RegExp` instance.
2. Let *matcher* be the value of *R*'s `[[RegExpMatcher]]` internal data property.
3. Let *length* be the length of *S*.
4. Let *lastIndex* be the result of `Get(R, "lastIndex")`.
5. Let *i* be the value of `ToInteger(lastIndex)`.
6. `ReturnIfAbrupt(i)`.
7. Let *global* be the result of `ToBoolean(Get(R, "global"))`.
8. `ReturnIfAbrupt(global)`.
9. If *global* is `false`, then let *i* = 0.
10. Let *matchSucceeded* be `false`.
11. Repeat, while *matchSucceeded* is `false`
 - a. If *i* < 0 or *i* > *length*, then
 - i. Let *putStatus* be the result of `Put(R, "lastIndex", 0, true)`.
 - ii. `ReturnIfAbrupt(putStatus)`.
 - iii. Return `null`.
 - b. Let *r* be the result of calling the *matcher* with arguments *S* and *i*.
 - c. If *r* is `failure`, then
 - i. Let *i* = *i* + 1.
 - d. else
 - i. Assert: *r* is a `State`.
 - ii. Set *matchSucceeded* to `true`.
12. Let *e* be *r*'s `endIndex` value.
13. If *global* is `true`,
 - a. Let *putStatus* be the result of `Put(R, "lastIndex", e, true)`.
 - b. `ReturnIfAbrupt(putStatus)`.
14. Let *n* be the length of *r*'s `captures` array. (This is the same value as 15.10.2.1's `NcapturingParens`.)
15. Let *A* be the result of the abstract operation `ArrayCreate` with argument 0.
16. Let *matchIndex* be *i*.
17. Assert: The following `[DefineOwnProperty]` calls will not result in an abrupt completion.
18. Call the `[[DefineOwnProperty]]` internal method of *A* with arguments "`index`" and Property Descriptor `{[[Value]]: matchIndex, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
19. Call the `[[DefineOwnProperty]]` internal method of *A* with arguments "`input`" and Property Descriptor `{[[Value]]: S, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
20. Call the `[[DefineOwnProperty]]` internal method of *A* with arguments "`length`" and Property Descriptor `{[[Value]]: n + 1}`.
21. Let *matchedSubstr* be the matched substring (i.e. the portion of *S* between offset *i* inclusive and offset *e* exclusive).

22. Call the `[[DefineOwnProperty]]` internal method of *A* with arguments `"0"` and Property Descriptor `{[[Value]]: matchedSubstr, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.

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23. For each integer *i* such that *i* > 0 and *i* ≤ *n*

a. Let *captureI* be *i*th element of *r*'s *captures* array.

b. Call the `[[DefineOwnProperty]]` internal method of *A* with arguments `ToString(i)` and Property Descriptor `{[[Value]]: captureI, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.

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24. Return *A*.

15.10.6.3 get RegExp.prototype.global

`RegExp.prototype.global` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let *R* be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If *R* does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
4. Let *flags* be the value of *R*'s `[[OriginalFlags]]` internal data property.
5. If *flags* is `undefined`, then throw a `TypeError` exception.
6. If *flags* contains the character "g", then return `true`.
7. Return `false`.

Deleted: `TypeError`

15.10.6.4 get RegExp.prototype.ignoreCase

`RegExp.prototype.ignoreCase` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let *R* be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If *R* does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
4. Let *flags* be the value of *R*'s `[[OriginalFlags]]` internal data property.
5. If *flags* is `undefined`, then throw a `TypeError` exception.
6. If *flags* contains the character "i", then return `true`.
7. Return `false`.

Deleted: `TypeError`

15.10.6.5 get RegExp.prototype.multiline

`RegExp.prototype.multiline` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let *R* be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If *R* does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
4. Let *flags* be the value of *R*'s `[[OriginalFlags]]` internal data property.
5. If *flags* is `undefined`, then throw a `TypeError` exception.
6. If *flags* contains the character "m", then return `true`.
7. Return `false`.

Deleted: `TypeError`

15.10.6.6 get RegExp.prototype.source

`RegExp.prototype.source` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let *R* be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If *R* does not have a `[[OriginalSource]]` internal data property throw a `TypeError` exception.
4. If *R* does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
5. Let *src* be the value of *R*'s `[[OriginalSource]]` internal data property.
6. Let *flags* be the value of *R*'s `[[OriginalFlags]]` internal data property.
7. If either *src* or *flags* is `undefined`, then throw a `TypeError` exception.

Deleted: `TypeError`

8. Return the result of the abstract operation `EscapeRegExpPattern` with arguments `src` and `flags`.

15.10.6.7 get RegExp.prototype.sticky

`RegExp.prototype.sticky` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `R` be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If `R` does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
4. Let `flags` be the value of `R`'s `[[OriginalFlags]]` internal data property.
5. If `flags` is `undefined`, then throw a `TypeError` exception.
6. If `flags` contains the character "`y`", then return `true`.
7. Return `false`.

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Deleted: `TypeError`

15.10.6.8 RegExp.prototype.test(string)

The following steps are taken:

1. Let `R` be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If `R` does not have a `[[RegExpMatcher]]` internal data property, then throw a `TypeError` exception.
4. If the value of `R`'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let `S` be the value of `ToString(string)`.
6. `ReturnIfAbrupt(S)`.
7. Let `match` be the result of the `RegExpExec` abstract operation with arguments `R` and `S`.
8. `ReturnIfAbrupt(match)`.
9. If `match` is not null, then return `true`; else return `false`.

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Deleted: <#>Let `R` be this `RegExp` object.
<#>ReturnIfAbrupt(`R`).¶

Deleted: abstraction operation

Deleted: evaluating the
`RegExp.prototype.exec` (15.10.6.2)
algorithm upon this `RegExp` object using `string` as
the argument

15.10.6.9 get RegExp.prototype.unicode

`RegExp.prototype.unicode` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `R` be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If `R` does not have a `[[OriginalFlags]]` internal data property throw a `TypeError` exception.
4. Let `flags` be the value of `R`'s `[[OriginalFlags]]` internal data property.
5. If `flags` is `undefined`, then throw a `TypeError` exception.
6. If `flags` contains the character "`u`", then return `true`.
7. Return `false`.

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Deleted: `SameValue(unicode, "u")`

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Deleted: `SameValue(ignoreCase, "i")`

15.10.6.10 RegExp.prototype.toString()

1. Let `R` be the `this` value.
2. If `Type(R)` is not `Object`, then throw a `TypeError` exception.
3. If `R` does not have a `[[RegExpMatcher]]` internal data property, then throw a `TypeError` exception.
4. If the value of `R`'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let `pattern` be the result of `ToString(Get(R, "source"))`.
6. `ReturnIfAbrupt(pattern)`.
7. Let `result` be the `String` value formed by concatenating `"/"`, `pattern`, and `"/"`.
8. Let `global` be the result of `ToBoolean(Get(R, "global"))`.
9. `ReturnIfAbrupt(global)`.
10. If `global` is `true`, then append `"g"` as the last character of `result`.
11. Let `ignoreCase` be the result of `ToBoolean(Get(R, "ignoreCase"))`.
12. `ReturnIfAbrupt(ignoreCase)`.
13. If `ignoreCase` is `true`, then append `"i"` as the last character of `result`.

14. Let `multiline` be the result of `ToBoolean(Get(R, "multiline"))`.
15. `ReturnIfAbrupt(multiline)`.
16. If `multiline` is `true`, then append "`m`" as the last character of `result`.
17. Let `unicode` be the result of `ToBoolean(Get(R, "unicode"))`.
18. `ReturnIfAbrupt(unicode)`.
19. If `unicode` is `true`, then append "`u`" as the last character of `result`.
20. Let `sticky` be the result of `ToBoolean(Get(R, "sticky"))`.
21. `ReturnIfAbrupt(sticky)`.
22. If `sticky` is `true`, then append "`y`" as the last character of `result`.
23. `Return result`.

Deleted: `SameValue(multiline, "m")`

NOTE The returned String has the form of a *RegularExpressionLiteral* that evaluates to another RegExp object with the same behaviour as this object.

15.10.6.11 `RegExp.prototype.match (string)`

When the `match` method is called with argument `string`, the following steps are taken:

1. Let `rx` be the `this` value.
2. If `Type(rx)` is not `Object`, then throw a **TypeError** exception.
3. If `rx` does not have a `[[RegExpMatcher]]` internal data property, then throw a **TypeError** exception.
4. If the value of `rx`'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a **TypeError** exception.
5. Let `S` be the value of `ToString(string)`.
6. `ReturnIfAbrupt(S)`.
7. Let `global` be the result of `ToBoolean(Get(rx, "global"))`.
8. `ReturnIfAbrupt(global)`.
9. If `global` is not `true`, then
 - a. Return the result of calling the abstract operation `RegExpExec` (see 15.10.6.2) with arguments `rx` and `S`.
10. Else `global` is `true`.
 - a. Let `putStatus` be the result of `Put(rx, "lastIndex", 0, true)`.
 - b. `ReturnIfAbrupt(putStatus)`.
 - c. Let `A` be the result of the abstract operation `ArrayCreate` with argument `0`.
 - d. Let `previousLastIndex` be `0`.
 - e. Let `n` be `0`.
 - f. Let `lastMatch` be `true`.
 - g. Repeat, while `lastMatch` is `true`
 - i. Let `result` be the result of the abstract operation `RegExpExec` with arguments `rx` and `S`.
 - ii. `ReturnIfAbrupt(result)`.
 - iii. If `result` is `null`, then set `lastMatch` to `false`.
 - iv. Else `result` is not `null`.
 1. Let `thisIndex` be the result of `ToInteger(Get(rx, "lastIndex"))`.
 2. `ReturnIfAbrupt(thisIndex)`.
 3. If `thisIndex = previousLastIndex` then
 - a. Let `putStatus` be the result of `Put(rx, "lastIndex", thisIndex+1, true)`.
 - b. `ReturnIfAbrupt(putStatus)`.
 - c. Set `previousLastIndex` to `thisIndex+1`.
 4. Else,
 - a. Set `previousLastIndex` to `thisIndex`.
 5. Let `matchStr` be the result of `Get(result, "0")`.
 6. Let `defineStatus` be the result of `DefinePropertyOrThrow(A, ToString(n), PropertyDescriptor {[[Value]]: matchStr, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true})`.
 7. `ReturnIfAbrupt(defineStatus)`.
 8. Increment `n`.
 - h. If `n = 0`, then return `null`.
 - i. Return `A`.

Deleted: `SameValue(global, "y")`

Deleted: Return the String value formed by concatenating the Strings "/" , the String value of the `source` property of this `RegExp` object, and "/" ; plus "g" if the `global` property is `true`, "i" if the `ignoreCase` property is `true`, and "m" if the `multiline` property is `true`. ¶

15.10.6.12 RegExp.prototype.replace (S, replaceValue)

When the `replace` method is called with arguments *S* and *replaceValue* the following steps are taken:

TODO: need to finish this and have it make use of **GetReplaceSubstitution** operation in 15.5.4.11

1. Let *rx* be the `this` value.
2. If `Type(rx)` is not `Object`, then throw a **TypeError** exception.
3. If *rx* does not have a `[[RegExpMatcher]]` internal data property, then throw a **TypeError** exception.
4. If the value of *rx*'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a **TypeError** exception.
5. Let *string* be `ToString(S)`.
6. `ReturnIfAbrupt(string)`.
7. 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 **RegExp.prototype.match**, including the update of *searchValue.lastIndex*. Let *m* be the number of left capturing parentheses in *searchValue* (using *NcapturingParens* as specified in 15.10.2.1).
8. If *replaceValue* is a function, then
 - a. 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.
9. Else.

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 elements in *newstring* by replacement text as specified in Table 34.

 - a. Table 34. 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(/(\$(\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.

15.10.6.13 RegExp.prototype.search (S)

When the `search` method is called with argument *S*, the following steps are taken:

1. Let *rx* be the `this` value.
2. If `Type(rx)` is not `Object`, then throw a **TypeError** exception.
3. If *rx* does not have a `[[RegExpMatcher]]` internal data property, then throw a **TypeError** exception.
4. If the value of *rx*'s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a **TypeError** exception.
5. Let *string* be `ToString(S)`.
6. `ReturnIfAbrupt(string)`.
7. Search the value *string* from its beginning for an occurrence of the regular expression pattern *rx*. Let *result* be a Number indicating the offset within *string* where the pattern matched, or `-1` if there was no match. If an abrupt completion occurs during the search, *result* is that Completion Record. The `lastIndex` and `global` properties of *regexp* are ignored when performing the search. The `lastIndex` property of *regexp* is left unchanged.
8. Return *result*.

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Table 33

Comment [AWB7191]: Needs an real algorithm and also completion record checks

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Comment [AWB7192]: Needs better spec language

15.10.6.14 RegExp.prototype.split (string, limit)

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Returns an Array object into which substrings of the result of converting *string* to a String have been stored. The substrings are determined by searching from left to right for matches of the *this* value regular expression; these occurrences are not part of any substring in the returned array, but serve to divide up the String value.

The *this* value may be an empty regular expression or a regular expression that can match an empty String. In this case, regular expression 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 the regular expression matches the empty String, the String is split up into individual code unit elements: the length of the result array equals the length of the String, and each substring contains one code unit.) 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, `/a*?/.split("ab")` evaluates to the array `["a", "b"]`, while `/a*/.split("ab")` evaluates to the array `["", "b"]`.)

If the *string* is (or converts to) the empty String, the result depends on whether the regular expression 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 the 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,

`/<(\w/)?([^\w>]+)>/.split("Aboldand<CODE>coded</CODE>")`

evaluates to the array

`["A", undefined, "B", "bold", "/", "B", "and", undefined,
"CODE", "coded", "/", "CODE", ""]`

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 *rx* be the *this* value.
2. If *Type(rx)* is not Object, then throw a **TypeError** exception.
3. If *rx* does not have a *[[RegExpMatcher]]* internal data property, then throw a **TypeError** exception.
4. If the value of *rx*'s *[[RegExpMatcher]]* internal data property is *undefined*, then throw a **TypeError** exception.
5. Let *matcher* be the value of *rx*'s *[[RegExpMatcher]]* internal data property.
6. Let *S* be *ToString(string)*.
7. ReturnIfAbrupt(*S*).
8. Let *A* be the result of the abstract operation *ArrayCreate* with argument 0.
9. ReturnIfAbrupt(*A*).
10. Let *lengthA* be 0.
11. If *limit* is *undefined*, let *lim* = $2^{32}-1$; else let *lim* = *ToUint32(limit)*.
12. Let *s* be the number of elements in *S*.
13. Let *p* = 0.
14. If *lim* = 0, return *A*.
15. If *s* = 0, then

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- a. Let *z* be the result of calling the *matcher* with arguments *S* and 0.
- b. ReturnIfAbrupt(*z*).
- c. If *z* is not *failure*, return *A*.
- d. Call the *[[DefineOwnProperty]]* internal method of *A* with arguments "0" and Property Descriptor `{[[Value]]: S, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
- e. Assert: the previous step will never result in an abrupt completion.
- f. Return *A*.

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16. Let *q* = *p*.
17. Repeat, while *q* ≠ *s*
 - a. Let *z* be the result of calling the *matcher* with arguments *S* and *q*.
 - b. ReturnIfAbrupt(*z*).
 - c. If *z* is *failure*, then let *q* = *q*+1.

- d. Else z is not **failure**.
- i. z must be a State. Let e be z 's *endIndex* and let cap be z 's *captures* array.
 - ii. If $e = p$, then let $q = q + 1$.
 - iii. Else $e \neq p$.
 1. Let T be a String value equal to the substring of S consisting of the elements at positions p (inclusive) through q (exclusive).
 2. Call the **[[DefineOwnProperty]]** internal method of A with arguments `ToString(lengthA)` and Property Descriptor `{[[Value]]: T, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 3. Assert: the previous step will never result in an abrupt completion.
 4. Increment $lengthA$ by 1.
 5. If $lengthA = lim$, return A .
 6. Let $p = e$.
 7. Let $i = 0$.
 8. Repeat, while i is not equal to the number of elements in cap .
 - a. Let $i = i + 1$.
 - b. Call the **[[DefineOwnProperty]]** internal method of A with arguments `ToString(lengthA)` and Property Descriptor `{[[Value]]: cap[i], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - c. Assert: the previous step will never result in an abrupt completion.
 - d. Increment $lengthA$ by 1.
 - e. If $lengthA = lim$, return A .
9. Let $q = p$.
18. Let T be a String value equal to the substring of S consisting of the elements at positions p (inclusive) through s (exclusive).
19. Call the **[[DefineOwnProperty]]** internal method of A with arguments `ToString(lengthA)` and Property Descriptor `{[[Value]]: T, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
20. Assert: the previous step will never result in an abrupt completion.
21. Return A .

The **length** property of the **split** method is **2**.

NOTE 1 The **split** method ignores the value of the **global** property of this **RegExp** object.

15.10.6.15 RegExp.prototype.@@isRegExp

The initial value of the **@@isRegExp** property is **true**.

15.10.7 Properties of RegExp Instances

RegExp instances are ordinary objects that inherit properties from the **RegExp** prototype object. **RegExp** instances have internal data properties **[[RegExpMatcher]], [[OriginalSource]], and [[OriginalFlags]]**. The value of the **[[RegExpMatcher]]** internal data property is an implementation dependent representation of the **Pattern** of the **RegExp** object.

RegExp instances also have the following properties.

15.10.7.1 lastIndex

The value of the **lastIndex** property specifies the String position at which to start the next match. It is coerced to an integer when used (see 15.10.6.2). This property shall have the attributes `{ [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }`.

NOTE Unlike the other standard built-in properties of **RegExp** instances, **lastIndex** is writable.

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.

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Deleted: whose value is NativeRegExpBuiltinRegExp value is "RegExp". RegExp instances also have a [[Match]]
Deleted: internal data property and a length property.
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Deleted: [[Match]]
Deleted: 15.10.7.1 source The value of the source property is a String in the form of a Pattern representing the current regular expression. This property shall have the attributes <code>{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }</code> .
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 <code>{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }</code> .
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 <code>{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }</code> .
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 <code>{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }</code> .
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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 generally equivalent to the object creation expression `new Error(...)` with the same arguments. However, if the `this` value passed in the call is an Object with an uninitialized `[[ErrorData]]` internal data property, it initializes the `this` value using the argument value rather than creating a new object. This permits `Error` to be used both as factory method and to perform constructor instance initialization.

`Error` may be subclassed and subclass constructors may perform a super invocation of the `Error` constructor to initialize subclass instances.

15.11.1.1 Error (message)

The following steps are taken:

1. Let `func` be this `Error` function object.
2. Let `O` be the `this` value.
3. If `Type(O)` is not `Object` or `Type(O)` is `Object` and `O` does not have an `[[ErrorData]]` internal data property or `Type(O)` is `Object` and `O` has an `[[ErrorData]]` internal data property and the value of `[[ErrorData]]` is not `undefined`, then
 - a. Let `O` be the result of calling `OrdinaryCreateFromConstructor(func, "%ErrorPrototype%", [[ErrorData]])`.
 - b. `ReturnIfAbrupt(O)`.
4. Assert: `Type(O)` is `Object`.
5. Set the value of `O`'s `[[ErrorData]]` internal data property to any value other than `undefined`.
6. If `message` is not `undefined`, then
 - a. Let `msg` be `ToString(message)`.
 - b. `ReturnIfAbrupt(msg)`.
 - c. Let `msgDesc` be the Property Descriptor.
 - `[[Value]]: msg, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true`
 - d. Let `status` be the result of calling the `[[DefineOwnProperty]]` internal method of `O` passing `"message"` and `msgDesc` as arguments.
 - e. `ReturnIfAbrupt(status)`.
 - f. If `status` is `false`, then throw a `TypeError` exception.
7. Return `O`.

15.11.2 The Error Constructor

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

15.11.2.1 new Error(... args)

When `Error` called as part of a new expression with argument list `args` it performs the following steps:

1. Let `F` be the `Error` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `Error` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.11.3 Properties of the Error Constructor

The value of the `[[Prototype]]` internal data property of the `Error` constructor is the Function prototype object (15.3.3).

Comment [AWB14193]: This then clause corresponds to the "called as a function" case in the ES5 spec.

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Deleted: <#>Let `status` be the result of `CreateOwnDataProperty(O, "message", msg)`. ¶

Deleted: The `[[Prototype]]` internal data 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]]` internal property of the newly constructed object is set to `"Error"` has an `[[IsErrorNativeBrandBuiltinBrand]]` internal data property whose value is `NativeErrorBuiltinError`. ¶ The `[[Extensible]]` internal data property of the newly constructed object is set to `true`. ¶ If the argument `message` is not `undefined`, the `message` own property of the newly constructed object is set to `ToString(message)`. ¶

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Deleted: 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]]` internal data 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]]` internal property of the newly constructed `Error` object has an `[[IsErrorNativeBrandBuiltinBrand]]` internal data property whose value is `NativeErrorBuiltinError` is set to `"Error"`. ¶

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

If the argument `message` is not `undefined`, the `message` own property of the newly constructed object is set to `ToString(message)`. ¶

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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` }.

15.11.3.2 `Error[@@create]`

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%ErrorPrototype%", ([[ErrorData]]))`.
3. Return `obj`.

This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true` }.

NOTE `[[ErrorData]]` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the `Boolean` constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

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15.11.4 Properties of the Error Prototype Object

The `Error` prototype object is an ordinary object. It is not an `Error` instance and does not have an `[[ErrorData]]` internal data property.

The value of the `[[Prototype]]` internal `data` property of the `Error` prototype object is the standard built-in `Object` prototype object (15.2.4).

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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 the empty String.

15.11.4.4 `Error.prototype.toString()`

The following steps are taken:

1. Let `O` be the `this` value.
2. If `Type(O)` is not `Object`, throw a `TypeError` exception.
3. Let `name` be the result of `Get(O, "name")`.
4. `ReturnIfAbrupt(name)`.
5. If `name` is `undefined`, then let `name` be "Error"; else let `name` be `ToString(name)`.
6. Let `msg` be the result of `Get(O, "message")`.
7. `ReturnIfAbrupt(msg)`.
8. If `msg` is `undefined`, then let `msg` be the empty String; else let `msg` be `ToString(msg)`.
9. If `name` is the empty String, return `msg`.
10. If `msg` is the empty String, return `name`.
11. Return the result of concatenating `name`, ":" , a single space character, and `msg`.

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Deleted: <#>If `msg` is undefined, then let `msg` be the empty String; else let `msg` be `ToString(msg)`.

15.11.5 Properties of Error Instances

Error instances are ordinary objects that inherit properties from the Error prototype object and have a `[[ErrorData]]` internal data property whose initial value is `undefined`. The only specified uses of `[[ErrorData]]` is to flag whether or not an Error instance has been initialized by the Error constructor and to identify them as Error objects within `Object.prototype.toString`.

15.11.6 Native Error Types Used in This Standard

One of the `BuiltinError` 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

This exception is not currently used within this specification. This object remains for compatibility with previous editions of this specification.

15.11.6.2 RangeError

Indicates a numeric value has exceeded the allowable range. See 15.4.2.2, 15.4.5.1, 15.7.4.2, 15.7.4.5, 15.7.4.6, 15.7.4.7, and 15.9.5.43.

15.11.6.3 ReferenceError

Indicate that an invalid reference value has been detected. See 8.9.1, 8.9.2, 10.2.1, 10.2.1.1.4, 10.2.1.2.4, and 11.13.1.

15.11.6.4 SyntaxError

Indicates that a parsing error has occurred. See 11.1.5, 11.3.1, 11.3.2, 11.4.1, 11.4.4, 11.4.5, 11.13.1, 11.13.2, 12.2.1, 12.10.1, 12.14.1, 13.1, 15.1.2.1, 15.3.2.1, 15.10.2.2, 15.10.2.5, 15.10.2.9, 15.10.2.15, 15.10.2.19, 15.10.4.1, and 15.12.2.

15.11.6.5 TypeError

Indicates the actual type of an operand is different than the expected type. See 8.6.2, 8.9.2, 8.10.5, 8.12.5, 8.12.7, 8.12.8, 8.12.9, 9.9, 9.10, 10.2.1, 10.2.1.1.3, 10.6, 11.2.2, 11.2.3, 11.4.1, 11.8.6, 11.8.7, 11.3.1, 13.2, 13.2.3, 15, 15.2.3.2, 15.2.3.3, 15.2.3.4, 15.2.3.5, 15.2.3.6, 15.2.3.7, 15.2.3.8, 15.2.3.9, 15.2.3.10, 15.2.3.11, 15.2.3.12, 15.2.3.13, 15.2.3.14, 15.2.4.3, 15.3.3.2, 15.3.3.3, 15.3.3.4, 15.3.3.5, 15.3.3.5.2, 15.3.3.5.3, 15.3.4, 15.3.4.3, 15.3.4.4, 15.4.3.3, 15.4.3.11, 15.4.3.16, 15.4.3.17, 15.4.3.18, 15.4.3.19, 15.4.3.20, 15.4.3.21, 15.4.3.22, 15.4.5.1, 15.5.4.2, 15.5.4.3, 15.6.4.2, 15.6.4.3, 15.7.4, 15.7.4.2, 15.7.4.4, 15.9.5, 15.9.5.44, 15.10.4.1, 15.10.6, 15.11.4.4 and 15.12.3.

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.

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- ~~Deleted: . Error instances have no special properties~~
- ~~Deleted: NativeError~~

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. However, if the `this` value passed in the call is an Object with an uninitialized `[[ErrorData]]` internal data property, it initializes the `this` value using the argument value. This permits `Error` to be used both as factory method and to perform constructor instance initialization.

A `NativeError` constructor may be subclassed and subclass constructors may perform a super invocation of the `NativeError` constructor to initialize subclass instances.

15.11.7.1.1 NativeError (message)

1. Let `func` be this `NativeError` function object.
2. Let `O` be the `this` value.
3. If `Type(O)` is not Object or `Type(O)` is Object and `O` does not have an `[[ErrorData]]` internal data property or `Type(O)` is Object and `O` has an `[[ErrorData]]` internal data property and the value of `[[ErrorData]]` is not `undefined`, then
 - a. Let `O` be the result of calling `OrdinaryCreateFromConstructor(func, "%NativeErrorPrototype%", [[ErrorData]])`.
 - b. ReturnIfAbrupt(`O`).
4. Assert: `Type(O)` is Object.
5. Set the value of `O`'s `[[ErrorData]]` internal data property to any value other than `undefined`.
6. If `message` is not `undefined`, then
 - a. Let `msg` be `ToString(message)`.
 - b. Let `msgDesc` be the Property Descriptor, `{[[Value]]: msg, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}`.
 - c. Let `status` be the result of calling the `[[DefineOwnProperty]]` internal method of `O` passing `"message"` and `msgDesc` as arguments.
 - d. ReturnIfAbrupt(`status`).
 - e. If `status` is `false`, then throw a `TypeError` exception.
7. Return `O`.

The actual value of the string passed in step 3.a is either `%EvalErrorPrototype%`, `%RangeErrorPrototype%`, `%ReferenceErrorPrototype%`, `%SyntaxErrorPrototype%`, `%TypeErrorPrototype%`, or `%URIErrorPrototype%` corresponding to which `NativeError` constructor is being defined.

15.11.7.2 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.

15.11.7.2.1 new NativeError (... args)

When a `NativeError` constructor is called as part of a `new` expression with argument list `args` it performs the following steps:

1. Let `F` be this `NativeError` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If a `NativeError` constructor is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

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Comment [AWB14195]: This then clause corresponds to the "called as a function" case of the ES5 spec.

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<#>Let `status` be the result of CreateOwnDataProperty(`O`, `"message"`, `msg`).¶

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If the argument `message` is not `undefined`, the `message` own property of the newly constructed object is set to `ToString(message)`.¶

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15.11.7.3 Properties of the *NativeError* Constructors

The value of the `[[Prototype]]` internal `data` property of a *NativeError* constructor is the `Error` constructor object (15.11.1).

Besides the `length` property (whose value is `1`), each *NativeError* constructor has the following property:

15.11.7.3.1 *NativeError.prototype*

The initial value of `NativeError.prototype` is a *NativeError* prototype object (15.11.7.4). Each *NativeError* constructor has a separate prototype object.

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

15.11.7.3.2 *NativeError* [@@create] ()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, NativeErrorPrototype, (||ErrorData||))`.
3. Return `obj`.

The actual value passed as `NativeErrorPrototype` in step 2 is either `"%EvalErrorPrototype%"`, `"%RangeErrorPrototype%"`, `"%ReferenceErrorPrototype%"`, `"%SyntaxErrorPrototype%"`, `"%TypeErrorPrototype%"`, or `"%URIErrorPrototype%"` corresponding to which *NativeError* constructor is being defined.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

NOTE `||ErrorData||` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the `Boolean` constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.11.7.4 Properties of the *NativeError* Prototype Objects

Each *NativeError* prototype object is an ordinary object. It is not an Error instance and does not have an `||ErrorData||` internal data property.

The value of the `[[Prototype]]` internal `data` property of each *NativeError* prototype object is the standard built-in `Error` prototype object (15.11.4).

15.11.7.4.1 *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).

15.11.7.4.2 *NativeError.prototype.name*

The initial value of the `name` property of the prototype for a given *NativeError* constructor is a string consisting of the name of the constructor (the name used instead of *NativeError*).

15.11.7.4.3 *NativeError.prototype.message*

The initial value of the `message` property of the prototype for a given *NativeError* constructor is the empty String.

Deleted: The `[[Prototype]]` internal data property of the newly constructed object is set to the prototype object of this *NativeError* constructor. The `[[Class]]` internal property of the newly constructed object has an `||IsErrorNativeBrandBuiltinBrand||` internal data property whose value is `NativeErrorBuiltinError` is set to `"Error"`. The `[[Extensible]]` internal data property of the newly constructed object is set to `true`. If the argument `message` is not `undefined`, the `message` own property of the newly constructed object is set to `ToString(message)`.

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15.11.7.5 Properties of *NativeError* Instances

NativeError instances are ordinary objects that inherit properties from their *NativeError* prototype object and have a `[[ErrorData]]` internal data property whose initial value is `undefined`. The only specified use of `[[ErrorData]]` is to flag whether or not an *Error* or *NativeError* instance has been initialized by its constructor.

15.12 The JSON Object

The **JSON** object is a single ordinary 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>>. The JSON interchange format used in this specification is exactly that described by RFC 4627 with two exceptions:

- The top level *JSONText* production of the ECMAScript JSON grammar may consist of any *JSONValue* rather than being restricted to being a *JSONObject* or a *JSONArray* as specified by RFC 4627.
- Conforming implementations of **JSON.parse** and **JSON.stringify** must support the exact interchange format described in this specification without any deletions or extensions to the format. This differs from RFC 4627 which permits a JSON parser to accept non-JSON forms and extensions.

The value of the `[[Prototype]]` internal data property of the **JSON** object is the standard built-in **Object** prototype object (15.2.4). The **JSON** object has a `[[JSONTag]]` internal data property whose value is `true`. The value of the `[[Extensible]]` internal data property of the **JSON** object is set to `true`.

The **JSON** object does not have a `[[Construct]]` internal method; it is not possible to use the **JSON** object as a constructor with the `new` operator.

The **JSON** object does not have a `[[Call]]` internal method; it is not possible to invoke the **JSON** object as a function.

15.12.1 The JSON Grammar

JSON.stringify produces a String that conforms to the following JSON grammar. **JSON.parse** accepts a String that conforms to the JSON grammar.

15.12.1.1 The JSON Lexical Grammar

JSON is similar to ECMAScript source text in that it consists of a sequence of Unicode characters conforming to the rules of *SourceCharacter*. The JSON Lexical Grammar defines the tokens that make up a JSON text similar to the manner that the ECMAScript lexical grammar defines the tokens of an ECMAScript source text. The JSON Lexical grammar only recognises the white space character specified by the production *JSONWhiteSpace*. The JSON lexical grammar shares some productions with the ECMAScript lexical grammar. All nonterminal symbols of the grammar that do not begin with the characters "JSON" are defined by productions of the ECMAScript lexical grammar.

Syntax

```

JSONWhiteSpace ::=
    <TAB>
    <CR>
    <LF>
    <SP>

JSONString ::=
    " JSONStringCharactersopt "

JSONStringCharacters ::=
    JSONStringCharacter JSONStringCharactersopt

JSONStringCharacter ::=

```

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*SourceCharacter but not one of " or \ or U+0000 through U+001F
 \ JSONEscapeSequence*

*JSONEscapeSequence ::
 JSONEscapeCharacter
 \ HexDigit HexDigit HexDigit HexDigit*

Deleted: *UnicodeEscapeSequence*

*JSONEscapeCharacter :: one of
 " / \ b f n r t*

*JSONNumber ::
 -_{opt} DecimalIntegerLiteral JSONFraction_{opt} ExponentPart_{opt}*

*JSONFraction ::
 . DecimalDigits*

*JSONNullLiteral ::
 NullLiteral*

*JSONBooleanLiteral ::
 BooleanLiteral*

15.12.1.2 The JSON Syntactic Grammar

The JSON Syntactic Grammar defines a valid JSON text in terms of tokens defined by the JSON lexical grammar. The goal symbol of the grammar is *JSONText*.

Syntax

JSONText :
JSONValue

JSONValue :
JSONNullLiteral
JSONBooleanLiteral
JSONObject
JSONArray
JSONString
JSONNumber

JSONObject :
 { }
 { *JSONMemberList* }

JSONMember :
JSONString : *JSONValue*

JSONMemberList :
JSONMember
JSONMemberList , *JSONMember*

JSONArray :
 []
 [*JSONElementList*]

JSONElementList :
JSONValue
JSONElementList , *JSONValue*

15.12.2 `JSON.parse (text [, reviver])`

The `parse` function parses a JSON text (a JSON-formatted String) and produces an 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` and allows Unicode code points U+2028 and U+2029 to directly appear in `JSONString` literals without using an escape sequence. The process of parsing is similar to 11.1.4 and 11.1.5 as constrained by the JSON grammar.

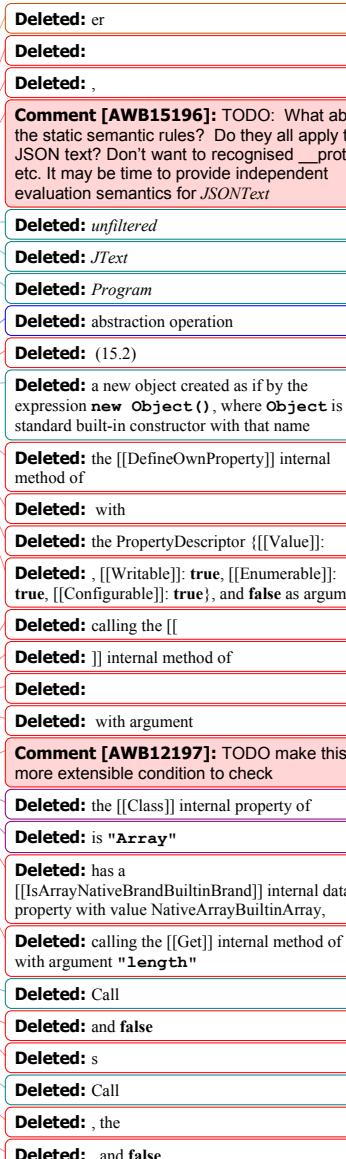
The optional `reviver` parameter is a function that takes two parameters, `(key and value)`. It can filter and transform the results. It is called with each of the `key/value` pairs produced by the `parse`, and its return value is used instead of the original value. If it returns what it received, the structure is not modified. If it returns `undefined` then the property is deleted from the result.

