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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 ECMAScript to keep it fully aligned with ISO/IEC 16262. Changes between the first and the second edition are editorial in nature.


After publication of the third edition, ECMAScript 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. However, that work was not completed and not published as the fourth edition of ECMAScript. The fifth edition of ECMAScript (published as ECMA-262 5th edition) codified de facto interpretations of the language specification that have become common among browser implementations and added support for new features that had 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.


Goals for the sixth edition include providing better support for large applications, library creation, and for use of ECMAScript as a compilation target for other languages. The sixth edition is the most extensive update to ECMAScript since the publication of the first edition. Some of its major enhancements include modules, class declarations, lexical block scoping, iterators and generators, promises for asynchronous programming, destructuring patterns, and proper tail calls. The ECMAScript library of built-ins has been expanded to support additional data abstractions including maps, sets, and arrays of binary numeric values as well as additional support for the Unicode supplemental characters in strings and regular expressions. The built-ins are now extensible via subclassing.

ECMAScript is now one of the world’s most widely used comprehensive general purpose programming languages. It has been adopted not just by browsers but also for servers and embedded applications. New uses and requirements for ECMAScript continue to emerge. The sixth edition provides the foundation for regular, incremental language and library enhancements.

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

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ECMAScript 2015 Language Specification

1 Scope
This Standard defines the ECMAScript 2015 general purpose programming 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 ECMAScript must interpret source code input 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 that provides an application programming interface that supports programs that need to adapt to the linguistic and cultural conventions used by different human languages and countries must implement the interface defined by the most recent edition of ECMA-402 that is compatible with this specification.

A conforming implementation of ECMAScript may provide additional types, values, objects, properties, and functions beyond those described in this specification. In particular, a conforming implementation of ECMAScript may 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 may support program and regular expression syntax not described in this specification. In particular, a conforming implementation of ECMAScript may support program syntax that makes use of the "future reserved words" listed in subclause 11.6.2.2 of this specification.

A conforming implementation of ECMAScript must not implement any extension that is listed as a Forbidden Extension in subclause 16.1.

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.


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

ECMAScript was originally designed to be used as a scripting language, but has become widely used as a general purpose programming language. A scripting language is a programming language that is used to manipulate, customize, and automate the facilities of an existing system. In such systems, useful functionality is already available through a user interface, and the scripting language is a mechanism for exposing that functionality to program control. In this way, the existing system is said to provide a host environment of objects and facilities, which completes the capabilities of the scripting language. A scripting language is intended for use by both professional and non-professional programmers.

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 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.

ECMAScript usage has moved beyond simple scripting and it is now used for the full spectrum of programming tasks in many different environments and scales. As the usage of ECMAScript has expanded, so has the features and facilities it provides. ECMAScript is now a fully featured general propose programming language.

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


4.1 Web Scripting

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

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

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

4.2 ECMAScript 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. In ECMAScript, an object is a collection of zero or more properties each with 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 assign a different value to 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, Boolean, Number, String, and Symbol; an object is a member of the built-in type Object; and a function is a callable object. A function that is associated with an object via a property is called 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; objects that are fundamental to the runtime semantics of the language including Object, Function, Boolean, Symbol, and various Error objects; objects that represent and manipulate numeric values including Math, Number, and Date; the text processing objects String and RegExp; objects that are indexed collections of values including Array and nine different kinds of Typed Arrays whose elements all have a specific numeric data representation; keyed collections including Map and Set objects; objects supporting structured data including the JSON object, ArrayBuffer, and DataView; objects supporting control abstractions including generator functions and Promise objects; and, reflection objects including Proxy and Reflect.

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.

Deleted: zero or more
Large ECMAScript programs are supported by modules which allow a program to be be divided into multiple sequences of statements and declarations. Each module explicitly identifies declarations it uses that need to be provided by other modules and which of its declarations are available for use by other modules.

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 objects are not fundamentally class-based 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 initializes 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.

Every object created by a constructor has an implicit reference (called the object’s prototype) to the value of its constructor’s “prototype” property. Furthermore, a prototype may have a non-null implicit reference to its prototype, and so on; this is called the prototype chain. When a reference is made to a property in an object, that reference is to the property of that name in the first object in the prototype chain that contains a property of that name. In other words, first the object mentioned directly is examined for such a property; if that object contains the named property, that is the property to which the reference refers; if that object does not contain the named property, the prototype for that object is examined next; and so on.
In a class-based object-oriented language, in general, state is carried by instances, methods are carried by classes, and inheritance is only of structure and behaviour. In ECMAScript, the state and methods are carried by objects, while structure, behaviour, and state are all inherited.

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

**Figure 1 — Object/Prototype Relationships**

- **CF** is a constructor (and also an object). Five objects have been created by using `new` expressions: `cf_1`, `cf_2`, `cf_3`, `cf_4`, and `cf_5`. Each of these objects contains properties named `q1` and `q2`. The dashed lines represent the implicit prototype relationship; so, for example, `cf_3`'s prototype is `CF_p`. The constructor, **CF**, has two properties itself, named `P1` and `P2`, which are not visible to `CF_p`, `cf_1`, `cf_2`, `cf_3`, `cf_4`, or `cf_5`. The property named `CFP1` in `CF_p` is shared by `cf_1`, `cf_2`, `cf_3`, `cf_4`, and `cf_5` (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 most 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 `cf_1`, `cf_2`, `cf_3`, `cf_4`, and `cf_5` by assigning a new value to the property in `CF_p`.

Although ECMAScript objects are not inherently class-based, it is often convenient to define class-like abstractions based upon a common pattern of constructor functions, prototype objects, and methods. The ECMAScript built-in objects themselves follow such a class-like pattern. The ECMAScript language includes syntactic class definitions that permit programmers to concisely define objects that conform to the same class-like abstraction pattern used by the built-in objects.

### 4.2.2 The Strict Variant of ECMAScript

The ECMAScript Language recognizes the possibility that some users of the language may wish to restrict their usage of some features available in the language. They might do so in the interests of
security, to avoid what they consider to be error-prone features, to get 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 6 of this specification

4.3.2 primitive value
member of one of the types Undefined, Null, Boolean, Number, Symbol, or String as defined in clause 6

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 initializes 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 essential internal methods that must be supported by all objects.

4.3.7
Exotic Object
Object that does not have the default behaviour for one or more of the essential internal methods that must be supported by all 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.

4.3.9
Built-in Object
Object specified and supplied by an ECMAScript implementation.

NOTE: Standard built-in objects are defined in this specification. An ECMAScript implementation may specify and supply additional kinds of built-in objects. A "built-in constructor" is a built-in object that is also a constructor.

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.

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

4.3.16  
Boolean object  
member of the Object type that is an instance of the standard built-in Boolean constructor

NOTE  A Boolean object is created by using the Boolean constructor in a new expression, supplying a Boolean value as an argument. The resulting object has an internal slot whose value is the Boolean value. A Boolean object can be coerced to a Boolean value.

4.3.17  
String value  
primitive value that is a finite ordered sequence of zero or more 16-bit unsigned integer

NOTE  A String value is a member of the String type. Each integer value in the sequence usually represents a single 16-bit unit of UTF-16 text. However, ECMAScript does not place any restrictions or requirements on the values except that they must be 16-bit unsigned integers.

4.3.18  
String type  
set of all possible String values

4.3.19  
String object  
member of the Object type that is an instance of the standard built-in String constructor

NOTE  A String object is created by using the String constructor in a new expression, supplying a String value as an argument. The resulting object has an internal slot whose value is the String value. A String object can be coerced to a String value by calling the String constructor as a function (21.1.1.1).

4.3.20  
Number value  
primitive value corresponding to a double-precision 64-bit binary format IEEE 754 value

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

4.3.21  
Number type  
set of all possible Number values including the special “Not-a-Number” (NaN) value, positive infinity, and negative infinity

4.3.22  
Number object  
member of the Object type that is an instance of the standard built-in Number constructor

NOTE  A Number object is created by using the Number constructor in a new expression, supplying a Number value as an argument. The resulting object has an internal slot whose value is the Number value. A Number object can be coerced to a Number value by calling the Number constructor as a function (20.1.1.1).
4.3.23
Infinity
number value that is the positive infinite Number value

4.3.24
NaN
number value that is an IEEE 754 “Not-a-Number” value

4.3.25
Symbol value
primitive value that represents a unique, non-String Object property key

4.3.26
Symbol type
set of all possible Symbol values

4.3.27
Symbol object
member of the Object type that is an instance of the standard built-in Symbol constructor

4.3.28
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.

4.3.29
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.

4.3.30
property
association between a key and a value that is a part of an object. The key be either a String value or a Symbol value

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.

4.3.31
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.

4.3.32
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.

4.3.33
attribute
internal value that defines some characteristic of a property

4.3.34
own property
property that is directly contained by its object

4.3.35
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

4.4 Organization of This Specification

The remainder of this specification is organized as follows:

Clause 5 defines the notational conventions used throughout the specification.

Clauses 6–9 define the execution environment within which ECMAScript programs operate.

Clauses 10–16 define the actual ECMAScript programming language including its syntactic encoding and the execution semantics of all language features.

Clauses 17–26 define the ECMAScript standard library. It includes the definitions of all of the standard objects that are available for use by ECMAScript programs as they execute.

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.

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

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 11. This grammar has as its terminal symbols Unicode code points that conform to the rules for SourceCharacter defined in 10.1. It defines a set of productions, starting from the goal symbol InputElementDiv or InputElementRegExp, that describe how sequences of such code points 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 (11.9). 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 21.2.1. This grammar also has as its terminal symbols the code points as defined by SourceCharacter. It defines a set of productions, starting from the goal symbol Pattern, that describe how sequences of code points 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 7.1.3.1.

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, 14, and 15. 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 two alternative goal symbols Script and Module, that describe how sequences of tokens can form syntactically correct independent components of an ECMAScript programs.

When a stream of code points is to be parsed as an ECMAScript Script or Module, 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 input stream 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 or Module), 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 12, 13, 14 and 15 is actually not a complete account of which token sequences are accepted as a correct ECMAScript Script or Module. 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 line terminator character appears in certain "awkward" places.

In certain cases in order to avoid ambiguities the syntactic grammar uses generalized productions that permit token sequences that do not form a valid ECMAScript Script or Module. For example, this technique is used for 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 input stream is syntactically in error if the tokens in the stream of input elements parsed by a cover grammar cannot be parsed as a single instance of the corresponding supplemental goal symbol, with no tokens left over.

5.1.5 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 exactly as written. All terminal symbol code points specified in this way are to be understood as the appropriate Unicode code points from the Basic Latin range, as opposed to any similar-looking code points from other Unicode ranges.

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:

\[
\text{WhileStatement} : \text{while} \ (\text{Expression}) \ \text{Statement}
\]

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:

\[
\text{ArgumentList} : \text{AssignmentExpression} \ \text{ArgumentList} \ , \ \text{AssignmentExpression}
\]

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:

\[
\text{VariableDeclaration} : \text{BindingIdentifier} \ \text{Initializer}_{\text{opt}}
\]

is a convenient abbreviation for:
VariableDeclaration:
    BindingIdentifier
    BindingIdentifier Initializer

and that:

IterationStatement:
    for ( LexicalDeclaration Expressionopt ; Expressionopt ) Statement

is a convenient abbreviation for:

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

which in turn is an abbreviation for:

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

so, in this example, the nonterminal IterationStatement actually has four alternative right-hand sides.

A production may be parameterized by a subscripted annotation of the form "[parameters]", which may appear as a suffix to the nonterminal symbol defined by the production. "parameters" may be either a single name or a comma separated list of names. A parameterized production is shorthand for a set of productions defining all combinations of the parameter names, preceded by an underscore, appended to the parameterized nonterminal symbol. This means that:

StatementList Returnopt:
    ReturnStatement
    ExpressionStatement

is a convenient abbreviation for:

StatementList:
    ReturnStatement
    ExpressionStatement

StatementList_Return:
    ReturnStatement
    ExpressionStatement

and that:

StatementList[Return, In] Returnopt:
    ReturnStatement
    ExpressionStatement

is an abbreviation for:
Multiple parameters produce a combinatory number of productions, not all of which are necessarily referenced in a complete grammar.

References to nonterminals on the right-hand side of a production can also be parameterized. For example:

```
StatementList : ReturnStatement
ExpressionStatement
```

is equivalent to saying:

```
StatementList : ReturnStatement
ExpressionStatement_In
```

A nonterminal reference may have both a parameter list and an "opt" suffix. For example:

```
VariableDeclaration : BindingIdentifier Initialize[opt]
```

is an abbreviation for:

```
VariableDeclaration : BindingIdentifier
BindingIdentifier Initializer_In
```

Prefixing a parameter name with "?" on a right-hand side nonterminal reference makes that parameter value dependent upon the occurrence of the parameter name on the reference to the current production's left-hand side symbol. For example:

```
VariableDeclaration[?]: BindingIdentifier Initialize[?opt]
```

is an abbreviation for:
VariableDeclaration:
  BindingIdentifier Initializer

VariableDeclaration_In:
  BindingIdentifier Initializer_In

If a right-hand side alternative is prefixed with "[-parameter]" that alternative is only available if the named parameter was used in referencing the production's nonterminal symbol. If a right-hand side alternative is prefixed with "[~parameter]" that alternative is only available if the named parameter was not used in referencing the production's nonterminal symbol. This means that:

```
StatementList_Return:
  [+Return] ReturnStatement
  ExpressionStatement
```
is an abbreviation for:

```
StatementList:
  ExpressionStatement

StatementList_Return:
  ReturnStatement
  ExpressionStatement
```

and that

```
StatementList_Return:
  [+Return] ReturnStatement
  ExpressionStatement
```
is an abbreviation for:

```
StatementList:
  ReturnStatement
  ExpressionStatement

StatementList_Return:
  ExpressionStatement
```

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 a 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 brackets. 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. If the set consists of a single terminal the phrase "[lookahead ≠ terminal]" may be used.

For example, given the definitions

\[\text{DecimalDigit} :: \text{one of} \quad 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9\]

\[\text{DecimalDigits} :: \text{DecimalDigit} \quad \text{DecimalDigits} \quad \text{DecimalDigit}\]

the definition

\[\text{LookaheadExample} :: \quad \text{n} \quad [\text{lookahead \ ε} \quad \{1, 3, 5, 7, 9\}] \quad \text{DecimalDigits} \quad \text{DecimalDigit} \quad [\text{lookahead ≠ DecimalDigit}]\]

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

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

\[\text{ThrowStatement} :: \quad \text{throw} \quad [\text{no LineTerminator here}] \quad \text{Expression} \quad ;\]

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

Unless the presence of a LineTerminator is forbidden by a restricted production, any number of occurrences of LineTerminator may appear between any two consecutive tokens in the stream of input elements without affecting the syntactic acceptability of the script.
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 recognized using the indicated goal symbol. In the absence of such a phrase the default lexical goal symbol is used.

When an alternative in a production of the lexical grammar or the numeric string grammar appears to be a multi-code point token, it represents the sequence of code points 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 code points that could replace IdentifierName provided that the same sequence of code points 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 code point

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 parameterized, 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 parameterized functional form so that they may be referenced by name from within other algorithms.

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 nonterminal symbols of the production alternative as if they were parameters of the algorithm. When used in this manner, nonterminal symbols refer to the actual alternative definition that is matched when parsing the script source code.

When an algorithm is associated with a production alternative, the alternative is typically shown without any "[ ]" grammar annotations. Such annotations should only affect the syntactic recognition of the alternative and have no effect on the associated semantics for the alternative.

Unless explicitly specified otherwise, all chain productions have an implicit definition for every algorithm that might be applied to that production's left-hand side nonterminal. The implicit definition simply reapplies the same algorithm name with the same parameters, if any, to the chain production's sole right-hand side nonterminal and then returns the result. For example, assume there is a production:
but there is no corresponding 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 an Evaluation algorithm exists 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.
   b. Substep.
      i. Subsubstep
         1. Subsubsubstep
            a. Subsubsubsubstep
               i. Subsubsubsubsubstep

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 that begins with “Assert:” asserts 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 \( \text{abs}(x) \) produces the absolute value of \( x \), which is \( -x \) if \( x \) is negative (less than zero) and otherwise is \( x \) itself.