1. Let `JText` be `ToString(text)`.
2. `ReturnIfAbrupt(text)`.
3. Parse `JText` interpreted as UTF-16 encoded Unicode characters using the grammars in 15.12.1. Throw a `SyntaxError` exception if `JText` did not conform to the JSON grammar for the goal symbol `JSONText`.
4. Let `scriptText` be the result of concatenating `"(", JText, and ")"; ".`
5. Let `completion` be the result of parsing and evaluating `scriptText` as if it was the source text of an ECMAScript `Script` but using `JSONString` in place of `StringLiteral`. Note that since `JText` conforms to the JSON grammar this result will be either a primitive value or an object that is defined by either an `ArrayLiteral` or an `ObjectLiteral`.
6. Let `unfiltered` be `completion [[value]]`.
7. If `IsCallable(reviver)` is `true`, then
 - a. Let `root` be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
 - b. Call CreateOwnProperty(`root`, the empty String, `unfiltered`).
 - c. Return the result of calling the abstract operation `Walk`, passing `root` and the empty String. The abstract operation `Walk` is described below.
8. Else
 - a. Return `unfiltered`.

Runtime Semantics: Walk Abstract Operation

The abstract operation `Walk` is a recursive abstract operation that takes two parameters: a `holder` object and the String `name` of a property in that object. `Walk` uses the value of `reviver` that was originally passed to the above `parse` function.

1. Let `val` be the result of `Get(holder, name)`.
2. `ReturnIfAbrupt(val)`.
3. If `val` is an object, then
 - a. If `val` is an exotic Array object then
 - i. Set `I` to 0.
 - ii. Let `len` be the result of `Get(val, "length")`.
 - iii. Assert: `len` is not an abrupt completion and its value is a positive integer.
 - iv. Repeat while `I < len`,
 1. Let `newElement` be the result of calling the abstract operation `Walk`, passing `val` and `ToString(I)`.
 2. If `newElement` is `undefined`, then
 - a. Let `status` be the result of calling the `[[Delete]]` internal method of `val` with `ToString(I)` as the argument.
 3. Else
 - a. Let `status` be the result of calling the `[[DefineOwnProperty]]` internal method of `val` with arguments `ToString(I)` and Property Descriptor `{[[Value]]: newElement, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
 - b. NOTE The above is intentionally not a strict define and does not throw if `status` is `false`.



4. `ReturnIfAbrupt(status).`
5. Add 1 to I .

- b. Else
- i. Let $keys$ be an internal List of String values consisting of the names of all the own properties of val whose $[[Enumerable]]$ attribute is **true**. The ordering of the Strings is the same as that used by the **Object.keys** standard built-in function.
 - ii. For each String P in $keys$ do,
 1. Let $newElement$ be the result of calling the abstract operation `Walk`, passing val and P .
 2. If $newElement$ is **undefined**, then
 - a. Let $status$ be the result of calling the $[[Delete]]$ internal method of val with P as the argument.
 3. Else
 - a. Let $status$ be the result of calling the $[[DefineOwnProperty]]$ internal method of val with arguments P and Property Descriptor $\{[[Value]]: newElement, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true\}$.
 - b. NOTE The above is intentionally not a strict define and does not throw if $status$ is **false**.
4. `ReturnIfAbrupt(status).`

4. Return the result of calling the $[[Call]]$ internal method of $reviver$ passing $holder$ as $thisArgument$ and with a List containing $name$ and val as $argumentsList$.

It is not permitted for a conforming implementation of **JSON.parse** to extend the JSON grammars. If an implementation wishes to support a modified or extended JSON interchange format it must do so by defining a different parse function.

NOTE In the case where there are duplicate name Strings within an object, lexically preceding values for the same key shall be overwritten.

15.12.3 **JSON.stringify (value [, replacer [, space]]**

The **stringify** function returns a String in UTF-16 encoded JSON format representing an ECMAScript value. It can take three parameters. The **value** parameter is an ECMAScript value, which 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 and Numbers that acts as a white list for selecting the object properties 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.

Deleted: The first parameter is required.

These are the steps in stringifying an object:

1. Let $stack$ be an empty List.
2. Let $indent$ be the empty String.
3. Let $PropertyList$ and $ReplacerFunction$ be **undefined**.
4. If $Type(replacer)$ is Object, then
 - a. If $IsCallable(replacer)$ is **true**, then
 - i. Let $ReplacerFunction$ be $replacer$.
 - b. Else if $replacer$ is an exotic Array object, then
 - i. Let $PropertyList$ be an empty internal List.
 - ii. For each value v of a property of $replacer$ that has an array index property name. The properties are enumerated in the ascending array index order of their names.
 1. Let $item$ be **undefined**.
 2. If $Type(v)$ is String then let $item$ be v .
 3. Else if $Type(v)$ is Number then let $item$ be $ToString(v)$.
 4. Else if $Type(v)$ is Object then,
 - a. If v has a $[[StringData]]$ or $[[NumberData]]$ internal data property, then let $item$ be $ToString(v)$.
 5. If $item$ is not **undefined** and $item$ is not currently an element of $PropertyList$ then,
 - a. Append $item$ to the end of $PropertyList$.
 5. If $Type(space)$ is Object then,

- Deleted:** the $[[Class]]$ internal property of
Deleted: has a $[[IsArrayNativeBrandBuiltinBrand]]$ internal data property with value NativeArrayBuiltinArray
Deleted: is "Array"
Deleted: the $[[Class]]$ internal property of
Deleted: is "String" or "Number"
Deleted: either
Deleted: n
Deleted: IsString
Deleted: NativeBrand
Deleted: or an $[[IsNumber]]$
Deleted: whose value is either StringWrapper or NumberWrapper

- a. If *space* has a **[[NumberData]]** internal data property, then,
 - i. Let *space* be *ToNumber*(*space*).
- b. Else if *space* has a **[[StringData]]** internal data property, then,
 - i. Let *space* be *ToString*(*space*).
6. If *Type*(*space*) is Number
 - a. Let *space* be *min*(10, *ToInteger*(*space*)).
 - b. Set *gap* to a String containing *space* occurrences of code unit 0x0020 (the Unicode space character). This will be the empty String if *space* is less than 1.
7. Else if *Type*(*space*) is String
 - a. If the number of elements in *space* is 10 or less, set *gap* to *space* otherwise set *gap* to a String consisting of the first 10 elements of *space*.
8. Else
 - a. Set *gap* to the empty String.
9. Let *wrapper* be the result of the abstract operation *ObjectCreate* with the intrinsic object **%ObjectPrototype%** as its argument.
10. *Call CreateOwnProperty*(*wrapper*, the empty String, *value*).
11. Return the result of calling the abstract operation *Str* with the empty String and *wrapper*.

Deleted: the **[[Class]]** internal property of
Deleted: *IsNumber*
Deleted: *NativeBrand*
Deleted: *is "Number"*
Deleted: the **[[Class]]** internal property of
Deleted: *IsString*
Deleted: *NativeBrand*
Deleted: *is "String"*
Deleted: *occurrences*
Deleted: *characters*
Deleted: characters ...lements in *space* is 10 or
Deleted: be ...he result of the abstraction opera
Deleted: (15.2)
Deleted: a new object created as if by the expression **new Object()**, where **Object** is the standard built-in constructor with that name
Deleted: Call the **[[DefineOwnProperty]]** internal method of *wrapper* with arguments the ... the em

Runtime Semantics: Str Abstract Operation

The abstract operation *Str*(*key*, *holder*) has access to *ReplacerFunction* from the invocation of the **stringify** method. Its algorithm is as follows:

1. Let *value* be the result of *Get*(*holder*, *key*).
2. *ReturnIfAbrupt*(*value*).
3. If *Type*(*value*) is Object, then
 - a. Let *toJSON* be the result of *Get*(*value*, **"toJSON"**).
 - b. If *IsCallable*(*toJSON*) is true
 - i. Let *value* be the result of calling the **[[Call]]** internal method of *toJSON* passing *value* as *thisArgument* and a List containing *key* as *argumentsList*.
 - ii. *ReturnIfAbrupt*(*value*).
4. If *ReplacerFunction* is not **undefined**, then
 - a. Let *value* be the result of calling the **[[Call]]** internal method of *ReplacerFunction* passing *holder* as the **this** value and with an argument list consisting of *key* and *value*.
 - b. *ReturnIfAbrupt*(*value*).
5. If *Type*(*value*) is Object then,
 - a. If *value* has an **[[NumberData]]** internal data property, then
 - i. Let *value* be *ToNumber*(*value*).
 - b. Else if *value* has an **[[StringData]]** internal data property, then
 - i. Let *value* be *ToString*(*value*).
 - c. Else if *value* has an **[[BooleanData]]** internal data property, then
 - i. Let *value* be the value of the **[[BooleanData]]** internal data property of *value*.
6. If *value* is **null** then return **"null"**.
7. If *value* is **true** then return **"true"**.
8. If *value* is **false** then return **"false"**.
9. If *Type*(*value*) is String, then return the result of calling the abstract operation *Quote* with argument *value*.
10. If *Type*(*value*) is Number
 - a. If *value* is finite then return *ToString*(*value*).
 - b. Else, return **"null"**.
11. If *Type*(*value*) is Object, and *IsCallable*(*value*) is false
 - a. If *value* is an exotic Array object, then
 - i. Return the result of calling the abstract operation *J4* with argument *value*.
 - b. Else, return the result of calling the abstract operation *J0* with argument *value*.
12. Return **undefined**.

Deleted: calling the **[[...et]]** internal method of
Deleted: calling the **[[...et]]** internal method of
Deleted: the **this** value ...nd with an argument
Deleted: the **[[Class]]** internal property of
Deleted: *IsNumber*
Deleted: *NativeBrand*
Deleted: *is "Number"*
Deleted: the **[[Class]]** internal property of
Deleted: *NativeBrand*
Deleted: *is "String"*
Deleted: the **[[Class]]** internal property of
Deleted: *NativeBrand*
Deleted: *is Boolean*
Deleted: *PrimitiveValue*
Deleted: the **[[Class]]** internal property of
Deleted: has an **[[IsArrayNativeBrandBuiltInBrand]]** internal data property with value *NativeArrayBuiltInArray*
Deleted: *is "Array"*

Runtime Semantics: Quote Abstract Operation

The abstract operation *Quote*(*value*) wraps a String value in double quotes and escapes characters within it.

1. Let *product* be code unit 0x0022 (the Unicode double quote character).

2. For each code unit C in value
- If C is 0x0022 or 0x005C (the Unicode reverse solidus character)
 - Let product be the concatenation of product and code unit 0x005C.
 - Let product be the concatenation of product and C.
 - Else if C is backspace, formfeed, newline, carriage return, or tab
 - Let product be the concatenation of product and code unit 0x005C (the Unicode backslash character).
 - Let abbrev be the string value corresponding to the value of C as follows:

backspace	"\b"
formfeed	"\f"
newline	"\n"
carriage return	"\r"
tab	"\t"

 - Let product be the concatenation of product and abbrev.
 - Else if C has a code unit value less than 0x0020 (the Unicode space character)
 - Let product be the concatenation of product and code unit 0x005C (the Unicode backslash character).
 - Let product be the concatenation of product and "\u".
 - Let hex be the string result of converting the numeric code unit value of C to a String of four hexadecimal digits. Alphabetic hexadecimal digits are presented as lowercase characters.
 - Let product be the concatenation of product and hex.
 - Else
 - Let product be the concatenation of product and C.
3. Let product be the concatenation of product and code unit 0x0022 (the Unicode double quote character).
4. Return product.

Runtime Semantics: JO Abstract Operation

The abstract operation JO(value) serializes an object. It has access to the stack, indent, gap, and PropertyList of the invocation of the stringify method.

- If stack contains value then throw a **TypeError** exception because the structure is cyclical.
- Append value to stack.
- Let stepback be indent.
- Let indent be the concatenation of indent and gap.
- If PropertyList is not undefined, then
 - Let K be PropertyList.
- Else
 - Let K be an internal List of Strings consisting of the keys of all the own properties of value whose [[Enumerable]] attribute is true and whose property key is a String value. The ordering of the Strings is the same as that used by the Object.keys standard built-in function.
- Let partial be an empty List.
- For each element P of K.
 - Let strP be the result of calling the abstract operation Str with arguments P and value.
 - ReturnIfAbrupt(strP).
 - If strP is not undefined
 - Let member be the result of calling the abstract operation Quote with argument P.
 - Let member be the concatenation of member and the string ":".
 - If gap is not the empty String
 - Let member be the concatenation of member and code unit 0x0020 (the Unicode space character).
 - Let member be the concatenation of member and strP.
 - Append member to partial.
- If partial is empty, then
 - Let final be "{ }{ }".
- Else
 - If gap is the empty String

- i. Let *properties* be a String formed by concatenating all the element Strings of *partial* with each adjacent pair of Strings separated with code unit 0x002C (the Unicode comma character). A comma is not inserted either before the first String or after the last String.
- ii. Let *final* be the result of concatenating "{", *properties*, and "}".
- b. Else *gap* is not the empty String
 - i. Let *separator* be the result of concatenating code unit 0x002C (the comma character), code unit 0x000A (the line feed character), and *indent*.
 - ii. Let *properties* be a String formed by concatenating all the element Strings of *partial* with each adjacent pair of Strings separated with *separator*. The *separator* String is not inserted either before the first String or after the last String.
 - iii. Let *final* be the result of concatenating "{", code unit 0x000A (the line feed character), *indent*, *properties*, code unit 0x000A, *stepback*, and "}".

Deleted: the line feed character

11. Remove the last element of *stack*.
12. Let *indent* be *stepback*.
13. Return *final*.

Runtime Semantics: JA Abstract Operation

The abstract operation *JA*(*value*) serializes an array. It has access to the *stack*, *indent*, and *gap* of the invocation of the *stringify* method. The representation of arrays includes only the elements between zero and **array.length - 1** inclusive. Properties whose keys are not array indexes are excluded from the stringification. An array is stringified as an open left bracket, elements separated by comma, and a closing right bracket.

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1. If *stack* contains *value* then throw a **TypeError** exception because the structure is cyclical.
2. Append *value* to *stack*.
3. Let *stepback* be *indent*.
4. Let *indent* be the concatenation of *indent* and *gap*.
5. Let *partial* be an empty List.
6. Assert: *value* is a standard array object and hence its "length" property is a non-negative integer.
7. Let *len* be the result of Get(*value*, "length")
8. Let *index* be 0.
9. Repeat while *index < len*
 - a. Let *strP* be the result of calling the abstract operation *Str* with arguments *ToString(index)* and *value*.
 - b. ReturnIfAbrupt(strP).
 - c. If *strP* is **undefined**
 - i. Append "null" to *partial*.
 - d. Else
 - i. Append *strP* to *partial*.
 - e. Increment *index* by 1.
10. If *partial* is empty ,then
 - a. Let *final* be "[".
11. Else
 - a. If *gap* is the empty String
 - i. Let *properties* be a String formed by concatenating all the element Strings of *partial* with each adjacent pair of Strings separated with code unit 0x002C (the comma character). A comma is not inserted either before the first String or after the last String.
 - ii. Let *final* be the result of concatenating "[", *properties*, and "]".
 - b. Else
 - i. Let *separator* be the result of concatenating code unit 0x002C (the comma character), code unit 0x000A (the line feed character), and *indent*.
 - ii. Let *properties* be a String formed by concatenating all the element Strings of *partial* with each adjacent pair of Strings separated with *separator*. The *separator* String is not inserted either before the first String or after the last String.
 - iii. Let *final* be the result of concatenating "[", code unit 0x000A (the line feed character), *indent*, *properties*, code unit 0x000A, *stepback*, and "]".
12. Remove the last element of *stack*.
13. Let *indent* be *stepback*.
14. Return *final*.

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Deleted: of calling the [[Get]] internal method on *value* with argument "length".

NOTE 1 JSON structures are allowed to be nested to any depth, but they must be acyclic. If *value* is or contains a cyclic structure, then the `stringify` function must throw a **TypeError** exception. This is an example of a value that cannot be stringified:

```
a = [];
a[0] = a;
my_text = JSON.stringify(a); // This must throw an TypeError.
```

NOTE 2 Symbolic primitive values are rendered as follows:

- The **null** value is rendered in JSON text as the String **null**.
- The **undefined** value is not rendered.
- The **true** value is rendered in JSON text as the String **true**.
- The **false** value is rendered in JSON text as the String **false**.

Deleted: false

NOTE 3 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).

NOTE 4 Finite numbers are stringified as if by calling `ToString(number)`. **Nan** and **Infinity** regardless of sign are represented as the String **null**.

NOTE 5 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.

NOTE 6 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.

15.13 Binary Data Objects

15.13.1 The BinaryData Module

15.13.2 The BinaryData.Type Object

15.13.2.5 BinaryData.ScalarType Type Instance Objects

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15.13.3 The BinaryData.ArrayType Object

15.13.4 The BinaryData.StructType Object

Comment [AWB10198]: This is a place holder for material in the Binary Data proposal
<http://wiki.ecmascript.org/doku.php?id=harmony:binaryata>

15.13.5 ArrayBuffer Objects

15.13.5.1 Abstract Operations For ArrayBuffer Objects

15.13.5.1.1 AllocateArrayBuffer(constructor)

The abstract operation `AllocateArrayBuffer` with argument *constructor* is used to create an uninitialized `ArrayBuffer` object. It performs the following steps:

1. Let *obj* be the result of calling `OrdinaryCreateFromConstructor(constructor, "%ArrayBufferPrototype%", {[[ArrayBufferData]], [[ArrayBufferByteLength]]})`.
2. `ReturnIfAbrupt(obj)`.
3. Set the `[[ArrayBufferByteLength]]` internal data property of *obj* to 0.
4. `Return obj`.

Deleted: <#>Assert: IsConstructor(*constructor*) is true.
Deleted:

Deleted: <#>Add a [[ArrayBufferData]] internal data property to *obj*.
Deleted: Add

Deleted: a

Deleted: to

Deleted: <#>Set *obj*'s [[ArrayBufferData]] internal data property to **undefined**.
<#>Set *obj*'s [[ArrayBufferByteLength]] internal data property to 0.

15.13.5.1.2 SetArrayBufferData(arrayBuffer, bytes)

The abstract operation `SetArrayBufferData` with arguments `arrayBuffer` and `bytes` is used to initialize the storage block encapsulated by an `ArrayBuffer` object. It performs the following steps:

1. Assert: `arrayBuffer` has an `[[ArrayBufferData]]` internal data property.
2. Assert: `bytes` is a positive integer.
3. Let `block` be the result of `CreateByteArrayBlock(bytes)`.
4. ReturnIfAbrupt(`block`).
5. Set `arrayBuffer`'s `[[ArrayBufferData]]` internal data property to `block`.
6. Set `arrayBuffer`'s `[[ArrayBufferByteLength]]` internal data property to `bytes`.
7. Return `arrayBuffer`.

Deleted: an Number value in the Uint32 range

Comment [AWB13199]: TODO: need to define abstract operations for allocating data blocks. Should throw a `RangeError` if alloc fails.

Deleted: `Length`

15.13.5.1.3 GetValueFromBuffer (arrayBuffer, byteIndex, type, isBigEndian)

The abstract operation `GetValueFromBuffer` takes four parameters, an `ArrayBuffer` `arrayBuffer`, an integer `byteIndex`, a String `valueType`, and optionally a Boolean `isBigEndian`. If `isBigEndian` is not present, its default value is `undefined`. This operation performs the follow steps:

1. Assert: There are sufficient bytes in `arrayBuffer` starting at `byteIndex` to represent a value of `valueType`.
2. Assert: `byteIndex` is a positive integer.
3. Let `block` be `arrayBuffer`'s `[[ArrayBufferData]]` internal data property.
4. Let `elementSize` be the Number value of the Element Size value specified in Table 36 for `valueType`.
5. Let `rawValue` be the `elementSize` bytes starting at `byteIndex` of `block`.
6. If `isBigEndian` is `undefined`, set `isBigEndian` to either `true` or `false`. The choice is implementation dependent and should be the alternative that is most efficient for the implementation. An implementation must use the same value each time this step is executed and the same value must be used for the corresponding step in the `SetValueInBuffer` abstraction operation.
7. If `isBigEndian` is `true`, reverse the order of the bytes of `rawValue`.
8. If `type` is "Float32", then
 - a. `rawValue` is interpreted, taking into account the value of `isBigEndian`, as a bit string encoding of an IEEE 754-208 binary32 value.
 - b. If `rawValue` is an IEEE 754-208 binary32 NaN value, return the `NaN` Number value.
 - c. Return the Number value that is encoded by `rawValue`.
9. If `type` is "Float64", then
 - a. `rawValue` is interpreted, taking into account the value of `isBigEndian`, as a bit string encoding of an IEEE 754-208 binary64 value.
 - b. If `rawValue` is an IEEE 754-208 binary64 NaN value, return the `NaN` Number value.
 - c. Return the Number value that is encoded by `rawValue`.
10. If the first character of `type` is "U", then
 - a. Let `intValue` be the positive integer that is the result of interpreting, taking into account the value of `isBigEndian`, `rawValue` as an unsigned binary number.
11. Else
 - a. Let `intValue` be the signed integer that is the result of interpreting, taking into account the value of `isBigEndian`, `rawValue` as a binary 2's complement number of bit length `elementSize × 4`.
12. Return `intValue`.

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NOTE The default number storage formal for all implementation is little endian, regardless of the native endianness of the underlying hardware.

15.13.5.1.4 SetValueInBuffer (arrayBuffer, byteIndex, type, value, isBigEndian)

The abstract operation `SetValueInBuffer` takes five parameters, an `ArrayBuffer` `arrayBuffer`, an integer `byteIndex`, a String `valueType`, a Number `value`, and optionally a Boolean `isBigEndian`. If `isBigEndian` is not present, its default value is `false`. This operation performs the follow steps:

Deleted: internal

1. Assert: There are sufficient bytes in `arrayBuffer` starting at `byteIndex` to represent a value of `valueType`.
2. Assert: `byteIndex` is a positive integer.
3. Let `block` be `arrayBuffer`'s `[[ArrayBufferData]]` internal data property.

4. Let `elementSize` be the Number value of the Element Size value specified in Table 36 on the row with Element Type is `type`. Deleted: Table 35Table 36
5. Let `rawValue` be the `elementSize` bytes starting at `byteIndex` of `arrayBuffer`.
6. If `isBigEndian` is `undefined`, set `isBigEndian` to either `true` or `false`. The choice is implementation dependent and should be the alternative that is most efficient for the implementation. An implementation must use the same value each time this step is executed and the same value must be used for the corresponding step in the `GetValueFromBuffer` abstraction operation.
7. If `isBigEndian` is `true`, reverse the order of the bytes of `rawValue`.
8. If `type` is "Float32", then
 - a. Set `rawValue` to the 4 bytes that are the result of converting `value` to IEEE-868-2005 binary32 format using "Round to nearest, ties to even" rounding mode. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order. If `value` is `NAN`, `rawValue` may be set to any implementation chosen non-signaling NaN encoding.
9. Else, if `type` is "Float64", then
 - a. Set `rawValue` to the 8 bytes that are the IEEE-868-2005 binary64 format encoding of `value`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order. If `value` is `NAN`, `rawValue` may be set to any implementation chosen non-signaling NaN encoding.
10. Else
 - a. Let `n` be the Size Element value in Table 36 for the row containing the value of `type` as its Element Type entry. Deleted: Table 35Table 36
 - b. Let `convOp` be the abstract operation named in the Conversion Opoeration column in Table 36 for the row containing the value of `type` as its Element Type entry. Deleted: ion
 - c. Let `intValue` be the result of calling `convOp` with `value` as its argument. Deleted: Table 35Table 36
 - d. If `intValue > 0`, then
 - i. Let `rawBytes` be the `n`-byte binary encoding of `intValue`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order.
 - e. Else
 - i. Let `rawBytes` be the `n`-byte binary 2's complement encoding of `intValue`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order.
11. Store the individual bytes of `rawBytes` in order starting at position `byteIndex` of `block`.
12. Return `NormalCompletion(undefined)`. Deleted: Normal

15.13.5.2 The ArrayBuffer Object Called as a Function

When `ArrayBuffer` is called as a function rather than as a constructor, it initializes its `this` value with the internal state that supports the `ArrayBuffer.prototype` internal methods. This permits super invocation of the `ArrayBuffer` constructor by `ArrayBuffer` subclasses. If its `this` value is `undefined`, it creates and initialises a new `ArrayBuffer` object. Thus the function call `ArrayBuffer(...)` is equivalent to the object creation expression `new ArrayBuffer(...)` with the same arguments.

15.13.5.2.1 ArrayBuffer(length)

`ArrayBuffer` called as function with argument `length` performs the following steps:

1. Let `O` be the `this` value.
2. If `Type(O)` is neither `Object` or `Undefined`, then throw a `TypeError` exception.
3. If `O` is `undefined` or does not have an `[[ArrayBufferData]]` internal data property, then
 - a. Let `F` be this function object.
 - b. Let `argumentsList` be the `argumentsList` argument of the `[[Call]]` internal method that invoked `F`.
 - c. Return the result of calling `OrdinaryCreateFromConstructor(F, argumentsList)`. Deleted: be the be the
4. If the value of `O`'s `[[ArrayBufferData]]` internal data property is not `undefined`, then throw a `TypeError` exception.
5. Let `numberLength` be `ToNumber(length)`.
6. Let `byteLength` be `ToInteger(numberLength)`.
7. Return `IfAbrupt(byteLength)`. Deleted: ToUint32
8. If `numberLength` ≠ `byteLength` or `byteLength` < 0, then throw a `RangeError` exception. Deleted: Positive
9. Return the result of `SetArrayBufferData(O, byteLength)`. Deleted: length

15.13.5.3 The ArrayBuffer Constructor

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

The `ArrayBuffer` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intended to inherit the specified `ArrayBuffer` behaviour must include a `super` call to `ArrayBuffer`.

15.13.5.3.1 `new ArrayBuffer(...args)`

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`ArrayBuffer` called as part of a new expression with argument `length` performs the following steps:

1. Let `F` be the `ArrayBuffer` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `ArrayBuffer` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

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Deleted: The `[[Prototype]]` internal data property of the newly constructed object is set to the original `ArrayBuffer` prototype object, the one that is the initial value of `ArrayBuffer.prototype` (16.1.3.1). The `[[Class]]` internal data property of the newly constructed object is set to "ArrayBuffer". The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.¹¹

The `length` property of the newly constructed object is set to `ToUInt32(len)`.¹¹

A fresh native buffer `nativeBuffer` of length `length` is allocated. The contents of this native buffer are zero initialized. If the requested number of bytes could not be allocated, a `RangeError` is raised. The `[[NativeBuffer]]` internal data property of the newly constructed object is set to `nativeBuffer`.¹¹

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Deleted: <#>If `IsConstructor(F)` is false, then throw a `TypeError` exception.¹¹

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Deleted: The `[[Class]]` internal data property of the newly constructed object is set to "Object".

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

15.13.5.4 Properties of the ArrayBuffer Constructor

The value of the `[[Prototype]]` internal data property of the `ArrayBuffer` constructor is the `Function` prototype object (15.3.3).

Besides its `length` property (whose value is 1), the `ArrayBuffer` constructor has the following properties:

15.13.5.4.1 `ArrayBuffer.prototype`

The initial value of `ArrayBuffer.prototype` is the `ArrayBuffer` prototype object (15.13.5.4).

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

15.13.5.4.2 `ArrayBuffer.isView (arg)`

The `isView` function takes one argument `arg`, and performs the following steps are taken:

1. If `Type(arg)` is not `Object`, return `false`.
2. If `arg` is an exotic `Array` object, then return `true`.
3. If `arg` has a `[[ViewedArrayBuffer]]` internal data property, then return `true`.
4. Return `false`.

15.13.5.4.3 `ArrayBuffer[@@create ()]`

The `[@@create` method of a `ArrayBuffer` function object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Return the result of calling `AllocateArrayBuffer(F)`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.13.5.5 Properties of the ArrayBuffer Prototype Object

The value of the `[[Prototype]]` internal data property of the `ArrayBuffer` prototype object is the standard built-in `Object` prototype object (15.2.4). The `ArrayBuffer` prototype object is an ordinary object. It does not have a `[[ArrayBufferData]]` or `[[ArrayBufferByteLength]]` internal data property.

15.13.5.5.1 ArrayBuffer.prototype.constructor

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

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15.13.5.5.2 get ArrayBuffer.prototype.byteLength

ArrayBuffer.prototype.byteLength is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ArrayBufferByteLength]]` internal data property throw a `TypeError` exception.
4. Let $length$ be the value of O 's `[[ArrayBufferByteLength]]` internal data property.
5. Return $length$.

Comment [AWB13200]: byteLength needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirement

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15.13.5.5.3 ArrayBuffer.prototype.slice (start , end)

The following steps are taken:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ArrayBufferData]]` internal data property throw a `TypeError` exception.
4. Let len be the value of O 's `[[ArrayBufferByteLength]]` internal data property.
5. Let $relativeStart$ be `ToInteger(start)`.
6. ReturnIfAbrupt($relativeStart$).
7. If $relativeStart$ is negative, let $first$ be $\max((len + relativeStart), 0)$; else let $first$ be $\min(relativeStart, len)$.
8. If end is undefined, let $relativeEnd$ be len ; else let $relativeEnd$ be `ToInteger(end)`.
9. ReturnIfAbrupt($relativeEnd$).
10. If $relativeEnd$ is negative, let $final$ be $\max((len + relativeEnd), 0)$; else let $final$ be $\min(relativeEnd, len)$.
11. Let $newLen$ be $final - first$.
12. Let $ctor$ be the result of `GetMethod(O, "constructor")`.
13. ReturnIfAbrupt($ctor$).
14. If `IsConstructor(ctor)` is false, then throw a `TypeError` exception.
15. Let new be the result of calling the `[[Construct]]` internal method of $ctor$ with a new List containing the single element $newLen$.
16. ReturnIfAbrupt(new).
17. If new does not have a `[[ArrayBufferData]]` internal data property throw a `TypeError` exception.
18. Let $fromBuf$ be the value of O 's `[[ArrayBufferData]]` internal data property.
19. Let $toBuf$ be the value of new 's `[[ArrayBufferData]]` internal data property.
20. Let $status$ be the result of `CopyBlockElements(fromBuf, first, toBuf, 0, newLen)`.
21. ReturnIfAbrupt($status$).
22. Return new .

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Comment [AWB13201]: TODO: need to define abstract operations for allocating and manipulating data blocks.

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Deleted: 15.13.5.5.1 byteLength¶

The `byteLength` property of this ArrayBuffer object is a data property whose value is the length of the ArrayBuffer in bytes, as fixed at construction time.¶

The `length` property has the attributes { `[[Writable]]: false`, `[[Enumerable]]: false`, `[[Configurable]]: false` }.¶

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15.13.5.5.4 ArrayBuffer.prototype.@@toStringTag

The initial value of the `@@toStringTag` property is the string value "ArrayBuffer".

15.13.5.6 Properties of the ArrayBuffer Instances

ArrayBuffer instances inherit properties from the ArrayBuffer prototype object. After initialisation by the ArrayBuffer constructor, ArrayBuffer instances also have a `[[ArrayBufferData]]` internal data property and a `[[ArrayBufferByteLength]]` internal data property.

15.13.6 TypedArray Object Structures

For each constructor in the Table 36 is a separate `TypedArray` constructor object, with corresponding prototype and instances. Each of these `TypedArray` constructor objects has the structure described below, differing only in the name used as the constructor name instead of `TypedArray`, in Table 36.

Table 36 – The *TypedArray* Constructors

Constructor Name	Element Type	Element Size	Conversion Operation	Description	Equivalent C Type
Int8Array	Int8	1	ToInt8	8-bit 2's complement signed integer	signed char
Uint8Array	Uint8	1	ToUint8	8-bit unsigned integer	unsigned char
Uint8ClampedArray	Uint8C	1	ToUint8Clamp	8-bit unsigned integer (clamped)	unsigned char
Int16Array	Int16	2	ToInt16	16-bit 2's complement signed integer	Short
Uint16Array	Uint16	2	ToUint16	16-bit unsigned integer	unsigned short
Int32Array	Int32	4	ToInt32	32-bit 2's complement signed integer	Int
Uint32Array	Uint32	4	ToUint32	32-bit unsigned integer	unsigned int
Float32Array	Float32	4		32-bit IEEE floating point	Float
Float64Array	Float64	8		64-bit IEEE floating point	Double

In the definitions below, references to *TypedArray* should be replaced with the appropriate constructor name from the above table. The phrase “the element size in bytes” refers to the value in the Element Size column of the table in the row corresponding to the constructor. The phrase “element Type” refers to the value in the Element Type column for that row.

15.13.6.1 *TypedArray* Constructors Called as a Function

When a *TypedArray* constructor is called as a function rather than as a constructor, it initializes its **this** value with the internal state that supports the *TypedArray.prototype* internal methods. This permits super invocation of the *TypedArray* constructor by *TypedArray* subclasses. If the **this** value is undefined, it creates and initializes a new *TypedArray* object. Thus the function call *TypedArray* (...) is equivalent to the object creation expression new *TypedArray* (...) with the same arguments.

15.13.6.1.1 *TypedArray* (length)

TypedArray called as function with argument *length* performs the following steps:

1. Assert: Type(*length*) is not Object.
2. Let *elementType* be the string value of the Element Type value in Table 36 for this *TypedArray* constructor.
3. Let *O* be the **this** value.
4. If Type(*O*) is neither Object or Undefined, then throw a **TypeError** exception.
5. If *O* is **undefined** or does not have an **[ViewedArrayBuffer]** internal data property, then
 - a. Let *F* be this function object.
 - b. Let *argumentsList* be the *argumentsList* argument of the **[[Call]]** internal method that invoked *F*.
 - c. Return the result of calling *OrdinaryConstruct* (*F*, *argumentsList*).
6. If the value of *O*'s **[ViewedArrayBuffer]** internal data property is not **undefined**, then throw a **TypeError** exception.
7. Let *numberLength* be *ToNumber*(*length*).
8. Let *elementLength* be *ToInteger*(*numberLength*).
9. ReturnIfAbrupt(*elementLength*).
10. If *numberLength* ≠ *elementLength* or *elementLength* < 0, then throw a **RangeError** exception.
11. Let *data* be the result of calling *AllocateArrayBuffer*(%ArrayBuffer%).
12. ReturnIfAbrupt(*data*).
13. Let *elementSize* be the Size Element value in Table 36 for this *TypedArray* constructor.
14. Let *byteLength* be *elementSize* × *elementLength*.
15. Let *status* be the result of *SetArrayBufferData*(*data*, *byteLength*)
16. ReturnIfAbrupt(*status*).
17. Set *O*'s **[ViewedArrayBuffer]** to *data*.