The mathematical function \( \text{sign}(x) \) produces 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 \( \min(x_1, x_2, \ldots, x_n) \) produces the mathematically smallest of \( x_1 \) through \( x_n \). The mathematical function \( \max(x_1, x_2, \ldots, x_n) \) produces the mathematically largest 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 \( \text{floor}(x) \) produces 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 form a valid ECMAScript Script or Module 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 \( \text{Contains} \) which takes an argument named \( \text{symbol} \) whose value is a terminal or nonterminal of the grammar that includes the associated production. The default definition of \( \text{Contains} \) is:

1. For each terminal and nonterminal grammar symbol, \( \text{sym} \), in the definition of this production do
   a. If \( \text{sym} \) is the same grammar symbol as \( \text{symbol} \), return \( \text{true} \).
   b. If \( \text{sym} \) is a nonterminal, then
      i. Let \( \text{contained} \) be the result of \( \text{sym} \text{ Contains } \text{symbol} \).
      ii. If \( \text{contained} \) is \( \text{true} \), return \( \text{true} \).
2. Return \( \text{false} \).

The above definition is explicitly overridden 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 associated 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 ECMAScript Data Types and Values

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 “\( \text{Type}(x) \)” is used as shorthand for “the type of \( x \)” where “type” refers to the ECMAScript language and specification types defined in this clause. When the term “empty” is used as if it was naming a value, it is equivalent to saying “no value of any type”.

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

6.1.1 The Undefined Type

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

6.1.2 The Null Type

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

6.1.3 The Boolean Type

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

6.1.4 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.

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.

\textbf{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 Normalized Form C, string literals are guaranteed to also be normalized, as long as they do not contain any Unicode escape sequences.

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 $c_1$ is in the range 0xD800 to 0xDBFF and the second code unit $c_2$ is in the range 0xDC00 to 0xDFFF, is a surrogate pair and is interpreted as a code point with the value $(c_1 - 0xD800) \times 0x10000 + (c_2 - 0xDC00) + 0x10000$. 
- A code unit that is in the range 0xD800 to 0xDBFF, but is not part of a surrogate pair, is interpreted as a code point with the same value.
6.1.5 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 (6.1.7).

Each possible Symbol value is unique and immutable.

Each Symbol value immutably holds an associated value called [[Description]] that is either undefined or a String value.

6.1.5.1 Well-Known Symbols

Well-known symbols are built-in Symbol values 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 (8.2).

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 1.
### Table 1 — Well-known Symbols

<table>
<thead>
<tr>
<th>Specification Name</th>
<th>[[Description]]</th>
<th>Value and Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>@@hasInstance</td>
<td>&quot;Symbol.hasInstance&quot;</td>
<td>A method that determines if a constructor object recognizes an object as one of the constructor’s instances. Called by the semantics of the <code>instanceof</code> operator.</td>
</tr>
<tr>
<td>@@isConcatSpreadable</td>
<td>&quot;Symbol.isConcatSpreadable&quot;</td>
<td>A Boolean valued property that if true indicates that an object should be flattened to its array elements by <code>Array.prototype.concat</code>.</td>
</tr>
<tr>
<td>@@iterator</td>
<td>&quot;Symbol.iterator&quot;</td>
<td>A method that returns the default iterator for an object. Called by the semantics of the <code>for-of</code> statement.</td>
</tr>
<tr>
<td>@@match</td>
<td>&quot;Symbol.match &quot;</td>
<td>A regular expression method that matches the regular expression against a string. Called by the <code>String.prototype.match</code> method.</td>
</tr>
<tr>
<td>@@replace</td>
<td>&quot;Symbol.replace &quot;</td>
<td>A regular expression method that replaces matched substrings of a string. Called by the <code>String.prototype.replace</code> method.</td>
</tr>
<tr>
<td>@@search</td>
<td>&quot;Symbol.search&quot;</td>
<td>A regular expression method that returns the index within a string that matches the regular expression. Called by the <code>String.prototype.search</code> method.</td>
</tr>
<tr>
<td>@@species</td>
<td>&quot;Symbol.species&quot;</td>
<td>A property whose value is the constructor function that is used to create derived objects.</td>
</tr>
<tr>
<td>@@split</td>
<td>&quot;Symbol.split&quot;</td>
<td>A regular expression method that splits a string at the indices that match the regular expression. Called by the <code>String.prototype.split</code> method.</td>
</tr>
<tr>
<td>@@toPrimitive</td>
<td>&quot;Symbol.toPrimitive&quot;</td>
<td>A method that converts an object to a corresponding primitive value. Called by the <code>ToPrimitive</code> abstract operation.</td>
</tr>
<tr>
<td>@@toStringTag</td>
<td>&quot;Symbol.toStringTag&quot;</td>
<td>A property whose 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>.</td>
</tr>
<tr>
<td>@@unscopables</td>
<td>&quot;Symbol.unscopables&quot;</td>
<td>A property whose value is an Object whose own property names are property names that are excluded from the <code>with</code> environment bindings of the associated object.</td>
</tr>
</tbody>
</table>

### 6.1.6 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.

NOTE The bit pattern that might be observed in an ArrayBuffer (see 24.1) after a Number value has been stored
into it is not necessarily the same as the internal representation of that Number value used by the ECMAScript
implementation.

There are two other special values, called positive Infinity and negative Infinity. For brevity, these
values are also referred to for expository purposes by the symbols +∞ and −∞, respectively. (Note that
these two infinite Number values are produced by the program expressions +Infinity (or simply
Infinity) and −Infinity.)

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 18428729675200069632 (that is, 2^64–2^54) finite nonzero values are of two kinds:

18437736874454810622 (that is, 2^64–2^53–2) finite nonzero values are of two kinds:

18437736874454810624 (that is, 2^64–2^53) of them are normalized, 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 denormalized, 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 2^51 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 \( \pi \)) means a Number value
chosen in the following manner. Consider the set of all finite values of the Number type, with −0 removed
and with two additional values added to it that are not representable in the Number type, namely 2^1024
(which is +1 × 2^1024) and −2^1024 (which is −1 × 2^1024). 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 +∞; if −2^1024 was chosen, replace it with −∞; 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, ties to even” mode.)

Some ECMAScript operators deal only with integers in specific ranges such as $-2^{31}$ through $2^{31}-1$, inclusive, or in the range $0$ through $2^{16}-1$, inclusive. These operators accept any value of the Number type but first convert each such value to an integer value in the expected range. See the descriptions of the numeric conversion operations in 7.1.

6.1.7 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.
- An **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. All String and Symbol values, including the empty string, are valid as property keys.

An **integer index** is a String-valued property key that is a canonical numeric String (see 7.1.16) and whose numeric value is either $+0$ or a positive integer $\leq 2^{32}-1$. An **array index** is an integer index whose numeric value $i$ is in the range $+0 \leq i < 2^{32}-1$.

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. Each own property of an object must each have a key value that is distinct from the key values of the other own properties of that 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.

6.1.7.1 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 2.
Table 2 — Attributes of a Data Property

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Value]]</td>
<td>Any ECMAScript language type</td>
<td>The value retrieved by a get access of the property.</td>
</tr>
<tr>
<td>[[Writable]]</td>
<td>Boolean</td>
<td>If false, attempts by ECMAScript code to change the property's [[Value]] attribute using [[Set]] will not succeed.</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>Boolean</td>
<td>If true, the property will be enumerated by a for-in enumeration (see 13.6.4). Otherwise, the property is said to be non-enumerable.</td>
</tr>
<tr>
<td>[[Configurable]]</td>
<td>Boolean</td>
<td>If false, attempts to delete the property, change the property to be an accessor property, or change its attributes (other than [[Value]], or changing [[Writable]] to false) will fail.</td>
</tr>
</tbody>
</table>

An accessor property associates a key value with the attributes listed in Table 3.

Table 3 — Attributes of an Accessor Property

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Get]]</td>
<td>Object or Undefined</td>
<td>If the value is an Object it must be a function Object. The function's [[Call]] internal method (Table 6) is called with an empty arguments list to retrieve the property value each time a get access of the property is performed.</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>Object or Undefined</td>
<td>If the value is an Object it must be a function Object. The function's [[Call]] internal method (Table 6) 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.</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>Boolean</td>
<td>If true, the property is to be enumerated by a for-in enumeration (see 13.6.4). Otherwise, the property is said to be non-enumerable.</td>
</tr>
<tr>
<td>[[Configurable]]</td>
<td>Boolean</td>
<td>If false, attempts to delete the property, change the property to be a data property, or change its attributes will fail.</td>
</tr>
</tbody>
</table>

If the initial values of a property’s attributes are not explicitly specified by this specification, the default value defined in Table 4 is used.
6.1.7.2 Object Internal Methods and Internal Slots

The actual semantics of objects, in ECMAScript, 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 method names are polymorphic. This means that different 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 slots correspond to internal state that is associated with objects and used by various ECMAScript specification algorithms. Internal slots are not object properties and they are not inherited. Depending upon the specific internal slot specification, such state may consist of values of any ECMAScript language type or of specific ECMAScript specification type values. Unless explicitly specified otherwise, internal slots are allocated as part of the process of creating an object and may not be dynamically added to an object. Unless specified otherwise, the initial value of an internal slot is the value `undefined`. Various algorithms within this specification create objects that have internal slots. However, the ECMAScript language provides no direct way to associate internal slots with an object.

Internal methods and internal slots are identified within this specification using names enclosed in double square brackets `[[ ]]`.

Table 5 summarizes the *essential internal methods* used by this specification that are applicable to all objects created or manipulated by ECMAScript code. 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 5 and other similar tables describes the invocation pattern for each internal method. The invocation pattern always includes a parenthesized 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 6 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 6.2.2. In addition to its parameters, an internal method always has access to the object upon which it is invoked as a method.

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Value]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Get]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Writable]]</td>
<td>false</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>false</td>
</tr>
<tr>
<td>[[Configurable]]</td>
<td>false</td>
</tr>
</tbody>
</table>
Table 5 — Essential Internal Methods

<table>
<thead>
<tr>
<th>Internal Method</th>
<th>Signature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[GetPrototypeOf]]</td>
<td>() → Object or Null</td>
<td>Determine the object that provides inherited properties for this object. A null value indicates that there are no inherited properties.</td>
</tr>
<tr>
<td>[[SetPrototypeOf]]</td>
<td>(Object or Null) → Boolean</td>
<td>Associate with this object another object that provides inherited properties. Passing null indicates that there are no inherited properties. Returns true indicating that the operation was completed successfully or false indicating that the operation was not successful.</td>
</tr>
<tr>
<td>[[IsExtensible]]</td>
<td>() → Boolean</td>
<td>Determine whether it is permitted to add additional properties to this object.</td>
</tr>
<tr>
<td>[[PreventExtensions]]</td>
<td>() → Boolean</td>
<td>Control whether new properties may be added to this object. Returns true if the operation was successful or false if the operation was unsuccessful.</td>
</tr>
<tr>
<td>[[GetOwnProperty]]</td>
<td>(propertyKey) → undefined or Property Descriptor</td>
<td>Returns a Property Descriptor for the own property of this object whose key is propertyKey, or undefined if no such property exists.</td>
</tr>
<tr>
<td>[[HasProperty]]</td>
<td>(propertyKey) → Boolean</td>
<td>Returns a Boolean value indicating whether this object already has either an own or inherited property whose key is propertyKey.</td>
</tr>
<tr>
<td>[[Get]]</td>
<td>(propertyKey, Receiver) → any</td>
<td>Return the value of the property whose key is propertyKey from this object. If any ECMAScript code must be executed to retrieve the property value, Receiver is used as the this value when evaluating the code.</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>(propertyKey, value, Receiver) → boolean</td>
<td>Set the value of this object property whose key is propertyKey to value. If any ECMAScript code must be executed to set the property value, Receiver is used as the this value when evaluating the code. Returns true if the property value was set or false if it could not be set.</td>
</tr>
<tr>
<td>[[Delete]]</td>
<td>(propertyKey) → boolean</td>
<td>Removes the own property whose key is propertyKey from this object. Return false if the property was not deleted and is still present. Return true if the property was deleted or is not present.</td>
</tr>
<tr>
<td>[[DefineOwnProperty]]</td>
<td>(propertyKey, PropertyDescriptor) → boolean</td>
<td>Creates or alters the this object own property whose key is propertyKey to have the state described by PropertyDescriptor. Returns true if that the property was successfully created/updated or false if that the property could not be created or updated.</td>
</tr>
<tr>
<td>[[Enumerate]]</td>
<td>() → Object</td>
<td>Returns an iterator object that produces the keys of the string-keyed enumerable properties of the object.</td>
</tr>
<tr>
<td>[[OwnPropertyKeys]]</td>
<td>() → List of propertyKey</td>
<td>Returns a List whose elements are all of the own property keys for the object.</td>
</tr>
</tbody>
</table>

Table 6 summarizes additional essential internal methods that are supported by objects that may be called as functions.
Table 6 — Additional Essential Internal Methods of Function Objects

<table>
<thead>
<tr>
<th>Internal Method</th>
<th>Signature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Call]]</td>
<td>(any, a List of any) → any</td>
<td>Executes code associated with this 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 callable.</td>
</tr>
<tr>
<td>![Construct]]</td>
<td>(a List of any, Object) → Object</td>
<td>Creates an object. Invoked via the new or super operators. The first arguments to the internal method is a list containing the arguments of the operator. The second argument is the object to which the new operator was initially applied. Objects that implement this internal method are called constructors. A Function object is not necessarily a constructor and such non-constructor Function objects do not have a [[Construct]] internal method.</td>
</tr>
</tbody>
</table>

The semantics of the essential internal methods for ordinary objects and standard exotic objects are specified in clause 8.6. If any specified use of an internal method of an exotic object is not supported by an implementation, that usage must throw a TypeError exception when attempted.

6.1.7.3 Invariants of the Essential Internal Methods

The Internal Methods of Objects of an ECMAScript engine must conform to the list of invariants specified below. Ordinary ECMAScript Objects as well as all standard exotic objects in this specification maintain these invariants. ECMAScript Proxy objects maintain these invariants by means of runtime checks on the result of traps invoked on the [[ProxyHandler]] object.

Any implementation provided exotic objects must also maintain these invariants for those objects. Violation of these invariants may cause ECMAScript code to have unpredictable behaviour and create security issues. However, violation of these invariants must never compromise the memory safety of an implementation.

Definitions:
- The target of an internal method is the object the internal method is called upon.
- A target is non-extensible if it has been observed to return false from its [[IsExtensible]] internal method, or true from its [[PreventExtensions]] internal method.
- A non-existent property is a property that does not exist as an own property on a non-extensible target.
- All references to SameValue are according to the definition of SameValue algorithm specified in 7.2.3.

[[GetPrototypeOf]] ( )
- The Type of the return value must be either Object or Null.
- If target is non-extensible, and [[GetPrototypeOf]] returns a value v, then any future calls to [[GetPrototypeOf]] should return the SameValue as v.

NOTE An object’s prototype chain should have finite length (that is, starting from any object, recursively applying the [[GetPrototypeOf]] internal method to its result should eventually lead to the value null). However, this requirement is not enforceable as an object level invariant if the prototype chain includes any exotic objects that do not use the ordinary object definition of [[GetPrototypeOf]]. Such a circular prototype chain may result in infinite loops when accessing object properties.
[[SetPrototypeOf]] (V)
- The Type of the return value must be Boolean.
- If target is non-extensible, [[SetPrototypeOf]] must return false, unless V is the SameValue as the target's observed [[GetPrototypeOf]] value.

[[PreventExtensions]] ()
- The Type of the return value must be Boolean.
- If [[PreventExtensions]] returns true, all future calls to [[IsExtensible]] on the target must return false and the target is now considered non-extensible.

[[GetOwnProperty]] (P)
- The Type of the return value must be either Property Descriptor or Undefined.
- If the Type of the return value is Property Descriptor, the return value must be a complete property descriptor (see 6.2.4.6).
- If a property P is described as a data property with Desc.[[Value]] equal to v and Desc.[[Writable]] and Desc.[[Configurable]] are both false, then the SameValue must be returned for the Desc.[[Value]] attribute of the property on all future calls to [[GetOwnProperty]] (P).
- If P's attributes other than [[Writable]] may change over time or if the property might disappear, then P's [[Configurable]] attribute must be true.
- If the [[Writable]] attribute may change from false to true, then the [[Configurable]] attribute must be true.
- If the target is non-extensible and P is non-existent, then all future calls to [[GetOwnProperty]] (P) on the target must describe P as non-existent (i.e. [[GetOwnProperty]] (P) must return undefined).

NOTE As a consequence of the third invariant, if a property is described as a data property and it may return different values over time, then either or both of the Desc.[[Writable]] and Desc.[[Configurable]] attributes must be true even if no mechanism to change the value is exposed via the other internal methods.

[[DefineOwnProperty]] (P, Desc)
- The Type of the return value must be Boolean.
- [[DefineOwnProperty]] must return false if P has previously been observed as a non-configurable own property of the target, unless either:
  1. P is a non-configurable writable own data property. A non-configurable writable data property can be changed into a non-configurable non-writable data property.
  2. All attributes in Desc are the SameValue as P's attributes.
- [[DefineOwnProperty]] (P, Desc) must return false if target is non-extensible and P is a non-existent own property. That is, a non-extensible target object cannot be extended with new properties.

[[HasProperty]] (P)
- The Type of the return value must be Boolean.
- If P was previously observed as a non-configurable data or accessor own property of the target, [[HasProperty]] must return true.

[[Get]] (P, Receiver)
- If P was previously observed as a non-configurable, non-writable own data property of the target with value v, then [[Get]] must return the SameValue.
- If P was previously observed as a non-configurable own accessor property of the target whose [[Get]] attribute is undefined, the [[Get]] operation must return undefined.
[[Set]] (P, V, Receiver)

- The Type of the return value must be Boolean.
- If P was previously observed as a non-configurable, non-writable own data property of the target, then [[Set]] must return false unless V is the SameValue as P's [[Value]] attribute.
- If P was previously observed as a non-configurable own accessor property of the target whose [[Set]] attribute is undefined, the [[Set]] operation must return false.

[[Delete]] (P)

- The Type of the return value must be Boolean.
- If P was previously observed to be a non-configurable own data or accessor property of the target, [[Delete]] must return false.

[[Enumerate]] ()

- The Type of the return value must be Object.

[[OwnPropertyKeys]] ()

- The return value must be a List.
- The Type of each element of the returned List is either String or Symbol.
- The returned List must contain at least the keys of all non-configurable own properties that have previously been observed.
- If the object is non-extensible, the returned List must contain only the keys of all own properties of the object that are observable using [[GetOwnProperty]].

[[Construct]] ()

- The Type of the return value must be Object.

6.1.7.4 Well-Known Intrinsic Objects

Well-known intrinsic objects 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 8.1.2.5. The well-known intrinsics are listed in Table 7.
### Table 7 — Well-known Intrinsic Objects

<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>Global Name</th>
<th>ECMAScript Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>%ObjectPrototype%</code></td>
<td></td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Object%</code>. (19.1.3)</td>
</tr>
<tr>
<td><code>%ThrowTypeError%</code></td>
<td></td>
<td>A function object that unconditionally throws a new instance of <code>%TypeError%</code>.</td>
</tr>
<tr>
<td><code>%FunctionPrototype%</code></td>
<td>&quot;Object&quot;</td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Function%</code>.</td>
</tr>
<tr>
<td><code>%Object%</code></td>
<td>&quot;Object&quot;</td>
<td>The Object constructor (19.1.1)</td>
</tr>
<tr>
<td><code>%ObjProto_toString%</code></td>
<td>&quot;eval&quot;</td>
<td>The <code>eval</code> function (18.2.1).</td>
</tr>
<tr>
<td><code>%eval%</code></td>
<td></td>
<td>The initial value of the &quot;toString&quot; data property of the intrinsic <code>%ObjectPrototype%</code>. (19.1.3.6)</td>
</tr>
<tr>
<td><code>%ArrayPrototype%</code></td>
<td>&quot;Array&quot;</td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Array%</code>.</td>
</tr>
<tr>
<td><code>%ArrayProto_values%</code></td>
<td></td>
<td>The initial value of the &quot;values&quot; data property of the intrinsic <code>%ArrayPrototype%</code>. (22.1.3.29)</td>
</tr>
<tr>
<td><code>%ArrayIteratorPrototype%</code></td>
<td></td>
<td>The prototype object used for Iterator objects created by the CreateArrayIterator abstract operation.</td>
</tr>
<tr>
<td><code>%String%</code></td>
<td>&quot;String&quot;</td>
<td>The String constructor (21.1.1)</td>
</tr>
<tr>
<td><code>%StringPrototype%</code></td>
<td></td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%String%</code>.</td>
</tr>
<tr>
<td><code>%StringIteratorPrototype%</code></td>
<td></td>
<td>The prototype object used for Iterator objects created by the CreateStringIterator abstract operation.</td>
</tr>
<tr>
<td><code>%Boolean%</code></td>
<td>&quot;Boolean&quot;</td>
<td>The initial value of the global object property named &quot;Boolean&quot;.</td>
</tr>
<tr>
<td><code>%BooleanPrototype%</code></td>
<td></td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Boolean%</code>.</td>
</tr>
<tr>
<td><code>%Number%</code></td>
<td>&quot;Number&quot;</td>
<td>The initial value of the global object property named &quot;Number&quot;.</td>
</tr>
<tr>
<td><code>%NumberPrototype%</code></td>
<td></td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Number%</code>.</td>
</tr>
<tr>
<td><code>%Date%</code></td>
<td>&quot;Date&quot;</td>
<td>The initial value of the global object property named &quot;Date&quot;.</td>
</tr>
<tr>
<td><code>%DatePrototype%</code></td>
<td></td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic <code>%Date%</code>.</td>
</tr>
<tr>
<td><code>%RegExp%</code></td>
<td>&quot;RegExp&quot;</td>
<td>The initial value of the global object property named &quot;RegExp&quot;.</td>
</tr>
</tbody>
</table>
| %RegExpPrototype% | The initial value of the "prototype" data property of the intrinsic %RegExp%.
|--------------------|------------------------------------------------------------------|
| %Map% | "Map" | The initial value of the global object property named "Map".
| %MapPrototype% | The initial value of the "prototype" data property of the intrinsic %Map%.
| %MapIteratorPrototype% | The prototype object used for Iterator objects created by the CreateMapIterator abstract operation.
| %WeakMap% | "WeakMap" | The initial value of the global object property named "WeakMap".
| %WeakMapPrototype% | The initial value of the "prototype" data property of the intrinsic %WeakMap%.
| %Set% | "Set" | The initial value of the global object property named "Set".
| %SetPrototype% | The initial value of the "prototype" data property of the intrinsic %Set%.
| %WeakSet% | "WeakSet" | The initial value of the global object property named "WeakSet".
| %WeakSetPrototype% | The initial value of the "prototype" data property of the intrinsic %WeakSet%.
<p>| %SetIteratorPrototype% | The prototype object used for Iterator objects created by the CreateSetIterator abstract operation. |</p>
<table>
<thead>
<tr>
<th>%GeneratorFunction%</th>
<th>The constructor of generator functions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Generator%</td>
<td>The initial value of the prototype property of the %GeneratorFunction% intrinsic</td>
</tr>
<tr>
<td>%GeneratorPrototype%</td>
<td>The initial value of the prototype property of the %Generator% intrinsic</td>
</tr>
<tr>
<td>%Error%</td>
<td></td>
</tr>
<tr>
<td>%EvalError%</td>
<td></td>
</tr>
<tr>
<td>%RangeError%</td>
<td></td>
</tr>
<tr>
<td>%ReferenceError%</td>
<td></td>
</tr>
<tr>
<td>%SyntaxError%</td>
<td></td>
</tr>
<tr>
<td>%TypeError%</td>
<td></td>
</tr>
<tr>
<td>%URIError%</td>
<td></td>
</tr>
<tr>
<td>%ErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%EvalErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%RangeErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%ReferenceErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%SyntaxErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%TypeErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%URIErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%ArrayBuffer%</td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic %ArrayBuffer%.</td>
</tr>
<tr>
<td>%TypedArray%</td>
<td>The initial value of the &quot;prototype&quot; data property of the intrinsic %TypedArray%.</td>
</tr>
<tr>
<td>%Int8Array%</td>
<td></td>
</tr>
<tr>
<td>%Int8ArrayPrototype%</td>
<td></td>
</tr>
<tr>
<td>%DataView%</td>
<td></td>
</tr>
<tr>
<td>%DataViewPrototype%</td>
<td></td>
</tr>
<tr>
<td>%Promise%</td>
<td></td>
</tr>
<tr>
<td>%PromisePrototype%</td>
<td></td>
</tr>
<tr>
<td>%Symbol%</td>
<td></td>
</tr>
<tr>
<td>%IteratorPrototype%</td>
<td>An object that all standard built-in iterator objects indirectly inherit from.</td>
</tr>
</tbody>
</table>

Comment [AWB161]: TODO add all the other TypedArray view intrinsics
6.2 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.

6.2.1 The List and Record Specification Type

The List type is used to explain the evaluation of argument lists (see 12.3.6) in new expressions, in function calls, and in other algorithms where a simple ordered list of values is needed. Values of the List type are simply ordered sequences of list elements containing the individual values. These sequences may be of any length. The elements of a list may be randomly accessed using 0-origin indices. For notational convenience an array-like syntax can be used to access List elements. For example, arguments[2] is shorthand for saying the 3rd element of the List arguments.

For notational convenience within this specification, a literal syntax can be used to express a new List value. For example, «1, 2» defines a List value that has two elements each of which is initialized to a specific value. A new empty List can be expressed as «».

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, PropertyDescriptor{[[Value]]: 42, [[Writable]]: false, [[Configurable]]: true}.

6.2.2 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 8.
Table 8 — Completion Record Fields

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

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

### 6.2.2.1 NormalCompletion

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

1. `Return NormalCompletion(argument)`.

Is a shorthand that is defined as follows:

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

### 6.2.2.2 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:

1. `Return "Infinity"`.

Generally means the same thing as:

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

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

1. `Return NormalCompletion(undefined)`.

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.

### 6.2.2.3 Throw an Exception

Algorithms steps that say to throw an exception, such as:

1. `Throw a TypeError exception`.

mean the same things as:

1. `Return Completion{[[type]]: throw, [[value]]: a newly created TypeError object, [[target]]: empty}`.

### 6.2.2.4 ReturnIfAbrupt

Algorithms steps that say
1. ReturnIfAbrupt(argument).

mean the same thing as:
1. If argument is an abrupt completion, return argument.
2. Else if argument is a Completion Record, let argument be argument.[[value]].

### 6.2.3 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.

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 Symbol, a Number, or an environment record (8.1.1). A base value of `undefined` indicates that the Reference could not be resolved to a binding. The referenced name is a String or Symbol value.

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.

The following abstract operations are used in this specification to access the components of references:
- `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 Type(base) is Boolean, String, Symbol, 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.
- `IsSuperReference(V)`. Returns true if this reference has a thisValue component.

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

#### 6.2.3.1 GetValue(V)

1. ReturnIfAbrupt(V).
2. If Type(V) is not Reference, return V.
3. Let base be 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 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 8.1.1) 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.
6.2.3.2 PutValue (V, W)

1. ReturnIfAbrupt(V).
2. ReturnIfAbrupt(W).
3. If Type(V) is not Reference, throw a ReferenceError exception.
4. Let base be 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 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 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, throw a TypeError exception.
   e. Return.
7. Else base must be an environment record.
   a. Return the result of calling the SetMutableBinding (8.1.1) concrete method of base, passing
      GetReferencedName(V), W, and IsStrictReference(V) as arguments.

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.

6.2.3.3 GetThisValue (V)

1. Assert: IsPropertyReference(V) is true.
2. If IsSuperReference(V), then
   a. Return the value of the thisValue component of the reference V.

6.2.3.4 InitializeReferencedBinding (V, W)

1. ReturnIfAbrupt(V).
2. ReturnIfAbrupt(W).
3. Assert: Type(V) is Reference.
4. Assert: IsUnresolvableReference(V) is false.
5. Let base be GetBase(V).
6. Assert: base is an Environment Record.
7. Return the result of calling the InitializeBinding concrete method of base passing
   GetReferencedName(V) and W as the arguments.

6.2.4 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. Each field's name is an attribute name and its value is a corresponding attribute value as specified in 6.1.7.1. In addition, any field may be present or absent. The schema name used within this specification to tag literal descriptions of Property Descriptor records is “PropertyDescriptor”.

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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 Table 2 or Table 3.

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

6.2.4.1 IsAccessorDescriptor (Desc)

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

1. If Desc is undefined, return false.
2. If both Desc.[[Get]] and Desc.[[Set]] are absent, return false.
3. Return true.

6.2.4.2 IsDataDescriptor (Desc)

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

1. If Desc is undefined, return false.
2. If both Desc.[[Value]] and Desc.[[Writable]] are absent, return false.
3. Return true.

6.2.4.3 IsGenericDescriptor (Desc)

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

1. If Desc is undefined, return false.
2. If IsAccessorDescriptor(Desc) and IsDataDescriptor(Desc) are both false, return true.
3. Return false.

6.2.4.4 FromPropertyDescriptor (Desc)

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

1. If Desc is undefined, return undefined.
2. Let obj be ObjectCreate(%ObjectPrototype%).
3. Assert: obj is an extensible ordinary object with no own properties.
4. If Desc has a [[Value]] field, then
   a. Call CreateDataProperty(obj, "value", Desc.[[Value]]).
5. If Desc has a [[Writable]] field, then
   a. Call CreateDataProperty(obj, "writable", Desc.[[Writable]])
6. If Desc has a [[Get]] field, then
a. Call CreateDataProperty(obj, "get", Desc.[[Get]]).
7. If Desc has a [[Set]] field, then
   a. Call CreateDataProperty(obj, "set", Desc.[[Set]])
8. If Desc has an [[Enumerable]] field, then
   a. Call CreateDataProperty(obj, "enumerable", Desc.[[Enumerable]])
9. If Desc has a [[Configurable]] field, then
   a. Call CreateDataProperty(obj, "configurable", Desc.[[Configurable]])
10. Assert: all of the above CreateDataProperty operations return true.
11. Return obj.

6.2.4.5 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 a new Property Descriptor that initially has no fields.
4. If HasProperty(Obj, "enumerable") is true, then
   a. Let enum be Get(Obj, "enumerable").
   b. ReturnIfAbrupt(enum).
   c. Set the [[Enumerable]] field of desc to ToBoolean(enum).
5. If HasProperty(Obj, "configurable") is true, then
   a. Let conf be Get(Obj, "configurable").
   b. ReturnIfAbrupt(conf).
   c. Set the [[Configurable]] field of desc to ToBoolean(conf).
6. If HasProperty(Obj, "value") is true, then
   a. Let value be Get(Obj, "value").
   b. ReturnIfAbrupt(value).
   c. Set the [[Value]] field of desc to value.
7. If HasProperty(Obj, "writable") is true, then
   a. Let writable be Get(Obj, "writable").
   b. ReturnIfAbrupt(writable).
   c. Set the [[Writable]] field of desc to ToBoolean(writable).
8. If HasProperty(Obj, "get") is true, then
   a. Let getter be Get(Obj, "get").
   b. ReturnIfAbrupt(getter).
   c. If IsCallable(getter) is false and getter is not undefined, throw a TypeError exception.
   d. Set the [[Get]] field of desc to getter.
9. If HasProperty(Obj, "set") is true, then
   a. Let setter be Get(Obj, "set").
   b. ReturnIfAbrupt(setter).
   c. If IsCallable(setter) is false and setter is not undefined, 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, throw a TypeError exception.
11. Return desc.

6.2.4.6 CompletePropertyDescriptor ( Desc )

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

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

6.2.5 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 8.1.

6.2.6 Data Blocks

The Data Block specification type is used to describe a distinct and mutable sequence of byte-sized (8 bit) numeric values. A Data Block value is created with a fixed number of bytes that each have the initial value 0.

For notational convenience within this specification, an array-like syntax can be used to express to the individual bytes of a Data Block value. This notation presents a Data Block value as a 0-originated integer indexed sequence of bytes. For example, if \( \text{db} \) is a 5 byte Data Block value then \( \text{db}[2] \) can be used to express access to its 3rd byte.

The following abstract operations are used in this specification to operate upon Data Block values:

6.2.6.1 CreateByteDataBlock(size)

When the abstract operation CreateByteDataBlock is called with integer argument \( \text{size} \), the following steps are taken:
1. Assert: \( \text{size} \geq 0 \).
2. Let \( \text{db} \) be a new Data Block value consisting of \( \text{size} \) bytes. If it is impossible to create such a Data Block, throw a \text{RangeError} exception.
3. Set all of the bytes of \( \text{db} \) to 0.
4. Return \( \text{db} \).