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Comment [AWB13202]: TODO

Comment [AWB13203]: TODO

Comment [AWB13204]: Issue: this is a made up name. What should it be?

Comment [AWB13205]: TODO

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Comment [AWB13206]: The BinaryData proposal, would like “called as a function” invocation of a TypedArray constructor to return a new BinaryData type rather than a array type instance. This could be accomplished by changing steps 5.a-5.c in the 15.13.6.1.c.

However, this seems like to be a breaking change for some current web apps.

Deleted: When a *TypeArray* constructor is called as a function rather than a constructor, it creates and initializes a new object. A call of the constructor as a function is equivalent to calling it as a constructor with the same arguments.¶

Comment [AWB13207]: Issue: we need to decide whether we are going to fully apply WebIDL’s complex set of overload resolution rules.

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18. Set O 's $\text{[[TypedArrayElementKind]]}$ internal data property to elementType .
19. Set O 's [[ByteLength]] internal data property to byteLength .
20. Set O 's [[ByteOffset]] internal data property to 0 .
21. Set O 's [[ArrayLength]] internal data property to elementLength .
22. Return O .

15.13.6.1.2 TypedArray (typedArray)

TypedArray called as function with argument typedArray performs the following steps:

1. Assert: $\text{Type}(\text{typedArray})$ is Object and typedArray has a $\text{[[ViewedArrayBuffer]]}$ internal data property.
2. Let srcArray be typedArray .
3. Let elementType be the string value of the Element Type value in Table 36 for this TypedArray constructor.
4. Let O be the this value.
5. If $\text{Type}(O)$ is neither Object or Undefined, then throw a **TypeError** exception.
6. If O is **undefined** or does not have an $\text{[[ViewedArrayBuffer]]}$ internal data property, then
 - a. Let F be this function object.
 - b. Let argumentsList be the argumentsList argument of the [[Call]] internal method that invoked F .
 - c. Return the result of calling $\text{OrdinaryConstruct}(F, \text{argumentsList})$.
7. If the value of O 's $\text{[[ViewedArrayBuffer]]}$ internal data property is not **undefined**, then throw a **TypeError** exception.
8. Let elementLength be the value of srcArray 's [[ArrayLength]] internal data property.
9. Let srcType be the value of srcArray 's $\text{[[TypedArrayElementKind]]}$ internal data property.
10. Let srcData be the value of srcArray 's $\text{[[ViewedArrayBuffer]]}$ internal data property.
11. Let data be the result of calling $\text{CloneArrayBuffer}(\text{srcData}, \text{srcType}, \text{elementType}, \text{elementLength})$.
12. ReturnIfAbrupt(data).
13. Let elementSize be the Size Element value in Table 36 for this TypedArray constructor.
14. Let byteLength be $\text{elementSize} \times \text{elementLength}$.
15. Let data be the result of $\text{SetArrayBufferData}(\text{data}, \text{byteLength})$.
16. ReturnIfAbrupt(data).
17. Set O 's $\text{[[ViewedArrayBuffer]]}$ to data .
18. Set O 's $\text{[[TypedArrayElementKind]]}$ internal data property to elementType .
19. Set O 's [[ByteLength]] internal data property to byteLength .
20. Set O 's [[ByteOffset]] internal data property to 0 .
21. Set O 's [[ArrayLength]] internal data property to elementLength .
22. Return O .

15.13.6.1.3 TypedArray (array)

TypedArray called as function with argument array performs the following steps:

1. Assert: $\text{Type}(\text{array})$ is Object and array does not have either a $\text{[[ViewedArrayBuffer]]}$ or a $\text{[[ArrayBufferData]]}$ internal data property.
2. Let O be the this value.
3. If $\text{Type}(O)$ is neither Object or Undefined, then throw a **TypeError** exception.
4. Let srcArray be array .
5. Let elementType be the string value of the Element Type value in Table 36 for this TypedArray constructor.
6. If O is **undefined** or does not have an $\text{[[ViewedArrayBuffer]]}$ internal data property, then
 - a. Let F be this function object.
 - b. Let argumentsList be the argumentsList argument of the [[Call]] internal method that invoked F .
 - c. Return the result of calling $\text{OrdinaryConstruct}(F, \text{argumentsList})$.
7. If the value of O 's $\text{[[ViewedArrayBuffer]]}$ internal data property is not **undefined**, then throw a **TypeError** exception.
8. Let arrayLength be the result of $\text{Get}(\text{array}, \text{"length"})$.
9. Let numberLength be $\text{ToNumber}(\text{arrayLength})$.
10. Let elementLength be $\text{ToInteger}(\text{numberLength})$.
11. ReturnIfAbrupt(elementLength).
12. If $\text{numberLength} \neq \text{elementLength}$ or $\text{elementLength} < 0$, then throw a **TypeError** exception.
13. Let data be the result of calling $\text{AllocateArrayBuffer}(\% \text{ArrayBuffer}\%)$.
14. ReturnIfAbrupt(data).
15. Let elementSize be the Size Element value in Table 36 for this TypedArray constructor.

Comment [AWB13208]: Issue: we need to decide whether we are going to fully apply WebIDL's complex of overload resolution rules.

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Comment [AWB13209]: TODO

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Comment [AWB13210]: Issue: The khronos spec allows array-likes here. Should we also recognize iterables and use $@\text{@} \text{iterator}$ for them? This algorithm current doesn't deal with iterables.

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Comment [AWB13211]: Issue: we need to decide whether we are going to fully apply WebIDL's complex of overload resolution rules.

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16. Let `byteLength` be $\text{elementSize} \times \text{elementLength}$.
17. Let `status` be the result of `SetArrayBufferData(data, byteLength)`
18. Let `k` be 0.
19. Repeat, while $k < \text{elementLength}$
 - a. Let `Pk` be `ToString(k)`.
 - b. Let `kValue` be the result of `Get(O, Pk)`.
 - c. Let `kNumber` be `ToNumber(kValue)`.
 - d. ReturnIfAbrupt(`kNumber`).
 - e. Perform `SetValueInBuffer(data, k \times \text{elementSize}, \text{elementType}, kNumber)`.
 - f. Increase `k` by 1.
20. Set `O`'s `[[ViewedArrayBuffer]]` to `data`.
21. Set `O`'s `[[TypedArrayElementKind]]` internal data property to `elementType`.
22. Set `O`'s `[[ByteLength]]` internal data property to `byteLength`.
23. Set `O`'s `[[ByteOffset]]` internal data property to 0.
24. Set `O`'s `[[ArrayLength]]` internal data property to `elementLength`.
25. Return `O`.

15.13.6.1.4 TypedArray (buffer, byteOffset=0, length=undefined)

`TypedArray` called as function with arguments `buffer`, `byteOffset`, and `length` performs the following steps:

1. Assert: `Type(buffer)` is Object and `buffer` has a `[[ArrayBufferData]]` internal data property.
2. Let `O` be the `this` value.
3. If `Type(O)` is neither Object or Undefined, then throw a **TypeError** exception.
4. Let `elementType` be the String value of the Element Type value in Table 36 for this `TypedArray` constructor.
5. Let `elementSize` be the Number value of the Element Size value in Table 36 for this `TypedArray` constructor.
6. Let `offset` be `ToInteger(byteOffset)`.
7. ReturnIfAbrupt(`offset`).
8. If `offset < 0`, then throw a **RangeError** exception.
9. If `offset` modulo `elementSize` ≠ 0, then throw a **RangeError** exception.
10. Let `bufferByteLength` be the value of `buffer`'s `[[ArrayBufferByteLength]]` internal data property.
11. If `offset + elementSize > bufferByteLength`, then throw a **RangeError** exception.
12. If `length` is `undefined`, then
 - a. If `bufferByteLength` modulo `elementSize` ≠ 0, then throw a **RangeError** exception.
 - b. Let `newByteLength` be `bufferByteLength - offset`.
13. Else,
 - a. Let `numberLength` be `ToNumber(length)`.
 - b. Let `newLength` be `ToInteger(numberLength)`.
 - c. ReturnIfAbrupt(`newLength`).
 - d. If `numberLength` ≠ `newLength` or `newLength < 0`, then throw a **RangeError** exception.
 - e. Let `newByteLength` be `newLength × elementSize`.
 - f. If `offset+newByteLength > bufferByteLength`, then throw a **RangeError** exception.
14. If the value of `O`'s `[[ViewedArrayBuffer]]` internal data property is not `undefined`, then throw a **TypeError** exception.
15. Set `O`'s `[[ViewedArrayBuffer]]` to `buffer`.
16. Set `O`'s `[[TypedArrayElementKind]]` internal data property to `elementType`.
17. Set `O`'s `[[ByteLength]]` internal data property to `newByteLength`.
18. Set `O`'s `[[ByteOffset]]` internal data property to `offset`.
19. Set `O`'s `[[ArrayLength]]` internal data property to `newByteLength / elementSize`.
20. Return `O`.

15.13.6.1.5 TypedArray (binary data stuff)

15.13.6.2 The `TypedArray` Constructors

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

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Comment [AWB13212]: Issue: we need to decide whether we are going to fully apply WebIDL's complex set of overload resolution rules.

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Comment [AWB13213]: Issue, the order of exceptions that may be thrown during argument validation is probably not currently the same as would be produced by WebIDL overloading per Khronos validation rules (if that order is even well defined??). It isn't clear that this difference is very important.

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Comment [AWB13214]: TODO: this is a place holder assuming that we may need to construct `TypedArrays` from binary data objects.

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The `TypedArray` constructors is designed to be subclassable. They may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intended to inherit the specified `TypedArray` behaviour must include a `super` call to the `TypedArray`.

15.13.6.2.1 new TypedArray (...args)

When a `TypedArray` function called as part of a new expression with argument lists `args` performs the following steps:

1. Let `F` be the `TypedArray` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `TypedArray` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.13.6.3 Properties of the `TypedArray` Constructors

The value of the `[[Prototype]]` internal data property of each `TypedArray` constructor is the Function prototype object (15.3.3).

Besides a `length` property (whose value is 3), each `TypedArray` constructor has the following properties:

15.13.6.3.1 `TypedArray.prototype`

The initial value of `TypedArray.prototype` is the corresponding `TypedArray` prototype object (15.13.5.4).

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

15.13.6.3.2 `TypedArray[@@create]()`

The `@@create` method of a `TypedArray` function object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `proto` be the result of `GetPrototypeOfConstructor(F, "%TypedArrayPrototype%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `IntegerIndexedObjectCreate(proto)`.
5. Add a `[[ViewedArrayBuffer]]` internal data property to `obj` and set its initial value to `undefined`.
6. Add a `[[TypedArrayElementKind]]` internal data property to `obj` and set its initial value to `undefined`.
7. Add a `[[ByteLength]]` internal data property to `obj` and set its initial value to 0.
8. Add a `[[ByteOffset]]` internal data property to `obj` and set its initial value to 0.
9. Add a `[[ArrayLength]]` internal data property to `obj` and set its initial value to 0.
10. Return `obj`.

This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true` }.

15.13.6.4 Properties of the `TypedArray` Prototype Object

The value of the `[[Prototype]]` internal data property of each `TypedArray` prototype object is the standard built-in `Object` prototype object (15.2.4). The `TypedArray` prototype objects are ordinary objects. They do not have a `[[ViewedArrayBuffer]]` or any other of the internal data properties that are specific to `TypedArray` instance objects.

15.13.6.4.1 `TypedArray.prototype.constructor`

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

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Deleted: When a `TypeArray` constructor is called as part of a new expression, it is a constructor: it initialises the newly created object.¶

15.13.6.2.1 new TypeArray(arg0 [, arg1, [, arg2]])

The `[[Prototype]]` internal data property of the newly constructed object is set to the original `TypeArray` prototype object, the one that is the initial value of `TypeArray.prototype` (16.2.3.1). The `[[Class]]` internal data property of the newly constructed object is set to "TypeArray". The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.¶ The remaining properties of the newly constructed object are set as follows:¶

<#> If `Type(arg0)` is Number, then¶
 <#> Let `length` be `ToUInt32(arg0)`.¶
 <#> ReturnIfAbrupt(`length`).¶
 <#> The `length` property of the newly constructed object is set to `length`.¶

<#> The `byteLength` property of the newly constructed object is set to `length` multiplied by the element size in bytes.¶
 <#> Let `arrayBuffer` be an object constructed as if by a call to the built-in `ArrayBuffer` constructor, as "new `ArrayBuffer(byteLength)`".¶

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Deleted: <#> If `IsConstructor(F)` is `false`, then throw a

Deleted: <#> If `Type(proto)` is not Object, then¶

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Deleted: <#> Set `obj`'s `[[TypedArrayData]]` internal data

Deleted: `false`

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Deleted: It's `[[Class]]` is "TypeArray".

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15.13.6.4.2 `TypedArray.prototype.BYTES_PER_ELEMENT`

The value of `TypedArray.prototype.BYTES_PER_ELEMENT` is the Number value of the Element Size value specified in Table 36 for `TypedArray`.

Deleted: Table 35Table 36

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

15.13.6.4.3 `|get| TypedArray.prototype.buffer`

`TypedArray.prototype.buffer` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of O 's `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Return `buffer`.

Comment [AWB13215]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

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15.13.6.4.4 `|get| TypedArray.prototype.byteLength`

`TypedArray.prototype.byteLength` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of O 's `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `size` be the value of O 's `[[ByteLength]]` internal data property.
7. Return `size`.

Comment [AWB13216]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

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15.13.6.4.5 `|get| TypedArray.prototype.byteOffset`

`TypedArray.prototype.byteOffset` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of O 's `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `offset` be the value of O 's `[[ByteOffset]]` internal data property.
7. Return `offset`.

Comment [AWB13217]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

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15.13.6.4.6 `|get| TypedArray.prototype.length`

`TypedArray.prototype.length` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let O be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of O 's `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `length` be the value of O 's `[[ArrayLength]]` internal data property.
7. Return `length`.

Comment [AWB13218]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

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15.13.6.4.7 TypedArray.prototype.set(array, offset = 0)

Set multiple values in this *TypedArray*, reading the values from the object *array*. The optional *offset* value indicates the first element index in this *TypedArray* where values are written. If omitted, it is assumed to be 0.

1. Assert: *typedArray* does not have a *[[ViewedArrayBuffer]]* internal data property. If it does, the definition in 15.13.6.6.8 applies.
2. Let *target* be the result of calling *ToObject* with the *this* value as its argument.
3. ReturnIfAbrupt(*target*).
4. If *target* does not have a *[[ViewedArrayBuffer]]* internal data property throw a **TypeError** exception.
5. Let *targetBuffer* be the value of *target*'s *[[ViewedArrayBuffer]]* internal data property.
6. If *targetBuffer* is **undefined**, then throw a **TypeError** exception.
7. Let *targetLength* be the value of *target*'s *[[ArrayLength]]* internal data property.
8. Let *targetOffset* be *ToInteger*(*offset*)
9. ReturnIfAbrupt(*targetOffset*).
10. If *targetOffset* < 0, then throw a **RangeError** exception.
11. Let *targetType* be the value of *target*'s *[[TypedArrayElementKind]]* internal data property.
12. Let *targetElementSize* be the Number value of the Element Size value specified in Table 36 for *targetType*.
13. Let *targetByteOffset* be the value of *target*'s *[[ByteOffset]]* internal data property.
14. Let *src* be the result of *ToObject*(*array*).
15. ReturnIfAbrupt(*src*).
16. Let *srcLen* be the result of *Get*(*src*, "length").
17. Let *numberLength* be *ToNumber*(*srcLen*).
18. Let *srcLength* be *ToInteger*(*numberLength*).
19. ReturnIfAbrupt(*srcLength*).
20. If *numberLength* ≠ *srcLength* or *srcLength* < 0, then throw a **TypeError** exception.
21. If *srcLength* + *targetOffset* > *targetLength*, then throw a **RangeError** exception.
22. Let *targetByteIndex* be *targetOffset* × *targetElementSize* + *targetByteOffset*.
23. Let *k* be 0.
24. Let *limit* be *targetByteIndex* + *targetElementSize* × min(*srcLength*, *targetLength* - *targetOffset*).
25. Repeat, while *targetByteIndex* < *limit*
 - a. Let *Pk* be *ToString*(*k*).
 - b. Let *kValue* be the result of *Get*(*src*, *Pk*).
 - c. Let *kNumber* be *ToNumber*(*kValue*).
 - d. ReturnIfAbrupt(*kNumber*).
 - e. Perform *SetValueInBuffer*(*targetBuffer*, *k* × *targetElementSize*, *targetType*, *kNumber*).
 - f. Set *k* to *k* + 1.
 - g. Set *targetByteIndex* to *targetByteIndex* + *targetElementSize*.
26. Return **undefined**.

15.13.6.4.8 TypedArray.prototype.set(*typedArray*, *offset* = 0)

Set multiple values in this *TypedArray*, reading the values from the *typedArray* parameter object. The optional *offset* value indicates the first element index in this *TypedArray* where values are written. If omitted, it is assumed to be 0.

1. Assert: *typedArray* has a *[[ViewedArrayBuffer]]* internal data property. If it does not, the definition in 15.13.6.6.7 applies.
2. Let *target* be the result of calling *ToObject* with the *this* value as its argument.
3. ReturnIfAbrupt(*target*).
4. If *target* does not have a *[[ViewedArrayBuffer]]* internal data property throw a **TypeError** exception.
5. Let *targetBuffer* be the value of *target*'s *[[ViewedArrayBuffer]]* internal data property.
6. If *targetBuffer* is **undefined**, then throw a **TypeError** exception.
7. Let *targetLength* be the value of *target*'s *[[ArrayLength]]* internal data property.
8. Let *targetOffset* be *ToInteger*(*offset*)
9. ReturnIfAbrupt(*targetOffset*).
10. If *targetOffset* < 0, then throw a **RangeError** exception.
11. Let *targetType* be the value of *target*'s *[[TypedArrayElementKind]]* internal data property.
12. Let *targetElementSize* be the Number value of the Element Size value specified in Table 36 for *targetType*.
13. Let *targetByteOffset* be the value of *target*'s *[[ByteOffset]]* internal data property.

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Deleted: <#>Let *srcLength* be *ToPositiveInteger*
Uint32(srcLen).¶
 <#>ReturnIfAbrupt(*srcLength*).¶

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14. Let `srcBuffer` be the value of `typedArray`'s `[[ViewedArrayBuffer]]` internal data property.
15. If `srcBuffer` is `undefined`, then throw a `TypeError` exception.
16. Let `srcType` be the value of `typedArray`'s `[[TypedArrayElementKind]]` internal data property.
17. Let `srcElementSize` be the `Number` value of the Element Size value specified in Table 36 for `srcType`.
18. Let `srcLength` be the value of `typedArray`'s `[[ArrayLength]]` internal data property.
19. Let `srcByteOffset` be the value of `typedArray`'s `[[ByteOffset]]` internal data property.
20. If `srcLength + targetOffset > targetLength`, then throw a `RangeError` exception.
21. If `SameValue(srcBuffer, targetBuffer)` is `true`, then
 - a. Let `srcBuffer` be the result of calling `CloneArrayBuffer(srcBuffer, srcType, srcType, srcLength)`.
22. Let `targetByteIndex` be $targetOffset \times targetElementSize + targetByteOffset$.
23. Let `srcByteIndex` be `srcByteOffset`.
24. Let `limit` be $targetByteIndex + targetElementSize \times \min(srcLength, targetLength - targetOffset)$.
25. Repeat, while `targetByteIndex < limit`
 - a. Let `value` be the result of `GetValueFromBuffer(srcBuffer, srcByteIndex, srcType)`.
 - b. Let `status` be the result of `SetValueInBuffer(targetBuffer, targetByteIndex, targetType, value)`.
 - c. Set `srcByteIndex` to $srcByteIndex + srcElementSize$ Return
 - d. Set `targetByteIndex` to $targetByteIndex + targetElementSize$
26. Return `undefined`.

15.13.6.4.9 `TypedArray.prototype.subarray(begin = 0, end = this.length)`

Returns a new `TypedArray` object whose element types is the same as this `TypedArray` and whose `ArrayBuffer` is the same as the `ArrayBuffer` of this `TypedArray`, referencing the elements at `begin`, inclusive, up to `end`, exclusive. If either `begin` or `end` is negative, it refers to an index from the end of the array, as opposed to from the beginning.

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(`O`).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `srcLength` be the value of `O`'s `[[ArrayLength]]` internal data property.
7. Let `beginInt` be `ToInteger(begin)`
8. ReturnIfAbrupt(`beginInt`).
9. If `beginInt < 0`, then let `beginInt` be $srcLength + beginInt$.
10. Let `beginIndex` be $\min(srcLength, \max(0, beginInt))$.
11. If `end` is `undefined`, then let `end` be `srcLength`.
12. Let `endInt` be `ToInteger(end)`.
13. ReturnIfAbrupt(`endInt`).
14. If `endInt < 0`, then let `endInt` be $srcLength + endInt$.
15. Let `endIndex` be $\max(0, \min(srcLength, endInt))$.
16. If `endIndex < beginIndex`, then let `endIndex` be `beginIndex`.
17. Let `newLength` be `endIndex - beginIndex`.
18. Let `elementType` be the value of `O`'s `[[TypedArrayElementKind]]` internal data property.
19. Let `elementSize` be the `Number` value of the Element Size value specified in Table 36 for `elementType`.
20. Let `srcByteOffset` be the value of `O`'s `[[ByteOffset]]` internal data property.
21. Let `beginByteOffset` be $srcByteOffset + beginIndex \times elementSize$.
22. Let `constructor` be the result of `Get(O, "constructor")`.
23. ReturnIfAbrupt(`constructor`).
24. If `IsConstructor(constructor)` is `false`, then throw a `TypeError` exception.
25. Let `argumentsList` be a List consisting of `buffer`, `beginByteOffset`, and `newLength`.
26. Return the result of calling the `[[Construct]]` internal method of `constructor` with `argumentsList` as the argument.

15.13.6.4.10 `TypedArray.prototype[@@elementGet](index)`

1. Assert: `Type(index)` is `number` and `index` is an `integer`.
2. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
3. ReturnIfAbrupt(`O`).
4. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.

Deleted: <#>Let `O` be the result of calling `ToObject(array)`.
<#>Let `srcLength` be the result `Get(O, "length")` of calling `[[Get]]` on `O` with property name `"length"`.
<#>Let `targetLength` be the result of calling `[[Get]]` on `(this with property name, "length").length`.

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Comment [AWB13219]: TODO

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Comment [AWB13220]: TODO: not yet updated from wik

Deleted: <#>Let `temp` be a new `TypeArray` created as if by a call to `"new TypeArray(srcLength)"`.
<#>Let `k` be `0`.
<#>While `k < srcLength`
<#>Let `v` be the result of calling `[[Get]]` on `(src v)` with property name, `toString(k)`.
<#>Call `[[Put]]` on `(temp, k, v)` with arguments `ToString(k), v, and false`.
<#>Let `k` be `offset`.
<#>While `k < targetLength`.

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Deleted: <#>If this does not have class

Deleted: Let `srcLength` be the result `Get(this, "length")`

Deleted: of calling `[[Get]]` on this with property name `"length"`

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Deleted: if `end` was provided, else `srcLength`

Deleted: Table 35Table 36

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Comment [AWB13221]: If we make this a

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5. Let *buffer* be the value of *O*'s `[[ViewedArrayBuffer]]` internal data property.
6. If *buffer* is `undefined`, then throw a `TypeError` exception.
7. Let *length* be the value of *O*'s `[[ArrayLength]]` internal data property.
8. If *index* < 0 or *index* ≥ *length*, then return `undefined`.
9. Let *offset* be the value of *O*'s `[[ByteOffset]]` internal data property.
10. Let *elementSize* be the Number value of the Element Size value specified in Table 36 for `TypedArray`.
11. Let *indexedPosition* = (*index* × *elementSize*) + *offset*.
12. Let *elementType* be the value of *O*'s `[[TypedArrayElementKind]]` internal data property.
13. Return the result of `GetValueInBuffer(buffer, indexedPosition, elementType)`.

15.13.6.4.11 `TypedArray.prototype[@@elementSet (index, value)`

1. Assert: `Type(index)` is number and *index* is an integer.
2. Let *O* be the result of calling `ToObject` with the `this` value as its argument.
3. `ReturnIfAbrupt(O)`.
4. If *O* does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
5. Let *buffer* be the value of *O*'s `[[ViewedArrayBuffer]]` internal data property.
6. If *buffer* is `undefined`, then throw a `TypeError` exception.
7. Let *length* be the value of *O*'s `[[ArrayLength]]` internal data property.
8. Let *numValue* be `ToNumber(value)`.
9. `ReturnIfAbrupt(numValue)`.
10. If *index* < 0 or *index* ≥ *length*, then return *numValue*.
11. Let *offset* be the value of *O*'s `[[ByteOffset]]` internal data property.
12. Let *elementSize* be the Number value of the Element Size value specified in Table 36 for `TypedArray`.
13. Let *indexedPosition* = (*index* × *elementSize*) + *offset*.
14. Let *elementType* be the value of *O*'s `[[TypedArrayElementKind]]` internal data property.
15. Let *status* be the result of `SetValueInBuffer(buffer, indexedPosition, elementType, numValue)`.
16. `ReturnIfAbrupt(status)`.
17. Return *numValue*.

15.13.6.4.12 `TypedArray.prototype[@@toStringTag]`

The initial value of the `@@toStringTag` property is the string value of the name `TypedArray`.

This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true` }.

15.13.6.5 Properties of `TypedArray` instances

`TypedArray` instances are exotic Index Delegation objects. Each `TypedArray` instances inherits properties from the corresponding `TypedArray` prototype object. After initialisation by a `TypedArray` constructor, `TypedArray` instances have the following internal data properties: `[[ViewedArrayBuffer]], [[TypedArrayElementKind]], [[ByteLength]], [[ByteOffset]],` and `[[ArrayLength]]`.

15.13.7 DataView Objects

The following sections define `DataViews` is derived from the Kronos specification. This material is a very early draft based upon the strawman at http://wiki.ecmascript.org/doku.php?id=strawman:typed_arrays. This material still needs significant work to fully integrate it into the ES6 spec. and also to integrate typed arrays with ES6 binary data.

Don't waste a lot of time reviewing this material until it is closer to a finished state.

Deleted: `[[TypedArrayData]]`

Deleted: <#>Let *intIndex* be `ToPositiveInteger` `UInt32(index)`.
<#>`ReturnIfAbrupt(index)`.

Deleted: *intIndex*

Deleted: *intIndex*

Deleted: `Array`

Comment [AWB13222]: If we make this a private symbol that is not exposed, then it is just a specification device. If we make it an exposed symbol (whether private or not) it becomes a ES programmer extension point.

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Deleted: <#>Let *intIndex* be `ToPositiveInteger` `UInt32(index)`.
<#>`ReturnIfAbrupt(index)`.

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Comment [AWB10223]: This entire section has been copied from the strawman with only minor formatting fix. It has not yet had any technical review or integration

Deleted: `TypeArray` instances inherit properties from the `TypeArray` prototype object and their `[[Class]]` internal data property value is "TypeArray". `TypeArray` instances also have the following properties.

15.13.6.5.1 [[DefineOwnProperty]] (*p*, *desc*, *throw*)
TypeArray objects use a variation of the `[[DefineOwnProperty]]` internal method used for other native ECMAScript objects (8.12.9).
When the `[[DefineOwnProperty]]` internal method of *A* is called with property *P*, Property Descriptor *Desc* and Boolean flag *Throw*, the following steps are taken:
 <#> Let *succeeded* be the result of calling the default `[[DefineOwnProperty]]` internal method (8.12.9) on *A* passing *P*, *Desc*, and *Throw* as arguments.
 <#> If *succeeded* is `false`, return `false`.
 <#> If *Desc* contains a `Value` field, let *newValue* be *Desc.Value*.
 <#> Let *convertedValue* to `ToType(newValue)`.
 <#> Let *index* be `ToUInt32(P)`.
 <#> Call the `SetValueInBuffer` internal operation with arguments *A.buffer.[[NativeBuffer]]*, *A.byteOffset*, *index*, *convertedValue*, and *Type*.
 <#> Return `true`.

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15.13.7.1 The DataView Constructor Called as a Function

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

15.13.7.2 The DataView Constructor

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

15.13.7.2.1 new DataView(buffer [, byteOffset [, byteLength]])

The `[[Prototype]]` internal data property of the newly constructed object is set to the original DataView prototype object, the one that is the initial value of `DataView.prototype` (15.13.3.3.1). The `[[Class]]` internal data property of the newly constructed object is set to "DataView". The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.

The remaining properties are set as follows:

1. Let `O` be `ToObject(buffer)`
2. If the `[[Class]]` internal data property of `O` is not "ArrayBuffer", throw a `TypeError` exception.
3. Let `byteOffset` be the result of calling `ToUInt32` on `byteOffset`, if provided, or else 0.
4. Let `bufferLength` be the result of `Get(O, "byteLength")`.
5. Let `byteLength` be the result of calling `ToUInt32` on `byteLength`, if provided, or else `bufferLength - byteOffset`.
6. If `byteOffset + byteLength` is greater than `bufferLength`, throw a `RangeError` exception.
7. The `byteLength` property of the newly constructed object is set to `byteLength`.
8. The `buffer` property of the newly constructed object is set to `O`.
9. The `byteOffset` property of the newly constructed object is set to `byteOffset`.

15.13.7.3 Properties of the DataView Constructor

The value of the `[[Prototype]]` internal data property of the `DataView` constructor is the `Function` prototype object (15.3.3).

Besides the internal properties and the `length` property (whose value is 3), the `DataView` constructor has the following properties:

15.13.7.3.1 DataView.prototype

The initial value of `DataView.prototype` is the `DataView` prototype object (15.13.3.4).

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

15.13.7.4 Properties of the DataView Prototype Object

The value of the `[[Prototype]]` internal data property of the `DataView` prototype object is the standard built-in `Object` prototype object (15.2.4). The `[[Class]]` internal data property of the newly constructed object is set to "Object". The `[[Extensible]]` internal data property of the newly constructed object is set to `true`.

The abstract operation `GetValue(byteOffset, isLittleEndian, type)` used by functions on `DataView` instances is defined as follows:

1. Let `byteOffsetInt` be `ToUInt32(byteOffset)`
2. Let `totalOffset` be `byteOffsetInt` plus the result of `Get(this, "byteOffset")`.
3. Let `byteLength` be the result of `Get(this, "byteLength")`.
4. If `totalOffset > byteLength`, throw a `RangeError` exception.
5. Let `value` be the result of calling the `GetValueFromBuffer` abstract operation (2.5.2) with arguments `this.buffer`, `[[NativeBuffer]]`, `totalOffset`, 0 and `type`.

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6. Return value

The abstract operation SetValue(byteOffset, isLittleEndian, type, value) used by functions on DataView instances is defined as follows:

1. Let byteOffsetInt be ToUInt32(byteOffset)
2. Let totalOffset be byteOffsetInt plus the result of Get(this, "byteOffset").
3. Let byteLength be the result of Get(this, "byteLength").
4. If totalOffset > byteLength, throw a **RangeError** exception.
5. Let value be the result of calling the SetValueInBuffer abstract operation (2.5.2) with arguments this.buffer.[[NativeBuffer]], totalOffset, 0, value and type.
6. Return value

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15.13.7.4.1 DataView.prototype.constructor

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

15.13.7.4.2 DataView.prototype.getInt8(byteOffset)

Gets the Int8 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
3. Return GetValue(byteOffset, true, Int8)

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15.13.7.4.3 DataView.prototype.getUint8(byteOffset)

Gets the UInt8 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
3. Return GetValue(byteOffset, true, UInt8)

Deleted: raise

15.13.7.4.4 DataView.prototype.getInt16(byteOffset, littleEndian)

Gets the Int16 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Int16)

Deleted: raise

15.13.7.4.5 DataView.prototype.getUint16(byteOffset, littleEndian)

Gets the UInt16 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Uint16)

Deleted: raise

15.13.7.4.6 DataView.prototype.getInt32(byteOffset, littleEndian)

Gets the Int32 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Int32)

Deleted: raise

15.13.7.4.7 DataView.prototype.getUint32(byteOffset, littleEndian)

Gets the Uint32 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Uint32)

Deleted: raise

15.13.7.4.8 DataView.prototype.getFloat32(byteOffset, littleEndian)

Gets the Float32 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Float32)

Deleted: raise

15.13.7.4.9 DataView.prototype.getFloat64(byteOffset, littleEndian)

Gets the Float64 value at offset byteOffset in the DataView, using the provided endianness.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Float64)

Deleted: raise

15.13.7.4.10 DataView.prototype.setInt8(byteOffset, value)

Sets the Int8 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
3. Return SetValue(byteOffset, **true**, Int8,ToInt8(value))

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15.13.7.4.11 DataView.prototype.setUint8(byteOffset, value)

Sets the Uint8 value at offset byteOffset in the DataView.

4. Let O be ToObject(this)
5. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
6. Return SetValue(byteOffset, **true**, Uint8,ToUint8(value))

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15.13.7.4.12 DataView.prototype.setInt16(byteOffset, value, littleEndian)

Sets the Int16 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.
4. Return SetValue(byteOffset, isLittleEndian, Int16,ToInt16(value))

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15.13.7.4.13 DataView.prototype.setUint16(byteOffset, value, littleEndian)

Sets the Uint16 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else **false**
3. If the [[Class]] internal data property of O is not “DataView”, throw a **TypeError** exception.

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4. Return SetValue(byteOffset, isLittleEndian, Uint16, ToUint16(value))

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15.13.7.4.14 DataView.prototype.setInt32(byteOffset, value, littleEndian)

Sets the Int32 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return SetValue(byteOffset, isLittleEndian, Int32,ToInt32(value))

Deleted: raise

Deleted: G

15.13.7.4.15 DataView.prototype.setUint32(byteOffset, value, littleEndian)

Sets the Uint32 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return GetValue(byteOffset, isLittleEndian, Uint32, ToUint32(value))

Deleted: raise

15.13.7.4.16 DataView.prototype.setFloat32(byteOffset, value, littleEndian)

Sets the Float32 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return SetValue(byteOffset, isLittleEndian, Float32, ToFloat32(value))

Deleted: raise

Deleted: G

15.13.7.4.17 DataView.prototype.setUint16(byteOffset, value, littleEndian)

Sets the Float64 value at offset byteOffset in the DataView.

1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not "DataView", throw a **TypeError** exception.
4. Return SetValue(byteOffset, isLittleEndian, Float64, ToFloat64(value))

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15.13.7.5 Properties of DataView Instances

DataView instances inherit properties from the DataView prototype object and their [[Class]] internal data property value is "DataView". DataView instances also have the following properties.

15.13.7.5.1 byteLength

The value of the byteLength property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.13.7.5.2 buffer

The value of the buffer property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.13.7.5.3 byteOffset

The value of the byteOffset property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.14 Map Objects

Map objects are collections of key/value pairs where both the keys and values may be arbitrary ECMAScript language values. A distinct key value may only occur in one key/value pair within the Map's collection. Distinct key values are discriminated using a comparison algorithm that is selected when the Map is created.

A Map object can iterate its elements in insertion order. Map object must be implemented using either hash tables or other mechanisms that, on average, provide access times that are sublinear on the number of elements in the collection. The data structures used in this Map objects specification is only intended to describe the required observable semantics of Map objects. It is not intended to be a viable implementation model.

15.14.1 The Map Constructor Called as a Function

When `Map` is called as a function rather than as a constructor, it initializes its `this` value with the internal state necessary to support the `Map.prototype` internal methods. The `Map` constructor is designed to be subclassable. It may be used as the value in an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified `Map` behaviour must include a `super` call to `Map`.

15.14.1.1 Map (iterable = undefined , comparator = undefined)

When the `Map` function is called with optional arguments `iterable` and `comparator` the following steps are taken:

1. Let `map` be the `this` value.
2. If `Type(map)` is not `Object` then, throw a `TypeError` exception.
3. If `map` does not have a `[[MapData]]` internal data property, then throw a `TypeError` exception.
4. If `map`'s `[[MapData]]` internal data property is not `undefined`, then throw a `TypeError` exception.
5. If `iterable` is not present, let `iterable` be `undefined`.
6. If `iterable` is either `undefined` or `null`, then let `itr` be `undefined`.
7. Else,
 - a. Let `hasValues` be the result of `HasProperty(iterable, "entries")`.
 - b. `ReturnIfAbrupt(hasValues)`.
 - c. If `hasValues` is `true`, then
 - i. Let `itr` be the result of `Invoke(iterable, "entries")`.
 - d. Else,
 - i. Let `iterator` be the well-known symbol `@@iterator`.
 - ii. Let `itr` be the result of `Invoke(iterable, iterator)`.
 - e. `ReturnIfAbrupt(itr)`.
 - f. `ReturnIfAbrupt(itr)`.
 - g. Let `adder` be the result of `Get(map, "set")`.
 - h. `ReturnIfAbrupt(adder)`.
 - i. If `IsCallable(adder)` is `false`, throw a `TypeError` Exception.
8. If `comparator` is not `undefined`, then
 - a. If `comparator` is not `"is"`, then throw a `RangeError` Exception.
9. Set `map`'s `[[MapData]]` internal data property to a new empty List.
10. Set `map`'s `[[MapComparator]]` internal data property to `comparator`.
11. If `itr` is `undefined`, then return `map`.
12. Repeat
 - a. Let `next` be the result of `Invoke(itr, "next")`.
 - b. `ReturnIfAbrupt(next)`.
 - c. If `Type(next)` is not `Object`, then throw a `TypeError` exception.
 - d. Let `done` be `IteratorComplete(next)`.
 - e. `ReturnIfAbrupt(done)`.
 - f. If `done` is `true`, then return `NormalCompletion(map)`.
 - g. Let `nextItem` be `IteratorValue(next)`.
 - h. `ReturnIfAbrupt(nextItem)`.
 - i. Let `k` be the result of `Get(nextItem, "0")`.
 - j. `ReturnIfAbrupt(k)`.
 - k. Let `v` be the result of `Get(nextItem, "1")`.

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Deleted: 15.14.1 Abstract Operations For Map Objects¶

15.14.1.1 MapInitialization¶
The abstract operation MapInitialization with arguments `object` and `iterable` is used to initialize an object as a map. It performs the following steps:
 ↘ If `Type(obj)` is not `Object`, throw a `TypeError` exception.
 ↘ If `obj` already does not have a `[[MapData]]` internal data property, throw a `TypeError` exception.
 ↘ If the result of calling the `[[GetIsExtensible]]` internal property method of `obj` is `false`, throw a `TypeError` exception.
 ↘ If `iterable` is not `undefined`, then
 ↗ Let `iterator` be `ToObject(iterator)`.
 ↗ ReturnIfAbrupt(iterator).
 ↗ Let `iterator` be the intrinsic symbol `@@iterator`.
 ↗ Let `itr` be the result of calling the `Invoke(iterator, obj)`, abstraction operation with `iterator`, `obj`, and an empty List as arguments.
 ↗ ReturnIfAbrupt(itr).
 ↗ Let `adder` be the result of calling the `[[Get]]` internal method of `obj` with argument, `"set"`.
 ↗ ReturnIfAbrupt(adder).
 ↗ If `IsCallable(adder)` is `false`, throw a `TypeError` Exception.
 ↗ Add a `[[MapData]]` internal data property to `obj`.
 ↗ Set `obj`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `iterable` is `undefined`, return `obj`.
 ↗ Repeat
 ↗ Let `next` be the result of performing `Invoke(iterator, "next")`, `itr`, and an empty arguments List.

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Deleted: ↗ If `m` is `undefined` or the intrinsic %MapPrototype%
 ↗ If `m` is `Object`, then set `m`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `m` is `Object`, then set `m`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `m` is `Object`, then set `m`'s `[[MapData]]` internal data method property to a new empty List.

Deleted: ↗ Let `map` be the result of `ToObject(m)`.
 ↗ ReturnIfAbrupt(map).
 ↗ If `map` is `Object`, then set `map`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `map` is `Object`, then set `map`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `map` is `Object`, then set `map`'s `[[MapData]]` internal data method property to a new empty List.

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Deleted: ↗ Let `next` be `ToObject(next)`.
 ↗ ReturnIfAbrupt(next).
 ↗ If `next` is `Object`, then set `next`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `next` is `Object`, then set `next`'s `[[MapData]]` internal data method property to a new empty List.
 ↗ If `next` is `Object`, then set `next`'s `[[MapData]]` internal data method property to a new empty List.

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- l. `ReturnIfAbrupt(v).`
- m. `Let status be the result of calling the [[Call]] internal method of adder with map as thisArgument and a List whose elements are k and v as argumentsList.`
- n. `ReturnIfAbrupt(status).`

NOTE If the parameter `iterable` is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as an Map key and whose second element is the value to associate with that key.

15.14.2 The Map Constructor

When `Map` is called as part of a `new` expression it is a constructor: it initialises a newly created object.

The `Map` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intended to inherit the specified `Map` behaviour must include a `super` call to `Map`.

15.14.2.1 new Map (... args)

`Map` called as part of a `new` expression with argument list `args` performs the following steps:

1. Let `F` be the `Map` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `Map` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.14.3 Properties of the Map Constructor

The value of the `[[Prototype]]` internal data property of the `Map` constructor is the Function prototype object (15.3.3).

Besides the `length` property (whose value is `0`), the `Map` constructor has the following property:

15.14.3.1 Map.prototype

The initial value of `Map.prototype` is the `Map` prototype object (15.14.4).

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

15.14.3.2 Map[@@create]()

The `@@create` method of a `Map` function object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%MapPrototype%", ([[MapData]], [[MapComparator]]))`.
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.14.4 Properties of the Map Prototype Object

The value of the `[[Prototype]]` internal data property of the `Map` prototype object is the standard built-in `Object` prototype object (15.2.4). The `Map` prototype object is an ordinary object. It does not have a `[[MapData]]` or a `[[MapComparator]]` internal data property.

Comment [AWB12227]: Note that using a method for inserting pairs during initialization provides allows subclasses to be more expressive.

Deleted: <#>Let `status` be the result of `MapInitialization` with `map` and `iterable` as arguments.
¶

Deleted: <#>Return `map`.¶

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Deleted: <#>Let `map` be the result of the abstract operation `ObjectCreate` (15.2) with the intrinsic `%MapPrototype%` as the argument.
¶
<#>If `iterable` is not present, let `iterable` be `undefined`.¶
<#>Let `status` be the result of `MapInitialization` with `map` `iterable` as arguments.
¶
<#>`ReturnIfAbrupt(status)`.¶
<#>Return `map`.¶

Deleted: NOTE If the parameter `iterable` is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as an Map key and whose second element is the value to associate with that key.¶

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Deleted: <#>Add a `[[MapData]]` internal data property to `obj`.¶
<#>Set `obj`'s `[[MapData]]` internal data property to a new empty List.¶

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15.14.4.1 Map.prototype.constructor

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

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15.14.4.2 Map.prototype.clear()

The following steps are taken:

1. Let M be the `this` value.
2. If `Type(M)` is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
6. Repeat for each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$.
 - a. Set $p.[[key]]$ to `empty`.
 - b. Set $p.[[value]]$ to `empty`.
7. Return `undefined`.

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15.14.4.3 Map.prototype.delete (key)

The following steps are taken:

1. Let M be the `this` value.
2. If `Type(M)` is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. If M 's `[[MapComparator]]` internal data property is `undefined`, then let $same$ be the abstract operation `SameValueZero`.
6. Else, let $same$ be the abstract operation `SameValue`.
7. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
8. Repeat for each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$.
 - a. If $same(p.[[key]], key)$, then
 - i. Set $p.[[key]]$ to `empty`.
 - ii. Set $p.[[value]]$ to `empty`.
 - iii. Return `true`.
9. Return `false`.

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Deleted: <#>Set the value of M 's `[[MapData]]` internal data property to a new empty List.

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15.14.4.4 Map.prototype.forEach (callbackfn , thisArg = undefined)

`callbackfn` should be a function that accepts three arguments. `forEach` calls `callbackfn` once for each key/value pair present in the map object, in key insertion order. `callbackfn` is called only for keys of the map which actually exist; it is not called for keys that have been deleted from the map.

If a `thisArg` parameter is provided, it will be used as the `this` value for each invocation of `callbackfn`. If it is not provided, `undefined` is used instead.

NOTE If `callbackfn` is an Arrow Function, `this` was lexically bound when the function was created so `thisArg` will have no effect.

`callbackfn` is called with three arguments: the value of the item, the key of the item, and the Map object being traversed.

`forEach` does not directly mutate the object on which it is called but the object may be mutated by the calls to `callbackfn`.

NOTE Each key is visited only once with the value that is current at the time of the visit. If the value associated with a key is modified after it has been visited, it is not re-visited. Keys that are deleted after the call to `forEach` begins and before being visited are not visited. New keys added, after the call to `forEach` begins are visited.

When the `forEach` method is called with one or two arguments, the following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
6. If `thisArg` was supplied, let T be `thisArg`; else let T be `undefined`.
7. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
8. Repeat for each Record $\{[[key]], [[value]]\}$ e that is an element of $entries$, in original key insertion order
 - a. If $e[[key]]$ is not empty, then
 - i. Let $funcResult$ be the result of calling the `[[Call]]` internal method of $callbackfn$ with T as `thisArgument` and a List containing $e[[value]]$, $e[[key]]$, and M as `argumentsList`.
 - ii. $\text{ReturnIfAbrupt}(funcResult)$.
9. Return `undefined`.

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

15.14.4.5 Map.prototype.get (key)

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
6. If M 's `[[MapComparator]]` internal data property is `undefined`, then let `same` be the abstract operation `SameValueZero`.
7. Else, let `same` be the abstract operation `SameValue`.
8. Repeat for each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$.
 - a. If $\text{same}(p[[key]], key)$, then return $p[[value]]$.
9. Return `undefined`.

15.14.4.6 Map.prototype.has (key)

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
6. If M 's `[[MapComparator]]` internal data property is `undefined`, then let `same` be the abstract operation `SameValueZero`.
7. Else, let `same` be the abstract operation `SameValue`.
8. Repeat for each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$.
 - a. If $\text{same}(p[[key]], key)$, then return `true`.
9. Return `false`.

15.14.4.7 Map.prototype.entries ()

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. Return the result of calling the `CreateMapIterator` abstract operation with arguments M and `"key+value"`.

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15.14.4.8 Map.prototype.keys ()

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. Return the result of calling the `CreateMapIterator` abstract operation with arguments M and `"key"`.

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15.14.4.9 Map.prototype.set (key , value)

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
6. If M 's `[[MapComparator]]` internal data property is `undefined`, then let $same$ be the abstract operation `SameValueZero`.
7. Else, let $same$ be the abstract operation `SameValue`.
8. Repeat for each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$.
 - a. If $same(p, [[key]], key)$, then
 - i. Set $p, [[value]]$ to $value$.
 - ii. Return M .
9. Let p be the Record $\{[[key]], key, [[value]], value\}$.
10. Append p as the last element of $entries$.
11. Return M .

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Comment [AWB10230]: Do we really want to do this sort of method sharing. It has a bad smell.

15.14.4.10 get Map.prototype.size

`Map.prototype.size` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If M 's `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of M 's `[[MapData]]` internal data property.
6. Let $count$ be 0.
7. For each Record $\{[[key]], [[value]]\}$ p that is an element of $entries$
 - a. If $p, [[key]]$ is not `empty` then
 - i. Set $count$ to $count+1$.
8. Return $count$.

15.14.4.11 Map.prototype.values ()

The following steps are taken:

1. Let M be the `this` value.
2. If $\text{Type}(M)$ is not `Object`, then throw a `TypeError` exception.
3. Return the result of calling the `CreateMapIterator` abstract operation with arguments M and `"value"`.

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Comment [AWB10229]: This is how we identify a property whose key is a built-in `Symbol`

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Comment [AWB10230]: Do we really want to do this sort of method sharing. It has a bad smell.

15.14.4.13 Map.prototype.[@@toStringTag]

The initial value of the `@@toStringTag` property is the string value "Map".

This property has the attributes { `[Writable]`: `false`, `[Enumerable]`: `false`, `[Configurable]`: `true` }.

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15.14.5 Properties of Map Instances

Map instances inherit properties from the Map prototype. After initialisation by the Map constructor, Map instances also have a `[MapData]` internal data property and a `[MapComparator]` internal data property.

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15.14.6 Map Iterator Object Structure

A Map Iterator is an object, with the structure defined below, that represent a specific iteration over some specific Map instance object. There is not a named constructor for Map Iterator objects. Instead, map iterator objects are created by calling certain methods of Map instance objects.

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15.14.6.1 CreateMapIterator Abstract Operation

Several methods of Map objects return Iterator objects. The abstract operation `CreateMapIterator` with arguments `map` and `kind` is used to create such iterator objects. It performs the following steps:

1. Let `M` be the result of calling `ToObject(map)`.
2. ReturnIfAbrupt(`M`).
3. If `M` does not have a `[MapData]` internal data property throw a `TypeError` exception.
4. Let `entries` be the List that is the value of `M`'s `[MapData]` internal data property.
5. Let `itr` be the result of `ObjectCreate(%MapIteratorPrototype%, {[Map], [MapNextIndex], [MapIterationKind]}).`
6. Set `itr`'s `[Map]` internal data property to `M`.
7. Set `itr`'s `[MapNextIndex]` internal data property to `0`.
8. Set `itr`'s `[MapIterationKind]` internal data property to `kind`.
9. Return `itr`.

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15.14.6.2 The Map Iterator Prototype

All Map Iterator Objects inherit properties from a common Map Iterator Prototype object. The `[Prototype]` internal data property of the Map Iterator Prototype is the `%ObjectPrototype%` intrinsic object. In addition, the Map Iterator Prototype has the following properties:

15.14.6.2.1 MapIterator.prototype.constructor

15.14.6.2.2 MapIterator.prototype.next()

1. Let `O` be the `this` value.
2. If `Type(O)` is not `Object`, throw a `TypeError` exception.
3. If `O` does not have all of the internal properties of a Map Iterator Instance (15.14.7.1.2), throw a `TypeError` exception.
4. Let `m` be the value of the `[Map]` internal data property of `O`.
5. Let `index` be the value of the `[MapNextIndex]` internal data property of `O`.
6. Let `itemKind` be the value of the `[MapIterationKind]` internal data property of `O`.
7. Assert: `m` has a `[MapData]` internal data property and `m` has been initialized so the value of `[MapData]` is not `undefined`.
8. Let `entries` be the List that is the value of the `[MapData]` internal data property of `m`.
9. Repeat while `index` is less than the total number of elements of `entries`. The number of elements must be redetermined each time this method is evaluated.
 - a. Let `e` be the Record `{[key], [value]}` at 0-origin insertion position `index` of `entries`.
 - b. Set `index` to `index+1`.
 - c. Set the `[MapNextIndex]` internal data property of `O` to `index`.
 - d. If `e.[key]` is not empty, then

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Comment [AWB10231]: TODO: need to decide what to use for a constructor for these sort of objects. Probably we should try to consistently follow the "class model" wherever we can.

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- i. If *itemKind* is "key" then, let *result* be *e*.[[key]].
 - ii. Else if *itemKind* is "value" then, let *result* be *e*.[[value]].
 - iii. Else,
 1. Assert: *itemKind* is "key+value".
 2. Let *result* be the result of the abstract operation *ArrayCreate* with argument 2.
 3. Assert: *result* is a new, well-formed Array object so the following operations will never fail.
 4. Call *CreateOwnProperty(result, "0", e.[[key]])*.
 5. Call *CreateOwnProperty(result, "1", e.[[value]])*.
 - iv. Return *CreateItrResultObject(result, false)*.
10. Return *CreateItrResultObject(undefined, true)*.

15.14.6.2.3 MapIterator.prototype.@@iterator()

The following steps are taken:

1. Return the **this** value.

15.14.6.2.4 MapIterator.prototype.@@toStringTag

The initial value of the @@toStringTag property is the string value "Map Iterator".

15.14.6.3 Properties of Map Iterator Instances

Map Iterator instances inherit properties from the Map Iterator prototype (the intrinsic, %MapIteratorPrototype%). Map Iterator instances are initially created with the internal properties described in Table 37.

Table 37—Internal Data Properties of Map Iterator Instances

Internal Data Property Name	Description
[[Map]]	The Map object that is being iterated.
[[MapNextIndex]]	The integer index of the next Map data element to be examined by this iteration.
[[MapIterationKind]]	A string value that identifies what is to be returned for each element of the iteration. The possible values are: "key", "value", "key+value".

15.15 WeakMap Objects

WeakMap objects are collections of key/value pairs where the keys are ECMAScript objects and values may be arbitrary ECMAScript language values. A WeakMap may be queried to see if it contains an key/value pair with a specific key, but no mechanisms is provided for enumerating the objects it holds as keys. If an object that is being used as the key of a WeakMap key/value pair is only reachable by following a chain of references that start within that WeakMap, then that key/value pair is inaccessible and is automatically removed from the WeakMap. WeakMap implementations must detect and remove such key/value pairs and any associated resources.

An implementation may impose an arbitrarily determined latency between the time a key/value pair of a WeakMap becomes inaccessible and the time when the key/value pair is removed from the WeakMap. If this latency was observable to ECMAScript program, it would be a source of indeterminacy that could impact program execution. For that reason, an ECMAScript implementation must not provide any means to observe a key of a WeakMap that does not require the observer to present the observed key.

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Deleted: Completion {[[type]]: throw, [[value]]: %StopIteration%, [[target]]: empty}

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WeakMap objects must be implemented using either hash tables or other mechanisms that, on average, provide access times that are sublinear on the number of key/value pairs in the collection. The data structures used in this WeakMap objects specification are only intended to describe the required observable semantics of WeakMap objects. It is not intended to be a viable implementation model.

NOTE WeakMap are intended to provide a mechanism for dynamically associating state with an object in a manner that does not "leak" memory resources if, in the absence of the WeakMap, the object otherwise became inaccessible and subject to resource reclamation by the implementation's garbage collection mechanisms. Achieving this characteristic requires coordination between the WeakMap implementation and the garbage collector. The following references describe mechanism that may be useful to implementations of WeakMap:

Barry Hayes. 1997. Ephemerons: a new finalization mechanism. In *Proceedings of the 12th ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications (OOPSLA '97)*, A. Michael Berman (Ed.). ACM, New York, NY, USA, 176-183. <http://doi.acm.org/10.1145/263698.263733>

Alexandra Barros, Roberto Ierusalimschy. Eliminating Cycles in Weak Tables. *Journal of Universal Computer Science - J.UCS*, vol. 14, no. 21, pp. 3481-3497, 2008. http://www.jucs.org/jucs_14_21/eliminating_cycles_in_weak

15.15.1 The WeakMap Constructor Called as a Function

When WeakMap is called as a function rather than as a constructor, it initializes its **this** value with the internal state necessary to support the WeakMap.prototype methods. The WeakMap constructor is designed to be subclassable. It may be used as the value in an extends clause of a class definition. Subclass constructors that intend to inherit the specified WeakMap behaviour must include a super call to WeakMap.

15.15.1.1 WeakMap (iterable = undefined)

When the WeakMap function is called with optional argument iterable the following steps are taken:

1. Let map be the **this** value.
2. If Type(map) is not Object then, throw a **TypeError** exception.
3. If map does not have a [[WeakMapData]] internal data property, then throw a **TypeError** exception.
4. If map's [[WeakMapData]] internal data property is not **undefined**, then throw a **TypeError** exception.
5. If iterable is not present, let iterable be **undefined**.
6. If iterable is either **undefined** or **null**, then let itr be **undefined**.
7. Else,
 - a. Let iterator be the well-known symbol @@iterator.
 - b. Let itr be the result of Invoke(iterable, iterator).
 - c. ReturnIfAbrupt(itr).
 - d. Let adder be the result of Get(map, "set").
 - e. ReturnIfAbrupt(adder).
 - f. If IsCallable(adder) is **false**, throw a **TypeError** Exception.
8. Set map's [[WeakMapData]] internal data property to a new empty List.
9. If itr is **undefined**, then return map.
10. Repeat
 - a. Let next be the result of Invoke(itr, "next").
 - b. ReturnIfAbrupt(next).
 - c. If Type(next) is not Object, then throw a **TypeError** exception.
 - d. Let done be IteratorComplete(next).
 - e. ReturnIfAbrupt(done).
 - f. If done is **true**, then return NormalCompletion(map).
 - g. Let nextValue be IteratorValue(next).
 - h. ReturnIfAbrupt(nextValue).
 - i. Let k be the result of Get(nextValue, "0").
 - j. ReturnIfAbrupt(k).
 - k. Let v be the result of Get(nextValue, "1").
 - l. ReturnIfAbrupt(v).
 - m. Let status be the result of calling the [[Call]] internal method of adder with map as thisArgument and a List whose elements are k and v as argumentsList.
 - n. ReturnIfAbrupt(status).

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15.15.1.1 WeakMapInitialisation

The abstract operation WeakMapInitialisation with arguments *obj* and *iterable* is used to initialize an object as a map. It performs the following steps:[¶]

```
<#> If Type(obj) is not Object, throw a TypeError exception.
<#> If obj does not have already has a [[WeakMapData]] internal data property, throw a TypeError exception.
<#> If the result of calling the [[GetIsExtensible]] internal property method of obj is false, throw a TypeError exception.
<#> If iterable is not undefined, then
  <#> If iterable is ToObject(iterable).
  <#> ReturnIfAbrupt(iterable).
  <#> Let iterator be the intrinsic symbol @@iterator.
  <#> Let itr be the result of calling the Invoke(iterable, obj, abstraction operation with iterator, obj, and an empty List as arguments).¶
  <#> ReturnIfAbrupt(itr).¶
  <#> Let adder be the result of calling the [[Get]] internal method of obj with argument, "set".¶
  <#> ReturnIfAbrupt(adder).¶
  <#> If IsCallable(adder) is false, throw a TypeError Exception.¶
  <#> Add a [[WeakMapData]] internal data property to obj.¶
  <#> Set obj's [[WeakMapData]] internal data property to a new empty List.¶
  <#> If iterable is undefined, return obj.¶
  <#> Repeat
    <#> Let next be the result of performing Invoke(itr, with arguments "next", itr, and an empty arguments List).¶
```

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Deleted: <#> If *m* is **undefined** or the intrinsic %WeakMapPrototype%[¶]

Deleted: Let *map* be the result of ToObject(*m*)

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Deleted: <#> If IteratorComplete(*next*) is **true**, then return NormalCompletion(*map*).[¶]

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Comment [AWB12232]: Note that using a method for inserting pairs during initialization provides allows

Deleted: <#> Let *status* be the result of MapInitialisation with *map* and *iterable* as arguments.[¶]

NOTE If the parameter `iterable` is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as a `WeakMap` key and whose second element is the value to associate with that key.

15.15.2 The WeakMap Constructor

When `WeakMap` is called as part of a `new` expression it is a constructor: it initialises a newly created object.

15.15.2.1 new WeakMap (... args)

`WeakMap` called as part of a new expression with argument list `args` performs the following steps:

1. Let `F` be the `WeakMap` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `WeakMap` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.15.3 Properties of the WeakMap Constructor

The value of the `[[Prototype]]` internal data property of the `WeakMap` constructor is the `Function` prototype object (15.3.3).

Besides the `length` property (whose value is `0`), the `WeakMap` constructor has the following property:

15.15.3.1 WeakMap.prototype

The initial value of `WeakMap.prototype` is the `WeakMap` prototype object (15.15.4).

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

15.15.3.2 WeakMap[@@create] ()

The `@@create` method of a `WeakMap` object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%WeakMapPrototype%", [[WeakMapData]])`.
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.15.4 Properties of the WeakMap Prototype Object

The value of the `[[Prototype]]` internal data property of the `WeakMap` prototype object is the standard built-in `Object` prototype object (15.2.4). The `WeakMap` prototype object is an ordinary object. It does not have a `[[WeakMapData]]` internal data property.

15.15.4.1 WeakMap.prototype.constructor

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

15.15.4.2 WeakMap.prototype.clear ()

The following steps are taken:

1. Let `M` be the `this` value.

Deleted: <#>Return map.`¶`

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Deleted: The `WeakMap` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intended to inherit the specified `WeakMap` behaviour must include a `super` call to `WeakMap`.`¶`

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Deleted: <#>Let `map` be the result of the abstract operation `ObjectCreate (15.2)` with the intrinsic `%WeakMapPrototype%` as the argument.`¶`

<#>If `iterable` is not present, let `iterable` be undefined.`¶`

<#>Let `status` be the result of `WeakMapInitialisation` with `map` and `iterable` as arguments.`¶`

<#>ReturnIfAbrupt(`status`).`¶`

<#>Return `map`.`¶`

Deleted: NOTE If the parameter `iterable` is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as a `WeakMap` key and whose second element is the value to associate with that key.`¶`

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Deleted: <#>Add a `[[WeakMapData]]` internal data property to `obj`.`¶`

<#>Set `obj`'s `[[WeakMapData]]` internal data property to a new empty List.`¶`

Comment [AWB14233]: Because the `@@create` method is essential to the integrity of this "class" definition, just like the prototype property, it seems appropriate to freeze it in the same manner.

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2. If Type(*M*) is not Object, then throw a **TypeError** exception.
3. If *M* does not have a **[[WeakMapData]]** internal data property throw a **TypeError** exception.
4. If *M*'s **[[WeakMapData]]** internal data property is **undefined**, then throw a **TypeError** exception.
5. Set the value of *M*'s **[[WeakMapData]]** internal data property to a new empty List.
6. Return **undefined**.

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15.15.4.3 WeakMap.prototype.delete (key)

The following steps are taken:

1. Let *M* be the **this** value.
2. If Type(*M*) is not Object, then throw a **TypeError** exception.
3. If *M* does not have a **[[WeakMapData]]** internal data property throw a **TypeError** exception.
4. Let *entries* be the List that is the value of *M*'s **[[WeakMapData]]** internal data property.
5. If *entries* is **undefined**, then throw a **TypeError** exception.
6. If Type(*key*) is not Object, then throw a **TypeError** exception.
7. Repeat for each Record **{[[key]], [[value]]}** *p* that is an element of *entries*.
 - a. If *p*.**[[key]]** and *key* are the same object, then
 - i. Set *p*.**[[key]]** to empty.
 - ii. Set *p*.**[[value]]** to empty.
 - iii. Return **true**.
8. Return **false**.

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Deleted: **<#>Let *k* be **ToObject(key)**.
<#>ReturnIfAbrupt(*k*).
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Deleted: **TypeError**
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<#>ReturnIfAbrupt(*k*).
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15.15.4.4 WeakMap.prototype.get (key)

The following steps are taken:

1. Let *M* be the **this** value.
2. If Type(*M*) is not Object, then throw a **TypeError** exception.
3. If *M* does not have a **[[WeakMapData]]** internal data property throw a **TypeError** exception.
4. Let *entries* be the List that is the value of *M*'s **[[WeakMapData]]** internal data property.
5. If *entries* is **undefined**, then throw a **TypeError** exception.
6. If Type(*key*) is not Object, then throw a **TypeError** exception.
7. Repeat for each Record **{[[key]], [[value]]}** *p* that is an element of *entries*.
 - a. If *p*.**[[key]]** and *key* are the same object, then return *p*.**[[value]]**
8. Return **undefined**.

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<#>ReturnIfAbrupt(*k*).
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15.15.4.5 WeakMap.prototype.has (key)

The following steps are taken:

1. Let *M* be the **this** value.
2. If Type(*M*) is not Object, then throw a **TypeError** exception.
3. If *M* does not have a **[[WeakMapData]]** internal data property throw a **TypeError** exception.
4. Let *entries* be the List that is the value of *M*'s **[[WeakMapData]]** internal data property.
5. If *entries* is **undefined**, then throw a **TypeError** exception.
6. If Type(*key*) is not Object, then throw a **TypeError** exception.
7. Repeat for each Record **{[[key]], [[value]]}** *p* that is an element of *entries*.
 - a. If *p*.**[[key]]** and *key* are the same object, then return **true**.
8. Return **false**.

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Deleted: **<#>Let *k* be **ToObject(key)**.
<#>ReturnIfAbrupt(*k*).
|**
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15.15.4.6 WeakMap.prototype.set (key , value)

The following steps are taken:

1. Let *M* be the **this** value.
2. If Type(*M*) is not Object, then throw a **TypeError** exception.
3. If *M* does not have a **[[WeakMapData]]** internal data property throw a **TypeError** exception.
4. Let *entries* be the List that is the value of *M*'s **[[WeakMapData]]** internal data property.
5. If *entries* is **undefined**, then throw a **TypeError** exception.

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6. If Type(key) is not Object, then throw a **TypeError** exception.
7. Repeat for each Record {[[key]], [[value]]} *p* that is an element of *entries*.
 - a. If *p*.[[key]] and key are the same object, then
 - i. Set *p*.[[value]] to value.
 - ii. Return *M*.
8. Let *p* be the Record {[[key]], key, [[value]], value}.
9. Append *p* as the last element of *entries*.
10. Return *M*.

15.15.4.7 WeakMap.prototype.[@@toStringTag]

The initial value of the `@@toStringTag` property is the string value "`WeakMap`".

This property has the attributes { `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true` }.

15.15.5 Properties of WeakMap Instances

WeakMap instances are ordinary objects that inherit properties from the WeakMap prototype. WeakMap instances also have a `[[WeakMapData]]` internal data property.

15.16 Set Objects

Set objects are collections of ECMAScript language values. A distinct value may only occur once as an element of a Set's collection. Distinct values are discriminated using a comparison algorithm that is selected when the Set is created.

A Set object can iterate its elements in insertion order. Set objects must be implemented using either hash tables or other mechanisms that, on average, provide access times that are sublinear on the number of elements in the collection. The data structures used in this Set objects specification is only intended to describe the required observable semantics of Set objects. It is not intended to be a viable implementation model.

15.16.1 The Set Constructor Called as a Function

When `set` is called as a function rather than as a constructor, it initializes its `this` value with the internal state necessary to support the `set.prototype` internal methods. The `set` constructor is designed to be subclassable. It may be used as the value in an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified `set` behaviour must include a `super` call to `set`.

15.16.1.1 Set (iterable = undefined, comparator = undefined)

When the `set` function is called with optional arguments `iterable` and `comparator` the following steps are taken:

1. Let `set` be the `this` value.
2. If Type(`set`) is not Object then, throw a **TypeError** exception.
3. If `set` does not have a `[[SetData]]` internal data property, then throw a **TypeError** exception.
4. If `set`'s `[[SetData]]` internal data property is not `undefined`, then throw a **TypeError** exception.
5. If `iterable` is not present, let `iterable` be `undefined`.
6. If `iterable` is `null`, then let `itr` be `undefined`.
7. Else,
 - a. Let `iterator` be the well-known symbol `@@iterator`.
 - b. Let `itr` be the result of `Invoke(iterator, iterable)`.
 - c. ReturnIfAbrupt(`itr`).
 - d. Let `adder` be the result of `Get(set, "add")`.
 - e. ReturnIfAbrupt(`adder`).
 - f. If `IsCallable(adder)` is `false`, throw a **TypeError** Exception.
8. If `comparator` is not present, let `comparator` be `undefined`.
9. If `comparator` is not `undefined`, then
 - a. If `comparator` is not `"is"`, then throw a **RangeError** Exception.

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 <#>ReturnIfAbrupt(*k*).
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Deleted: 15.16.1.1 SetInitialisation
 The abstract operation `SetInitialisation` with arguments `obj` and `iterable` is used to initialize an object as a set instance. It performs the following steps:
<#>If Type(`obj`) is not Object, throw a **TypeError** exception.
<#>If `obj` already hasdoes not have a `[[SetData]]` internal data property, throw a **TypeError** exception.
<#>If the result of calling the `[[GetIsExtensible]` internal propertymethod of `obj` is `false`, throw a **TypeError** exception.
<#>If `iterable` is not `undefined`, then
<#>Let `iterable` be `ToObject(iterable)`.
<#>ReturnIfAbrupt(`iterable`).
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Deleted: <#>If *O* is `undefined` or the intrinsic
Deleted: <#>Let `set` be the result of
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10. Set *set*'s `[[SetData]]` internal data property to a new empty List.
11. Set *set*'s `[[SetComparator]]` internal data property to *comparator*.
12. If *itr* is `undefined`, then return *set*.
13. Repeat
 - a. Let *next* be the result of `Invoke(itr, "next")`.
 - b. `ReturnIfAbrupt(next)`.
 - c. If `Type(next)` is not `Object`, then throw a `TypeError` exception.
 - d. Let *done* be `IteratorComplete(next)`.
 - e. `ReturnIfAbrupt(done)`.
 - f. If *done* is `true`, then return `NormalCompletion(set)`.
 - g. Let *nextValue* be `IteratorValue(next)`.
 - h. `ReturnIfAbrupt(nextValue)`.
 - i. Let *status* be the result of calling the `[[Call]]` internal method of *adder* with *set* as *thisArgument* and a List whose sole element is *nextValue* as *argumentsList*.
 - j. `ReturnIfAbrupt(status)`.

15.16.2 The Set Constructor

When `Set` is called as part of a `new` expression it is a constructor: it initialises a newly created object.

15.16.2.1 new Set (... args)

`Set` called as part of a new expression with argument list *args* performs the following steps:

1. Let *F* be the `Set` function object on which the `new` operator was applied.
2. Let *argumentsList* be the *argumentsList* argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `Set` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.16.3 Properties of the Set Constructor

The value of the `[[Prototype]]` internal data property of the `Set` constructor is the Function prototype object (15.3.3).

Besides the `length` property (whose value is `0`), the `Set` constructor has the following property:

15.16.3.1 Set.prototype

The initial value of `Set.prototype` is the intrinsic `%SetPrototype%` object (15.16.4).