6.2.6.2 CopyDataBlockBytes(toBlock, toIndex, fromBlock, fromIndex, count)

When the abstract operation CopyDataBlockBytes is called the following steps are taken:
1. Assert: \( \text{fromBlock} \) and \( \text{toBlock} \) are distinct Data Block values.
2. Assert: \( \text{fromIndex}, \text{toIndex}, \text{and count} \) are positive integer values.
3. Let \( \text{fromSize} \) be the number of bytes in \( \text{fromBlock} \).
4. Assert: \( \text{fromIndex} + \text{count} \leq \text{fromSize} \).
5. Let \( \text{toSize} \) be the number of bytes in \( \text{toBlock} \).
6. Assert: \( \text{toIndex} + \text{count} \leq \text{toSize} \).
7. Repeat, while \( \text{count} > 0 \)
   a. Set \( \text{toBlock}[\text{toIndex}] \) to the value of \( \text{fromBlock}[\text{fromIndex}] \).
b. Increment `toIndex` and `fromIndex` each by 1.
c. Decrement `count` by 1.
8. Return `NormalCompletion(empty)`

7 Abstract Operations

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.

7.1 Type Conversion

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.

7.1.1 `ToPrimitive(input [, PreferredType])`

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 9:

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If <code>input</code> is an abrupt completion, return <code>input</code>. Otherwise return <code>ToPrimitive(input.[[value]])</code> also passing the optional hint <code>PreferredType</code>.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>Null</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>Number</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>String</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Return <code>input</code>.</td>
</tr>
<tr>
<td>Object</td>
<td>Perform the steps following this table.</td>
</tr>
</tbody>
</table>

When `Type(input)` is Object, the following steps are taken:
1. If `PreferredType` was not passed, let `hint` be "default".
2. Else if `PreferredType` is hint String, let `hint` be "string".
3. Else `PreferredType` is hint Number, let `hint` be "number".
4. Let `exoticToPrim` be `GetMethod(input, @@toPrimitive)`.
5. ReturnIfAbrupt(`exoticToPrim`).
6. If `exoticToPrim` is not `undefined`, then
   a. Let `result` be `Call(exoticToPrim, input, «hint»)`.
   b. ReturnIfAbrupt(`result`).
   c. If `Type(result)` is not Object, return `result`.
   d. Throw a `TypeError` exception.
7. If hint is "default", let hint be "number".
8. Return OrdinaryToPrimitive(input, hint).

When the abstract operation 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 methodNames be the List ("toString", "valueOf").
4. Else,
   a. Let methodNames be the List ("valueOf", "toString").
5. For each name in methodNames in List order, do
   a. Let method be Get(O, name).
   b. ReturnIfAbrupt(method).
   c. If IsCallable(method) is true, then
      i. Let result be Call(method, O).
      ii. ReturnIfAbrupt(result).
      iii. If Type(result) is not Object, return result.
6. Throw a TypeError exception.

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 20.3.4.45) and Symbol objects (see 19.4.3.4) over-ride the default ToPrimitive behaviour. Date objects treat no hint as if the hint were String.

7.1.2 ToBoolean (argument)

The abstract operation ToBoolean converts argument to a value of type Boolean according to Table 10:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If argument is an abrupt completion, return argument. Otherwise return ToBoolean(argument,[value]).</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return false.</td>
</tr>
<tr>
<td>Null</td>
<td>Return false.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return argument.</td>
</tr>
<tr>
<td>Number</td>
<td>Return false if argument is +0, -0, or NaN; otherwise return true.</td>
</tr>
<tr>
<td>String</td>
<td>Return false if argument is the empty String (its length is zero); otherwise return true.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Return true.</td>
</tr>
<tr>
<td>Object</td>
<td>Return true.</td>
</tr>
</tbody>
</table>
7.1.3 ToNumber (argument)

The abstract operation ToNumber converts argument to a value of type Number according to Table 11:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If argument is an abrupt completion, return argument. Otherwise return ToNumber(argument.[value]).</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return NaN.</td>
</tr>
<tr>
<td>Null</td>
<td>Return +0.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return 1 if argument is true. Return +0 if argument is false.</td>
</tr>
<tr>
<td>Number</td>
<td>Return argument (no conversion).</td>
</tr>
<tr>
<td>String</td>
<td>See grammar and conversion algorithm below.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Throw a TypeError exception.</td>
</tr>
</tbody>
</table>
| Object            | Apply the following steps:  
|                   | 1. Let primValue be ToPrimitive(argument, hint Number).  
|                   | 2. Return ToNumber(primValue).              |

7.1.3.1 ToNumber Applied to the String Type

ToNumber applied to Strings applies the following grammar to the input String interpreted as a sequence of UTF-16 encoded code points. If the grammar cannot interpret the String as an expansion of StringNumericLiteral, then the result of ToNumber is NaN.

NOTE The terminal symbols of this grammar are all composed of Unicode BMP code points so the result will be NaN if the string contains the UTF-16 encoding of any supplementary code points or any unpaired surrogate code points.

Syntax

StringNumericLiteral ::=  
| StringWhiteSpaceopt | StrWhiteSpaceopt StrNumericLiteral StrWhiteSpaceopt |

StrWhiteSpace ::=  
| StrWhiteSpaceChar StrWhiteSpaceopt |

StrWhiteSpaceChar ::=  
| WhiteSpace |
| LineTerminator |

StrNumericLiteral ::=  
| StrDecimalLiteral |
| BinaryIntegerLiteral |
| OctalIntegerLiteral |
| HexIntegerLiteral |
StrDecimalLiteral ::: 
  StrUnsignedDecimalLiteral 
  + StrUnsignedDecimalLiteral 
  - StrUnsignedDecimalLiteral

StrUnsignedDecimalLiteral ::: 
  Infinity 
  DecimalDigits . DecimalDigits ExponentPartOpt 
  . DecimalDigits ExponentPartOpt 
  DecimalDigits ExponentPartOpt

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

All grammar symbols not explicitly defined above have the definitions used in the Lexical Grammar for numeric literals (11.8.3).

NOTE Some differences should be noted between the syntax of a StringNumericLiteral and a NumericLiteral (see 11.8.3):
  • A StringNumericLiteral may include leading and/or trailing 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 include a + or – to indicate its sign.
  • A StringNumericLiteral that is empty or contains only white space is converted to +0.
  • Infinity and –Infinity are recognized as a StringNumericLiteral but not as a NumericLiteral.

7.1.3.1.1 Runtime Semantics: MV's

The conversion of a String to a Number value is similar overall to the determination of the Number value for a numeric literal (see 11.8.3), 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. 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 on any grammar symbol, not provided below, is the MV for that symbol defined in 11.8.3.1.

• 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 StringNumericLiteral, no matter whether white space is present or not.

The MV of StrNumericLiteral :: StrDecimalLiteral is the MV of StrDecimalLiteral.

The MV of StrNumericLiteral :: BinaryIntegerLiteral is the MV of BinaryIntegerLiteral.

The MV of StrNumericLiteral :: OctalIntegerLiteral is the MV of OctalIntegerLiteral.

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 $10^{10000}$ (a value so large that it will round to $+\infty$).

The MV of StrUnsignedDecimalLiteral :: DecimalDigits . 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 code points in the second DecimalDigits.

The MV of StrUnsignedDecimalLiteral :: DecimalDigits . ExponentPart is the MV of DecimalDigits times $10^n$, where $n$ 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 code points 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 code points in DecimalDigits.

The MV of StrUnsignedDecimalLiteral :: - DecimalDigits ExponentPart is the MV of DecimalDigits times $10^{-e}$, where $n$ is the number of code points 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 StrUnsignedDecimalLiteral is the MV of DecimalDigits.

The MV of StrUnsignedDecimalLiteral + StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.

The MV of StrUnsignedDecimalLiteral – StrUnsignedDecimalLiteral is the negative of the MV of StrUnsignedDecimalLiteral.

The MV of StrUnsignedDecimalLiteral * StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.

The MV of StrUnsignedDecimalLiteral / StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.

The MV of StrUnsignedDecimalLiteral % StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.

The MV of StrUnsignedDecimalLiteral ** StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.

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 code point 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 6.1.6), 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.

7.1.4 ToInteger ( argument )

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

1. Let number be ToNumber(argument).
2. ReturnIfAbrupt(number).
3. If number is NaN, return +0.
4. If \( \text{number} \) is \(+0\), \( -0\), \(+\infty\), or \(-\infty\), return \( \text{number} \).

5. Return the number value that is the same sign as \( \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number})) \).

### 7.1.5 ToInt32 (argument) — Signed 32 Bit Integer

The abstract operation ToInt32 converts \( \text{argument} \) 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 \( \text{number} \) be ToNumber\((\text{argument})\).
2. ReturnIfAbrupt\((\text{number})\).
3. If \( \text{number} \) is NaN, \(+0\), \(-0\), \(+\infty\), or \(-\infty\), return \(+0\).
4. Let \( \text{int} \) be the mathematical value that is the same sign as \( \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number})) \).
5. Let \( \text{int32bit} \) be \( \text{int} \) modulo \( 2^{32} \).
6. If \( \text{int32bit} \geq 2^{31} \), return \( \text{int32bit} - 2^{32} \), otherwise return \( \text{int32bit} \).

#### 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\((\text{ToInt32}(x))\) is equal to ToInt32\((x)\) for all values of \( x \). (It is to preserve this latter property that \(+\infty\) and \(-\infty\) are mapped to \(+0\).)
  - ToInt32 maps \(-0\) to \(+0\).

### 7.1.6 ToUint32 (argument) — Unsigned 32 Bit Integer

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

1. Let \( \text{number} \) be ToNumber\((\text{argument})\).
2. ReturnIfAbrupt\((\text{number})\).
3. If \( \text{number} \) is NaN, \(+0\), \(-0\), \(+\infty\), or \(-\infty\), return \(+0\).
4. Let \( \text{int} \) be the mathematical value that is the same sign as \( \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number})) \).
5. Let \( \text{int32bit} \) be \( \text{int} \) modulo \( 2^{32} \).
6. Return \( \text{int32bit} \).

#### 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\((\text{ToInt32}(x))\) 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 \(+0\).

### 7.1.7 ToInt16 (argument) — Signed 16 Bit Integer

The abstract operation ToInt16 converts \( \text{argument} \) to one of \( 2^{16} \) integer values in the range \(-32768\) through \( 32767 \), inclusive. This abstract operation functions as follows:

1. Let \( \text{number} \) be ToNumber\((\text{argument})\).
2. ReturnIfAbrupt\((\text{number})\).
3. If \( \text{number} \) is \( \text{NaN}, +0, -0, +\infty, \) or \( -\infty, \) return \(+0\).
4. Let \( \text{int} \) be \( \text{the mathematical value that is the same sign as } \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number}))\).
5. Let \( \text{int16bit} \) be \( \text{int} \) modulo \( 2^{16} \).
6. If \( \text{int16bit} \geq 2^{15} \), return \( \text{int16bit} - 2^{16} \), otherwise return \( \text{int16bit} \).

### 7.1.8 ToUint16 ( argument ) — Unsigned 16 Bit Integer

The abstract operation ToUint16 converts \( \text{argument} \) to one of \( 2^{16} \) integer values in the range \( 0 \) through \( 2^{16} - 1 \), inclusive. This abstract operation functions as follows:

1. Let \( \text{number} \) be ToNumber(\( \text{argument} \)).
2. ReturnIfAbrupt(\( \text{number} \)).
3. If \( \text{number} \) is \( \text{NaN}, +0, -0, +\infty, \) or \( -\infty, \) return \(+0\).
4. Let \( \text{int} \) be \( \text{the mathematical value that is the same sign as } \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number}))\).
5. Let \( \text{int16bit} \) be \( \text{int} \) modulo \( 2^{16} \).
6. Return \( \text{int16bit} \).

**NOTE** Given the above definition of ToUint16:
- The substitution of \( 2^{16} \) for \( 2^{32} \) in step 5 is the only difference between ToUint32 and ToUint16.
- ToUint16 maps \(-0\) to \(+0\).

### 7.1.9 ToInt8 ( argument ) — Signed 8 Bit Integer

The abstract operation ToInt8 converts \( \text{argument} \) to one of \( 2^{8} \) integer values in the range \(-128 \) through \( 127 \), inclusive. This abstract operation functions as follows:

1. Let \( \text{number} \) be ToNumber(\( \text{argument} \)).
2. ReturnIfAbrupt(\( \text{number} \)).
3. If \( \text{number} \) is \( \text{NaN}, +0, -0, +\infty, \) or \( -\infty, \) return \(+0\).
4. Let \( \text{int} \) be \( \text{the mathematical value that is the same sign as } \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number}))\).
5. Let \( \text{int8bit} \) be \( \text{int} \) modulo \( 2^{8} \).
6. If \( \text{int8bit} \geq 2^{7} \), return \( \text{int8bit} - 2^{8} \), otherwise return \( \text{int8bit} \).

### 7.1.10 ToUint8 ( argument ) — Unsigned 8 Bit Integer

The abstract operation ToUint8 converts \( \text{argument} \) to one of \( 2^{8} \) integer values in the range \( 0 \) through \( 255 \), inclusive. This abstract operation functions as follows:

1. Let \( \text{number} \) be ToNumber(\( \text{argument} \)).
2. ReturnIfAbrupt(\( \text{number} \)).
3. If \( \text{number} \) is \( \text{NaN}, +0, -0, +\infty, \) or \( -\infty, \) return \(+0\).
4. Let \( \text{int} \) be \( \text{the mathematical value that is the same sign as } \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number}))\).
5. Let \( \text{int8bit} \) be \( \text{int} \) modulo \( 2^{8} \).
6. Return \( \text{int8bit} \).

### 7.1.11 ToUint8Clamp ( argument ) — Unsigned 8 Bit Integer, Clamped

The abstract operation ToUint8Clamp converts \( \text{argument} \) to one of \( 2^{8} \) integer values in the range \( 0 \) through \( 255 \), inclusive. This abstract operation functions as follows:

1. Let \( \text{number} \) be ToNumber(\( \text{argument} \)).
2. ReturnIfAbrupt(\( \text{number} \)).
3. If \( \text{number} \) is \( \text{NaN}, +0, -0, +\infty, \) or \( -\infty, \) return \(+0\).
4. Let \( \text{int} \) be \( \text{the mathematical value that is the same sign as } \text{number} \) and whose magnitude is \( \text{floor}(\text{abs}(\text{number}))\).
5. Let \( \text{int8bit} \) be \( \text{int} \) modulo \( 2^{8} \).
6. Return \( \text{int8bit} \).
1. Let `number` be ToNumber(`argument`).
2. ReturnIfAbrupt(`number`).
3. If `number` is `NaN`, return `+0`.
4. If `number` ≤ 0, return `+0`.
5. If `number` ≥ 255, return 255.
6. Let `f` be floor(`number`).
7. If `f + 0.5 < number`, return `f + 1`.
8. If `number < f + 0.5`, return `f`.
9. If `f` is odd, return `f + 1`.
10. Return `f`.

**NOTE**  Note that unlike the other ECMAScript integer conversion abstract operation, ToUint8Clamp rounds rather than truncates non-integer values and does not convert `+∞` to 0. ToUint8Clamp does “round half to even” tie-breaking. This differs from Math.round which does “round half up” tie-breaking.

### 7.1.12 ToString (argument)

The abstract operation `ToString` converts `argument` to a value of type String according to Table 12:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If <code>argument</code> is an abrupt completion, return <code>argument</code>. Otherwise return <code>ToString(argument[[value]])</code>.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return &quot;undefined&quot;.</td>
</tr>
<tr>
<td>Null</td>
<td>Return &quot;null&quot;.</td>
</tr>
<tr>
<td>Boolean</td>
<td>If <code>argument</code> is <code>true</code>, return &quot;true&quot;. If <code>argument</code> is <code>false</code>, return &quot;false&quot;.</td>
</tr>
<tr>
<td>Number</td>
<td>See 7.1.12.1.</td>
</tr>
<tr>
<td>String</td>
<td>Return <code>argument</code>.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Throw a TypeError exception.</td>
</tr>
<tr>
<td>Object</td>
<td>Apply the following steps: 1. Let <code>primValue</code> be ToPrimitive(<code>argument</code>, hint String). 2. Return <code>ToString(primValue)</code></td>
</tr>
</tbody>
</table>

#### 7.1.12.1 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 `+∞`, return the String "Infinity".
5. Otherwise, let `n`, `k`, and `s` be integers such that `k ≥ 1`, `10^{k-1} ≤ s < 10^k`, the Number value for `s × 10^{−k}` is `m`, and `k` is as small as possible. Note that `k` is the number of digits in the decimal representation of `s`, that `s` is not divisible by 10, and that the least significant digit of `s` is not necessarily uniquely determined by these criteria.
6. If `k ≤ n ≤ 21`, return the String consisting of the code points of the `k` digits of the decimal representation of `s` (in order, with no leading zeroes), followed by `n-k` occurrences of the code point \U000030 (DIGIT ZERO).
7. If \(0 < n \leq 21\), return the String consisting of the code points of the most significant \(n\) digits of the decimal representation of \(s\), followed by the code point U+002E (FULL STOP), followed by the code points of the remaining \(k-n\) digits of the decimal representation of \(s\).