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

15.16.3.2 Set[@@create]()

The `@@create` method of a `Set` function object *F* performs the following steps:

1. Let *F* be the `this` value.
2. Let *obj* be the result of calling `OrdinaryCreateFromConstructor(F, "%SetPrototype%", { [[SetData]], [[SetComparator]] })`.
3. Return *obj*.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

Deleted: `IteratorComplete(next)`

Deleted: `<#>ReturnIfAbrupt(next)`

Comment [AWB12235]: Note that using a method for inserting pairs during initialization allows subclasses be more expressive.

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Deleted: `<#>Let status be the result of SetInitialisation with set and iterable as arguments.`

Deleted: `<#>Return set.`

Deleted: NOTE If the parameter iterable is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two-element array-like objects whose first element is a value that will be used as an Map key and whose second element is the value to associate with that key.

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Deleted: The `Set` constructor is designed to be subclassable. It may be used as the value of an `extensible` clause of a class declaration. Subclass constructors that intended to inherit the specified `Set` behaviour must include a `super` call to `Set`.

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Deleted: `iterable = undefined`

Deleted: `<#>Let set be the result of the abstract operation ObjectCreate (15.2) with the intrinsic %SetPrototype% as the argument.`

`<#>If iterable is not present, let iterable be undefined.`

`<#>Let status be the result of SetInitialisation with set and iterable as arguments.`

`<#>ReturnIfAbrupt(status).`

`<#>Return set.`

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Deleted: NOTE If the parameter iterable is present, it is expected to be an object that implements either a `values` method or an `@@iterator` method. Either method is expected to return an iterator object that returns the values that will be the initial elements of the set.

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Deleted: `<#>Add a [[SetData]] internal data property to obj.`

`<#>Set obj's [[SetData]] internal data property to a new empty List.`

Comment [AWB14236]: Because the `@@create` method is essential to the integrity of this "class" definition.

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15.16.4 Properties of the Set Prototype Object

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The value of the `[[Prototype]]` internal data property of the Set prototype object is the standard built-in `Object.prototype` object (15.2.4). The set prototype object is an ordinary object. It does not have a `[[SetData]]` or a `[[SetComparator]]` internal data property.

15.16.4.1 Set.prototype.constructor

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

15.16.4.2 Set.prototype.add (value)

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The following steps are taken:

1. Let S be the `this` value.
2. If `Type(S)` is not `Object`, then throw a `TypeError` exception.
3. If S does not have a `[[SetData]]` internal data property throw a `TypeError` exception.
4. If S 's `[[SetData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of S 's `[[SetData]]` internal data property.
6. If S 's `[[SetComparator]]` internal data property is `undefined`, then let $same$ be the abstract operation `SameValueZero`.
7. Else, let $same$ be the abstract operation `SameValue`.
8. Repeat for each e that is an element of $entries$, in original insertion order
 - a. If e is not empty and $same(e, value)$ is `true`, then
 - i. Return S .
9. Append $value$ as the last element of $entries$.
10. Return S .

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Deleted: value as its argument
Deleted: `TypeError`
Deleted: `ReturnIfAbrupt(S)`
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15.16.4.3 Set.prototype.clear ()

Deleted: <#>Repeat for each p that is an element of $entries$, ¶

The following steps are taken:

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15.16.4.4 Set.prototype.delete (value)

The following steps are taken:

1. Let S be the `this` value.
2. If `Type(S)` is not `Object`, then throw a `TypeError` exception.
3. If S does not have a `[[SetData]]` internal data property throw a `TypeError` exception.
4. If S 's `[[SetData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let $entries$ be the List that is the value of S 's `[[SetData]]` internal data property.
6. If S 's `[[SetComparator]]` internal data property is `undefined`, then let $same$ be the abstract operation `SameValueZero`.
7. Else, let $same$ be the abstract operation `SameValue`.
8. Repeat for each e that is an element of $entries$, in original insertion order
 - a. If e is not empty and $same(e, value)$ is `true`, then
 - i. Replace the element of $entries$ whose value is e with an element whose value is `empty`.
 - ii. Return `true`.
9. Return `false`.

15.16.4.5 Set.prototype.entries ()

The following steps are taken:

1. Let S be the **this** value.
2. If $\text{Type}(S)$ is not Object, then throw a **TypeError** exception.
3. Return the result of calling the **CreateSetIterator** abstract operation with arguments S and "**key+value**".

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NOTE For iteration purposes, a Set appears similar to a Map where each entry has the same value for its key and value.

15.16.4.6 Set.prototype.forEach (callbackfn , thisArg = undefined)

callbackfn should be a function that accepts three arguments. forEach calls callbackfn once for each value present in the set object, in value insertion order. callbackfn is called only for values of the Set which actually exist; it is not called for keys that have been deleted from the set.

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If a thisArg parameter is provided, it will be used as the **this** value for each invocation of callbackfn. If it is not provided, **undefined** is used instead.

NOTE 1 If callbackfn is an Arrow Function, **this** was lexically bound when the function was created so thisArg will have no effect.

callbackfn is called with three arguments: the first two arguments are a value contained in the Set. The same value of passed for both arguments. The Set object being traversed is passed as the third argument.

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NOTE 2 The callbackfn is called with three arguments to be consistent with the call back functions used by forEach methods for Map and Array. For Sets, each item value is considered to be both the key and the value.

forEach does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

NOTE 3 Each value is normally visited only once. However, a value will be revisited if it is deleted after it has been visited and then re-added before the to forEach call completes. Values that are deleted after the call to forEach begins and before being visited are not visited unless the value is added again before the to forEach call completes. New values added, after the call to forEach begins are visited.

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When the forEach method is called with one or two arguments, the following steps are taken:

1. Let S be the **this** value.
2. If $\text{Type}(S)$ is not Object, then throw a **TypeError** exception.
3. If S does not have a **[[SetData]]** internal data property throw a **TypeError** exception.
4. If S 's **[[SetData]]** internal data property is **undefined**, then throw a **TypeError** exception.
5. If **IsCallable(callbackfn)** is **false**, throw a **TypeError** exception.
6. If **thisArg** was supplied, let T be **thisArg**; else let T be **undefined**.
7. Let **entries** be the List that is the value of S 's **[[SetData]]** internal data property.
8. Repeat for each e that is an element of **entries**, in original insertion order
 - a. If e is not empty, then
 - i. Let **funcResult** be the result of calling the **[[Call]]** internal method of **callbackfn** with T as **thisArgument** and a List containing e , e , and S as **argumentsList**.
 - ii. **ReturnIfAbrupt(funcResult)**.
9. **Return undefined**.

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The **length** property of the forEach method is **1**.

15.16.4.7 Set.prototype.has (value)

The following steps are taken:

1. Let S be the **this** value.

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Deleted: as its argument

2. If Type(*S*) is not Object, then throw a **TypeError** exception.
3. If *S* does not have a **[[SetData]]** internal data property throw a **TypeError** exception.
4. If *S*'s **[[SetData]]** internal data property is **undefined**, then throw a **TypeError** exception.
5. Let *entries* be the List that is the value of *S*'s **[[SetData]]** internal data property.
6. If *S*'s **[[SetComparator]]** internal data property is **undefined**, then let *same* be the abstract operation **SameValueZero**.
7. Else, let *same* be the abstract operation **SameValue**.
8. Repeat for each *e* that is an element of *entries*.
 - a. If *e* is not empty and *same(e, value)*, then return **true**.
9. Return **false**.

15.16.4.8 Set.prototype.keys ()

The initial value of the **keys** property is the same function object as the initial value of the **values** property.

NOTE For iteration purposes, a Set appears similar to a Map where each entry has the same value for its key and value.

15.16.4.9 get Set.prototype.size

Set.prototype.size is an accessor property whose set accessor function is **undefined**. Its get accessor function performs the following steps:

1. Let *S* be the **this** value.
2. If Type(*S*) is not Object, then throw a **TypeError** exception.
3. If *S* does not have a **[[SetData]]** internal data property throw a **TypeError** exception.
4. If *S*'s **[[SetData]]** internal data property is **undefined**, then throw a **TypeError** exception.
5. Let *entries* be the List that is the value of *S*'s **[[SetData]]** internal data property.
6. Let *count* be 0.
7. For each *e* that is an element of *entries*
 - a. If *e* is not empty then
 - i. Set *count* to *count*+1.
8. Return *count*.

15.16.4.10 Set.prototype.values ()

The following steps are taken:

1. Let *S* be the **this** value.
2. If Type(*S*) is not Object, then throw a **TypeError** exception.
3. Return the result of calling the **CreateSetIterator** abstract operation with argument *S* and "value".

15.16.4.11 Set.prototype[@@iterator] ()

The initial value of the **@@iterator** property is the same function object as the initial value of the **values** property.

15.16.4.12 Set.prototype[@@toStringTag]

The initial value of the **@@toStringTag** property is the string value "**Set**".

This property has the attributes { **[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true** }.

15.16.5 Properties of Set Instances

Set instances inherit properties from the Set prototype. After initialisation by the Set constructor, Set instances also have a **[[SetData]]** internal data property and a **[[SetComparator]]** internal data property.

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15.16.6 Set Iterator Object Structure

A Set Iterator is an ordinary object, with the structure defined below, that represents a specific iteration over some specific Set instance object. There is not a named constructor for Set Iterator objects. Instead, set iterator objects are created by calling certain methods of Set instance objects.

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15.16.6.1 CreateSetIterator Abstract Operation

Several methods of Set objects return Iterator objects. The abstract operation CreateSetIterator with arguments *set* and *kind* is used to create such iterator objects. It performs the following steps:

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1. Let *S* be the result of calling `ToObject(set)`.
2. ReturnIfAbrupt(*S*).
3. If *S* does not have a `[[SetData]]` internal data property throw a `TypeError` exception.
4. If *S*'s `[[SetData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let *entries* be the List that is the value of *S*'s `[[SetData]]` internal data property.
6. Let *itr* be the result of `ObjectCreate(%SetIteratorPrototype%, {[[IteratedSet]], [[SetNextIndex]], [[SetIterationKind]]})`.
7. Set *itr*'s `[[IteratedSet]]` internal data property to *S*.
8. Set *itr*'s `[[SetNextIndex]]` internal data property to `0`.
9. Set *itr*'s `[[SetIterationKind]]` internal data property to *kind*.
10. Return *itr*.

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15.16.6.2 The Set Iterator Prototype

All Set Iterator Objects inherit properties from a common Set Iterator Prototype object. The `[[Prototype]]` internal data property of the Set Iterator Prototype is the `%ObjectPrototype%` intrinsic object. In addition, the Set Iterator Prototype has the following properties:

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15.16.6.2.1 SetIterator.prototype.constructor

15.16.6.2.2 SetIterator.prototype.next()

Comment [AWB10240]: TODO: need to decide what to use for a constructor for these sort of objects.

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1. Let *O* be the `this` value.
2. If `Type(O)` is not `Object`, throw a `TypeError` exception.
3. If *O* does not have all of the internal properties of a Set Iterator Instance (15.16.7.1.2), throw a `TypeError` exception.
4. Let *s* be the value of the `[[IteratedSet]]` internal data property of *O*.
5. Let *index* be the value of the `[[SetNextIndex]]` internal data property of *O*.
6. Let *itemKind* be the value of the `[[SetIterationKind]]` internal data property of *O*.
7. Assert: *s* has a `[[SetData]]` internal data property and *s* has been initialized so the value of `[[SetData]]` is not `undefined`.
8. Let *entries* be the List that is the value of the `[[SetData]]` internal data property of *s*.
9. Repeat while *index* is less than the total number of elements of *entries*. The number of elements must be redetermined each time this method is evaluated.
 - a. Let *e* be the element at 0-origin insertion position *index* of *entries*.
 - b. Set *index* to *index*+1;
 - c. Set the `[[SetNextIndex]]` internal data property of *O* to *index*.
 - d. If *e* is not empty, then
 - i. If *itemKind* is `"key+value"` then,
 1. Let *result* be the result of the abstract operation `ArrayCreate` with argument 2.
 2. Assert: *result* is a new, well-formed Array object so the following operations will never fail.
 3. Call `CreateOwnProperty(result, "0", e)`.
 4. Call `CreateOwnProperty(result, "1", e)`.
 5. Return `CreateItrResultObject(result, false)`.
 - ii. Return *e*.
10. Return `CreateItrResultObject(undefined, true)`.

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15.16.6.2.3 SetIterator.prototype.[@@iterator] ()

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The following steps are taken:

1. Return the **this** value.

15.16.6.2.4 SetIterator.prototype.[@@toStringTag]

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The initial value of the **[@@toStringTag]** property is the string value "Set Iterator".

15.16.6.3 Properties of Set Iterator Instances

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Set Iterator instances inherit properties from the Set Iterator prototype (the intrinsic, %SetIteratorPrototype%). Set Iterator instances are initially created with the internal properties specified in Table 38.

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Table 38 — Internal Data Properties of Set Iterator Instances

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Internal Data Property Name	Description
<code>[[IteratedSet]]</code>	The Set object that is being iterated.
<code>[[SetNextIndex]]</code>	The integer index of the next Set data element to be examined by this iteration.
<code>[[SetIterationKind]]</code>	A string value that identifies what is to be returned for each element of the iteration. The possible values are: "key", "value", "key+value". "key" and "value" have the same meaning.

15.17 The Reflect Module

This is a place holder for the material in http://wiki.ecmascript.org/doku.php?id=harmony:reflect_api

Comment [AWB10241]: TODO

15.17.1 Exported Function Properties Reflecting the Essential Internal Methods

15.17.1.1 Reflect.getPrototypeOf (target)

When the `getPrototypeOf` function is called with argument `target` the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. Return the result of calling the `[[GetInheritance]]` internal method of `obj`.

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15.17.1.2 Reflect.setPrototypeOf (target, proto)

When the `setPrototypeOf` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. If `Type(proto)` is not `Object` and `proto` is not `null`, then throw a `TypeError` exception.
4. Return the result of calling the `[[SetInheritance]]` internal method of `obj` with argument `proto`.

15.17.1.3 Reflect.isExtensible (target)

When the `isExtensible` function is called with argument `target` the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. Return the result of calling `IsExtensible(obj)`.

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15.17.1.4 Reflect.preventExtensions (target)

When the `preventExtensions` function is called with argument *target*, the following steps are taken:

5. Let *obj* be `ToObject(target)`.
6. `ReturnIfAbrupt(obj)`.
7. Return the result of calling the `[[SetIntegrity]]` internal method of *obj* with argument "`nonextensible`".

Deleted: PreventExtensions

15.17.1.5 Reflect.has (target, propertyKey)

When the `has` function is called with arguments *target* and *propertyKey*, the following steps are taken:

1. Let *obj* be `ToObject(target)`.
2. `ReturnIfAbrupt(obj)`.
3. Let *key* be `ToPropertyKey(propertyKey)`.
4. `ReturnIfAbrupt(key)`.
5. Return the result of calling the `[[HasProperty]]` internal method of *obj* with argument *key*.

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15.17.1.6 Reflect.hasOwn (target, propertyKey)

When the `hasOwn` function is called with arguments *target* and *propertyKey*, the following steps are taken:

6. Let *obj* be `ToObject(target)`.
7. `ReturnIfAbrupt(obj)`.
8. Let *key* be `ToPropertyKey(propertyKey)`.
9. `ReturnIfAbrupt(key)`.
10. Return the result of calling the `[[HasOwnProperty]]` internal method of *obj* with argument *key*.

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15.17.1.7 Reflect.getOwnPropertyDescriptor(target, propertyKey)

When the `getOwnPropertyDescriptor` function is called with arguments *target* and *propertyKey*, the following steps are taken:

1. Let *obj* be `ToObject(target)`.
2. `ReturnIfAbrupt(obj)`.
3. Let *key* be `ToPropertyKey(propertyKey)`.
4. `ReturnIfAbrupt(key)`.
5. Let *desc* be the result of calling the `[[GetOwnProperty]]` internal method of *obj* with argument *key*.
6. `ReturnIfAbrupt(desc)`.
7. Return the result of calling `FromPropertyDescriptor(desc)`.

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15.17.1.8 Reflect.get (target, propertyKey, receiver=target)

When the `get` function is called with arguments *target*, *propertyKey*, and *receiver* the following steps are taken:

1. Let *obj* be `ToObject(target)`.
2. `ReturnIfAbrupt(obj)`.
3. Let *key* be `ToPropertyKey(propertyKey)`.
4. `ReturnIfAbrupt(key)`.
5. If *receiver* is not present, then
 - a. Let *receiver* be *target*.
6. Return the result of calling the `[[Get]]` internal method of *obj* with arguments *key*, and *receiver*.

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15.17.1.9 Reflect.set (target, propertyKey, V, receiver=target)

When the `set` function is called with arguments *target*, *V*, *propertyKey*, and *receiver* the following steps are taken:

1. Let *obj* be `ToObject(target)`.

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2. ReturnIfAbrupt(*obj*).
 3. Let *key* be ToPropertyKey(*propertyKey*).
 4. ReturnIfAbrupt(*key*).
 5. If *receiver* is not present, then
 - a. Let *receiver* be *target*.
 6. Return the result of calling the [[Set]] internal method of *obj* with arguments *key*, *V*, and *receiver*.

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15.17.1.10 Reflect.deleteProperty (target, propertyKey)

When the `deleteProperty` function is called with arguments *target* and *propertyKey*, the following steps are taken:

1. Let *obj* be `ToObject(target)`.
 2. ReturnIfAbrupt(*obj*).
 3. Let *key* be `ToPropertyKey(propertyKey)`.
 4. ReturnIfAbrupt(*key*).
 5. Return the result of calling the [[Delete]] internal method of *obj* with argument *key*.

15.17.1.11 Reflect.defineProperty(target, propertyKey, attributes)

When the `defineProperty` function is called with arguments *target*, *propertyKey*, and *attributes* the following steps are taken:

1. Let *obj* be `ToObject(target)`.
 2. ReturnIfAbrupt(*obj*).
 3. Let *key* be `ToPropertyKey(propertyKey)`.
 4. ReturnIfAbrupt(*key*).
 5. Let *desc* be the result of calling `ToPropertyDescriptor` with *attributes* as the argument.
 6. ReturnIfAbrupt(*desc*).
 7. Return the result of calling the [[DefineOwnProperty]] internal method of *obj* with arguments *key*, and *desc*.

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15.17.1.12 Reflect.enumerate (target)

When the `enumerate` function is called with argument *target* the following steps are taken:

1. Let *obj* be `ToObject(target)`.
 2. ReturnIfAbrupt(*obj*).
 3. Let *itr* be the result of calling the [[Enumerate]] internal method of *obj*.
 4. Return *itr*.

15.17.1.13 Reflect.keys (target)

When the `keys` function is called with argument *target* the following steps are taken:

1. Let *obj* be `ToObject(target)`.
 2. ReturnIfAbrupt(*obj*).
 3. Let *keys* be the result of calling the [[OwnPropertyKeys]] internal method of *obj*.

Deleted: 15.17.1.12 Reflect.keys (target)
 When the `keys` function is called with argument *target* the following steps are taken:
 <#> Let *obj* be `ToObject(target)`.
 <#> ReturnIfAbrupt(*obj*).
 <#> Let *keys* be the result of calling the [[Keys]] internal method of *obj*.
 <#> ReturnIfAbrupt(*keys*).
 <#> Return `CreateArrayFromList(keys)`.

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Deleted: `propertyNames`

Deleted: <#> Let *keys* be the result of calling the [[OwnPropertyKeys]] internal method of *obj*.
 <#> ReturnIfAbrupt(*keys*).
Deleted: Return `CreateArrayFromList(keys)`.

15.17.1.14 Reflect.freeze (target)

When the `freeze` function is called with argument *target* the following steps are taken:

1. Let *obj* be `ToObject(target)`.
 2. ReturnIfAbrupt(*obj*).
 3. Return the result of calling the [[Freeze]] internal method of *obj*.

15.17.1.15 Reflect.seal (target)

When the `seal` function is called with argument *target* the following steps are taken:

1. Let *obj* be *ToObject(target)*.
2. ReturnIfAbrupt(*obj*).
3. Return the result of calling the **[[Seal]]** internal method of *obj*.

Deleted: Freeze

15.17.1.16 Reflect.isFrozen (target)

When the **isFrozen** function is called with argument *target* the following steps are taken:

1. Let *obj* be *ToObject(target)*.
2. ReturnIfAbrupt(*obj*).
3. Return the result of calling the **[[IsFrozen]]** internal method of *obj*.

15.17.1.17 Reflect.isSealed (target)

When the **isSealed** function is called with argument *target* the following steps are taken:

1. Let *obj* be *ToObject(target)*.
2. ReturnIfAbrupt(*obj*).
3. Return the result of calling the **[[IsSealed]]** internal method of *obj*.

15.18 Proxy Objects

15.19 The "std:iteration" Module

The **"std:iteration"** module defines built-in objects that support the for-of statement and similar iteration use cases. It also defines the built-in objects that support Generator Functions.

15.19.1 Common Iteration Interfaces

An interface is a set of object property keys whose associated values match a specific specification. Any object that provides all the properties of an interface in conformance to the interface's specification *conforms* to that interface. An interface isn't represented by a single object and there may be many distinctly implemented objects that conform to any interface. An individual object may conform to multiple interfaces.

15.19.1.1 The Iterable Interface

The *Iterable* interface includes the following property:

Property	Value	Requirements
<u>@@iterator</u>	A zero arguments function that returns an object.	The function returns an object that conforms to the <i>Iterator</i> interface.

15.19.1.2 The Iterator Interface

The *Iterator* interface includes the following properties:

Property	Value	Requirements
<u>next</u>	A function that returns an object.	The function returns an object that conforms to the <i>ItrResult</i> interface.

NOTE Arguments may be passed to the *next* function but their interpretation and validity is dependent upon the target *Iterator*. Generic use of *Iterators* should not pass any arguments.

15.19.1.3 The *ItrResult* Interface

The *ItrResult* interface includes the following properties:

Property	Value	Requirements
<u>done</u>	<u>Either true or false.</u>	This is the result status of the an <i>iterator</i> <i>next</i> method call. If the end of the iterator was reached done is true . If the end was not reached done is false and a value is available.
<u>value</u>	<u>Any ECMAScript language value.</u>	If done is false , this is the current iteration element value. If done is true , this is the return value of the iterator, if it supplied one. If the iterator does not have a return value, value is undefined . In that case, the value property may be absent from the conforming object if it does not inherit an explicit value property.

15.19.2 "std:iteration" Exports

The "std:iteration" module exports the names:

- Iterator\$
- GeneratorFunction
- Generator

15.19.3 GeneratorFunction Objects

Generator Function objects are constructor functions that are usually created by evaluating *GeneratorDeclaration*, *GeneratorExpression*, and *GeneratorMethod* syntactic productions. They may also be created by calling the *GeneratorFunction* constructor.

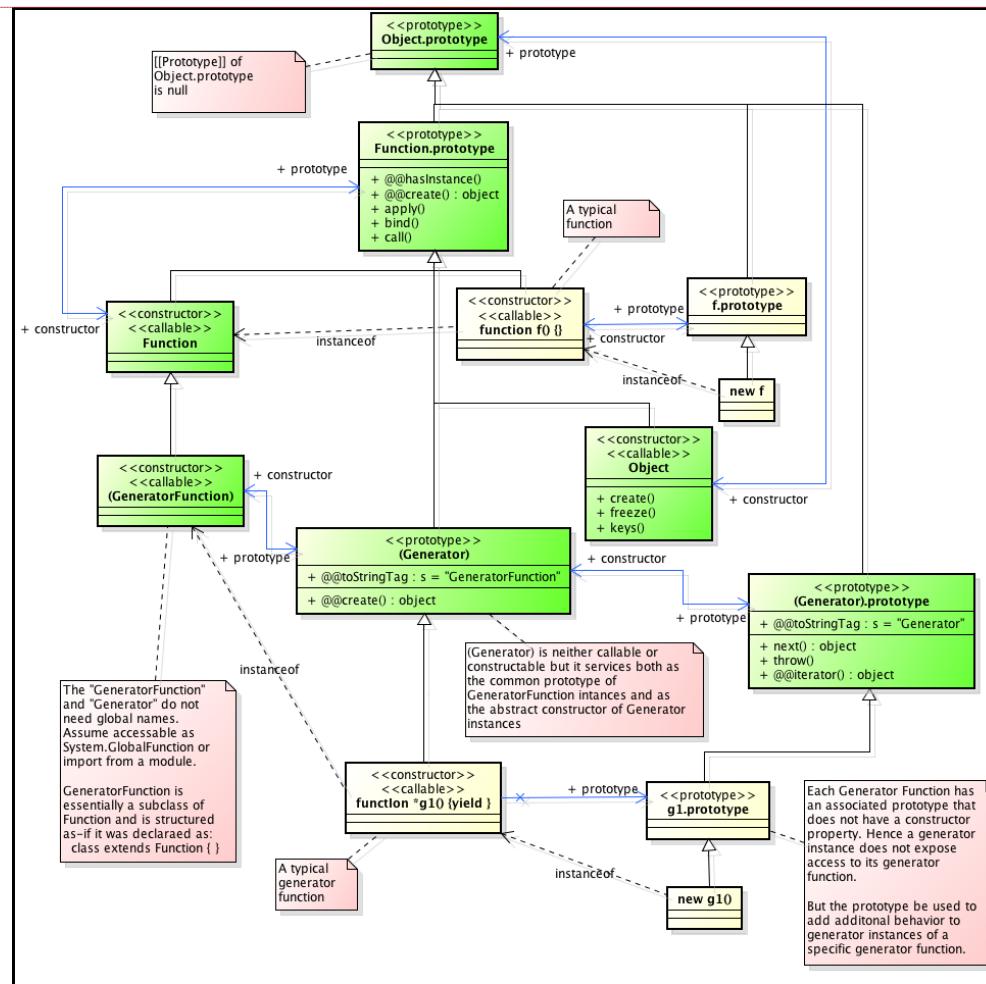


Figure 2 (Informative) -- Generator Objects Relationships

Deleted: 15.17.2.1 Reflect.has (target, propertyKey)
 When the `has` function is called with arguments `target` and `propertyKey`, the following steps are taken:
 ↪ Let `obj` be `ToObject(target)`.
 ↪ ReturnIfAbrupt(`obj`).
 ↪ Let `key` be `ToPropertyKey(propertyKey)`.
 ↪ ReturnIfAbrupt(`key`).
 ↪ Return the result of `HasProperty(obj, key)`.

15.17.2.1 Reflect.instanceOf (target, O)
 When the `instanceof` function is called with arguments `target` and `O`, the following steps are taken:
 ↪ Return the result of `OrdinaryInstanceOf(target, O)`.

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15.19.3.1 The GeneratorFunction Constructor

The `GeneratorFunction` constructor is the `%GeneratorFunction%` intrinsic object and the value of the name `GeneratorFunction` exported from the built-in module `"std:iteration"`. When `GeneratorFunction` is called as a function rather than as a constructor, it creates and initializes a new `GeneratorFunction` object. Thus the function call `GeneratorFunction (...)` is equivalent to the object creation expression `new GeneratorFunction (...)` with the same arguments. However, if the `this` value passed in the call is an Object with an `[[Code]]` internal data property whose value is `undefined`, it initializes the `this` value using the argument values. This permits `GeneratorFunction` to be used both as factory method and to perform constructor instance initialization.

`GeneratorFunction` may be subclassed and subclass constructors may perform a `super` invocation of the `GeneratorFunction` constructor to initialize subclass instances. However, all syntactic forms for defining generator function objects create direct instances of `GeneratorFunction`. There is no syntactic means to create instances of `GeneratorFunction` subclasses.

Comment [AWB15242]: Before final publication we should try to get a vector graphics version of this diagram

15.19.3.1.1 GeneratorFunction (p1, p2, ..., pn, body)

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

When the `GeneratorFunction` function is called with some arguments $p_1, p_2, \dots, p_n, body$ (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 $argCount$ be the total number of arguments passed to this function invocation.
2. Let P be the empty String.
3. If $argCount = 0$, let $bodyText$ be the empty String.
4. Else if $argCount = 1$, let $bodyText$ be that argument.
5. Else $argCount > 1$
 - a. Let $firstArg$ be the first argument.
 - b. Let P be `ToString(firstArg)`.
 - c. ReturnIfAbrupt(P).
 - d. Let k be 2.
 - e. Repeat, while $k < argCount$
 - i. Let $nextArg$ be the k 'th argument.
 - ii. Let $nextArgString$ be `ToString(nextArg)`.
 - iii. ReturnIfAbrupt($nextArgString$).
 - iv. Let P be the result of concatenating the previous value of P , the String ", " (a comma), and $nextArgString$.
 - v. Increase k by 1.
 - f. Let $bodyText$ be the k 'th argument.
6. Let $bodyText$ be `ToString(bodyText).`
7. ReturnIfAbrupt($bodyText$).
8. Let $parameters$ be the result of parsing P , interpreted as UTF-16 encoded Unicode text as described in 8.4, using `FormalParameters` as the goal symbol. Throw a `SyntaxError` exception if the parse fails.
9. Let $funcBody$ be the result of parsing $bodyText$, interpreted as UTF-16 encoded Unicode text as described in 8.4, using `FunctionBody` as the goal symbol. Throw a `SyntaxError` exception if the parse fails or if any static semantics errors are detected.
10. If $funcBody$ Contains `YieldExpression` is `false`, then throw a `SyntaxError` exception.
11. If `IsSimpleParameterList` of $parameters$ is `false` and any element of the `BoundNames` of $parameters$ also occurs in the `VarDeclaredNames` of $funcBody$, then throw a `SyntaxError` exception.
12. If any element of the `BoundNames` of $parameters$ also occurs in the `LexicallyDeclaredNames` of $funcBody$, then throw a `SyntaxError` exception.
13. Let $scope$ be the Global Environment.
14. Let F be the `this` value.
15. If `Type(F)` is not `Object` or if F does not have a `[[Code]]` internal data property or if the value of `[[Code]]` is not `undefined`, then
 - a. Let F be the result of calling `FunctionAllocate` with arguments `%Generator%` and `"generator"`.
16. If the value of F 's `[[FunctionKind]]` internal data property is not `"generator"`, then throw a `TypeError` exception.
17. Using $funcBody$ as the `FunctionBody` production, let $body$ be the supplemental syntactic grammar production: `GeneratorBody : FunctionBody`.
18. Perform the `FunctionInitialize` abstract operation with arguments F , `Normal`, $parameters$, $body$, $scope$, and `strict`.
19. Let $prototype$ be the result of the abstract operation `ObjectCreate` with the intrinsic object `%GeneratorPrototype%` as its argument.
20. Perform the abstract operation `MakeConstructor` with arguments F , `true`, and $prototype$.
21. Return F .

A `prototype` property is automatically created for every function created using the `GeneratorFunction` constructor, to provide for the possibility that the function will be used as a constructor.

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15.19.3.1.2 new GeneratorFunction (... argumentsList)

When `GeneratorFunction` is called as part of a `new` expression, it creates and initialises a newly created object.

1. Let `F` be the `GeneratorFunction` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct (F, argumentsList)`.

If `GeneratorFunction` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.19.3.2 Properties of the GeneratorFunction Constructor

The `GeneratorFunction` constructor is a built-in Function object that inherits from the `Function` constructor. The value of the `[[Prototype]]` internal data property of the `GeneratorFunction` constructor is the intrinsic object `%Function%`.

The value of the `[[Extensible]]` internal data property of the `GeneratorFunction` constructor is `true`.

The `GeneratorFunction` constructor has the following properties:

15.19.3.2.1 GeneratorFunction.prototype

The initial value of `GeneratorFunction.prototype` is `%Generator%`, the standard built-in `GeneratorFunction` prototype.

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

15.19.3.2.2 GeneratorFunction.length

This is a data property with a value of 1. This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }`.

15.19.3.2.3 GeneratorFunction[@@create]()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `proto` be the result of `GetPrototypeOfFromConstructor(F, "%Generator%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `FunctionAllocate` with argument `proto` and `"generator"`.
5. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

NOTE The `GeneratorFunction @@create` function is intentionally generic; it does not require that its `this` value be the `GeneratorFunction` constructor object. It can be transferred to other constructor functions for use as a `@@create` method. When used with other constructors, this function will create a function object whose `[[Prototype]]` value is obtained from the associated constructor.

15.19.3.3 Properties of the GeneratorFunction Prototype Object

The `GeneratorFunction` prototype object is an ordinary object. It is not a function object and does not have a `[[Code]]` internal data property or any other of the internal data properties listed in Table 13. In addition to being the value of the `prototype` property of the `%GeneratorFunction%` intrinsic and is itself the `%Generator%` intrinsic.

The value of the `[[Prototype]]` internal data property of the `GeneratorFunction` prototype object is the `%FunctionPrototype%` intrinsic object. The initial value of the `[[Extensible]]` internal data property of the `GeneratorFunction` prototype object is `true`.

15.19.3.3.1 GeneratorFunction.prototype.constructor

The initial value of `GeneratorFunction.prototype.constructor` is the intrinsic object `%GeneratorFunction%`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.3.3.2 GeneratorFunction.prototype.prototype

The value of `Function.prototype.prototype` is the `%GeneratorPrototype%`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.3.3.3 GeneratorFunction.prototype [@@toStringTag]

The initial value of the `@@toStringTag` property is the string value `"GeneratorFunction"`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.3.3.4 GeneratorFunction.prototype [@@create]()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%GeneratorPrototype%", {[[GeneratorState]], [[GeneratorContext]]})`.
3. Return `obj`.

This property has the attributes `{ [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.3.4 GeneratorFunction Instances

Every `GeneratorFunction` instance is an ordinary function object and has the internal data properties listed in Table 13. The value of the `[[FunctionKind]]` internal data property for all such instances is `"generator"`.

The `GeneratorFunction` instances have the following own properties:

15.3.4.1 length

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

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.3.4.2 prototype

Whenever a `GeneratorFunction` instance is created another ordinary object is also created and is the initial value of the generator function's `prototype` property. The value of the `prototype` property is used to initialise the `[[Prototype]]` internal data property of a newly created `Generator` object before the `generator` function object is invoked as a constructor for that newly created object.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

NOTE Unlike function instances, the object that is the value of the a GeneratorFunction's `prototype` property does not have a `constructor` property whose value is the GeneratorFunction instance.

15.19. 4 Generator Objects

A Generator object is an instance of a generator function and conforms to both the `Iterator` and `Iterable` interfaces.

Generator instances directly inherit properties from the object that is the value of the `prototype` property of the Generator function that created the instance. Generator instances indirectly inherit properties from the Generator Prototype intrinsic, `%GeneratorPrototype%`.

15.19.4.2 Properties of Generator Prototype

The Generator prototype object is the `%GeneratorPrototype%` intrinsic. It is also the initial value of the `prototype` property of the `%Generator%` intrinsic (the `GeneratorFunction.prototype`).

The Generator prototype is an ordinary object. It is not a Generator instance and does not have a `[[GeneratorState]]` internal data property.

The value of the `[[Prototype]]` internal data property of the Generator prototype object is the intrinsic object `%ObjectPrototype%` (15.2.4). The initial value of the `[[Extensible]]` internal data property of the Function prototype object is `true`.