8. If \(-6 < n \leq 0\), return the String consisting of the code point U+0030 (DIGIT ZERO), followed by \(n\) occurrences of the code point U+002E (FULL STOP), followed by the code points of the \(k\) digits of the decimal representation of \(s\).

9. Otherwise, if \(k = 1\), return the String consisting of the code point of the single digit of \(s\), followed by code point U+0065 (LATIN SMALL LETTER E), followed by the code-point U+002D (HYPHEN-MINUS) according to whether \(n-1\) is positive or negative, followed by the code points of the decimal representation of the integer abs\((n-1)\) (with no leading zeroes).

10. Return the String consisting of the code point of the most significant digit of the decimal representation of \(s\), followed by code point U+002E (FULL STOP), followed by the code points of the remaining \(k-1\) digits of the decimal representation of \(s\), followed by code point U+0065 (LATIN SMALL LETTER E), followed by code point U+002B (PLUS SIGN) or the code point U+002D (HYPHEN-MINUS) according to whether \(n-1\) is positive or negative, followed by the code points of the decimal representation of the integer 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 ToNumber(ToString\((x)\)) is exactly the same Number value as \(x\).
- The least significant digit of \(s\) is not always uniquely determined by the requirements listed in step 5.

**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 \(s \times 10^{-n}\) is \(m\), and \(k\) is as small as possible. If there are multiple possibilities for \(s\), choose the value of \(s\) for which \(s \times 10^{-n}\) 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:


### 7.1.13 ToObject \(\text{ ( argument )}\)

The abstract operation ToObject converts \text{argument} to a value of type Object according to Table 13:
Table 13 — ToObject Conversions

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If <code>argument</code> is an abrupt completion, return <code>argument</code>. Otherwise return <code>ToObject([value])</code>.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Throw a <code>TypeError</code> exception.</td>
</tr>
<tr>
<td>Null</td>
<td>Throw a <code>TypeError</code> exception.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return a new Boolean object whose <code>[[BooleanData]]</code> internal slot is set to the value of <code>argument</code>. See 19.3 for a description of Boolean objects.</td>
</tr>
<tr>
<td>Number</td>
<td>Return a new Number object whose <code>[[NumberData]]</code> internal slot is set to the value of <code>argument</code>. See 20.1 for a description of Number objects.</td>
</tr>
<tr>
<td>String</td>
<td>Return a new String object whose <code>[[StringData]]</code> internal slot is set to the value of <code>argument</code>. See 21.1 for a description of String objects.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Return a new Symbol object whose <code>[[SymbolData]]</code> internal slot is set to the value of <code>argument</code>. See 19.4 for a description of Symbol objects.</td>
</tr>
<tr>
<td>Object</td>
<td>Return <code>argument</code>.</td>
</tr>
</tbody>
</table>

7.1.14 `ToPropertyKey` (argument)

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

1. Let `key` be `ToPrimitive(argument, hint String)`.  
2. ReturnIfAbrupt(key).  
3. If Type(`key`) is Symbol, then  
   a. Return `key`.  
4. Return `ToString(key)`.

7.1.15 `ToLength` (argument)

The abstract operation `ToLength` converts `argument` to an integer suitable for use as the length of an array-like object. It performs the following steps:

1. ReturnIfAbrupt(`argument`).  
2. Let `len` be `ToInteger(`argument`)`.  
3. ReturnIfAbrupt(`len`).  
4. If `len` ≤ +0, return +0.  
5. Return `min(len, 2^{53}-1)`.

7.1.16 `CanonicalNumericIndexString` (argument)

The abstract operation `CanonicalNumericIndexString` converts `argument` to a numeric value if it is a String representation of a Number that would be produced by `ToString`, or the string “+0”. Otherwise, it returns `undefined`. This abstract operation functions as follows:

1. Assert: Type(`argument`) is String.  
2. If `argument` is “+0”, return +0.  
3. Let `n` be `ToNumber(`argument`)`.  
4. If `SameValue(ToString(`n`), argument)` is `false`, return `undefined`.  
5. Return `n`.
A canonical numeric string is any String value for which the CanonicalNumericIndexString abstraction operation does not return undefined.

7.2 Testing and Comparison Operations

7.2.1 RequireObjectCoercible (argument)

The abstract operation RequireObjectCoercible throws an error if argument is a value that cannot be converted to an Object using ToObject. It is defined by Table 14:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If argument is an abrupt completion, return argument. Otherwise return RequireObjectCoercible(argument.[[value]].)</td>
</tr>
<tr>
<td>Undefined</td>
<td>Throw a TypeError exception.</td>
</tr>
<tr>
<td>Null</td>
<td>Throw a TypeError exception.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return argument.</td>
</tr>
<tr>
<td>Number</td>
<td>Return argument.</td>
</tr>
<tr>
<td>String</td>
<td>Return argument.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Return argument.</td>
</tr>
<tr>
<td>Object</td>
<td>Return argument.</td>
</tr>
</tbody>
</table>

7.2.2 IsArray (argument)

The abstract operation IsArray takes one argument argument, and performs the following steps:

1. If Type(argument) is not Object, return false.
2. If argument is an Array exotic object, return true.
3. If argument is a Proxy exotic object, then
   a. Let target be the value of the [[ProxyTarget]] internal slot of argument.
   b. Return IsArray(target).
4. Return false.

7.2.3 IsCallable (argument)

The abstract operation IsCallable determines if argument, which must be an ECMAScript language value or a Completion Record, is a callable function with a [[Call]] internal method:

1. ReturnIfAbrupt(argument).
2. If Type(argument) is not Object, return false.
3. If argument has a [[Call]] internal method, return true.
4. Return false.

7.2.4 IsConstructor (argument)

The abstract operation IsConstructor determines if argument, which must be an ECMAScript language value or a Completion Record, is a function object with a [[Construct]] internal method:

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`.

### 7.2.5 `IsExtensible(O)`

The abstract operation `IsExtensible` is used to determine whether additional properties can be added to the object that is `O`. A Boolean value is returned. This abstract operation performs the following steps:

1. Assert: `Type(O)` is `Object`.
2. Return the result of calling the `[[Extensible]]` internal method of `O`.

### 7.2.6 `IsInteger( argument )`

The abstract operation `IsInteger` determines if `argument` is a finite integer numeric value.

1. ReturnIfAbrupt(`argument`).
2. If `Type(argument)` is not `Number`, return `false`.
3. If `argument` is `NaN`, `+∞`, or `−∞`, return `false`.
4. If `floor(abs(argument)) ≠ abs(argument)`, return `false`.
5. Return `true`.

### 7.2.7 `IsPropertyKey( argument )`

The abstract operation `IsPropertyKey` determines if `argument`, which must be an ECMAScript language value or a Completion Record, is a value that may be used as a property key.

1. ReturnIfAbrupt(`argument`).
2. If `Type(argument)` is `String`, return `true`.
3. If `Type(argument)` is `Symbol`, return `true`.
4. Return `false`.

### 7.2.8 `IsRegExp( argument )`

The abstract operation `IsRegExp` with argument `argument` performs the following steps:

1. If `Type(argument)` is not `Object`, return `false`.
2. Let `isRegExp` be `Get(argument, @@match)`.
3. ReturnIfAbrupt(`isRegExp`).
4. If `isRegExp` is not `undefined`, return `ToBoolean(isRegExp)`.
5. If `argument` has a `[[RegExpMatcher]]` internal slot, return `true`.
6. Return `false`.

### 7.2.9 `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 at corresponding indices) return true; otherwise, return false.

8. If Type(\(x\)) is Boolean, then
   a. If \(x\) and \(y\) are both true or both false, return true; otherwise, return false.

9. If Type(\(x\)) is Symbol, then
   a. If \(x\) and \(y\) are both the same Symbol value, return true; otherwise, return false.

10. Return true if \(x\) and \(y\) are the same Object value. Otherwise, return false.

7.2.10 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 at corresponding indices) return true; otherwise, return false.
8. If Type(\(x\)) is Boolean, then
   a. If \(x\) and \(y\) are both true or both false, return true; otherwise, return false.
9. If Type(\(x\)) is Symbol, then
   a. If \(x\) and \(y\) are both the same Symbol value, 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.

7.2.11 Abstract Relational Comparison

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 ToPrimitive(x, hint Number).
   b. ReturnIfAbrupt(px).
   c. Let py be 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 ToPrimitive(y, hint Number).
   b. ReturnIfAbrupt(py).
   c. Let px be ToPrimitive(x, hint Number).
   d. ReturnIfAbrupt(px).

5. If both px and py are Strings, then
   a. 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.)
   b. If px is a prefix of py, return true.
   c. Let k be the smallest nonnegative integer such that the code unit at index k within px is different from the code unit at index k within py. (There must be such a k, for neither String is a prefix of the other.)
   d. Let m be the integer that is the code unit value at index k within px.
   e. Let n be the integer that is the code unit value at index k within py.
   f. If m < n, return true. Otherwise, return false.

6. Else, a. Let nx be ToNumber(px). Because px and py are primitive values evaluation order is not important.
   b. ReturnIfAbrupt(nx).
   c. Let ny be ToNumber(py).
   d. ReturnIfAbrupt(ny).
   e. If nx is NaN, return undefined.
   f. If ny is NaN, return undefined.
   g. If nx and ny are the same Number value, return false.
   h. If nx is +0 and ny is -0, return false.
   i. If nx is -0 and ny is +0, return false.
   j. If nx is +Infinity, return false.
   k. If ny is +Infinity, return true.
   l. If ny is -Infinity, return false.
   m. If nx is -Infinity, return true.
   n. 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 5 differs from step 11 in the algorithm for the addition operator + (12.7.3) 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 normalized 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.

7.2.12 Abstract Equality Comparison

The comparison x == y, where x and y are values, produces true or false. Such a comparison is performed as follows:
1. ReturnIfAbrupt(x).
2. ReturnIfAbrupt(y).
3. If Type(x) is the same as Type(y), then
   a. Return the result of performing Strict Equality Comparison \( x === y \).
4. If \( x \) is \texttt{null} and \( y \) is \texttt{undefined}, return \text{true}.
5. If \( x \) is \texttt{undefined} and \( y \) is \texttt{null}, return \text{true}.
6. If Type(x) is Number and Type(y) is String,
   return the result of the comparison \( x == \) ToNumber(y).
7. If Type(x) is String and Type(y) is Number,
   return the result of the comparison ToNumber(x) == \( y \).
8. If Type(x) is Boolean, return the result of the comparison ToNumber(x) == \( y \).
9. If Type(y) is Boolean, return the result of the comparison \( x == \) ToNumber(y).
10. If Type(x) is either String, Number, or Symbol and Type(y) is Object, then
    return the result of the comparison \( x == \) ToPrimitive(y).
11. If Type(x) is Object and Type(y) is either String, Number, or Symbol, then
    return the result of the comparison ToPrimitive(x) == \( y \).
12. Return \text{false}.

### 7.2.13 Strict Equality Comparison

The comparison \( x === y \), where \( x \) and \( y \) are values, produces \text{true} or \text{false}. Such a comparison is performed as follows:

1. If Type(x) is different from Type(y), return \text{false}.
2. If Type(x) is Undefined, return \text{true}.
3. If Type(x) is Null, return \text{true}.
4. If Type(x) is Number, then
   a. If \( x \) is \text{NaN}, return \text{false}.
   b. If \( y \) is \text{NaN}, return \text{false}.
   c. If \( x \) is the same Number value as \( y \), return \text{true}.
   d. If \( x \) is \(+0\) and \( y \) is \(-0\), return \text{true}.
   e. If \( x \) is \(-0\) and \( y \) is \(+0\), return \text{true}.
   f. Return \text{false}.
5. 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 at corresponding indices), return \text{true}.
   b. Else, return \text{false}.
6. If Type(x) is Boolean, then
   a. If \( x \) and \( y \) are both \text{true} or both \text{false}, return \text{true}.
   b. Else, return \text{false}.
7. If \( x \) and \( y \) are the same Symbol value, return \text{true}.
8. If \( x \) and \( y \) are the same Object value, return \text{true}.
9. Return \text{false}.

**NOTE**
This algorithm differs from the SameValue Algorithm (7.2.3) in its treatment of signed zeroes and NaNs.

### 7.3 Operations on Objects

#### 7.3.1 Get \((O, P)\)

The abstract operation \text{Get} is used to retrieve the value of a 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:
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.

### 7.3.2 GetV (V, P)

The abstract operation GetV is used to retrieve the value of a specific property of an ECMAScript language value. If the value is not an object, the property lookup is performed using a wrapper object appropriate for the type of the value. The operation is called with arguments V and P where V is the value and P is the property key. This abstract operation performs the following steps:

1. Assert: IsPropertyKey(P) is true.
2. Let O be ToObject(V).
3. ReturnIfAbrupt(O).
4. Return the result of calling the [[Get]] internal method of O passing P and V as the arguments.

### 7.3.3 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:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
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, throw a TypeError exception.
7. Return success.

### 7.3.4 CreateDataProperty (O, P, V)

The abstract operation CreateDataProperty 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 value for the property. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Let newDesc be the PropertyDescriptor{[[Value]]: V, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
4. 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. Normally, the property will not already exist. If it does exist and is not configurable or if O is not extensible, [[DefineOwnProperty]] will return false.

### 7.3.5 CreateDataPropertyOrThrow (O, P, V)

The abstract operation CreateDataPropertyOrThrow is used to create a new own property of an object. It throws a TypeError exception if the requested property update cannot be performed. The operation is called with arguments O, P, and V where O is the object, P is the property key, and V is the value 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 CreateDataProperty(O, P, V).
4. ReturnIfAbrupt(success).
5. If success is false, throw a TypeError exception.

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. Normally, the property will not already exist. If it does exist and is not configurable or if O is not extensible, [[DefineOwnProperty]] will return false causing this operation to throw a TypeError exception.

7.3.6 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, throw a TypeError exception.

7.3.7 DeletePropertyOrThrow (O, P)

The abstract operation DeletePropertyOrThrow 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, throw a TypeError exception.

7.3.8 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: IsPropertyKey(P) is true.
2. Let func be GetV(O, P).
3. ReturnIfAbrupt(func).
4. If func is either undefined or null, return undefined.
5. If IsCallable(func) is false, throw a TypeError exception.
6. Return func.
7.3.9 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.

7.3.10 HasOwnProperty (O, P)

The abstract operation HasOwnProperty is used to determine whether an object has an own property with the specified property key. 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. Let desc be the result of calling the [[GetOwnProperty]] internal method of O passing P as the argument.
4. ReturnIfAbrupt(desc).
5. If desc is undefined, return false.
6. Return true.

7.3.11 Call(F, V, argumentsList)

The abstract operation Call is used to call the [[Call]] internal method of a function object. The operation is called with arguments F, V, and optionally argumentsList where F is the function object, V is an ECMAScript language value that is the this value of the [[Call]], and argumentsList is the value passed to the corresponding argument of the internal method. If argumentsList is not present, an empty List is used as its value. This abstract operation performs the following steps:

1. ReturnIfAbrupt(F).
2. If argumentsList was not passed, let argumentsList be a new empty List.
3. If IsCallable(F) is false, throw a TypeError exception.
4. Return the result of calling the [[Call]] internal method of F with arguments V and argumentsList.

7.3.12 Invoke(O, P, argumentsList)

The abstract operation Invoke is used to call a method property of an object. The operation is called with arguments O, P, and optionally argumentsList where O serves as both the lookup point for the property and the this value of the call, P is the property key, and argumentsList is the list of arguments values passed to the method. If argumentsList 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 argumentsList was not passed, let argumentsList be a new empty List.
3. Let func be GetV(O, P).
4. Return Call(func, O, argumentsList).
7.3.13 Construct (F, [argumentsList], [newTarget])

The abstract operation Construct is used to call the [[Construct]] internal method of a function object. The operation is called with arguments \( F \), and optionally \( \text{argumentsList} \) and \( \text{newTarget} \) where \( F \) is the function object. \( \text{argumentsList} \) and \( \text{newTarget} \) are the values to be passed as the corresponding arguments of the internal method. If \( \text{argumentsList} \) is not present, an empty List is used as its value. If \( \text{newTarget} \) is not present, \( F \) is used as its value. This abstract operation performs the following steps:

1. If \( \text{newTarget} \) was not passed, let \( \text{newTarget} \) be \( F \).
2. If \( \text{argumentsList} \) was not passed, let \( \text{argumentsList} \) be a new empty List.
3. Assert: IsConstructor (\( F \)) is true.
4. Assert: IsConstructor (\( \text{newTarget} \)) is true.
5. Return the result of calling the [[Construct]] internal method of \( F \) passing \( \text{argumentsList} \) and \( \text{newTarget} \) as the arguments.

NOTE If \( \text{newTarget} \) is not passed, this operation is equivalent to: \( \text{new F(...)argumentsList} \).

7.3.14 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: \( \text{Type}(O) \) is Object.
2. Assert: \( \text{level} \) is either "sealed" or "frozen".
3. Let \( \text{status} \) be the result of calling the [[PreventExtensions]] internal method of \( O \).
4. ReturnIfAbrupt(\( \text{status} \)).
5. If \( \text{status} \) is false, return false.
6. Let \( \text{keys} \) be the result of calling the [[OwnPropertyKeys]] internal method of \( O \).
7. ReturnIfAbrupt(\( \text{keys} \)).
8. If \( \text{level} \) is "sealed", then
   a. Repeat for each element \( k \) of \( \text{keys} \),
      i. Let \( \text{status} \) be DefinePropertyOrThrow(\( O, k \), PropertyDescriptor{ [[Configurable]]: false}).
      ii. ReturnIfAbrupt(\( \text{status} \)).
9. Else \( \text{level} \) is "frozen", then
   a. Repeat for each element \( k \) of \( \text{keys} \),
      i. Let \( \text{currentDesc} \) be the result of calling the [[GetOwnProperty]] internal method of \( O \) with argument \( k \).
      ii. ReturnIfAbrupt(\( \text{currentDesc} \)).
   iii. If \( \text{currentDesc} \) is not undefined, then
      1. If IsAccessorDescriptor(\( \text{currentDesc} \)) is true, then
         a. Let \( \text{desc} \) be the PropertyDescriptor{ [[Configurable]]: false }.
      2. Else,
         a. Let \( \text{desc} \) be the PropertyDescriptor{ [[Configurable]]: false, [[Writable]]: false }.
      3. Let \( \text{status} \) be DefinePropertyOrThrow(\( O, k, \text{desc} \)).
      4. ReturnIfAbrupt(\( \text{status} \)).
10. Return true.

7.3.15 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: \( \text{Type}(O) \) is Object.
2. Assert: `level` is either "sealed" or "frozen".
3. Let `status` be `IsExtensible(O)`.
4. ReturnIfAbrupt(`status`).
5. If `status` is `true`, 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 `configurable` be `false`.
10. Let `writable` be `false`.
11. Repeat for each element `k` of `keys`:
    a. Let `currentDesc` be the result of calling the `[[GetOwnProperty]]` internal method of `O` with `k`.
    b. ReturnIfAbrupt(`currentDesc`).
    c. If `currentDesc` is not `undefined`, then
       i. If `currentDesc.[[Configurable]]` is `true`, return `false`.
       ii. If `IsDataDescriptor(currentDesc)` is `true`, then
          1. If `currentDesc.[[Writable]]` is `true`, return `false`.
12. Return `true`.

7.3.16 CreateArrayFromList (elements)

The abstract operation `CreateArrayFromList` is used to create an Array object whose elements are provided by a 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 `ArrayCreate(0)` (see 9.4.2.2).
3. Let `n` be `0`.
4. For each element `e` of `elements`:
    a. Let `status` be the result of calling the `CreateDataProperty(array, ToString(n), e)`.
    b. Assert: `status` is `true`.
    c. Increment `n` by `1`.
5. Return `array`.

7.3.17 CreateListFromArrayLike (obj [, elementTypes] )

The abstract operation `CreateListFromArrayLike` is used to create a List value whose elements are provided by the indexed properties of an array-like object. The optional argument `elementTypes` is a List containing the names of ECMAScript Language Types that are allowed for element values of the List that is created. This abstract operation performs the following steps:

1. ReturnIfAbrupt(`obj`).
2. If `elementTypes` was not passed, let `elementTypes` be (Undefined, Null, Boolean, String, Symbol, Number, Object).
3. If `Type(obj)` is not Object, throw a `TypeError` exception.
4. Let `len` be `ToLength(Get(obj, "length"))`.
5. ReturnIfAbrupt(`len`).
6. Let `list` be an empty List.
7. Let `index` be `0`.
8. Repeat while `index < len`:
    a. Let `indexName` be `ToString(index)`.
    b. Let `next` be `Get(obj, indexName)`.
    c. ReturnIfAbrupt(`next`).
    d. If `Type(next)` is not an element of `elementTypes`, throw a `TypeError` exception.
    e. Append `next` as the last element of `list`.
9. return list.

7.3.18 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.
2. If C has a [[BoundTargetFunction]] internal slot, then
   a. Let BC be the value of C's [[BoundTargetFunction]] internal slot.
   b. Return InstanceofOperator(O, BC) (see 12.9.4).
3. If Type(O) is not Object, return false.
4. Let P be 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 [[GetPrototypeOf]] 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.

7.3.19 SpeciesConstructor (O, defaultConstructor)

The abstract operation SpeciesConstructor is used to retrieve the constructor that should be used to create new objects that are derived from the argument object O. The defaultConstructor argument is the constructor to use if O does not have a @@species property. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Let C be Get(O, "constructor").
3. ReturnIfAbrupt(C).
4. If C is undefined, return defaultConstructor.
5. If Type(C) is not Object, throw a TypeError exception.
7. ReturnIfAbrupt(S).
8. If S is either undefined or null, return defaultConstructor.
9. If IsConstructor(S) is true, return S.
10. Throw a TypeError exception.

7.3.20 EnumerableOwnNames (O)

When the abstract operation EnumerableOwnNames is called with Object O the following steps are taken:

1. Assert: Type(O) is Object.
2. Let ownKeys be the result of calling the [[OwnPropertyKeys]] internal method of O with no arguments.
3. ReturnIfAbrupt(ownKeys).
4. Let names be a new empty List.
5. Repeat, for each element key of ownKeys in List order
   a. If Type(key) is String, then
i. Let desc be the resulting of calling the [[GetOwnProperty]] internal method of O with argument key.
ii. ReturnIfAbrupt(desc).
iii. If desc is not undefined, then
   1. If desc. [[Enumerable]] is true, append key to names.
6. Order the elements of names so they are in the same relative order as would be produced by the Iterator that would be returned if the [[Enumerate]] internal method was invoked on O.
7. Return names.

NOTE The order of elements is returned list is the same as the enumeration order that used by a for-in statement.

7.3.21 GetFunctionRealm (obj) Abstract Operation

The abstract operation GetFunctionRealm with argument obj performs the following steps:
1. Assert: obj is a callable object.
2. If obj has a [[Realm]] internal slot, then
   a. Return obj’s [[Realm]] internal slot.
3. If obj is a Bound Function exotic object, then
   a. Let target be obj’s [[BoundTargetFunction]] internal slot.
   b. Return GetFunctionRealm(target).
4. If obj is a Proxy exotic object, then
   a. Let proxyTarget be the value of obj’s [[ProxyTarget]] internal slot.
   b. If proxyTarget is not null, return GetFunctionRealm(proxyTarget).
5. Return the running execution context’s Realm.

NOTE Step 5 will only be reached if target is a revoked proxy function or a non-standard exotic function object that does not have a [[Realm]] internal slot.

7.4 Operations on Iterator Objects

See Common Iteration Interfaces (25.1).

7.4.1 GetIterator (obj, method)

The abstract operation GetIterator with argument obj and optional argument method performs the following steps:
1. ReturnIfAbrupt(obj).
2. If method was not passed, then
   a. Let method beGetMethod(obj, @@iterator).
   b. ReturnIfAbrupt(method).
3. Let iterator be Call(method, obj).
4. ReturnIfAbrupt(iterator).
5. If Type(iterator) is not Object, throw a TypeError exception.
6. Return iterator.

7.4.2 IteratorNext (iterator, value)

The abstract operation IteratorNext with argument iterator and optional argument value performs the following steps:
1. If value was not passed, then
a. Let result be Invoke(iterator, "next", « »).
2. Else,
   a. Let result be Invoke(iterator, "next", «value»).
3. ReturnIfAbrupt(result).
4. If Type(result) is not Object, throw a TypeError exception.
5. Return result.

7.4.3 IteratorComplete ( iterResult )

The abstract operation IteratorComplete with argument iterResult performs the following steps:
1. Assert: Type(iterResult) is Object.
2. Return ToBoolean(Get(iterResult, "done")).

7.4.4 IteratorValue ( iterResult )

The abstract operation IteratorValue with argument iterResult performs the following steps:
1. Assert: Type(iterResult) is Object.
2. Return Get(iterResult, "value").

7.4.5 IteratorStep ( iterator )

The abstract operation IteratorStep with argument iterator requests the next value from iterator and returns either false indicating that the iterator has reached its end or the IteratorResult object if a next value is available. IteratorStep performs the following steps:
1. Let result be IteratorNext(iterator).
2. ReturnIfAbrupt(result).
3. Let done be IteratorComplete(result).
4. ReturnIfAbrupt(done).
5. If done is true, return false.
6. Return result.

7.4.6 IteratorClose( iterator, completion )

The abstract operation IteratorClose with arguments iterator and completion is used to notify an iterator that should perform any actions it would normally perform when it has reached its completed state:
1. Assert: Type(iterator) is Object.
2. Assert: completion is a Completion Record.
3. Let return be GetMethod(iterator, "return").
4. ReturnIfAbrupt(return).
5. If return is undefined, return completion.
6. Let innerResult be Call(return, iterator, « »).
7. If completion.[[type]] is throw, return completion.
8. If innerResult.[[type]] is throw, return innerResult.
9. If Type(innerResult.[[value]]) is not Object, throw a TypeError exception.
10. Return completion.

7.4.7 CreateIterResultObject ( value, done )

The abstract operation CreateIterResultObject with arguments value and done creates an object that supports the IteratorResult interface by performing the following steps:
1. Assert: Type(done) is Boolean.
2. Let obj be ObjectCreate(%ObjectPrototype%).
3. Perform CreateDataProperty(obj, "value", value).
4. Perform CreateDataProperty(obj, "done", done).
5. Return obj.

7.4.8 `CreateListIterator` (list)

The abstract operation `CreateListIterator` with argument list creates an Iterator (25.1.1.2) object whose next method returns the successive elements of list. It performs the following steps:

1. Let iterator be ObjectCreate(%,IteratorPrototype%, «[[IteratorNext]], [[IteratedList]],
   [[ListIteratorNextIndex]]»).
2. Set iterator's [[IteratedList]] internal slot to list.
3. Set iterator's [[ListIteratorNextIndex]] internal slot to 0.
4. Let next be a new built-in function object as defined in ListIterator next(7.4.8.1).
5. Set iterator's [[IteratorNext]] internal slot to next.
6. Let status be the result of CreateDataProperty(iterator, "next", next).
7. Return iterator.

7.4.8.1 ListIterator next( )

The ListIterator next( ) method is a standard built-in function object (clause 17) that performs the following steps:

1. Let O be the this value.
2. Let f be the active function object.
3. If O does not have a [[IteratorNext]] internal slot, throw a TypeError exception.
4. Let next be the value of the [[IteratorNext]] internal slot of O.
5. If SameValue(f, next) is false, throw a TypeError exception.
6. If O does not have a [[IteratedList]] internal slot, throw a TypeError exception.
7. Let list be the value of the [[IteratedList]] internal slot of O.
8. Let index be the value of the [[ListIteratorNextIndex]] internal slot of O.
9. Let len be the number of elements of list.
10. If index ≥ len, then
    a. Return CreateIterResultObject(undefined, true).
11. Set the value of the [[ListIteratorNextIndex]] internal slot of O to index+1.
12. Return CreateIterResultObject(list[index], false).

NOTE: A ListIterator next( ) method will throw an exception if applied to any object other than the one with which it was originally associated.

7.4.9 `CreateCompoundIterator` (iterator1, iterator2)

The abstract operation `CreateCompoundIterator` with arguments iterator1 and iterator2 creates an Iterator (25.1.1.2) object whose next method returns the successive elements of iterator1 followed by the successive elements of iterator2. It performs the following steps:

1. Let iterator be ObjectCreate(%,IteratorPrototype%, «[[Iterator1]], [[Iterator2]], [[State]],
   [[IteratorNext]]»).
2. Set iterator's [[Iterator1]] internal slot to iterator1.
3. Set iterator's [[Iterator2]] internal slot to iterator2.
4. Set iterator's [[State]] internal slot to 1.
5. Let \( \textit{next} \) be a new built-in function object as defined in CompoundIterator \( \textit{next} \) (7.4.9.1).
6. Set \( \textit{iterator} \)’s [[IteratorNext]] internal slot to \( \textit{next} \).
7. Let \( \textit{status} \) be the result of CreateDataProperty(\( \textit{iterator} \), "\textit{next}", \( \textit{next} \)).
8. Return \( \textit{iterator} \).

### 7.4.9.1 CompoundIterator \( \textit{next}() \)

The CompoundIterator \( \textit{next}() \) method is a standard built-in function object that performs the following steps:

1. Let \( \textit{O} \) be the \textit{this} value.
2. Let \( \textit{f} \) be the active function object.
3. If \( \textit{O} \) does not have a [[IteratorNext]] internal slot, throw a \textbf{TypeError} exception.
4. Let \( \textit{next} \) be the value of the [[IteratorNext]] internal slot of \( \textit{O} \).
5. If SameValue(\( \textit{f} \), \( \textit{next} \)) is false, throw a \textbf{TypeError} exception.
6. If \( \textit{O} \) does not have a [[Iterator1]] internal slot, throw a \textbf{TypeError} exception.
7. Assert: \( \textit{O} \) is an object created and initialized by CreateCompoundIterator.
8. Let \( \textit{state} \) be the value of \( \textit{O} \)’s [[State]] internal slot.
9. If \( \textit{state} = 1 \), then
   a. Let \( \textit{iterator1} \) be the value of \( \textit{O} \)’s [[Iterator1]] internal slot.
   b. Let \( \textit{result1} \) be IteratorStep(\( \textit{iterator1} \)).
   c. If \( \textit{result1} \) is not false, then
      i. Return \( \textit{result1} \).
   d. Set \( \textit{O} \)’s [[State]] internal slot to 2.
10. Let \( \textit{iterator2} \) be the value of \( \textit{O} \)’s [[Iterator2]] internal slot.
11. Return IteratorNext(\( \textit{iterator2} \)).

**NOTE** A CompoundIterator \( \textit{next}() \) method will throw an exception if applied to any object other than the one with which it was originally associated.

### 8 Executable Code and Execution Contexts

#### 8.1 Lexical Environments

A \textit{Lexical Environment} is a specification type used to define the association of \textit{Identifiers} to specific variables and functions based upon the lexical nesting structure of **ECMAScript** code. A Lexical Environment consists of an Environment Record and a possibly null reference to an outer Lexical Environment. Usually a Lexical Environment is associated with some specific syntactic structure of **ECMAScript** code such as a **FunctionDeclaration**, a **BlockStatement**, or a **Catch** clause of a **TryStatement** and a new Lexical Environment is created each time such code is evaluated.

An Environment Record records the identifier bindings that are created within the scope of its associated Lexical Environment.

The outer environment reference is used to model the 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.
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 **module environment** is a Lexical Environment that contains the bindings for the top level declarations of a *Module*. It also contains the bindings that are explicitly imported by the *Module*. The outer environment of a module environment is a global environment.