All Generator instances indirectly inherit properties of the Generator prototype object.

15.19.4.2.1 Generator.prototype.constructor

The initial value of `Generator.prototype.constructor` is the intrinsic object `%Generator%`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.4.2.3 Generator.prototype.next (value)

The `next` method performs the following steps:

1. Let `g` be the `this` value.
2. Return the result of `GeneratorResume(g, value)`.

15.19.4.2.4 Generator.prototype.throw (exception)

The `throw` method performs the following steps:

1. Let `g` be the `this` value.
2. If `Type(generator)` is not `Object`, then throw a `TypeError` exception.
3. If `generator` does not have a `[[GeneratorState]]` internal data property, then throw a `TypeError` exception.
4. Let `state` be the value of `generator`'s `[[GeneratorState]]` internal data property.
5. Asset: `generator` also has a `[[GeneratorContext]]` internal data property.
6. If `state` is neither `"suspendedStart"` or `"suspendedYield"`, then throw a `TypeError` exception.
7. Let `E` be `Completion {[[type]]: throw, [[value]]: exception, [[target]]: empty}`.
8. If `state` is `"suspendedStart"` then,
 - a. Set `generator`'s `[[GeneratorState]]` internal data property to `"completed"`.
 - b. Once a generator enters the `"completed"` state it never leaves it and its associated execution context is never resumed. Any execution state associated with `generator` can be discarded at this point.
 - c. Return `E`.
9. Let `gContext` be value of `generator`'s `[[GeneratorContext]]` internal data property.
10. Let `methodContext` be the running execution context.
11. Suspend `methodContext`.

12. Set *generator*'s `[[GeneratorState]]` internal data property to `"executing"`.
13. Push *gContext* onto the execution context stack; *gContext* is now the running execution context.
14. Resume the suspended evaluation of *gContext* using *E* as the result of the operation that suspended it. Let *result* be the value returned by the resumed computation.
15. Assert: When we return here, *gContext* has already been removed from the execution context stack and *methodContext* is the currently running execution context.
16. Return *result*.

15.19.4.2.5 Generator.prototype [@@toStringTag]

The initial value of the `@@toStringTag` property is the string value `"Generator"`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.4.2 Properties of Generator Instances

Generator instances are initially created with the internal data properties described in Table 37.

Table 39 — Internal Data Properties of Generator Instances

<u>Internal Data Property Name</u>	<u>Description</u>
<code>[[GeneratorState]]</code>	The current execution state of the generator. The possible values are: <code>undefined</code> , <code>"suspendedStart"</code> , <code>"suspendedYield"</code> , <code>"executing"</code> , and <code>"completed"</code> .
<code>[[GeneratorContext]]</code>	The execution context that is used when executing the code of this generator.

15.19.4.2.1 @@iterator

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The value of the `@@iterator` own property of a Generator instance is that Generator instance.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }`.

15.19.4.3 Iteration Related Abstract Operations

15.19.4.3.1 GeneratorStart (*generator*, *generatorBody*)

1. Let *genContext* be the running execution context.
2. Set the Generator component of *genContext* to *generator*.
3. Set the code evaluation state of *genContext* such that when evaluation is resumed for that execution context the following steps will be performed:
 - a. Let *result* be the result of evaluating *generatorBody*.
 - b. Assert: If we return here, the generator either threw an exception or performed either an implicit or explicit `return`.
 - c. Remove *genContext* from the execution context stack and restore the execution context that is at the top of the execution context stack as the running execution context.
 - d. Set *g*'s `[[GeneratorState]]` internal data property to `"completed"`.
 - e. Once a generator enters the `"completed"` state it never leaves it and its associated execution context is never resumed. Any execution state associated with *generator* can be discarded at this point.
 - f. Return `IfAbrupt(result)`.
 - g. Return `CreateItrResultObject(result, true)`.
4. Set *generator*'s `[[GeneratorContext]]` internal data property to *genContext*.
5. Set *generator*'s `[[GeneratorState]]` internal data property to `"suspendedStart"`.
6. Return `NormalCompletion(generator)`.

15.19.4.3.2 GeneratorResume (generator, value)

The abstract operation `GeneratorResume` with arguments `generator` and `value` performs the following steps:

1. If `Type(generator)` is not `Object`, then throw a `TypeError` exception.
2. If `generator` does not have a `[[GeneratorState]]` internal data property, then throw a `TypeError` exception.
3. Let `state` be the value of `generator`'s `[[GeneratorState]]` internal data property.
4. Assert: `generator` also has a `[[GeneratorContext]]` internal data property.
5. If `state` is neither `"suspendedStart"` or `"suspendedYield"`, then throw a `TypeError` exception.
6. If `state` is `"suspendedStart"` and `value` is not `undefined`, then throw a `TypeError` exception.
7. Let `gContext` be value of `generator`'s `[[GeneratorContext]]` internal data property.
8. Let `methodContext` be the running execution context.
9. Suspend `methodContext`.
10. Set `generator`'s `[[GeneratorState]]` internal data property to `"executing"`.
11. Push `gContext` onto the execution context stack; `gContext` is now the running execution context.
12. Resume the suspended evaluation of `gContext` using `NormalCompletion(value)` as the result of the operation that suspended it. Let `result` be the value returned by the resumed computation.
13. Assert: When we return here, `gContext` has already been removed from the execution context stack and `methodContext` is the currently running execution context.
14. Return `result`.

15.19.4.3.3 GeneratorYield (itrNextObj)

The abstract operation `GeneratorYield` with argument `itrNextObj` performs the following steps:

1. Assert: `itrNextObj` is an `Object` that implemented the `ItrResult` interface.
2. Let `genContext` be the running execution context.
3. Assert: `genContext` is the execution context of a `generator`.
4. Let `generator` be the value of the `Generator` component of `genContext`.
5. Set the value of `generator`'s `[[GeneratorState]]` internal data property to `"suspendedYield"`.
6. Remove `genContext` from the execution context stack and restore the execution context that is at the top of the execution context stack as the running execution context.
7. Set the code evaluation state of `genContext` such that when evaluation is resumed with a `Completion` `resumptionValue` the following steps will be performed:
 - a. Return `resumptionValue`.
 - b. NOTE: This returns to the evaluation of the `YieldExpression` production that originally called this abstract operation.
8. Resume the suspended evaluation of `gContext` using `NormalCompletion(value)` as the result of the operation that suspended it. Let `result` be the value returned by the resumed computation.
9. Assert: When we return here, `gContext` has already been removed from the execution context stack and `methodContext` is the currently running execution context.
10. Return `NormalCompletion(itrNextObj)`.
11. NOTE: This returns to the evaluation of the operation that had most previously resumed evaluation of `gContext`.

15.19.4.3.4 CreateItrResultObject (value, done)

The abstract operation `CreateItrResultObject` with arguments `value` and `done` creates an object that supports the `ItrResult` interface by performing the following steps:

1. Assert: `Type(done)` is `Boolean`.
2. Let `obj` be the result of performing `ObjectCreate()`.
3. Perform `CreateOwnDataProperty(obj, "value", value)`.
4. Perform `CreateOwnDataProperty(obj, "done", done)`.
5. Return `obj`.

15.19.4.3.5 IteratorComplete (itrResult)

The abstract operation `IteratorComplete` with argument `itrResult` performing the following steps:

1. Assert: `Type(itrResult)` is `Object`.

2. Let `done` be the result of `Get(itrResult, "done")`.
3. Return `ToBoolean(done)`.

15.19.4.3.6 IteratorValue (*itrResult*)

The abstract operation `IteratorValue` with argument `itrResult` performing the following steps:

1. Assert: `Type(itrResult)` is Object.
2. Return the result of `Get(itrResult, "value")`.

16 Errors

An implementation must report most errors at the time the relevant ECMAScript language construct is evaluated. An *early error* is an error that can be detected and reported prior to the evaluation of any construct in the *Script* containing the error. An implementation must report early errors in a *Script* prior to the first evaluation of that *Script*. Early errors in `eval` code are reported at the time `eval` is called but prior to evaluation of any construct within the `eval` code. All errors that are not early errors are runtime errors.

An implementation must treat as an early error any instance of an early error that is specified in a static.

An implementation shall not treat other kinds of errors as early errors 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 *script* syntax and regular expression pattern or flag 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 *script* syntax or regular expression pattern or flag 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 may define behaviour other than throwing `RangeError` for `toFixed`, `toExponential`, and `toPrecision` when the `fractionDigits` or `precision` argument is outside the specified range.

Deleted: Program
Deleted: Program
Deleted: Program

Deleted: of the following kinds of errors as an early error:

Deleted: ¶
Any syntax error.¶
Attempts to define an *ObjectLiteral* that has multiple `get` property assignments with the same name or multiple `set` property assignments with the same name.¶
Attempts to define an *ObjectLiteral* that has both a data property assignment and a `get` or `set` property assignment with the same name.¶
Errors in regular expression literals that are not implementation-defined syntax extensions.¶
Attempts in strict mode code to define an *ObjectLiteral* that has multiple data property assignments with the same name.¶
The occurrence of a `WithStatement` in strict mode code.¶
The occurrence of an *Identifier* value appearing more than once within a *FormalParameterList* of an individual strict mode `FunctionDeclaration` or `FunctionExpression`.¶
Improper uses of `return`, `break`, and `continue`.

Comment [AWB15243]: TODO: need to verify that we actually have replicably overriden the `PutValue` cases there the deleted item would have applied to

Deleted: <#> Attempts to call `PutValue` on a value for which an early determination can be made that the value is not a Reference (for example, executing the assignment statement `3=4`).¶

Deleted: program
Deleted: program

DRAFT

Annex A (informative)

Grammar Summary

Field Code Changed
Field Code Changed
Field Code Changed

A.1 Lexical Grammar

SourceCharacter ::
any Unicode code unit

InputElementDiv ::
WhiteSpace
LineTerminator
Comment
Token
DivPunctuator

InputElementRegExp ::
WhiteSpace
LineTerminator
Comment
Token
RegularExpressionLiteral

WhiteSpace ::
<TAB>
<VT>
<FF>
<SP>
<NBSP>
<BOM>
<USP>

LineTerminator ::
<LF>
<CR>
<LS>
<PS>

LineTerminatorSequence ::
<LF>
<CR> [lookahead \notin <LF>]
<LS>
<PS>
<CR> <LF>

Comment ::
MultiLineComment
SingleLineComment

See clause 6

See clause 7

See clause 7

See 7.2

See 7.3

See 7.3

See 7.4

MultiLineComment ::
/ MultiLineCommentChars_{opt} */*

See 7.4

MultiLineCommentChars ::
MultiLineNotAsteriskChar MultiLineCommentChars_{opt}
** PostAsteriskCommentChars_{opt}*

See 7.4

PostAsteriskCommentChars ::
MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentChars_{opt}
** PostAsteriskCommentChars_{opt}*

See 7.4

MultiLineNotAsteriskChar ::
*SourceCharacter but not **

See 7.4

MultiLineNotForwardSlashOrAsteriskChar ::
*SourceCharacter but not one of / or **

See 7.4

SingleLineComment ::
// SingleLineCommentChars_{opt}

See 7.4

SingleLineCommentChars ::
SingleLineCommentChar SingleLineCommentChars_{opt}

See 7.4

SingleLineCommentChar ::
SourceCharacter but not LineTerminator

See 7.4

Token ::
IdentifierName
Punctuator
NumericLiteral
StringLiteral

See 7.5

Identifier ::
IdentifierName but not ReservedWord

See 7.6

IdentifierName ::
IdentifierStart
IdentifierName IdentifierPart

See 7.6

IdentifierStart ::
UnicodeLetter
\$

See 7.6

\ UnicodeEscapeSequence

IdentifierPart ::

IdentifierStart
UnicodeCombiningMark
UnicodeDigit
UnicodeConnectorPunctuation
<ZWNJ>
<ZWJ>

See 7.6

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 (Ni)”.

See 7.6

UnicodeCombiningMark ::

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

See 7.6

UnicodeDigit ::

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

See 7.6

UnicodeConnectorPunctuation ::

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

See 7.6

ReservedWord ::

Keyword
FutureReservedWord
NullLiteral
BooleanLiteral

See 7.6.1

Keyword :: one of

break
case
catch
continue
debugger
default
delete
do
else
finally
for
function
if
in

instanceof
new
return
switch
this
throw
try

typeof
var
void
while
with

See 7.6.1.1

FutureReservedWord :: one of

class
const
enum
export

extends
import

super

See 7.6.1.2

The following tokens are also considered to be *FutureReservedWords* when parsing strict mode code (see 10.1.1).

implements
interface
yield

let
package

private
protected

public
static

<i>Punctuator :: one of</i>						<i>See 7.7</i>
{	}	()	[]	
.	;	,	<	>	<=	
>=	==	!=	====	!==		
+	-	*	%	++	--	
<<	>>	>>>	&		^	
!	~	&&	 	?	:	
=	+=	-=	*=	%=	<<=	
>>=	>>>=	&=	 =	^=		
<i>DivPunctuator :: one of</i>						<i>See 7.7</i>
/	/=					
<i>Literal ::</i>						<i>See 7.8</i>
<i>NullLiteral</i>						
<i>BooleanLiteral</i>						
<i>NumericLiteral</i>						
<i>StringLiteral</i>						
<i>RegularExpressionLiteral</i>						
<i>NullLiteral ::</i>						<i>See 7.8.1</i>
null						
<i>BooleanLiteral ::</i>						<i>See 7.8.2</i>
true						
false						
<i>NumericLiteral ::</i>						<i>See 7.8.3</i>
<i>DecimalLiteral</i>						
<i>HexIntegerLiteral</i>						
<i>DecimalLiteral ::</i>						<i>See 7.8.3</i>
<i>DecimalIntegerLiteral</i>	.	<i>DecimalDigits_{opt}</i>	<i>ExponentPart_{opt}</i>			
.	<i>DecimalDigits</i>	<i>ExponentPart_{opt}</i>				
<i>DecimalIntegerLiteral</i>			<i>ExponentPart_{opt}</i>			
<i>DecimalIntegerLiteral ::</i>						<i>See 7.8.3</i>
0						
<i>NonZeroDigit DecimalDigits_{opt}</i>						
<i>DecimalDigits ::</i>						<i>See 7.8.3</i>
<i>DecimalDigit</i>						
<i>DecimalDigits DecimalDigit</i>						
<i>DecimalDigit :: one of</i>						<i>See 7.8.3</i>
0	1	2	3	4	5	
6	7	8	9			

<i>NonZeroDigit</i> :: one of	See 7.8.3
1 2 3 4 5 6 7 8 9	
<i>ExponentPart</i> ::	See 7.8.3
<i>ExponentIndicator</i> <i>SignedInteger</i>	
<i>ExponentIndicator</i> :: one of	See 7.8.3
e E	
<i>SignedInteger</i> ::	See 7.8.3
<i>DecimalDigits</i>	
+ <i>DecimalDigits</i>	
- <i>DecimalDigits</i>	
<i>HexIntegerLiteral</i> ::	See 7.8.3
0x <i>HexDigit</i>	
0X <i>HexDigit</i>	
<i>HexIntegerLiteral</i> <i>HexDigit</i>	
<i>HexDigit</i> :: one of	See 7.8.3
0 1 2 3 4 5 6 7 8 9 a b c d e f A B C D E F	
<i>StringLiteral</i> ::	See 7.8.4
" <i>DoubleStringCharacters</i> _{opt} "	
' <i>SingleStringCharacters</i> _{opt} '	
<i>DoubleStringCharacters</i> ::	See 7.8.4
<i>DoubleStringCharacter</i> <i>DoubleStringCharacters</i> _{opt}	
<i>SingleStringCharacters</i> ::	See 7.8.4
<i>SingleStringCharacter</i> <i>SingleStringCharacters</i> _{opt}	
<i>DoubleStringCharacter</i> ::	See 7.8.4
<i>SourceCharacter</i> but not one of " or \ or <i>LineTerminator</i>	
\ <i>EscapeSequence</i>	
<i>LineContinuation</i>	
<i>SingleStringCharacter</i> ::	See 7.8.4
<i>SourceCharacter</i> but not one of ' or \ or <i>LineTerminator</i>	
\ <i>EscapeSequence</i>	
<i>LineContinuation</i>	
<i>LineContinuation</i> ::	See 7.8.4
\ <i>LineTerminatorSequence</i>	
<i>EscapeSequence</i> ::	See 7.8.4
<i>CharacterEscapeSequence</i>	
0 [lookahead \notin <i>DecimalDigit</i>]	
<i>HexEscapeSequence</i>	
<i>UnicodeEscapeSequence</i>	
<i>CharacterEscapeSequence</i> ::	See 7.8.4
<i>SingleEscapeCharacter</i>	
<i>NonEscapeCharacter</i>	
<i>SingleEscapeCharacter</i> :: one of	See 7.8.4
' " \ b f n r t v	

<i>NonEscapeCharacter</i> ::		See 7.8.4
<i>SourceCharacter</i> but not one of <i>EscapeCharacter</i> or <i>LineTerminator</i>		
<i>EscapeCharacter</i> ::		See 7.8.4
<i>SingleEscapeCharacter</i>		
<i>DecimalDigit</i>		
x		
u		
<i>HexEscapeSequence</i> ::		See 7.8.4
x <i>HexDigit HexDigit</i>		
<i>UnicodeEscapeSequence</i> ::		See 7.8.4
u <i>HexDigit HexDigit HexDigit HexDigit</i>		
<i>RegularExpressionLiteral</i> ::		See 7.8.5
/ <i>RegularExpressionBody</i> / <i>RegularExpressionFlags</i>		
<i>RegularExpressionBody</i> ::		See 7.8.5
<i>RegularExpressionFirstChar</i> <i>RegularExpressionChars</i>		
<i>RegularExpressionChars</i> ::		See 7.8.5
[empty]		
<i>RegularExpressionChars</i> <i>RegularExpressionChar</i>		
<i>RegularExpressionFirstChar</i> ::		See 7.8.5
<i>RegularExpressionNonTerminator</i> but not one of * or \ or / or [
<i>RegularExpressionBackslashSequence</i>		
<i>RegularExpressionClass</i>		
<i>RegularExpressionChar</i> ::		See 7.8.5
<i>RegularExpressionNonTerminator</i> but not \ or / or [
<i>RegularExpressionBackslashSequence</i>		
<i>RegularExpressionClass</i>		
<i>RegularExpressionBackslashSequence</i> ::		See 7.8.5
\ <i>RegularExpressionNonTerminator</i>		
<i>RegularExpressionNonTerminator</i> ::		See 7.8.5
<i>SourceCharacter</i> but not <i>LineTerminator</i>		
<i>RegularExpressionClass</i> ::		See 7.8.5
[<i>RegularExpressionClassChars</i>]		
<i>RegularExpressionClassChars</i> ::		See 7.8.5
[empty]		
<i>RegularExpressionClassChars</i> <i>RegularExpressionClassChar</i>		
<i>RegularExpressionClassChar</i> ::		See 7.8.5
<i>RegularExpressionNonTerminator</i> but not] or \		
<i>RegularExpressionBackslashSequence</i>		

RegularExpressionFlags ::=
[empty]
RegularExpressionFlags IdentifierPart

See 7.8.5

A.2 Number Conversions

<i>StringNumericLiteral</i> ::= <i>StrWhiteSpace_{opt}</i> <i>StrWhiteSpace_{opt}</i> <i>StrNumericLiteral</i> <i>StrWhiteSpace_{opt}</i>	See 9.1.3.1	
<i>StrWhiteSpace</i> ::= <i>StrWhiteSpaceChar</i> <i>StrWhiteSpace_{opt}</i>	See 9.1.3.1	
<i>StrWhiteSpaceChar</i> ::= <i>WhiteSpace</i> <i>LineTerminator</i>	See 9.1.3.1	
<i>StrNumericLiteral</i> ::= <i>StrDecimalLiteral</i> <i>HexIntegerLiteral</i>	See 9.1.3.1	
<i>StrDecimalLiteral</i> ::= <i>StrUnsignedDecimalLiteral</i> + <i>StrUnsignedDecimalLiteral</i> - <i>StrUnsignedDecimalLiteral</i>	See 9.1.3.1	
<i>StrUnsignedDecimalLiteral</i> ::= infinity <i>DecimalDigits</i> . <i>DecimalDigits_{opt}</i> <i>ExponentPart_{opt}</i> . <i>DecimalDigits</i> <i>ExponentPart_{opt}</i> <i>DecimalDigits</i> <i>ExponentPart_{opt}</i>	See 9.1.3.1	
<i>DecimalDigits</i> ::= <i>DecimalDigit</i> <i>DecimalDigits</i> <i>DecimalDigit</i>	See 9.1.3.1	
<i>DecimalDigit</i> :: one of 0 1 2 3 4 5 6 7 8 9	See 9.1.3.1	
<i>ExponentPart</i> ::= <i>ExponentIndicator</i> <i>SignedInteger</i>	See 9.1.3.1	
<i>ExponentIndicator</i> :: one of e E	See 9.1.3.1	
<i>SignedInteger</i> ::= <i>DecimalDigits</i> + <i>DecimalDigits</i> - <i>DecimalDigits</i>	See 9.1.3.1	

| *HexIntegerLiteral* ::=
 0x *HexDigit*
 0X *HexDigit*
HexIntegerLiteral *HexDigit*

See 9.1.3.1

| *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

See 9.1.3.1

A.3 Expressions

PrimaryExpression :
 this
 Identifier
 Literal
 ArrayLiteral
 ObjectLiteral
 (Expression)

See 11.1

ArrayLiteral :
 [Elision_{opt}]
 [ElementList]
 [ElementList , Elision_{opt}]

See 11.1.4

ElementList :
 Elision_{opt} AssignmentExpression
ElementList , Elision_{opt} AssignmentExpression

See 11.1.4

Elision :
 ' Elision ,

See 11.1.4

ObjectLiteral :
 { }
 { *PropertyNameAndValueList* }
 { *PropertyNameAndValueList* , }

See 11.1.5

Deleted: *PropertyNameAndValueList*
Deleted: *PropertyNameAndValueList*

PropertyNameAndValueList :
PropertyNameAssignment
PropertyNameAndValueList , *PropertyNameAssignment*

See 11.1.5

Deleted: *PropertyNameAndValueList*
Deleted: *PropertyNameAssignment*
Deleted: *PropertyNameAndValueList*
Deleted: *PropertyNameAssignment*

PropertyNameAssignment :
PropertyName : AssignmentExpression
get *PropertyName* () { FunctionBody }
set *PropertyName* (*PropertySetParameterList*) { FunctionBody }

See 11.1.5

Deleted: *PropertyNameAssignment*
Deleted: *PropertyNameAssignment*

PropertyName :
 IdentifierName
 StringLiteral
 NumericLiteral

See 11.1.5

PropertySetParameterList :
 Identifier

See 11.1.5

MemberExpression :

- PrimaryExpression*
- FunctionExpression*
- MemberExpression [Expression]*
- MemberExpression . IdentifierName*
- new MemberExpression Arguments**

See 11.2

NewExpression :

- MemberExpression*
- new NewExpression**

See 11.2

CallExpression :

- MemberExpression Arguments*
- CallExpression Arguments*
- CallExpression [Expression]*
- CallExpression . IdentifierName*

See 11.2

Arguments :

- ()*
- (ArgumentList)*

See 11.2

ArgumentList :

- AssignmentExpression*
- ArgumentList , AssignmentExpression*

See 11.2

LeftHandSideExpression :

- NewExpression*
- CallExpression*

See 11.2

PostfixExpression :

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

See 11.3

UnaryExpression :

- PostfixExpression*
- delete UnaryExpression**
- void UnaryExpression**
- typeof UnaryExpression**
- ++ UnaryExpression**
- UnaryExpression**
- + UnaryExpression**
- UnaryExpression**
- ~ UnaryExpression**
- ! UnaryExpression**

See 11.4

MultiplicativeExpression :

- UnaryExpression*
- MultiplicativeExpression * UnaryExpression*
- MultiplicativeExpression / UnaryExpression*
- MultiplicativeExpression % UnaryExpression*

See 11.5

AdditiveExpression :
MultiplicativeExpression
AdditiveExpression + MultiplicativeExpression
AdditiveExpression - MultiplicativeExpression

See 11.6

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

See 11.7

RelationalExpression :
ShiftExpression
RelationalExpression < ShiftExpression
RelationalExpression > ShiftExpression
RelationalExpression <= ShiftExpression
RelationalExpression >= ShiftExpression
RelationalExpression instanceof ShiftExpression
RelationalExpression in ShiftExpression

See 11.8

RelationalExpressionNoIn :
ShiftExpression
RelationalExpressionNoIn < ShiftExpression
RelationalExpressionNoIn > ShiftExpression
RelationalExpressionNoIn <= ShiftExpression
RelationalExpressionNoIn >= ShiftExpression
RelationalExpressionNoIn instanceof ShiftExpression

See 11.8

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

See 11.9

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

See 11.9

BitwiseANDExpression :
EqualityExpression
BitwiseANDExpression & EqualityExpression

See 11.10

BitwiseANDExpressionNoIn :
EqualityExpressionNoIn
BitwiseANDExpressionNoIn & EqualityExpressionNoIn

See 11.10

BitwiseXORExpression : See 11.10
BitwiseANDExpression
BitwiseXORExpression ^ BitwiseANDExpression

BitwiseXORExpressionNoIn : See 11.10
BitwiseANDExpressionNoIn
BitwiseXORExpressionNoIn ^ BitwiseANDExpressionNoIn

BitwiseORExpression : See 11.10
BitwiseXORExpression
BitwiseORExpression | BitwiseXORExpression

BitwiseORExpressionNoIn : See 11.10
BitwiseXORExpressionNoIn
BitwiseORExpressionNoIn | BitwiseXORExpressionNoIn

LogicalANDExpression : See 11.11
BitwiseORExpression
LogicalANDExpression && BitwiseORExpression

LogicalANDExpressionNoIn : See 11.11
BitwiseORExpressionNoIn
LogicalANDExpressionNoIn && BitwiseORExpressionNoIn

LogicalORExpression : See 11.11
LogicalANDExpression
LogicalORExpression || LogicalANDExpression

LogicalORExpressionNoIn : See 11.11
LogicalANDExpressionNoIn
LogicalORExpressionNoIn || LogicalANDExpressionNoIn

ConditionalExpression : See 11.12
LogicalORExpression
LogicalORExpression ? AssignmentExpression : AssignmentExpression

ConditionalExpressionNoIn : See 11.12
LogicalORExpressionNoIn
LogicalORExpressionNoIn ? AssignmentExpression : AssignmentExpressionNoIn

AssignmentExpression : See 11.13
ConditionalExpression
LeftHandSideExpression = AssignmentExpression
LeftHandSideExpression AssignmentOperator AssignmentExpression

AssignmentExpressionNoIn : See 11.13
ConditionalExpressionNoIn
LeftHandSideExpression = AssignmentExpressionNoIn
LeftHandSideExpression AssignmentOperator AssignmentExpressionNoIn

AssignmentOperator : **one of**
 $\ast=$ $/=$ $\%=$ $+=$ $-=$ $<=$ $>=$ $>>=$ $\&=$ $\wedge=$ $|=$

See 11.13

Expression :
AssignmentExpression
Expression , AssignmentExpression

See 11.14

ExpressionNoIn :
AssignmentExpressionNoIn
ExpressionNoIn , AssignmentExpressionNoIn

See 11.14

A.4 Statements

Statement :
Block

See clause 12

VariableStatement
EmptyStatement
ExpressionStatement
IfStatement
IterationStatement
ContinueStatement
BreakStatement
ReturnStatement
WithStatement
LabelledStatement
SwitchStatement
ThrowStatement
TryStatement
DebuggerStatement

Block :
 $\{ \text{StatementList}_{\text{opt}} \}$

See 12.1

StatementList :
Statement
StatementList Statement

See 12.1

VariableStatement :
 $\text{var } \text{VariableDeclarationList} ;$

See 12.2

VariableDeclarationList :
VariableDeclaration
VariableDeclarationList , VariableDeclaration

See 12.2

VariableDeclarationListNoIn :
VariableDeclarationNoIn
VariableDeclarationListNoIn , VariableDeclarationNoIn

See 12.2

VariableDeclaration :
Identifier Initialiser_{opt}

See 12.2

VariableDeclarationNoIn :
Identifier InitialiserNoIn_{opt}

See 12.2

<i>Initialiser :</i>	<i>= AssignmentExpression</i>	See 12.2
<i>InitialiserNoIn :</i>	<i>= AssignmentExpressionNoIn</i>	See 12.2
<i>EmptyStatement :</i>	<i>;</i>	See 12.3
<i>ExpressionStatement :</i>	<i>[lookahead $\notin \{\{, \text{function}\}$] Expression ;</i>	See 12.4
<i>IfStatement :</i>	<i>if (Expression) Statement else Statement</i> <i>if (Expression) Statement</i>	See 12.5
<i>IterationStatement :</i>	<i>do Statement while (Expression) ;</i> <i>while (Expression) Statement</i> <i>for (ExpressionNoIn_{opt}; Expression_{opt}; Expression_{opt}) Statement</i> <i>for (var VariableDeclarationListNoIn; Expression_{opt}; Expression_{opt}) Statement</i> <i>for (LeftHandSideExpression in Expression) Statement</i> <i>for (var VariableDeclarationNoIn in Expression) Statement</i>	See 12.6
<i>ContinueStatement :</i>	<i>continue ;</i> <i>continue [no LineTerminator here] Identifier ;</i>	See 12.7
<i>BreakStatement :</i>	<i>break ;</i> <i>break [no LineTerminator here] Identifier ;</i>	See 12.8
<i>ReturnStatement :</i>	<i>return ;</i> <i>return [no LineTerminator here] Expression ;</i>	See 12.9
<i>WithStatement :</i>	<i>with (Expression) Statement</i>	See 12.10
<i>SwitchStatement :</i>	<i>switch (Expression) CaseBlock</i>	See 12.11
<i>CaseBlock :</i>	<i>{ CaseClauses_{opt} }</i> <i>{ CaseClauses_{opt} DefaultClause CaseClauses_{opt} }</i>	See 12.11
<i>CaseClauses :</i>	<i>CaseClause</i> <i>CaseClauses CaseClause</i>	See 12.11

CaseClause : **case** Expression : StatementList_{opt} See 12.11

DefaultClause : **default** : StatementList_{opt} See 12.11

LabelledStatement : Identifier : Statement See 12.12

ThrowStatement : **throw** [no LineTerminator here] Expression ; See 12.13

TryStatement : **try** Block **Catch**
try Block **Finally**
try Block **Catch Finally** See 12.14

Catch : **catch** (Identifier) Block See 12.14

Finally : **finally** Block See 12.14

DebuggerStatement : **debugger** ; See 12.15

A.5 Functions and Scripts

FunctionDeclaration : **function** Identifier (FormalParameterList_{opt}) { FunctionBody } See clause 13

FunctionExpression : **function** Identifier_{opt} (FormalParameterList_{opt}) { FunctionBody } See clause 13

FormalParameterList : Identifier
 FormalParameterList , Identifier See clause 13

FunctionBody : SourceElements_{opt} See clause 13

Program : SourceElements_{opt} See clause 14

SourceElements : SourceElement
 SourceElements SourceElement See clause 14

Deleted: Programs

SourceElement :
Statement
FunctionDeclaration

See clause 14

A.6 Universal Resource Identifier Character Classes

uri ::=

 $uriCharacters_{opt}$ *See 15.1.3*

uriCharacters ::=

 $uriCharacter\ uriCharacters_{opt}$ *See 15.1.3*

uriCharacter ::=

 $uriReserved$
 $uriUnescaped$
 $uriEscaped$ *See 15.1.3*

uriReserved :: **one of**
 $; / ? : @ & = + \$,$ *See 15.1.3*

uriUnescaped ::=

 $uriAlpha$
 $DecimalDigit$
 $uriMark$ *See 15.1.3*

uriEscaped ::=

 $\% HexDigit HexDigit$ *See 15.1.3*

uriAlpha :: **one of**
 $a b c d e f g h i j k l m n o p q r s t u v w x y z$
 $A B C D E F G H I J K L M N O P Q R S T U V W X Y Z$ *See 15.1.3*

uriMark :: **one of**
 $- _ . ! ~ * ^ ()$ *See 15.1.3*

A.7 Regular Expressions

Pattern ::=

 $Disjunction$ *See 15.10.1*

Disjunction ::=

 $Alternative$
 $Alternative \mid Disjunction$ *See 15.10.1*

Alternative ::=

 $[empty]$
 $Alternative\ Term$ *See 15.10.1*

Term ::=

 $Assertion$
 $Atom$
 $Atom\ Quantifier$ *See 15.10.1*

Assertion ::

^
\$
\ b
\ B
(? = Disjunction)
(? ! Disjunction)

See 15.10.1

Quantifier ::

QuantifierPrefix
QuantifierPrefix ?

See 15.10.1

QuantifierPrefix ::

*

+

?

{ DecimalDigits }

{ DecimalDigits , }

{ DecimalDigits , DecimalDigits }

See 15.10.1

Atom ::

PatternCharacter
.br/>
\ AtomEscape
CharacterClass
(Disjunction)
(?: Disjunction)

See 15.10.1

PatternCharacter ::

SourceCharacter but not one of:
^ \$ \ . * + ? () [] { } |

See 15.10.1

AtomEscape ::

DecimalEscape
CharacterEscape
CharacterClassEscape

See 15.10.1

CharacterEscape ::

ControlEscape
c ControlLetter
HexEscapeSequence
UnicodeEscapeSequence
IdentityEscape

See 15.10.1

ControlEscape :: one of

f n r t v

See 15.10.1

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

See 15.10.1

IdentityEscape :: See 15.10.1
SourceCharacter but not IdentifierPart

<ZWJ>
<ZWNJ>

DecimalEscape :: See 15.10.1
DecimalIntegerLiteral [lookahead \notin *DecimalDigit*]

CharacterClassEscape :: one of See 15.10.1
 d D s S w W

CharacterClass :: See 15.10.1
 [[lookahead \notin {^}] *ClassRanges*]
 [^ *ClassRanges*]

ClassRanges :: See 15.10.1
 [empty]
NonemptyClassRanges

NonemptyClassRanges :: See 15.10.1
ClassAtom
ClassAtom NonemptyClassRangesNoDash
ClassAtom – *ClassAtom ClassRanges*

NonemptyClassRangesNoDash :: See 15.10.1
ClassAtom
ClassAtomNoDash NonemptyClassRangesNoDash
ClassAtomNoDash – *ClassAtom ClassRanges*

ClassAtom :: See 15.10.1
 –
ClassAtomNoDash

ClassAtomNoDash :: See 15.10.1
SourceCharacter but not one of \ or] or -
 \ *ClassEscape*

ClassEscape :: See 15.10.1
DecimalEscape
b
CharacterEscape
CharacterClassEscape

A.8 JSON

A.8.1 JSON Lexical Grammar

JSONWhiteSpace :: See 15.12.1.1
 <TAB>
 <CR>

<LF>
<SP>

JSONString ::
 " *JSONStringCharacters_{opt}* "

See 15.12.1.1

JSONStringCharacters ::
 JSONStringCharacter *JSONStringCharacters_{opt}*

See 15.12.1.1

JSONStringCharacter ::
 SourceCharacter **but not one of " or \ or U+0000 through U+001F**
 \ *JSONEscapeSequence*

See 15.12.1.1

JSONEscapeSequence ::
 JSONEscapeCharacter
 UnicodeEscapeSequence

See 15.12.1.1

JSONEscapeCharacter :: **one of**
 " / \ b f n r t

See 15.12.1.1

JSONNumber ::
 -_{opt} *DecimalIntegerLiteral* *JSONFraction_{opt}* *ExponentPart_{opt}*

See 15.12.1.1

JSONFraction ::
 . *DecimalDigits*

See 15.12.1.1

JSONNullLiteral ::
 NullLiteral

See 15.12.1.1

JSONBooleanLiteral ::
 BooleanLiteral

See 15.12.1.1

A.8.2 JSON Syntactic Grammar

JSONText ::
 JSONValue

See 15.12.1.2

JSONValue ::
 JSONNullLiteral
 JSONBooleanLiteral
 JSONObject
 JSONArray
 JSONString
 JSONNumber

See 15.12.1.2

JSONObject ::
 { }
 { *JSONMemberList* }

See 15.12.1.2

JSONMember ::
 JSONString : *JSONValue*

See 15.12.1.2

JSONMemberList ::
 JSONMember
 JSONMemberList , *JSONMember*

See 15.12.1.2

JSONArray ::
 []
 [*JSONElementList*]

See 15.12.1.2

JSONElementList :
 JSONValue
 JSONElementList , JSONValue

See 15.12.1.2

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Annex B (normative)

Additional ECMAScript Features for Web Browsers

The ECMAScript language syntax and semantics defined in this annex are required when the ECMAScript host is a web browser. The content of this annex is normative but optional if the ECMAScript host is not a web browser.