A **function environment** is a Lexical Environment that corresponds to the invocation of an ECMAScript function object. A function environment may establish a new `this` binding. A function environment also captures the state necessary to support `super` method invocations.

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.

### 8.1.1 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.

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 and module environment records are subclasses of declarative environment record. The abstract class includes the abstract specification methods defined in Table 16. These abstract methods have distinct concrete algorithms for each of the concrete subclasses.
### Table 16 — Abstract Methods of Environment Records

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>HasBinding(N)</td>
<td>Determine if an environment record has a binding for the String value N. Return <code>true</code> if it does and <code>false</code> if it does not.</td>
</tr>
<tr>
<td>CreateMutableBinding(N, D)</td>
<td>Create a new but uninitialized mutable binding in an environment record. The String value N is the text of the bound name. If the optional Boolean argument D is <code>true</code> the binding is may be subsequently deleted.</td>
</tr>
<tr>
<td>CreateImmutableBinding(N, S)</td>
<td>Create a new but uninitialized immutable binding in an environment record. The String value N is the text of the bound name. If S is <code>true</code> then attempts to access the value of the binding before it is initialized or set, if after it has been initialized will always throw an exception, regardless of the strict mode setting of operations that reference that binding. S is an optional parameter that defaults to <code>false</code>.</td>
</tr>
<tr>
<td>InitializeBinding(N,V)</td>
<td>Set the value of an already existing but uninitialized 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 ECMA Script language type.</td>
</tr>
<tr>
<td>SetMutableBinding(N,V, S)</td>
<td>Set the value of an already existing mutable binding in an environment record. The String value N is the text of the bound name. V is the value for the binding and may be a value of any ECMA Script language type. S is a Boolean flag. If S is <code>true</code> and the binding cannot be set throw a <code>TypeError</code> exception.</td>
</tr>
<tr>
<td>GetBindingValue(N,S)</td>
<td>Returns the value of an already existing binding from an environment record. The String value N is the text of the bound name. S is used to identify strict mode references. If S is <code>true</code> and the binding does not exist throw a <code>ReferenceError</code> exception. If the binding exists but is uninitialized a <code>ReferenceError</code> is thrown, regardless of the value of S.</td>
</tr>
<tr>
<td>DeleteBinding(N)</td>
<td>Delete a binding from an environment record. The String value N is the text of the bound name. If a binding for N exists, remove the binding and return <code>true</code>. If the binding exists but cannot be removed return <code>false</code>. If the binding does not exist return <code>true</code>.</td>
</tr>
<tr>
<td>HasThisBinding()</td>
<td>Determine if an environment record establishes a this binding. Return <code>true</code> if it does and <code>false</code> if it does not.</td>
</tr>
<tr>
<td>HasSuperBinding()</td>
<td>Determine if an environment record establishes a super method binding. Return <code>true</code> if it does and <code>false</code> if it does not.</td>
</tr>
<tr>
<td>WithBaseObject ()</td>
<td>If this environment record is associated with a with statement, return the with object. Otherwise, return undefined.</td>
</tr>
</tbody>
</table>

### 8.1.1.1 Declarative Environment Records

Each declarative environment record is associated with an ECMA Script 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.

Comment [AWB242]: Note that this isn't a breaking change from ES5 because in ES5 all immutable bindings were immediately initialized.
The behaviour of the concrete specification methods for Declarative Environment Records is defined by
the following algorithms.

8.1.1.1 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. Return false.

8.1.1.2 CreateMutableBinding (N, D)

The concrete Environment Record method CreateMutableBinding for declarative environment records
creates a new mutable binding for the name N that is uninitialized. 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 uninitialized. If D is true record that
the newly created binding may be deleted by a subsequent DeleteBinding call.
4. Return NormalCompletion(empty).

8.1.1.3 CreateImmutableBinding (N, S)

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. If Boolean argument S is provided and has the value true the new binding is
marked as a strict binding.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Assert: envRec must have an uninitialized binding for N.
3. Create an immutable binding in envRec for N and record that it is uninitialized. If S is true record that
the newly created binding is a strict binding.
4. Return NormalCompletion(empty).

8.1.1.4 InitializeBinding (N,V)

The concrete Environment Record method InitializeBinding 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 uninitialized 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 uninitialized 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 initialized.
5. Return NormalCompletion(empty).
8.1.1.1.5 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 normally already exist, but in rare cases it may not. 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. If envRec does not have a binding for N, then
   a. If S is true throw a ReferenceError exception.
   b. Call the CreateMutableBinding concrete method of envRec with arguments N and true.
   c. Call the InitializeBinding concrete method of envRec with arguments N and V.
   d. Return NormalCompletion(empty).
3. If the binding for N in envRec is a strict binding, let S be true.
4. If the binding for N in envRec has not yet been initialized throw a ReferenceError exception.
5. Else if the binding for N in envRec is a mutable binding, change its bound value to V.
6. Else this must be an attempt to change the value of an immutable binding so if S is true throw a TypeError exception.
7. Return NormalCompletion(empty).

NOTE An example of ECMAScript code that results in a missing binding at step 2 is:
function f(){eval("var x; x = (delete x, 0);")}

8.1.1.6 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. If the binding exists but is uninitialized a ReferenceError is thrown, regardless of the value of S.

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 uninitialized binding, throw a ReferenceError exception.
4. Return the value currently bound to N in envRec.

8.1.1.7 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 false.
3. If the binding for N in envRec cannot be deleted, return false.
4. Remove the binding for N from envRec.
5. Return true.

8.1.1.8 HasThisBinding ()

Regular Declarative Environment Records do not provide a this binding.

1. Return false.

8.1.1.9 HasSuperBinding ()

Regular Declarative Environment Records do not provide a super binding.
1. Return `false`.

### 8.1.1.10 WithBaseObject()

Declarative Environment Records always return `undefined` as their `WithBaseObject`.

1. Return `undefined`.

### 8.1.2 Object Environment Records

Each object environment record is associated with an object called its `binding object`. An object environment record binds the set of string identifier names that directly correspond to the property names of its binding object. Property keys that are not strings in the form of 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 (13.10) 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.

#### 8.1.1.2.1 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. Let `foundBinding` be `HasProperty(bindings, N)`
4. ReturnIfAbrupt(`foundBinding`).
5. If `foundBinding` is `false`, return `false`.
6. If the `withEnvironment` flag of `envRec` is `false`, return `true`.
7. Let `unscopables` be `Get(bindings, @@unscopables)`.
8. ReturnIfAbrupt(`unscopables`).
9. If `Type(unscopables)` is `Object`, then
   a. Let `blocked` be `Get(unscopables, N)`.
   b. ReturnIfAbrupt(`blocked`).
   c. If `ToBoolean(blocked)` is `true`, return `false`.
10. Return `true`.

#### 8.1.1.2.2 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 initializes it to the value `undefined`. 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`. 

---

Deleted: blocked is not undefined
1. Let \( envRec \) be the object environment record for which the method was invoked.
2. Let \( bindings \) be the binding object for \( envRec \).
3. If \( D \) is \( \text{true} \) then let \( configValue \) be \( \text{true} \) otherwise let \( configValue \) be \( \text{false} \).
4. Return DefinePropertyOrThrow(\( bindings \), \( N \), PropertyDescriptor\{[[Value]]: undefined, [[Writable]]: \( \text{true} \), [[Enumerable]]: \( \text{true} \), [[Configurable]]: \( configValue \)\}).

NOTE Normally \( envRec \) will not have a binding for \( N \) but if it does, the semantics of DefinePropertyOrThrow may result in an existing binding being replaced or shadowed or cause an abrupt completion to be returned.

8.1.1.2.3 CreateImmutableBinding (\( N, S \))

The concrete Environment Record method CreateImmutableBinding is never used within this specification in association with Object environment records.

8.1.1.2.4 InitializeBinding (\( N, V \))

The concrete Environment Record method InitializeBinding 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 uninitialized 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 uninitialized binding for \( N \).
3. Record that the binding for \( N \) in \( envRec \) has been initialized.
4. Return the result of calling the SetMutableBinding concrete method of \( envRec \) with \( N \), \( V \), and \( \text{false} \) as arguments.

8.1.1.2.5 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 \( \text{Put}(bindings, N, V, and S) \).

8.1.1.2.6 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 HasProperty(\( bindings \), \( N \)).
4. ReturnIfAbrupt(\( value \)).
5. If \( value \) is \( \text{false} \), then
   a. If \( S \) is \( \text{false} \), return the value \( \text{undefined} \), otherwise throw a \( \text{ReferenceError} \) exception.
6. Return Get(\( bindings \), \( N \)).
8.1.1.2.7 **DeleteBinding (N)**

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.

8.1.1.2.8 **HasThisBinding ()**

Regular Object Environment Records do not provide a **this** binding.

1. Return **false**.

8.1.1.2.9 **HasSuperBinding ()**

Regular Object Environment Records do not provide a **super** binding.

1. Return **false**.

8.1.1.2.10 **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**.

8.1.1.3 **Function Environment Records**

A function environment record is a declarative environment record that is used to represent the top-level scope of a function and, if the function is not an ArrowFunction, provides a **this** binding. If a function is not an ArrowFunction function and 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 have the additional state fields listed in Table 17.
Table 17 — Additional Fields of Function Environment Records

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[thisValue]]</code></td>
<td>If the value is empty, this is an <em>ArrowFunction</em> and does not have a local this value. Otherwise, this is the this value used for this invocation of the function.</td>
</tr>
<tr>
<td><code>[[thisInitializationState]]</code></td>
<td>If false, the <code>[[thisValue]]</code> field has not yet been initialized, otherwise true.</td>
</tr>
<tr>
<td><code>[[FunctionObject]]</code></td>
<td>The Function Object whose invocation caused this environment record to be created.</td>
</tr>
<tr>
<td><code>[[HomeObject]]</code></td>
<td>If the associated function has <code>super</code> property accesses and is not an <em>ArrowFunction</em>, <code>[[HomeObject]]</code> is the object that the function is bound to as a method. The default value for <code>[[HomeObject]]</code> is <code>undefined</code>.</td>
</tr>
<tr>
<td><code>[[NewTarget]]</code></td>
<td>If this environment record was created by the <code>[[Construct]]</code> internal method, <code>[[NewTarget]]</code> is the value of the <code>[[Construct]] newTarget</code> parameter. Otherwise, its value is <code>undefined</code>.</td>
</tr>
<tr>
<td><code>[[topLex]]</code></td>
<td>The lexical environment record that contains the bindings for lexical declarations that occur at the top-level of the function. For strict mode functions, this is the same as current function environment record.</td>
</tr>
</tbody>
</table>

Function environment records support all of Declarative Environment Record methods listed in Table 16 and share the same specifications for all of those methods except for HasThisBinding and HasSuperBinding. In addition, Function Environment Records support the methods listed in Table 18:

Table 18 — Additional Methods of Function Environment Records

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>BindThisValue(V)</code></td>
<td>Set the <code>[[thisValue]]</code> and record that it has been initialized.</td>
</tr>
<tr>
<td><code>GetThisBinding()</code></td>
<td>Return the value of this environment record’s this binding.</td>
</tr>
<tr>
<td><code>GetSuperBase()</code></td>
<td>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> field. The value <code>undefined</code> indicates that <code>super</code> property accesses will produce runtime errors.</td>
</tr>
</tbody>
</table>

The behaviour of the additional concrete specification methods for Function Environment Records is defined by the following algorithms:

8.1.3.1 *BindThisValue(V)*

1. Let `envRec` be the function environment record for which the method was invoked.
2. Assert: `envRec. [[thisInitializationState]]` is `false`.
3. Set `envRec. [[thisValue]]` to V.
4. If `envRec. [[thisInitializationState]]` is `true`, throw a `ReferenceError` exception.
5. Set `envRec. [[thisInitializationState]]` to `true`.
6. Return V.
8.1.1.3.2 HasThisBinding ()

1. Let envRec be the function environment record for which the method was invoked.
2. If envRec.[[thisValue]] has the value empty, return false; otherwise, return true.

8.1.1.3.3 HasSuperBinding ()

1. Let envRec be the function environment record for which the method was invoked.
2. If envRec.[[thisValue]] has the value empty, return false.
3. If envRec.[[HomeObject]] has the value undefined, return false; otherwise, return true.

8.1.1.3.4 GetThisBinding ()

1. Let envRec be the function environment record for which the method was invoked.
2. If envRec.[[thisInitializationState]] is false, throw a ReferenceError exception.
3. Return envRec.[[thisValue]].

8.1.1.3.5 GetSuperBase ()

1. Let envRec be the function environment record for which the method was invoked.
2. Let home be the value of envRec.[[HomeObject]].
3. If home has the value undefined, return undefined.
4. Assert: Type(home) is Object.
5. Return the result of calling home’s [[GetPrototypeOf]] internal method.

8.1.1.4 Global Environment Records

A global environment record is used to represent the outermost scope that is shared by all of the ECMAScript script elements that are processed in a common Realm (8.2). A global environment record provides the bindings for built-in globals (clause 18), 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 GetThisBinding concrete method. The object environment record component of a global environment record contains the bindings for all built-in globals (clause 18) and all bindings introduced by a FunctionDeclaration, GeneratorDeclaration, 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, GeneratorDeclaration, or VariableDeclaration 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 fields listed in Table 19 and the additional methods listed in Table 20.
### Table 19 — Fields of Global Environment Records

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[ObjectRecord]]</code></td>
<td>An Object Environment Record whose base object is the global object. It contains global built-in bindings as well as FunctionDeclaration, GeneratorDeclaration, and VariableDeclaration bindings in global code for the associated Realm.</td>
</tr>
<tr>
<td><code>[[DeclarativeRecord]]</code></td>
<td>A Declarative Environment Record that contains bindings for all declarations in global code for the associated Realm code except for FunctionDeclaration, GeneratorDeclaration, and VariableDeclaration bindings.</td>
</tr>
<tr>
<td><code>[[VarNames]]</code></td>
<td>A List containing the string names bound by FunctionDeclaration, GeneratorDeclaration, and VariableDeclaration declarations in global code for the associated Realm.</td>
</tr>
</tbody>
</table>

### Table 20 — Additional Methods of Global Environment Records

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetThisBinding()</td>
<td>Return the value of this environment record’s this binding.</td>
</tr>
<tr>
<td>HasVarDeclaration (N)</td>
<td>Determines if the argument identifier has a binding in this environment record that was created using a VariableDeclaration, FunctionDeclaration, or GeneratorDeclaration.</td>
</tr>
<tr>
<td>HasLexicalDeclaration (N)</td>
<td>Determines if the argument identifier has a binding in this environment record that was created using a lexical declaration such as a LexicalDeclaration or a ClassDeclaration.</td>
</tr>
<tr>
<td>HasRestrictedGlobalProperty (N)</td>
<td>Determines if the argument is the name of a global object property that may not be shadowed by a global lexically binding.</td>
</tr>
<tr>
<td>CanDeclareGlobalVar (N)</td>
<td>Determines if a corresponding CreateGlobalVarBinding call would succeed if called for the same argument N.</td>
</tr>
<tr>
<td>CanDeclareGlobalFunction (N)</td>
<td>Determines if a corresponding CreateGlobalFunctionBinding call would succeed if called for the same argument N.</td>
</tr>
<tr>
<td>CreateGlobalVarBinding(N, D)</td>
<td>Used to create global var bindings in the <code>[[ObjectRecord]]</code> component of a global environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values appropriate for a var. The String value N is bound name. If D is true the binding may be subsequently deleted. This is logically equivalent to CreateMutableBinding but it allows var declarations to receive special treatment.</td>
</tr>
<tr>
<td>CreateGlobalFunctionBinding(N, V, D)</td>
<td>Used to create and initialize global function bindings in the <code>[[ObjectRecord]]</code> component of a global environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values appropriate for a function. The String value N is the text of the bound name. V is the initial value of the binding. If the optional Boolean argument D is true the binding is may be subsequently deleted. This is logically equivalent to CreateMutableBinding followed by a SetMutableBinding but it allows function declarations to receive special treatment.</td>
</tr>
</tbody>
</table>
The behaviour of the concrete specification methods for Global Environment Records is defined by the following algorithms.

8.1.1.4.1 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.\([\text{DeclarativeRecord}]\).
3. If the result of calling DclRec’s HasBinding concrete method with argument N is \(\text{true} \), return \(\text{true} \).
4. Let ObjRec be envRec.\([\text{ObjectRecord}]\).
5. Return the result of calling ObjRec’s HasBinding concrete method with argument N.