B.1 Additional Syntax

B.1.1 Numeric Literals

The syntax and semantics of 7.8.3 is extended as follows except that this extension is not allowed for strict mode code:

Syntax

NumericLiteral ::
DecimalLiteral
BinaryIntegerLiteral
OctalIntegerLiteral
HexIntegerLiteral
LegacyOctalIntegerLiteral

LegacyOctalIntegerLiteral ::
0 OctalDigit
LegacyOctalIntegerLiteral OctalDigit

Static Semantics

- The MV of *LegacyOctalIntegerLiteral :: 0 OctalDigit* is the MV of *OctalDigit*.
- The MV of *LegacyOctalIntegerLiteral :: LegacyOctalIntegerLiteral OctalDigit* is (the MV of *LegacyOctalIntegerLiteral* times 8) plus the MV of *OctalDigit*.

B.1.2 String Literals

The syntax and semantics of 7.8.4 is extended as follows except that this extension is not allowed for strict mode code:

Syntax

EscapeSequence ::
CharacterEscapeSequence
OctalEscapeSequence
HexEscapeSequence
UnicodeEscapeSequence

OctalEscapeSequence ::
OctalDigit [lookahead \notin *DecimalDigit*]
ZeroToThree OctalDigit [lookahead \notin *DecimalDigit*]
FourToSeven OctalDigit
ZeroToThree OctalDigit OctalDigit

ZeroToThree :: one of
 0 1 2 3

Comment [AW244]: Need to add new material that is not in previous versions of annex B

Deleted: informative

Deleted: Compatibility

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Deleted: s

Deleted: It

Deleted: <#> 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. ¶

Deleted: can be

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

Deleted: <#> 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. ¶

Deleted: can be

FourToSeven :: one of

4 5 6 7

Static Semantics

- The CV of *EscapeSequence :: OctalEscapeSequence* is the CV of the *OctalEscapeSequence*.
- The CV of *OctalEscapeSequence :: OctalDigit* [*lookahead* \notin *DecimalDigit*] is the character whose code unit value is the MV of the *OctalDigit*.
- The CV of *OctalEscapeSequence :: ZeroToThree OctalDigit* [*lookahead* \notin *DecimalDigit*] is the character whose code unit 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 unit 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 unit 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.1.3 HTML-like Comments

TODO See <http://javascript.spec.whatwg.org/#comment-syntax>

B.2 Additional Properties

When the ECMAScript host is a web browser the following additional properties of the standard built-in objects are defined.

B.2.1 Additional Properties of the Global Object

B.2.1.1 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 unit value is **0xFF** or less, a two-digit escape sequence of the form **%xx** is used. For those characters being replaced whose code unit 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.
8. If **Result(6)** is less than 256, go to step 11.

Deleted: Some implementations of

Deleted: have included

Deleted: these

Deleted: for some

Deleted: native

Deleted: This non-normative annex suggests uniform semantics for such properties without making the properties or their semantics part of this standard.

9. Let S be a String containing six characters "% $uvwxyz$ " where $wxyz$ are four hexadecimal digits encoding the value of Result(6).
10. Go to step 14.
11. Let S be a String containing three characters "% xy " where xy are two hexadecimal digits encoding the value of Result(6).
12. Go to step 14.
13. Let S be a String containing the single character Result(6).
14. Let R be a new String value computed by concatenating the previous value of R and S .
15. Increase k by 1.
16. Go to step 5.

NOTE The encoding is partly based on the encoding described in RFC 1738, but the entire encoding specified in this standard is described above without regard to the contents of RFC 1738. This encoding does not reflect changes to RFC 1738 made by RFC 3986.

B.2.1.2 `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 unit 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.
13. Go to step 18.
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 unit 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.2.2 Additional Properties of the Object.prototype Object

B.2.2.1 `Object.prototype. proto`

`Object.prototype. proto` is an accessor property with attributes { `[[Enumerable]]: false, [[Configurable]]: true` }. The `[[Get]]` and `[[Set]]` attributes are defined as follows

`get Object.prototype. proto`

The value of the `[[Get]]` attribute is a built-in function that requires no arguments. It performs the following steps:

1. Let O be the **this** value.
2. If $\text{Type}(O)$ is not **Object**, then throw a **TypeError** exception.
3. Return the result of calling the **[[GetInheritance]]** internal method of O .

set Object.prototype. proto

The value of the **[[Set]]** attribute is a built-in function that takes an argument $proto$. It performs the following steps:

1. Let O be the **this** value.
2. If $\text{Type}(O)$ is not **Object**, then throw a **TypeError** exception.
3. If $\text{Type}(proto)$ is neither **Object** or **Null**, then throw a **TypeError** exception.
4. Let $status$ be the result of calling the **[[SetInheritance]]** internal method of O with argument $proto$.
5. ReturnIfAbrupt($status$).
6. If $status$ is **false**, then throw a **TypeError** exception.
7. Return $proto$.

B.2.3 Additional Properties of the String.prototype Object

B.2.3.1 String.prototype.substr (start, length)

The **substr** method takes two arguments, $start$ and $length$, and returns a substring of the result of converting the **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. Let O be **CheckObjectCoercible(this value)**.
2. Let S be **ToString(O)**.
3. Let $intStart$ be **ToInteger($start$)**.
4. ReturnIfAbrupt($intStart$).
5. If $length$ is **undefined**, let end be $+\infty$; otherwise let end be **ToInteger($length$)**.
6. ReturnIfAbrupt(end).
7. Let $size$ be the number of characters in S .
8. If $intStart$ is negative, then let $intStart$ be $\max(size + intStart, 0)$.
9. Let $resultLength$ be $\min(\max(end, 0), size - intStart)$.
10. If $resultLength \leq 0$, return the empty String **" "**.
11. Return a String containing $resultLength$ consecutive characters from S beginning with the character at position $intStart$.

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.2.3.2 String.prototype.anchor (name)

When the **anchor** method is called with argument $name$, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation **CreateHTML** with arguments S , **"a"**, **"name"** and $name$.

The abstract operation **CreateHTML** is called with arguments **string**, **tag**, **attribute**, and **value**. The arguments **tag** and **attribute** must be string values. The following steps are taken:

1. Let str be **CheckObjectCoercible(string)**.
2. Let S be **ToString(str)**.
3. ReturnIfAbrupt(S).
4. Let $p1$ be the string value that is the concatenation of **"<"** and **tag**.

Deleted: <code>ReturnIfAbrupt()</code>
Deleted: <code>)</code>
Deleted: <code>Call</code>
Deleted: the result of performing
Deleted: , giving it the this value as its argument
Deleted: <code>Call</code>
Deleted: <code>use</code>
Deleted: <code>call</code>
Deleted: <code>Compute</code>
Deleted: <code>Result(1)</code>
Deleted: <code>Result(2)</code>
Deleted: positive or zero
Deleted: use <code>Result(2)</code> ; else
Deleted: <code>use</code>
Deleted: <code>Result(4)</code>
Deleted: <code>Result(2)</code>
Deleted: <code>Compute</code>
Deleted: <code>Result(3)</code>
Deleted: <code>Result(4)</code>
Deleted: <code>Result(5)</code>
Deleted: <code>Result(6)</code>
Deleted: <code>""</code>
Deleted: <code>Result(6)</code>
Deleted: <code>Result(1)</code>
Deleted: <code>Result(5)</code>
Deleted: <code>ReturnIfAbrupt()</code>
Deleted: <code>)</code>
Deleted: the result of performing
Deleted: <code>string</code>
Deleted: <code><#>If attribute is not the empty String, then</code>
<code><#>Let V be the result of performing <code>ToString(value)</code>.</code>
<code><#>ReturnIfAbrupt(V).</code>

5. If *attribute* is not the empty String, then

- a. Let *V* be the result of performing *ToString(value)*.
- b. ReturnIfAbrupt(*V*).
- c. Let *escapedV* be the string value that is the same as *V* except that each occurrence of the character " (code unit value 0x0022) in *V* has been replaced with the six character sequence """.
- d. Let *p1* be the string value that is the concatenation of the following string values:

- *p1*
- a single space code unit 0x0020
- *attribute*
- "="
- ' '
- *escapedV*
- ' '

Deleted: character

6. Let *p2* be the string value that is the concatenation of *p1* and ">".

7. Let *p3* be the string value that is the concatenation of *p2* and *S*.

8. Let *p4* be the string value that is the concatenation of *p3*, "</", *tag*, and ">".

9. Return *p4*.

Deleted: *V*

Deleted: 3

Deleted: 3

B.2.3.3 *String.prototype.big()*

When the **big** method is called with no arguments, the following steps are taken:

1. Let *S* be the **this** value.
2. Return the result of performing the abstract operation *CreateHTML* with arguments *S*, "big", "" and "".

B.2.3.4 *String.prototype.blink()*

When the **blink** method is called with no arguments, the following steps are taken:

1. Let *S* be the **this** value.
2. Return the result of performing the abstract operation *CreateHTML* with arguments *S*, "blink", "" and "".

Deleted: c

B.2.3.5 *String.prototype.bold()*

When the **bold** method is called with no arguments, the following steps are taken:

1. Let *S* be the **this** value.
2. Return the result of performing the abstract operation *CreateHTML* with arguments *S*, "b", "" and "".

Deleted: S

B.2.3.6 *String.prototype.fixed()*

When the **fixed** method is called with no arguments, the following steps are taken:

1. Let *S* be the **this** value.
2. Return the result of performing the abstract operation *CreateHTML* with arguments *S*, "tt", "" and "".

Deleted: S

B.2.3.7 *String.prototype.fontcolor (color)*

When the **fontcolor** method is called with argument *color*, the following steps are taken:

1. Let *S* be the **this** value.
2. Return the result of performing the abstract operation *CreateHTML* with arguments *S*, "font", "color" and *color*.

Deleted: A

B.2.3.8 *String.prototype.fontSize (size)*

When the **fontSize** method is called with argument *size*, the following steps are taken:

Deleted: S

Deleted: A

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "font", "size" and *size*.

Deleted: S

B.2.3.9 String.prototype.italics ()

Deleted: A

When the **italics** method is called with no arguments, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "i", "" and "".

Deleted: S

B.2.3.10 String.prototype.link (url)

Deleted: A

When the **link** method is called with argument *url*, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "a", "href" and *url*.

Deleted: S

B.2.3.11 String.prototype.small ()

Deleted: A

When the **small** method is called with no arguments, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "small", "" and "".

Deleted: S

Deleted: s

B.2.3.12 String.prototype.strike ()

Deleted: A

When the **strike** method is called with no arguments, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "strike", "" and "".

Deleted: S

Deleted: return

Deleted: s

Deleted: A

B.2.3.13 String.prototype.sub ()

When the **sub** method is called with no arguments, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "sub", "" and "".

Deleted: S

Deleted: return

Deleted: s

Deleted: A

B.2.3.14 String.prototype.sup ()

Deleted: A

When the **sup** method is called with no arguments, the following steps are taken:

1. Let S be the **this** value.
2. Return the result of performing the abstract operation CreateHTML with arguments S , "sup", "" and "".

Deleted: S

Deleted: return

Deleted: s

Deleted: A

B.2.4 Additional Properties of the Date.prototype Object

B.2.4.1 Date.prototype.getFullYear ()

NOTE The **getFullYear** method is preferred for nearly all purposes, because it avoids the "year 2000 problem."

When the **getFullYear** method is called with no arguments, the following steps are taken:

1. Let t be this time value.
2. ReturnIfAbrupt(t).

Deleted: S

3. If t is ***NAN***, return ***NAN***.
4. Return $\text{YearFromTime}(\text{LocalTime}(t)) - 1900$.

B.2.4.2 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 $\text{LocalTime}(\text{this time value})$; but if this time value is ***NAN***, let t be ***+0***.
2. Let y be $\text{ToNumber}(year)$.
3. If y is ***NAN***, set the ***[[DateValue]]*** internal *data* property of ***this Date object*** to ***NAN*** and return ***NAN***.
4. If y is not ***NAN*** and $0 \leq \text{ToInt32}(y) \leq 99$ then let $yyyy$ be $\text{ToInt32}(y) + 1900$. Otherwise, let $yyyy$ be y .
5. Let d be $\text{MakeDay}(yyyy, \text{MonthFromTime}(t), \text{DateFromTime}(t))$.
6. Let $date$ be $\text{UTC}(\text{MakeDate}(d, \text{TimeWithinDay}(t)))$.
7. Set the ***[[DateValue]]*** internal *data* property of ***this Date object*** to $\text{TimeClip}(date)$.
8. Return the value of the ***[[DateValue]]*** internal *data* property of ***this Date object***.

Deleted: Call
Deleted: Result(2)
Deleted: PrimitiveValue
Deleted: the <i>this</i> value
Deleted: Result(2)
Deleted: Result(2)
Deleted: Result(4)
Deleted: is
Deleted: Result(2)
Deleted: Result(4)
Deleted: is
Deleted: Result(2)
Deleted: Compute
Deleted: Result(4)
Deleted: Compute
Deleted: Result(5)
Deleted: PrimitiveValue
Deleted: the <i>this</i> value
Deleted: Result(6)
Deleted: PrimitiveValue
Deleted: the <i>this</i> value

B.2.4.3 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***.

B.2.5 Additional Properties of the ***RegExp.prototype*** Object

B.2.5.1 ***RegExp.prototype.compile (pattern, flags)***

When the ***compile*** method is called with no arguments, the following steps are taken:

1. Let O be the ***this*** value.
2. If ***Type(O)*** is not ***Object*** or ***Type(O)*** is ***Object*** and O does not have a ***[[RegExpMatcher]]*** internal *data* property, then
 - a. Throw a ***TypeError*** exception.
3. Let ***extensible*** be the result of calling the ***[[IsExtensible]]*** internal method of O .
4. If ***extensible*** is ***false***, then throw a ***TypeError*** exception.
5. If ***Type(pattern)*** is ***Object*** and ***pattern*** has a ***[[RegExpMatcher]]*** internal *data* property, then
 - a. If the value of ***pattern***’s ***[[RegExpMatcher]]*** internal *data* property is ***undefined***, then throw a ***TypeError*** exception.
 - b. If ***flags*** is not ***undefined***, then throw a ***TypeError*** exception.
 - c. Let P be the value of ***pattern***’s ***[[OriginalSource]]*** internal *data* property.
 - d. Let F be the value of ***pattern***’s ***[[OriginalFlags]]*** internal *data* property.
6. Else,
 - a. let P be ***pattern***.
 - b. let F be ***flags***.
7. Return the result of the abstract operation ***RegExpInitialize*** with arguments ***obj***, P , and F .

NOTE The ***compile*** method completely reinitialized the ***this*** object ***RegExp*** with a new ***pattern*** and ***flags***. An implementaton may interpret use of this method as an assertion that the resulting ***RegExp*** object will be used multiple times and hence is a candidate for extra optimization.

B.3 Other Additional Features

B.3.1 proto Property Names in Object Initialisers

In 11.1.5 the Property Definition Evaluation algorithm for the production ***PropertyDefinition :PropertyName : AssignmentExpression*** is replaced with the following:

PropertyDefinition : PropertyName : AssignmentExpression

1. Let propName be PropName of PropertyName.
2. Let exprValue be the result of evaluating AssignmentExpression.
3. Let propValue be GetValue(exprValue).
4. ReturnIfAbrupt(propValue).
5. If propName is the string value "proto", then
 - a. If Type(v) is neither Object or Null, then throw a TypeError exception.
 - b. Return the result of calling the [[SetInheritance]] internal method of object with argument propValue.
6. Let desc be the Property Descriptor [[Value]]: propValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true.
7. Return the result of DefinePropertyOrThrow(object, propName desc).

B.3.2 Web Legacy Compatibility for Block-Level Function Declarations

Prior to the Sixth Edition, the ECMAScript specification did not define the occurrence of a FunctionDeclaration as an element of a Block statement's StatementList. However, support for that form of FunctionDeclaration was an allowable extension and most browser-hosted ECMAScript implementations permitted them. However, the semantics of such declarations differ among those implementations. Because of these semantic differences, existing web ECMAScript code that uses Block level function declarations is only portable among browser implementation if the usage only depends upon the semantic intersection of all of the browser implementations for such declarations. The following are the use cases that fall within that intersection semantics:

1. A function is declared and only referenced within a single block
 - A function declaration with the name f is declared exactly once within the function code of an enclosing function g and that declaration is nested within a Block.
 - No other declaration of f that is not a var declaration occurs within the function code of g.
 - All references to f occur within the StatementList of the Block containing the declaration of f.
2. A function is declared and possibly used within a single Block but also referenced by an inner function definition that is not contained within that same Block.
 - A function declaration with the name f is declared exactly once within the function code of an enclosing function g and that declaration is nested within a Block.
 - No other declaration of f that is not a var declaration occurs within the function code of g.
 - References to f may occur within the StatementList of the Block containing the declaration of f.
 - References to f occur within the function code of g that lexically follows the Block containing the declaration of f.
3. A function is declared and possibly used within a single block but also referenced within subsequent blocks.
 - A function declaration with the name f is declared exactly once within the function code of an enclosing function g and that declaration is nested within a Block.
 - No other declaration of f that is not a var declaration occurs within the function code of g.
 - References to f may occur within the StatementList of the Block containing the declaration of f.
 - References to f occur within another function h that is nested within g and no other declaration of f shadows the references to f from within h.
 - All invocations of h occur after the declaration of f has been evaluated.

The first use case is interoperable with the inclusion of Block level function declarations in the sixth edition. Any pre-existing ECMAScript code that employees that use case will operate using the Block level function declarations semantics defined by clauses 10 and 13 of this specification.

Sixth edition interoperability for the second and third use cases requires the following extensions to the clauses 10 and 13 semantics. These extensions are applied to a non-strict mode functions g if the above pre-conditions of use cases 2 and 3 above exist at the time of static semantic analysis of g. However, the last pre-condition of use case 3 is not included in this determination and the determination is not applied to any

Deleted: <#>The __proto__ pseudo property.

<#>Object.prototype.__proto__
The initial value of the __proto__ property of the Object prototype object is a data property whose initial value is null. This property initially has the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true }. Manipulations of this property as tracked by the Boolean valued primordial internal variable UnderscoreProtoEnabled. The default initial value of UnderscoreProtoEnabled is true only if this property is initially present on the primordial Object prototype object.

NOTE Any modification of this property or its attribute causes UnderscoreProtoEnabled to be set to false.

<#> Changes To Internal Methods

The definition of the [[GetP]] internal method given in 8.12.3 is replaced with the following:

<#>If P is the string value "__proto__" and UnderscoreProtoEnabled is true, then
<#>Let desc be the result of calling the [[GetProperty]] internal method of O with property name P.
<#>If desc is not undefined and was created by step 1.a to describe the property defined in B.3.1.1 then,
<#>Return the value of the [[Prototype]] internal data property of O.
<#>Continue by executing the steps of 8.12.3 starting with step 1.¶

The definition of the [[Put]] internal method given in 8.12.5 is replaced with the following:

<#>If P is the string value "__proto__" and UnderscoreProtoEnabled is true and O is not the standard built-in Object prototype object, then
<#>Let desc be the result of calling the [[GetProperty]] internal method of O with property name P.
<#>If desc is not undefined and was created by step 1.a to describe the property defined in B.3.1.1 then,
<#>If the type of V is neither Object or Null, return
<#>Set the value of the [[Prototype]] internal data property O to V.
<#>Return.
<#>Continue by executing the steps of 8.12.5 starting with step 1.¶

The definition of the [[Delete]] internal method given in 8.12.7 is replaced with the following:

<#>If UnderscoreProtoEnabled is true and P is the string value "__proto__" and O is the standard built-in Object prototype object, then
<#>Set UnderscoreProtoEnabled to false.
<#>Continue by executing the steps of 8.12.7 starting with step 1.¶

The definition of the [[DefineOwnProperty]] internal method given in 8.12.9 is replaced with the following:

<#>If UnderscoreProtoEnabled is true and P is the string value "__proto__" and O is the standard built-in Object prototype object, then
<#>If any attribute contained in Desc is not present or has a different value from the corresponding attribute in { [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true } then,
<#>Set UnderscoreProtoEnabled to false.
<#>Continue by executing the steps of 8.12.9 starting with step 1.¶

<#>__proto__ Object Initialisers
Definitions of two algorithms in 11.1.5 are replaced with the following:
The production

PropertyNameAndValueListPropertyDefinitionList :

function declaration that is nested within syntactic constructs that are specified in the Fifth edition of this specification.

1. Let B be environment record for the construct within g that introduces a new environment contour and which most closely encloses the declaration of f , all function code references to f , and the definitions of all nested functions that contain unshadowed references to f . This syntactic construct may be the definition of g itself, in which case B is the function environment record for g .
2. As part of the instantiation of B , its `CreateMutableBinding` concrete method is called with arguments “ f ” (the string name of the function) and `false`. This creates an uninitialised binding for the name f . Any reference that resolves to that binding prior to step 3 below will throw a `ReferenceError` exception.
3. When the `InitialiseBinding` concrete method is used to initialise the binding for the function declaration f also invoke `InitializeBind` on B using the same arguments.

If an ECMAScript implication has a mechanism that produces diagnostic warning messages, a warning should be produced for each function g for which the above steps are performed.

DRAFT

Annex C (informative)

The Strict Mode of ECMAScript

Field Code Changed
Field Code Changed
Field Code Changed

The strict mode restriction and exceptions

- The identifiers "implements", "interface", "let", "package", "private", "protected", "public", "static", and "yield" are classified as *FutureReservedWord* tokens within strict mode code. (7.6.1.2).
- A conforming implementation, when processing strict mode code, may not extend the syntax of *NumericLiteral* (7.8.3) to include *OctalIntegerLiteral* as described in B.1.1.
- A conforming implementation, when processing strict mode code (see 10.1.1), may not extend the syntax of *EscapeSequence* to include *OctalEscapeSequence* as described in B.1.2.
- Assignment to an undeclared identifier or otherwise unresolvable reference does not create a property in the global object. When a simple assignment occurs within strict mode code, its *LeftHandSide* must not evaluate to an unresolvable Reference. If it does a **ReferenceError** exception is thrown (8.9.2). The *LeftHandSide* also may not be a reference to a data property with the attribute value `{[[Writable]]:false}`, to an accessor property with the attribute value `{[[Set]]:undefined}`, nor to a non-existent property of an object whose `[[Extensible]]` internal `data` property has the value `false`. In these cases a **TypeError** exception is thrown (11.13.1).
- The identifier `eval` or `arguments` may not appear as the *LeftHandSideExpression* of an Assignment operator (11.13) or of a *PostfixExpression* (11.3) or as the *UnaryExpression* operated upon by a Prefix Increment (11.4.4) or a Prefix Decrement (11.4.5) operator.
- Arguments objects for strict mode functions define non-configurable accessor properties named "`caller`" and "`callee`" which throw a **TypeError** exception on access (10.6).
- Arguments objects for strict mode functions do not dynamically share their array indexed property values with the corresponding formal parameter bindings of their functions. (10.6).
- For strict mode functions, if an arguments object is created the binding of the local identifier `arguments` to the arguments object is immutable and hence may not be the target of an assignment expression. (10.5).
- It is a **SyntaxError** if strict mode code contains an *ObjectLiteral* with more than one definition of any data property (11.1.5).
- It is a **SyntaxError** if the Identifier "`eval`" or the Identifier "`arguments`" occurs as the Identifier in a *PropertySetParameterList* of a *PropertyDefinition* that is contained in strict code or if its *FunctionBody* is strict code (11.1.5).
- Strict mode eval code cannot instantiate variables or functions in the variable environment of the caller to eval. Instead, a new variable environment is created and that environment is used for declaration binding instantiation for the eval code (10.4.2).
- If `this` is evaluated within strict mode code, then the `this` value is not coerced to an object. A `this` value of `null` or `undefined` is not converted to the global object and primitive values are not converted to wrapper objects. The `this` value passed via a function call (including calls made using `Function.prototype.apply` and `Function.prototype.call`) do not coerce the passed this value to an object (10.4.3, 11.1.1, 15.3.3.3, 15.3.3.4).
- When a `delete` operator occurs within strict mode code, a **SyntaxError** is thrown if its *UnaryExpression* is a direct reference to a variable, function argument, or function name(11.4.1).

Deleted: 7

Deleted: PropertyAssignment

Deleted: 15.3.4

Deleted: 15.3.4

- When a `delete` operator occurs within strict mode code, a **TypeError** is thrown if the property to be deleted has the attribute `{ [[Configurable]]: false }` (11.4.1).
- It is a **SyntaxError** if a `VariableDeclaration` or `VariableDeclarationNoIn` occurs within strict code and its `Identifier` is `eval` or `arguments` (12.2.1).
- Strict mode code may not include a `WithStatement`. The occurrence of a `WithStatement` in such a context is an **SyntaxError** (12.10).
- It is a **SyntaxError** if a `TryStatement` with a `Catch` occurs within strict code and the `Identifier` of the `Catch` production is `eval` or `arguments` (12.14.1)
- It is a **SyntaxError** if the identifier `eval` or `arguments` appears within the FormalParameters of a strict mode `FunctionDeclaration` or `FunctionExpression` (13.1) | Deleted: a
Deleted: FormalParameterList
- A strict mode function may not have two or more formal parameters that have the same name. An attempt to create such a function using a `FunctionDeclaration`, `FunctionExpression`, or `Function` constructor is a **SyntaxError** (13.1, 15.3.1). | Deleted: 2
- An implementation may not extend, beyond that defined in this specification, the meanings within strict mode functions of properties named `caller` or `arguments` of function instances. ECMAScript code may not create or modify properties with these names on function objects that correspond to strict mode functions (8.3.15.6, 10.6, 15.3.3.5.3). | Deleted: 13.26, 15.3.4
- It is a **SyntaxError** to use within strict mode code the identifiers `eval` or `arguments` as the `Identifier` of a `FunctionDeclaration` or `FunctionExpression` or as a formal parameter name (13.1). Attempting to dynamically define such a strict mode function using the `Function` constructor (15.3.1) will throw a **SyntaxError** exception. | Deleted: 2

Annex D (informative)

Corrections and Clarifications with Possible Compatibility Impact

Deleted: in the 5th Edition

Deleted: 3rd Edition

In Edition 6

15.9.1.14: Previous editions permitted the TimeClip abstract operation to return either +0 or -0 as the representation of a 0 time value. The 6th Edition specifies that +0 always returned. This means that for the 6th Edition the time value of a Date object is never observably -0 and methods that return time values never return -0.

15.9.1.15: If a time zone offset is not present, the local time zone is used. Edition 5.1 incorrectly stated that a missing time zone should be interpreted as "z".

15.9.5.2: Previous editions did not specify the value returned by Date.prototype.toString when this time value is NaN. The 6th Edition specifies the result to be the String value is "Invalid Date"

Deleted: species

Deleted: 5.1

In Edition 5.1

7.8.4: CV definitions added for DoubleStringCharacter :: LineContinuation and SingleStringCharacter :: LineContinuation.

10.2.1.1.3: The argument S is not ignored. It controls whether an exception is thrown when attempting to set an immutable binding.

10.2.1.2.2: In algorithm step 5, true is passed as the last argument to [[DefineOwnProperty]].

10.5: Former algorithm step 5.e is now 5.f and a new step 5.e was added to restore compatibility with 3rd Edition when redefining global functions.

11.5.3: In the final bullet item, use of IEEE 754 round-to-nearest mode is specified.

12.6.3: Missing ToBoolean restored in step 3.a.ii of both algorithms.

12.6.4: Additional final sentences in each of the last two paragraphs clarify certain property enumeration requirements.

12.7, 12.8, 12.9: BNF modified to clarify that a continue or break statement without an Identifier or a return statement without an Expression may have a LineTerminator before the semi-colon.

12.14: Step 3 of algorithm 1 and step 2.a of algorithm 3 are corrected such that the value field of B is passed as a parameter rather than B itself.

15.1.2.2: In step 2 of algorithm, clarify that S may be the empty string.

15.1.2.3: In step 2 of algorithm clarify that trimmedString may be the empty string.

15.1.3: Added notes clarifying that ECMAScript's URI syntax is based upon RFC 2396 and not the newer RFC 3986. In the algorithm for Decode, a step was removed that immediately preceded the current step 4.d.vii.10.a because it tested for a condition that cannot occur.

15.2.3.7: Corrected use of variable P in steps 5 and 6 of algorithm.

15.2.4.2: Edition 5 handling of **undefined** and **null** as **this** value caused existing code to fail. Specification modified to maintain compatibility with such code. New steps 1 and 2 added to the algorithm.

15.3.3.3: Steps 5 and 7 of Edition 5 algorithm have been deleted because they imposed requirements upon the *argArray* argument that are inconsistent with other uses of generic array-like objects.

Deleted: 15.3.4

15.4.3.12: In step 9.a, incorrect reference to *relativeStart* was replaced with a reference to *actualStart*.

Deleted: 15.4.4

15.4.3.15: Clarified that the default value for *fromIndex* is the length minus 1 of the array.

Deleted: 15.4.4

15.4.3.18: In step 9 of the algorithm, **undefined** is now the specified return value.

Deleted: 15.4.4

15.4.3.22: In step 9.c.ii the first argument to the **[[Call]]** internal method has been changed to **undefined** for consistency with the definition of `Array.prototype.reduce`.

Deleted: 15.4.4

15.4.5.1: In Algorithm steps 3.I.ii and 3.I.iii the variable name was inverted resulting in an incorrectly inverted test.

15.5.4.9: Normative requirement concerning canonically equivalent strings deleted from paragraph following algorithm because it is listed as a recommendation in NOTE 2.

15.5.4.14: In *split* algorithm step 11.a and 13.a, the positional order of the arguments to *SplitMatch* was corrected to match the actual parameter signature of *SplitMatch*. In step 13.a.iii.7.d, *lengthA* replaces *A.length*.

15.5.5.2: In first paragraph, removed the implication that the individual character property access had “array index” semantics. Modified algorithm steps 3 and 5 such that they do not enforce “array index” requirement.

15.9.1.15: Specified legal value ranges for fields that lacked them. Eliminated “time-only” formats. Specified default values for all optional fields.

15.10.2.2: The step numbers of the algorithm for the internal closure produced by step 2 were incorrectly numbered in a manner that implied that they were steps of the outer algorithm.

15.10.2.6: In the abstract operation *IsWordChar* the first character in the list in step 3 is “*a*” rather than “*A*”.

15.10.2.8: In the algorithm for the closure returned by the abstract operation *CharacterSetMatcher*, the variable defined by step 3 and passed as an argument in step 4 was renamed to *ch* in order to avoid a name conflict with a formal parameter of the closure.

15.10.6.2: Step 9.e was deleted because it performed an extra increment of *i*.

15.11.1.1: Removed requirement that the *message own* property is set to the empty String when the *message* argument is **undefined**.

15.11.1.2: Removed requirement that the *message own* property is set to the empty String when the *message* argument is **undefined**.

15.11.4.4: Steps 6-10 modified/added to correctly deal with missing or empty *message* property value.

15.11.1.2: Removed requirement that the *message own* property is set to the empty String when the *message* argument is **undefined**.

15.12.3: In step 10.b.iii of the *J4* abstract operation, the last element of the concatenation is “1”.

Deleted: internal

B.2.1: Added to NOTE that the encoding is based upon RFC 1738 rather than the newer RFC 3986.

Annex C: An item was added corresponding to 7.6.12 regarding *FutureReservedWords* in strict mode.

In Edition 5

Throughout: In the Edition 3 specification the meaning of phrases such as “as if by the expression `new Array()`” are subject to misinterpretation. In the Edition 5 specification text for all internal references and invocations of standard built-in objects and methods has been clarified by making it explicit that the intent is that the actual built-in object is to be used rather than the current dynamically resolved value of the correspondingly identifier binding.

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Deleted: 5th

11.8.1: ECMAScript generally uses a left to right evaluation order, however the Edition 3 specification language for the `>` and `<=` operators resulted in 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 side-effects occur during the evaluation process.

Deleted: named property
Deleted: 2
Deleted: , 11.8.3, 11.8.5

11.1.4: Edition 5 clarifies the fact that a trailing comma at the end of an *ArrayInitialiser* does not add to the length of the array. This is not a semantic change from Edition 3 but some implementations may have previously misinterpreted this.

11.2.3: Edition 5 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 affect the result of evaluating *MemberExpression*.

12.4: In Edition 3, an object is created, as if by `new Object()` to serve as the scope for resolving the name of the exception parameter passed to a `catch` clause of a `try` statement. If the actual exception object is a function and it is called from within the `catch` clause, the scope object will be passed as the `this` value of the call. The body of the function can then define new properties on its `this` value and those property names become visible identifiers bindings within the scope of the `catch` clause after the function returns. In Edition 5, when an exception parameter is called as a function, `undefined` is passed as the `this` value.

13: In Edition 3, the algorithm for the production *FunctionExpression* with an *Identifier* adds an object created as if by `new Object()` to the scope chain to serve as a scope for looking up the name of the function. The identifier resolution rules (10.1.4 in Edition 3) when applied to such an object will, if necessary, follow the object's prototype chain when attempting to resolve an identifier. This means all the properties of `Object.prototype` are visible as identifiers within that scope. In practice most implementations of Edition 3 have not implemented this semantics. Edition 5 changes the specified semantics by using a Declarative Environment Record to bind the name of the function.

14: In Edition 3, the algorithm for the production *SourceElements : SourceElements SourceElement* did not correctly propagate statement result values in the same manner as *Block*. This could result in the `eval` function producing an incorrect result when evaluating a *Program* text. In practice most implementations of Edition 3 have implemented the correct propagation rather than what was specified in Edition 5.

15.10.6: `RegExp.prototype` is now a `RegExp` object rather than an instance of `Object`. The value of its `[[Class]]` internal data property which is observable using `Object.prototype.toString` is now “`RegExp`” rather than “`Object`”.

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Annex E (informative)

Additions and Changes that Introduce Incompatibilities with Prior Editions

Field Code Changed
Field Code Changed
Field Code Changed
Deleted: in the 5 th Edition
Deleted: the 3 rd

In the 6th Edition

12.6: In Edition 6, a terminating semi-colon is no longer required at the end of a do-while statement.

Deleted:

12.14: In Edition 6, it is an early error for a *Catch* clause to contain a `var` declaration for the same *Identifier* that appears as the *Catch* clause parameter. In previous editions, such a variable declaration would be instantiated in the enclosing variable environment but the declaration's *Initializer* value would be assigned to the *Catch* parameter.

13.3 In Edition 6, the function objects that are created as the values of the `[[Get]]` or `[[Set]]` attribute of accessor properties in an *ObjectLiteral* are not constructor functions. In Edition 5, they were constructors.

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15.2.3.5 and 15.2.3.7: In Edition 6, all property additions and changes are processed, even if one of them throws an exception. If an exception occurs during such processing, the first such exception is thrown after all properties are processed. In Edition 5, processing of property additions and changes immediately terminated when the first exception occurred.

15.5.4 In Edition 6, the Array prototype object is not a `Arrayn` instance. In previous editions it was an `Array` instance with a `length` property whose value was `+0`.

Deleted: number

15.5.4 In Edition 6, the String prototype object is not a `String` instance. In previous editions it was a `String` instance whose `String` value was the empty string.

Deleted: number

15.6.4 In Edition 6, the Boolean prototype object is not a `Boolean` instance. In previous editions it was a `Boolean` instance whose `Boolean` value was `false`.

Deleted: Date

15.7.4 In Edition 6, the Number prototype object is not a `Number` instance. In previous editions it was a `Number` instance whose `number` value was `+0`.

15.9.5 In Edition 6, the Date prototype object is not a `Date` instance. In previous editions it was a `Date` instance whose `TimeValue` was `Nan`.

15.10.6 In Edition 6, the RegExp prototype object is not a `RegExp` instance. In previous editions it was a `RegExp` instance whose pattern is the empty string.

15.10.7 In Edition 6, `source`, `global`, `ignoreCase`, and `multiline` are accessor properties defined on the `RegExp` prototype object. In previous editions they were data properties defined on `RegExp` instances.

In the 5th Edition

7.1: Unicode format control characters are no longer stripped from ECMAScript source text before processing. In Edition 5, if such a character appears in a *StringLiteral* or *RegularExpressionLiteral* the character will be incorporated into the literal where in Edition 3 the character would not be incorporated into the literal.

7.2: Unicode character <BOM> is now treated as whitespace and its presence in the middle of what appears to be an identifier could result in a syntax error which would not have occurred in Edition 3

7.3: Line terminator characters that are preceded by an escape sequence are now allowed within a string literal token. In Edition 3 a syntax error would have been produced.

7.8.5: Regular expression literals now return a 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.

7.8.5: Edition 5 requires early reporting of any possible RegExp constructor errors that would be produced when converting a *RegularExpressionLiteral* to a RegExp object. Prior to Edition 5 implementations were permitted to defer the reporting of such errors until the actual execution time creation of the object.

7.8.5: In Edition 5 unescaped "/" characters may appear as a *CharacterClass* in a regular expression literal. In Edition 3 such a character would have been interpreted as the final character of the literal.

10.4.2: In Edition 5, indirect calls to the `eval` function use the global environment as both the variable environment and lexical environment for the eval code. In Edition 3, the variable and lexical environments of the caller of an indirect `eval` was used as the environments for the eval code.

~~15.4.3: In Edition 5 all methods of `Array.prototype` are intentionally generic. In Edition 3 `toString` and `toLocaleString` were not generic and would throw a `TypeError` exception if applied to objects that were not instances of Array.~~

Deleted: 15.4.4

10.6: In Edition 5 the array indexed properties of argument objects that correspond to actual formal parameters are enumerable. In Edition 3, such properties were not enumerable.

10.6: In Edition 5 the value of the `[[Class]]` internal `data` property of an arguments object is "Arguments". In Edition 3, it was "Object". This is observable if `toString` is called as a method of an arguments object.

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.

15: In Edition 5, the following new properties are defined on built-in objects that exist in Edition 3:
`Object.getPrototypeOf`, `Object.getOwnPropertyDescriptor`, `Object.getOwnPropertyNames`,
`Object.create`, `Object.defineProperty`, `Object.defineProperties`, `Object.seal`,
`Object.freeze`, `Object.preventExtensions`, `Object.isSealed`, `Object.isFrozen`,
`Object.isExtensible`, `Object.keys`, `Function.prototype.bind`, `Array.prototype.indexOf`,
`Array.prototype.lastIndexOf`, `Array.prototype.every`, `Array.prototype.some`,
`Array.prototype.forEach`, `Array.prototype.map`, `Array.prototype.filter`,
`Array.prototype.reduce`, `Array.prototype.reduceRight`, `String.prototype.trim`, `Date.now`,
`Date.prototype.toISOString`, `Date.prototype.toJSON`.

15: Implementations are now required to ignore extra arguments to standard built-in methods unless otherwise explicitly specified. In Edition 3 the handling of extra arguments was unspecified and implementations were explicitly allowed to throw a `TypeError` exception.

15.1.1: The value properties `Nan`, `Infinity`, and `undefined` of the Global Object have been changed to be read-only properties.

15.1.2.1: Implementations are no longer permitted to restrict the use of eval in ways that are not a direct call. In addition, any invocation of eval that is not a direct call uses the global environment as its variable environment rather than the caller's variable environment.

15.1.2.2: The specification of the function `parseInt` no longer allows implementations to treat Strings beginning with a 0 character as octal values.

~~15.3.3.3: In Edition 3, a `TypeError` is thrown if the second argument passed to `Function.prototype.apply` is neither an array object nor an arguments object. In Edition 5, the second argument may be any kind of generic array-like object that has a valid `length` property.~~

Deleted: 15.3.4

~~15.3.3.3, 15.3.3.4: In Edition 3 passing `undefined` or `null` as the first argument to either `Function.prototype.apply` or `Function.prototype.call` causes the global object to be passed to~~

Deleted: 15.3.4

the indirectly invoked target function as the **this** value. If the first argument is a primitive value the result of calling `ToObject` on the primitive value is passed as the **this** value. In Edition 5, these transformations are not performed and the actual first argument value is passed as the **this** value. This difference will normally be unobservable to existing ECMAScript Edition 3 code because a corresponding transformation takes place upon activation of the target function. However, depending upon the implementation, this difference may be observable by host object functions called using `apply` or `call`. In addition, invoking a standard built-in function in this manner with `null` or `undefined` passed as the **this** value will in many cases cause behaviour in Edition 5 implementations that differ from Edition 3 behaviour. In particular, in Edition 5 built-in functions that are specified to actually use the passed **this** value as an object typically throw a `TypeError` exception if passed `null` or `undefined` as the **this** value.

15.3.4.2: In Edition 5, the `prototype` property of Function instances is not enumerable. In Edition 3, this property was enumerable. Deleted: 15.3.5

15.5.5.2: In Edition 5, the individual characters of a String object's `[[StringData]]` may be accessed as array indexed properties of the String object. These properties are non-writable and non-configurable and shadow any inherited properties with the same names. In Edition 3, these properties did not exist and ECMAScript code could dynamically add and remove writable properties with such names and could access inherited properties with such names. Deleted: PrimitiveValue

15.9.4.2: `Date.parse` is now required to first attempt to parse its argument as an ISO format string. Programs that use this format but depended upon implementation specific behaviour (including failure) may behave differently.

15.10.2.12: In Edition 5, `\s` now additionally matches <BOM>.

15.10.4.1: In Edition 3, the exact form of the String value of the `source` property of an object created by the `RegExp` constructor is implementation defined. In Edition 5, the String must conform to certain specified requirements and hence may be different from that produced by an Edition 3 implementation.

15.10.6.4: In Edition 3, the result of `RegExp.prototype.toString` need not be derived from the value of the `RegExp` object's `source` property. In Edition 5 the result must be derived from the `source` property in a specified manner and hence may be different from the result produced by an Edition 3 implementation.

15.11.2.1, 15.11.4.3: In Edition 5, if an initial value for the `message` property of an Error object is not specified via the `Error` constructor the initial value of the property is the empty String. In Edition 3, such an initial value is implementation defined.

15.11.4.4: In Edition 3, the result of `Error.prototype.toString` is implementation defined. In Edition 5, the result is fully specified and hence may differ from some Edition 3 implementations.

15.12: In Edition 5, the name `JSON` is defined in the global environment. In Edition 3, testing for the presence of that name will show it to be `undefined` unless it is defined by the program or implementation.

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Annex F (informative)

Static Semantic Rule Cross Reference

Field Code Changed
Field Code Changed
Field Code Changed
Deleted: Technically Significant Corrections and Clarifications in the 5.1 Edition

<u>BoundNames</u>	Produces a list of the Identifiers bound by a production. Does not include Identifiers that are bound within inner environments associated with the production.	12.2.1, 12.2.2, 12.2.4, 12.6.4, 13.1, 13.2, 13.5		
<u>ConstructorMethod</u>	From a <i>ClassBody</i> return the first <i>ClassElement</i> whose PropName is "constructor". Returns empty if the <i>ClassBody</i> does not contain one.	13.5		
<u>Contains</u>	Determine if a grammar production either directly or indirectly includes a grammar symbol.	5.3, 13.1, 13.2, 13.5		
<u>CoveredFormalsList</u>	Reparse a covered <i>Expression</i> using <i>FormalsList</i> as the goal symbol.	13.2		
<u>CV</u>	Determines the "character value" of a component of a <i>StringLiteral</i> .	7.8.4		
<u>Elision Width</u>	Determine the number of commas in an <i>Elision</i> .	11.1.4.1		
<u>ExpectedArgumentCount</u>	Determine the "length" of an argument list for the purpose of initializing the "length" property of a function object.	13.1, 13.2, 13.3		
<u>HasInitialiser</u>	Determines whether the production contains an <i>Initialiser</i> production.	12.2.4, 13.1		
<u>IsConstantDeclaration</u>	Determines whether the production introduces a immutable environment record binding	12.2, 13.1, 13.5		
<u>IsValidAssignmentPattern</u>	Determines if a <i>LeftHandSideExpression</i> is a valid assignment target. Primarily for dealing with destructuring assignment targets.	11.2		
<u>LexicalDeclarations</u>	Return a List containing the components of a production that are processed as lexical declarations	12.1, 12.11, 12.5		
<u>LexicallyDeclaredNames</u>	Returns a list of the lexically scoped identifiers declared by a production.	12.1, 13.1, 13.2, 13.5		
<u>PrototypeMethodDefinitions</u>	Return a list of the non-static <i>MethodDefinition</i> productions that are part of a <i>ClassElementList</i> .	13.5		
<u>MV</u>	Determines the "mathematical value" of a numeric	7.8.3		

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	<u>literal or component of a numeric literal.</u>		
<u>PropName</u>	Determines the string value of the property name referenced by a production.	<u>11.1.5.1,</u> <u>13.3, 13.5</u>	
<u>PropNameList</u>	Returns a List of the string values of the property names referenced by a production. The list reflects the order of the references in the source text. The list may contain duplicate elements.	<u>11.5.1, 13.5</u>	
<u>PrototypeMethodDefinitions</u>	Return a list of the non-static <i>MethodDefinition</i> productions that are part of a <i>ClassElementList</i> .	<u>13.5</u>	
<u>ReferencesSuper</u>	Determine if a <i>MethodDefinition</i> contains any references to the ReservedWord super .	<u>13.3</u>	
<u>SpecialMethod</u>	Determine if a <i>MethodDefinition</i> defines a generator method or an accessor property.	<u>13.3</u>	
<u>StaticMethodDefinitions</u>	Return a list of the static <i>MethodDefinition</i> productions that are part of a <i>ClassElementList</i> .	<u>13.5</u>	
<u>SV</u>	Determines the “string value” of a <i>StringLiteral</i> or component of a <i>StringLiteral</i> .	<u>7.8.4</u>	
<u>VarDeclaredNames</u>	Returns a list of the local top-level scoped identifiers declared by a production. These are identifier that are scoped as if by a var statement.	<u>12.1, 12.5,</u> <u>12.6.1,</u> <u>12.6.2,</u> <u>12.6.3,</u> <u>12.6.4,</u> <u>12.12, 13.1,</u> <u>13.5</u>	


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Scrap Heap

A place to temporarily hand on to stuff that's been deleted

MemberExpression :

MemberExpression <| TriangleLiteral

TriangleLiteral :

SealedArrayLiteral

SealedObjectLiteral

FunctionExpression

ArrowFunction

ValueLiteral

CallExpression :

CallExpression <| TriangleLiteral

15.2.3.15 Object.isObject (O)

When the **isObject** function is called with argument *O*, the following steps are taken:

1. If Type(*O*) is Object return true.
2. Return false.

15.5.4.25 String.prototype.toArray()

The following steps are taken:

1. Let *O* be CheckObjectCoercible(this value).
2. Let *S* be ToString(*O*).
3. ReturnIfAbrupt(*S*).
4. Let *len* be the number of characters in *S*.
5. Let *array* be the result of the abstract operation ArrayCreate with argument *len*.
6. Let *n* be 0.
7. Repeat, while *n* < *len*:
 - a. Let *c* be the character at position *n* in *S*.
 - b. Call the [[DefineOwnProperty]] internal method of *array* with arguments ToString(*n*), the PropertyDescriptor {[[Value]]: *c*, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}, and false.
 - c. Increment *n* by 1.
8. Return *array*.

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Deleted: , giving it the this value as its argument

Deleted: (15.4)

The **length** property of the **toArray** method is 0.

NOTE 1 Returns an Array object with elements corresponding to the characters of this object (converted to a String).

NOTE 2 The **toArray** 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.

Static Semantics: TopLevelLexicallyDeclaredNames

OuterStatementList : OuterStatementList OuterItem

1. Let *names* be *TopLevelLexicallyDeclaredNames* of *OuterStatementList*.
2. Append to *names* the elements of the *TopLevelLexicallyDeclaredNames* of *OuterItem*.
3. Return *names*.

OuterItem : StatementListItem

1. Return a new empty List.

StatementListItem : Declaration

1. If *Declaration* is *Declaration* : *FunctionDeclaration*, then return a new empty List.
2. Return the *BoundNames* of *Declaration*.

8.4.4 Symbol Exotic Objects

A *Symbol object* is an exotic object that may be used as a property key. Symbol exotic objects are unique in that they are always immutable and never observably reference any other object.

Exotic String objects have a single internal data properties named *[[Private]]* that is set when the object is created and never modified.

Exotic Symbol objects provide alternative definitions for all of the essential internal methods.

8.4.4.1 [[GetInheritance]] ()

When the *[[GetInheritance]]* internal method of an exotic Symbol object *O* is called the following steps are taken:

1. Return **null**.

8.4.4.2 [[SetInheritance]] (V)

When the *[[SetInheritance]]* internal method of an exotic Symbol object *O* is called with argument *V* the following steps are taken:

1. Assert: Either *Type(V)* is *Object* or *Type(V)* is *Null*.
2. Return **false**.

8.4.4.3 [[HasIntegrity]] (Level)

When the *[[HasIntegrity]]* internal method of an exotic Symbol object *O* is called the following steps are taken:

1. Assert: *Level* is one of "nonextensible", "sealed", or "frozen".
2. Return **true**.

8.4.4.4 [[SetIntegrity]] (Level)

When the *[[SetIntegrity]]* internal method of an exotic Symbol object *O* is called the following steps are taken:

1. Assert: *Level* is one of "nonextensible", "sealed", or "frozen".
2. Return **true**.

8.4.4.5 [[HasOwnProperty]] (P)

When the [[HasOwnProperty]] internal method of an exotic Symbol object O is called with property key P , the following steps are taken:

1. Return `false`.

8.4.4.6 [[GetOwnProperty]] (P)

When the [[GetOwnProperty]] internal method of an exotic Symbol object O is called with property key P , the following steps are taken:

1. Return `undefined`.

8.4.4.7 [[DefineOwnProperty]] (P, Desc)

When the [[DefineOwnProperty]] internal method of an exotic Symbol object O is called with property key P and property descriptor $Desc$, the following steps are taken:

1. Return `false`.

8.4.4.8 [[HasProperty]] (P)

When the [[HasProperty]] internal method of an exotic Symbol object O is called with property key P , the following steps are taken:

1. Return `false`.

8.4.4.9 [[Get]] (P, Receiver)

When the [[Get]] internal method of an exotic Symbol object O is called with property key P and ECMAScript language value $Receiver$ the following steps are taken:

1. Assert: IsPropertyKey(P) is `true`.
2. If P is "`toString`", then
 - a. Let ctx be the running execution context.
 - b. Let $ctxRealm$ be ctx 's Realm component.
 - c. Return $ctxRealm.[[intrinsic]].%ObjProto_toString%$.
3. Return `undefined`.

8.4.4.10 [[Set]] (P, V, Receiver)

When the [[Set]] internal method of an exotic Symbol object O is called with property key P , value V , and ECMAScript language value $Receiver$, the following steps are taken:

1. Return `false`.

8.4.4.11 [[Delete]] (P)

When the [[Delete]] internal method of an exotic Symbol object O is called with property key P the following steps are taken:

1. Assert: IsPropertyKey(P) is `true`.
2. Return `true`.

8.4.4.12 [[Enumerate]] ()

When the [[Enumerate]] internal method of an exotic Symbol object O is called the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method immediately throws %StopIteration% and forms no other action.

Comment [AWB6245]: TODO

8.4.4.13 [[OwnPropertyKeys]]()

When the `[[OwnPropertyKeys]]` internal method of an exotic Symbol object O is called the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method immediately throws `%StopIteration%` and forms no other action.

Comment [AWB6246]: TODO

8.3.10 [[Enumerate]](includePrototype, onlyEnumerable)

When the `[[Enumerate]]` internal method of O is called with Boolean arguments `includePrototype` and `onlyEnumerable`, the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method iterates over all the keys of enumerable property keys of O . If `includePrototype` is `false`, then only own properties of O are included. If `onlyEnumerable` is `false`, then all properties that do not have private name keys are included. The mechanics and order of enumerating the properties is not specified but must conform to the rules specified below.

Comment [AWB6247]: This is an experiment to see if we can use this internal method to define `Object.key`, `Object.getOwnPropertyNames`, and perhaps some other things

Comment [AWB6248]: TODO

Enumerated properties do not include properties whose property key is a private name. Properties of the object being enumerated may be deleted during enumeration. If a property that has not yet been visited during enumeration is deleted, then it will not be visited. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be visited in the active enumeration. A property name must not be visited more than once in any 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. The values of `[[Enumerable]]` attributes are not considered when determining if a property of a prototype object is shadowed by a previous object on the prototype chain.

The following is an informative algorithm that conforms to these rules

Comment [AWB6249]: TODO: Finish this and turn it into iterator definition include a new method

1. Let obj be O .
2. Let $proto$ be the value of the `[[Prototype]]` internal data property of O .
3. If `includePrototype` is `false` or $proto$ is the value `null`, then
 - a. Let $propList$ be a new empty List.
4. Else
 - a. Let $propList$ be the result of calling the `[[Enumerate]]` internal method of $proto$ with arguments `true` and `onlyEnumerable`.
5. For each string $name$ that is the property key of an own property of O
 - a. Let $desc$ be the result of calling the `[[GetOwnProperty]]` internal method of O with argument $name$.
 - b. If $name$ is an element of $propList$, then remove $name$ as an element of $propList$.
 - c. If `onlyEnumerable` is `false` or $desc.[[Enumerable]]$ is `true`, then add $name$ as an element of $propList$.
6. Order the elements of $propList$ in an implementation defined order.
7. Return $propList$.

This follow version places function body declarations in scope of parameter initializers

9.1.11 ToPositiveInteger

The abstract operation `ToInteger` converts its argument to an integral numeric value. This abstract operation functions as follows:

1. Let $number$ be the result of calling `ToNumber` on the input argument.
2. ReturnIfAbrupt($number$).
3. If $number$ is `NaN`, return `+0`.

4. If *number* is $+\infty$, or $-\infty$, return *number*.
5. If *number* < 0 , return $+0$.
6. Return the result of computing *floor(number)*.

10.5.3 Function Declaration Instantiation

NOTE When an execution context is established for evaluating function code a new Declarative Environment Record is created and bindings for each formal parameter, and each function level variable, constant, or function declared in the function are instantiated in the environment record. Formal parameters and functions are initialized as part of this process. All other bindings are initialized during execution of the function code.

Function Declaration Instantiation is performed as follows using arguments *func*, *argumentsList*, and *env*. *func* is the function object that for which the execution context is being established. *env* is the declarative environment record in which bindings are to be created.

1. Let *code* be the value of the **[[Code]]** internal property of *func*.
2. Let *strict* be the value of the **[[Strict]]** internal property of *func*.
3. Let *formals* be the value of the **[[FormalParameterList]]** internal property of *func*.
4. Let *parameterNames* be the *BoundNames* of *formals*.
5. Let *varDeclarations* be the *VarScopedDeclarations* of *code*.
6. Let *functionsToInitialize* be an emptyList.
7. Let *argumentsObjectNotNeeded* be **false**.
8. For each *d* in *varDeclarations*, in reverse list order do
 - a. If *d* is a *FunctionDeclaration* then
 - i. NOTE If there are multiple *FunctionDeclarations* for the same name, the last declaration is used.
 - ii. Let *fn* be the sole element of the *BoundNames* of *d*.
 - iii. If *fn* is "arguments", then let *argumentsObjectNotNeeded* be **true**.
 - iv. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *fn* as the argument.
 - v. If *alreadyDeclared* is **false**, then
 1. Let *status* be the result of calling *env*'s *CreateMutableBinding* concrete method passing *fn* as the argument.
 2. Assert: *status* is never an *Abrupt Completion*.
 3. Append *d* to *functionsToInitialize*.
9. For each String *paramName* in *parameterNames*, do
 - a. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *paramName* as the argument.
 - b. NOTE Duplicate parameter names can only occur in non-strict functions. Parameter names that are the same as function declaration names do not get initialized to **undefined**.
 - c. If *alreadyDeclared* is **false**, then
 - i. If *paramName* is "arguments", then let *argumentsObjectNotNeeded* be **true**.
 - ii. Let *status* be the result of calling *env*'s *CreateMutableBinding* concrete method passing *paramName* as the argument.
 - iii. Assert: *status* is never an *Abrupt Completion*.
 - iv. Call *env*'s *InitialiseBinding* concrete method passing *paramName*, and **undefined** as the arguments.
10. NOTE If there is a function declaration or formal parameter with the name "arguments" then an argument object is not created.
11. If *argumentsObjectNotNeeded* is **false**, then
 - a. If *strict* is **true**, then
 - i. Call *env*'s *CreateImmutableBinding* concrete method passing the String "arguments" as the argument.
 - b. Else,
 - i. Call *env*'s *CreateMutableBinding* concrete method passing the String "arguments" as the argument.
12. Let *varNames* be the *VarDeclaredNames* of *code*.
13. For each String *varName* in *varNames*, in list order do
 - a. Let *alreadyDeclared* be the result of calling *env*'s *HasBinding* concrete method passing *varName* as the argument.

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Comment [AWB7250]: TODO: don't create an arguments binding for arrow functions (and perhaps for concise methods)

- b. NOTE A VarDeclaredNames is only instantiated and initialised here if it is not also the name of a formal parameter or a *FunctionDeclarations*.
- c. If *alreadyDeclared* is **false**, then
- Call *env*'s *CreateMutableBinding* concrete method passing *varName* as the argument.
14. Let *lexDeclarations* be the LexicalDeclarations of *code*.
15. For each element *d* in *lexDeclarations* do
- NOTE A lexically declared name cannot be the same as a function declaration, formal parameter, or a var name. Lexically declared names are only instantiated here but not initialized.
 - For each element *dn* of the BoundNames of *d* do
 - If *IsConstantDeclaration* of *d* is **true**, then
 - Call *env*'s *CreateImmutableBinding* concrete method passing *dn* as the argument.
 - Else,
 - Call *env*'s *CreateMutableBinding* concrete method passing *dn* and **false** as the arguments.
16. For each *FunctionDeclaration* *f* in *functionsToInitialize*, do
- Let *fn* be the sole element of the BoundNames of *f*.
 - Let *fo* be the result of performing *InstantiateFunctionObject* for *f* with argument *env*.
 - Call *env*'s *SetMutableBinding* concrete method passing *fn*, *fo*, and **false** as the arguments.
17. NOTE Function declarations are initialised prior to parameter initialisation so that default value expressions may reference them. It is not extended code. "arguments" is not initialized until after parameter initialization.
18. Let *ao* be the result of *InstantiateArgumentsObject* with argument *argumentsList*.
19. NOTE If *argumentsObjectNotNeeded* is **true** then the value of *ao* is not directly observable to ECMAScript code and need not actually exist. In that case, its use in the above steps is strictly as a device for specifying formal parameter initialisation semantics.
20. If *argumentsObjectNotNeeded* is **false**, then
- If *strict* is **true**, then
 - Perform the abstract operation *CompleteStrictArgumentsObject* with argument *ao*.
 - Else,
 - Perform the abstract operation *CompleteMappedArgumentsObject* with arguments *ao*, *func*, *formals*, and *env*.
 - Call *env*'s *InitialiseBinding* concrete method passing "arguments" and *ao* as arguments.
21. Let *formalStatus* be the result of performing Binding Initialisation for *formals* with *ao* and **undefined** as arguments.
22. ReturnIfAbrupt(*formalStatus*).
23. Return NormalCompletion(empty).

F.1.1 The `proto` pseudo property.

F.1.1.1 `Object.prototype.proto`

The initial value of the `proto` property of the Object prototype object is a data property whose initial value is `null`. This property initially has the attributes { `[[Writable]]: true`, `[[Enumerable]]: false`, `[[Configurable]]: true` }.

Manipulations of this property as tracked by the Boolean valued primordial internal variable `UnderscoreProtoEnabled`. The default initial value of `UnderscoreProtoEnabled` is **true** only if this property is initially present on the primordial Object prototype object.

NOTE Any modification of this property or its attributes causes `UnderscoreProtoEnabled` to be set to **false**.

F.1.1.2 Changes To Internal Methods

The definition of the `[[Get]]` internal method given in 8.12.3 is replaced with the following:

- If *P* is the string value "`proto`" and `UnderscoreProtoEnabled` is **true**, then
 - Let *desc* be the result of calling the `[[GetProperty]]` internal method of *O* with property name *P*.
 - If *desc* is not **undefined** and was created by step 1.a to describe the property defined in B.3.1.1 then,
 - Return the value of the `[[Prototype]]` internal data property of *O*.
- Continue by executing the steps of 8.12.3 starting with step 1.

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Comment [AWB7251]: TODO: don't create an arguments binding for arrow functions (and perhaps for concise methods)

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Comment [AWB252]: The section and algorithm reference in this draft are based upon the ES5.1 spec. When the corresponding sections of this document are stable, this section will need to be updated.

Comment [AWB253]: This material is going to be made mandatory and integrated into the main body of the spec.

Comment [AWB254]: This is anticipating new specification material related to Module loader and establishing a primordial environment. The basic assumption is that a module loader must be able to disable this feature. This seems to suggest that the ability to do so must exist in the module loader APIs even if this feature is not present in an implementation.

Comment [AWB12255]: This whole thing needs to be rewritten, and in the process we will eliminate using `[[GetProperty]]`

The definition of the `[[Put]]` internal method given in 8.12.5 is replaced with the following:

1. If P is the string value "`proto`" and `UnderscoreProtoEnabled` is `true` and O is not the standard built-in `Object` prototype object, then
 - a. Let $desc$ be the result of calling the `[[GetProperty]]` internal method of O with property name P .
 - b. If $desc$ is not `undefined` and was created by step 1.a to describe the property defined in B.3.1.1 then,
 - i. If the type of V is neither `Object` or `Null`, return.
 - ii. Set the value of the `[[Prototype]]` internal data property of O to V .
 - iii. Return.
2. Continue by executing the steps of 8.12.5 starting with step 1.

Comment [AWB12256]: Need to be updated to use `[[SetP]]`

Comment [AWB12257]: This whole thing needs to be rewritten, and in the process we will eliminate using `[[GetProperty]]`

The definition of the `[[Delete]]` internal method given in 8.12.7 is replaced with the following:

1. If `UnderscoreProtoEnabled` is `true` and P is the string value "`proto`" and O is the standard built-in `Object` prototype object, then
 - a. Set `UnderscoreProtoEnabled` to `false`.
2. Continue by executing the steps of 8.12.7 starting with step 1.

The definition of the `[[DefineOwnProperty]]` internal method given in 8.12.9 is replaced with the following:

1. If `UnderscoreProtoEnabled` is `true` and P is the string value "`proto`" and O is the standard built-in `Object` prototype object, then
 - a. If any attribute contained in $Desc$ is not present or has a different value from the corresponding attribute in `{ [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true }` then,
 - i. Set `UnderscoreProtoEnabled` to `false`.
2. Continue by executing the steps of 8.12.9 starting with step 1.

Comment [AWB258]: Note that `Object.defineProperty(obj, 'proto', desc)` nor any other call of `[[DefineOwnProperty]]` does not modify `[[Prototype]]`.

F.1.1.3 `proto` Object Initialisers

Definitions of two algorithms in 11.1.5 are replaced with the following:

The production `PropertyDefinitionList : PropertyDefinition` is evaluated as follows:

1. Let obj be the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
2. Let $propId$ be the result of evaluating `PropertyDefinition`.
3. If $propId.name$ is the string value "`proto`" and `UnderscoreProtoEnabled` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`, then
 - a. Let v be $propId.descriptor.value$.
 - b. If $desc$ be $propId.descriptor$
 - c. If the type of v is either `Object` or `Null`,
 - i. Set the value of the `[[Prototype]]` internal data property of obj to v .
 - d. Return obj .
4. Call the `[[DefineOwnProperty]]` internal method of obj with arguments $propId.name$, $propId.descriptor$, and `false`.
5. Return obj .

The production
`PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition`
 is evaluated as follows:

1. Let obj be the result of evaluating `PropertyDefinitionList`.

2. Let `propId` be the result of evaluating `PropertyDefinition`.
3. Let `previous` be the result of calling the `[[GetOwnProperty]]` internal method of `obj` with argument `propId.name`.
4. If `previous` is not `undefined` then throw a **SyntaxError** exception if any of the following conditions are `true`
 - a. This production is contained in strict code and `IsDataDescriptor(previous)` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`.
 - b. `IsDataDescriptor(previous)` is `true` and `IsAccessorDescriptor(propId.descriptor)` is `true`.
 - c. `IsAccessorDescriptor(previous)` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`.
 - d. `IsAccessorDescriptor(previous)` is `true` and `IsAccessorDescriptor(propId.descriptor)` is `true` and either both `previous` and `propId.descriptor` have `[[Get]]` fields or both `previous` and `propId.descriptor` have `[[Set]]` fields
5. If `propId.name` is the string value "`proto`" and `UnderscoreProtoEnabled` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`, then
 - a. Let `v` be `propId.descriptor.value`.
 - b. If `desc` be `propId.descriptor`
 - c. If the type of `v` is either `Object` or `Null`
 - i. Set the value of the `[[Prototype]]` internal data property of `obj` to `v`.
 - d. Return `obj`.
5. Call the `[[DefineOwnProperty]]` internal method of `obj` with arguments `propId.name`, `propId.descriptor`, and `false`.
6. Return `obj`.

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Table 1 — Internal Properties Only Defined for Some Objects

<i>Internal Property</i>	<i>Value Type Domain</i>	<i>Description</i>
<code>[[BuiltinBrand]]</code>	The <code>BuiltinBrand</code> enumeration.	A tag value used by this specification to categorize various kinds of ECMAScript objects defined in this specification.
<code>[[PrimitiveValue]]</code>	<i>primitive</i>	Internal state information associated with this object. Of the standard built-in ECMAScript objects, only Boolean, Date, Number, and String objects implement <code>[[PrimitiveValue]]</code> .
<code>[[Scope]]</code>	Lexical Environment	A lexical environment that is the environment in which a Function object is executed. Of the standard built-in ECMAScript objects, only Function objects implement <code>[[Scope]]</code> .
<code>[[FormalParameters]]</code>	Parse Tree	A parse tree for ECMAScript code parsed with <code>FormalParameters</code> as the goal symbol. Of the standard built-in ECMAScript objects, only Function objects implement <code>[[FormalParameters]]</code> .
<code>[[Code]]</code>	Parse Tree	A parse tree for ECMAScript code parsed with <code>FunctionBody</code> as the goal symbol. Of the standard built-in ECMAScript objects, only Function objects implement <code>[[Code]]</code> .
<code>[[Strict]]</code>	Boolean	true if a Function object is a strict mode function. Of the standard built-in ECMAScript objects, only Function objects implement <code>[[Strict]]</code>.
<code>[[BoundTargetFunction]]</code>	Object	The target function of a function object created using the standard built-in <code>Function.prototype.bind</code> method. Only ECMAScript objects created using <code>Function.prototype.bind</code> have a <code>[[BoundTargetFunction]]</code> internal property.
<code>[[BoundThis]]</code>	<i>any</i>	The pre-bound <code>this</code> value of a function Object created using the standard built-in <code>Function.prototype.bind</code> method. Only ECMAScript objects created using <code>Function.prototype.bind</code> have a <code>[[BoundThis]]</code> internal property.
<code>[[BoundArguments]]</code>	List of <i>any</i>	The pre-bound argument values of a function Object created by the standard built-in <code>Function.prototype.bind</code> method. Only objects created by <code>Function.prototype.bind</code> have a <code>[[BoundArguments]]</code> internal property.
<code>[[RegExpMatcher]]</code>	<i>SpecOp(String, index) → MatchResult</i>	Tests for a regular expression match and returns a <code>MatchResult</code> value (see 15.10.2.1). Of the standard built-in ECMAScript objects, only <code>RegExp</code> objects implement <code>[[RegExpMatch]]</code> .
<code>[[ParameterMap]]</code>	Object	Provides a mapping between the properties of an arguments object (see 10.6) and the formal parameters of the associated function. Only objects that are arguments objects have a <code>[[ParameterMap]]</code> internal property.

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- [8] ~~Unicode Inc. (2010), Unicode Technical Report #15: “Unicode Normalization Forms”, available at <<http://www.unicode.org/reports/tr15/tr15-29.html>>~~

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Unicode Inc. (2010), Unicode Technical Report #15: Unicode Normalization Forms

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