8.1.1.4.2 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 DeclarativeRecord. A binding for N must not already exist in the DeclarativeRecord. If Boolean argument D is provided and has the value \(\text{true} \) the new binding is marked as being subject to deletion.

1. Let envRec be the global environment record for which the method was invoked.
2. Let DclRec be envRec.\([\text{DeclarativeRecord}]\).
3. Let alreadyThere be the result of calling the HasBinding concrete method of DclRec with argument N.
4. ReturnIfAbrupt(\(\text{alreadyThere} \)).
5. If alreadyThere is \(\text{true} \), throw a \text{TypeError} exception.
6. Return the result of calling the CreateMutableBinding concrete method of DclRec with arguments N and D.

8.1.1.4.3 CreateImmutableBinding(N, S)

The concrete Environment Record method CreateImmutableBinding for global 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. If Boolean argument S is provided and has the value \(\text{true} \) the new binding is marked as a strict binding.

1. Let envRec be the global environment record for which the method was invoked.
2. Let DclRec be envRec.\([\text{DeclarativeRecord}]\).
3. Let alreadyThere be the result of calling the HasBinding concrete method of DclRec with argument N.
4. ReturnIfAbrupt(\(\text{alreadyThere} \)).
5. If alreadyThere is \(\text{true} \), throw a \text{TypeError} exception.
6. Return the result of calling the CreateImmutableBinding concrete method of DclRec with argument N and S.

8.1.1.4.4 InitializeBinding(N, V)

The concrete Environment Record method InitializeBinding 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.

1. Let envRec be the global environment record for which the method was invoked.
2. Let DclRec be envRec.\([\text{DeclarativeRecord}]\).
3. If the result of calling \texttt{DclRec}'s \texttt{HasBinding} concrete method with argument \texttt{N} is \texttt{true}, then
   a. Return the result of calling \texttt{DclRec}'s \texttt{InitializeBinding} concrete method with arguments \texttt{N} and \texttt{V}.
4. Assert: If the binding exists it must be in the object environment record.
5. Let \texttt{ObjRec} be envRec.\texttt{[ObjectRecord]}.
6. Return the result of calling \texttt{ObjRec}'s \texttt{InitializeBinding} concrete method with arguments \texttt{N} and \texttt{V}.

8.1.1.4.5 \texttt{SetMutableBinding (N,V,S)}

The concrete Environment Record method \texttt{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 \texttt{N} to the value of argument \texttt{V}. If the binding is an immutable binding, a \texttt{TypeError} is thrown if \texttt{S} is \texttt{true}. A property named \texttt{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 \texttt{S}.

1. Let \texttt{envRec} be the global environment record for which the method was invoked.
2. Let \texttt{DclRec} be envRec.\texttt{[DeclarativeRecord]}.
3. If the result of calling \texttt{DclRec}'s \texttt{HasBinding} concrete method with argument \texttt{N} is \texttt{true}, then
   a. Return the result of calling the \texttt{SetMutableBinding} concrete method of \texttt{DclRec} with arguments \texttt{N}, \texttt{V}, and \texttt{S}.
4. Let \texttt{ObjRec} be envRec.\texttt{[ObjectRecord]}.
5. Return the result of calling the \texttt{SetMutableBinding} concrete method of \texttt{ObjRec} with arguments \texttt{N}, \texttt{V}, and \texttt{S}.

8.1.1.4.6 \texttt{GetBindingValue(N,S)}

The concrete Environment Record method \texttt{GetBindingValue} for global environment records returns the value of its bound identifier whose name is the value of the argument \texttt{N}. If the binding is an uninitialized binding throw a \texttt{ReferenceError} exception. A property named \texttt{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 \texttt{S}.

1. Let \texttt{envRec} be the global environment record for which the method was invoked.
2. Let \texttt{DclRec} be envRec.\texttt{[DeclarativeRecord]}.
3. If the result of calling \texttt{DclRec}'s \texttt{HasBinding} concrete method with argument \texttt{N} is \texttt{true}, then
   a. Return the result of calling the \texttt{GetBindingValue} concrete method of \texttt{DclRec} with arguments \texttt{N} and \texttt{S}.
4. Let \texttt{ObjRec} be envRec.\texttt{[ObjectRecord]}.
5. Return the result of calling the \texttt{GetBindingValue} concrete method of \texttt{ObjRec} with arguments \texttt{N}, and \texttt{S}.

8.1.1.4.7 \texttt{DeleteBinding (N)}

The concrete Environment Record method \texttt{DeleteBinding} for global environment records can only delete bindings that have been explicitly designated as being subject to deletion.

1. Let \texttt{envRec} be the global environment record for which the method was invoked.
2. Let \texttt{DclRec} be envRec.\texttt{[DeclarativeRecord]}.
3. If the result of calling \texttt{DclRec}'s \texttt{HasBinding} concrete method with argument \texttt{N} is \texttt{true}, then
   a. Return the result of calling the \texttt{DeleteBinding} concrete method of \texttt{DclRec} with argument \texttt{N}.
4. Let \texttt{ObjRec} be envRec.\texttt{[ObjectRecord]}.
5. If the result of calling \texttt{ObjRec}'s \texttt{HasBinding} concrete method with argument \texttt{N} is \texttt{true}, then
   a. Let \texttt{status} be the result of calling the \texttt{DeleteBinding} concrete method of \texttt{ObjRec} with argument \texttt{N}.
   b. ReturnIfAbrupt(\texttt{status}).
c. If status is true, then
   i. Let varNames be envRec.\([\text{VarNames}]\) List.
   ii. If N is an element of varNames, remove that element from the varNames.
   d. Return status.
   6. Return true.

8.1.1.4.8 HasThisBinding ()
Global Environment Records always provide a this binding whose value is the associated global object.
1. Return true.

8.1.1.4.9 HasSuperBinding ()
1. Return false.

8.1.1.4.10 WithBaseObject()
Global Environment Records always return undefined as their WithBaseObject.
1. Return undefined.

8.1.1.4.11 GetThisBinding ()
1. Let envRec be the global environment record for which the method was invoked.
2. Let ObjRec be envRec.\([\text{ObjectRecord}]\).
3. Let bindings be the binding object for ObjRec.
4. Return bindings.

8.1.1.4.12 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.\([\text{VarNames}]\).
3. If varDeclaredNames contains the value of N, return true.
4. Return false.

8.1.1.4.13 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 DeclRec be envRec.\([\text{DeclarativeRecord}]\).
3. Return the result of calling DeclRec’s HasBinding concrete method with argument N.
8.1.1.4.14 HasRestrictedGlobalProperty (N)

The concrete environment record method HasRestrictedGlobalProperty for global environment records determines if the argument identifier is the name of a property of the global object that must not be shadowed by a global lexically binding:

1. Let envRec be the global environment record for which the method was invoked.
2. Let ObjRec be envRec.[[ObjectRecord]].
3. Let globalObject be the binding object for ObjRec.
4. Let existingProp be the result of calling the [[GetOwnProperty]] internal method of globalObject with argument N.
5. ReturnIfAbrupt(existingProp).
6. If existingProp is undefined, return false.
7. If existingProp.[[Configurable]] is true, return false.
8. Return true.

**NOTE** Properties may exist upon a global object that were directly created rather than being declared using a var or function declaration. A global lexical binding may not be created that has the same name as a non-configurable property of the global object. The global property undefined is an example of such a property.

8.1.1.4.15 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.[[ObjectRecord]].
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 IsExtensible(bindings).
6. Return extensible.

8.1.1.4.16 CanDeclareGlobalFunction (N)

The concrete environment record method CanDeclareGlobalFunction 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.[[ObjectRecord]].
3. Let globalObject be the binding object for ObjRec.
4. Let extensible be IsExtensible(globalObject).
5. ReturnIfAbrupt(extensible).
6. If the result of calling ObjRec’s HasBinding concrete method with argument N is false, return extensible.
7. Let existingProp be the result of calling the [[GetOwnProperty]] internal method of globalObject with argument N.
8. ReturnIfAbrupt(existingProp).
9. If existingProp is undefined, return true.
10. If existingProp.[[Configurable]] is true, return true.
11. If IsDataDescriptor(existingProp) is true and existingProp has attribute values {[[Writable]]: true, [[Enumerable]]: true}, return true.
12. Return false.

8.1.1.4.17  CreateGlobalVarBinding (N, D)

The concrete Environment Record method CreateGlobalVarBinding 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 global environment record for which the method was invoked.
2. Let `ObjRec` be `envRec`.[[ObjectRecord]].
3. If the result of calling `ObjRec`'s HasBinding concrete method with argument `N` is false, then
   a. Let `status` be the result of calling the CreateMutableBinding concrete method of `ObjRec` with arguments `N` and `D`.
   b. ReturnIfAbrupt(`status`).
4. Let `varDeclaredNames` be `envRec`.[[VarNames]].
5. If `varDeclaredNames` does not contain the value of `N`, then
   a. Append `N` to `varDeclaredNames`.
6. Return NormalCompletion(empty).

NOTE  Global function declarations are always represented as own properties of the global object. If possible, an existing own property is reconfigured to have a standard set of attribute values.

8.1.1.4.18  CreateGlobalFunctionBinding (N, V, D)

The concrete Environment Record method CreateGlobalFunctionBinding 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 global environment record for which the method was invoked.
2. Let `ObjRec` be `envRec`.[[ObjectRecord]].
3. Let `globalObject` be the binding object for `ObjRec`.
4. Let `existingProp` be the result of calling the [[GetOwnProperty]] internal method of `globalObject` with argument `N`.
5. ReturnIfAbrupt(`existingProp`).
6. If `existingProp` is undefined or `existingProp`.[[Configurable]] is true, then
   a. Let `desc` be the PropertyDescriptor{[[Value]]: `V`, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: `D`}
7. Else,
   a. Let `desc` be the PropertyDescriptor{[[Value]]: `V`}
8. Let `status` be DefinePropertyOrThrow(`globalObject`, `N`, `desc`).
9. ReturnIfAbrupt(status).
10. Let `varDeclaredNames` be `envRec`.[[VarNames]]
11. If `varDeclaredNames` does not contain the value of `N`, then
   a. Append `N` to `varDeclaredNames`.
12. Return NormalCompletion(empty).

NOTE  Global function declarations are always represented as own properties of the global object. If possible, an existing own property is reconfigured to have a standard set of attribute values.

8.1.1.5  Module Environment Records

A module environment record is a declarative environment record that is used to represent the outer scope of an ECMAScript Module. In additional to normal mutable and immutable bindings, module environment records also provide immutable import bindings which are bindings that provide indirect access to a target binding that exists in another environment record.
Module environment records support all of the Declarative Environment Record methods listed in Table 16 and share the same specifications for all of those methods except for GetBindingValue, DeleteBinding, HasThisBinding and GetThisBinding. In addition, module environment records support the methods listed in Table 21:

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CreateImportBinding(N, M, N2)</td>
<td>Create an immutable indirect binding in a module environment record. The String value N is the text of the bound name. M is a Module Record (see 15.2.1.15), and N2 is a binding that exists in M's module environment record.</td>
</tr>
<tr>
<td>GetThisBinding()</td>
<td>Return the value of this environment record's this binding.</td>
</tr>
</tbody>
</table>

The behaviour of the additional concrete specification methods for Module Environment Records is defined by the following algorithms:

8.1.1.5.1 GetBindingValue(N, S)

The concrete Environment Record method GetBindingValue for module environment records returns the value of its bound identifier whose name is the value of the argument N. However, if the binding is an indirect binding the value of the target binding is returned. If the binding exists but is uninitialized a ReferenceError is thrown, regardless of the value of S.

1. Let envRec be the module 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 indirect binding, then
   a. Assert: M and N2 are the indirection values provided when this binding for N was created.
   b. Let targetER be M.[[Environment]]’s environment record.
   c. Return the result of calling the GetBindingValue concrete method of targetER with arguments N2 and S.
4. If the binding for N in envRec is an uninitialized binding, throw a ReferenceError exception.
5. Return the value currently bound to N in envRec.

NOTE Because a Module is always strict mode code, calls to GetBindingValue should always pass true as the value of S.

8.1.1.5.2 DeleteBinding (N)

The concrete Environment Record method DeleteBinding for module environment records refuses to delete bindings.

1. Let envRec be the module 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. Return false.

NOTE Because the bindings of a module environment record are not deletable.

8.1.1.5.3 HasThisBinding ()

Module Environment Records provide a this binding.

1. Return true.
8.1.1.5.4 GetThisBinding ()

1. Return undefined.

8.1.1.5.5 CreateImportBinding (N, M, N2)

The concrete Environment Record method CreateImportBinding for module environment records creates a new initialized immutable indirect binding for the name N. A binding must not already exist in this environment record for N. M is a Module Record (see 15.2.1.15), and N2 is the name of a binding that exists in M's module environment record. Accesses to the value of the new binding will indirectly access the bound value of value of the target binding.

1. Let envRec be the module environment record for which the method was invoked.
2. Assert: envRec does not already have a binding for N.
3. Assert: M is a Module Record.
4. Assert: When M.[[Environment]] is instantiated it will have a direct binding for N2.
5. Create an immutable indirect binding in envRec for N that references M and N2 as its target binding and record that the binding is initialized.
6. Return NormalCompletion(empty).

8.1.2 Lexical Environment Operations

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

8.1.2.1 GetIdentifierReference (lex, name, strict) Abstract Operation

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 concrete method of envRec passing name as the argument.
4. ReturnIfAbrupt(exists).
5. 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.
6. Else
   a. Let outer be the value of lex's outer environment reference.
   b. Return GetIdentifierReference(outer, name, strict).

8.1.2.2 NewDeclarativeEnvironment (E) Abstract Operation

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.
8.1.2.3 NewObjectEnvironment (O, E) Abstract Operation

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 envRec.
4. Set the outer lexical environment reference of env to E.
5. Return env.

8.1.2.4 NewFunctionEnvironment (F) Abstract Operation

When the abstract operation NewFunctionEnvironment is called with an ECMAScript function Object F as its argument, the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let envRec be a new function environment record containing no bindings.
3. Set envRec.[[FunctionObject]] to F.
4. Set envRec.[[thisInitializationState]] to false.
5. If F’s [[ThisMode]] internal slot is lexical, set envRec.[[thisValue]] to empty.
6. If F’s [[NeedsSuper]] internal slot is true, then
   a. Let home be the value of F’s [[HomeObject]] internal slot.
   b. If home is undefined, throw a ReferenceError exception.
   c. Set envRec.[[HomeObject]] to home.
7. Else,
   a. Set envRec.[[HomeObject]] to undefined.
8. Set envRec.[[NewTarget]] to undefined.
9. Set env’s environment record to be envRec.
10. Set the outer lexical environment reference of env to the value of F’s [[Environment]] internal slot.

8.1.2.5 NewGlobalEnvironment (G) Abstract Operation

When the abstract operation NewGlobalEnvironment is called with an ECMAScript Object G as its argument, the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let objRec be a new object environment record containing G as the binding object.
3. Set objRec.[[Unscopables]] to an empty List.
4. Let dclRec be a new declarative environment record containing no bindings.
5. Let globalRec be a new global environment record.
6. Set globalRec.[[ObjectRecord]] to objRec.
7. Set globalRec.[[DeclarativeRecord]] to dclRec.
8. Set globalRec.[[VarNames]] to a new empty List.
9. Set env’s environment record to globalRec.
10. Set the outer lexical environment reference of env to null.

8.1.2.6 NewModuleEnvironment (E) Abstract Operation

When the abstract operation NewModuleEnvironment is called with a Lexical Environment argument E, the following steps are performed:
1. Let `env` be a new Lexical Environment.
2. Let `envRec` be a new module 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`.

8.2 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, and other associated state and resources.

A Realm is specified as a Record with the fields specified in Table 22:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[intrinsics]]</td>
<td>A record whose field names are intrinsic keys and whose values are objects</td>
<td>These are the intrinsic values used by code associated with this Realm</td>
</tr>
<tr>
<td>[[globalThis]]</td>
<td>An object</td>
<td>The global object for this Realm</td>
</tr>
<tr>
<td>[[globalEnv]]</td>
<td>An ECMAScript environment</td>
<td>The global environment for this Realm</td>
</tr>
<tr>
<td>[[templateMap]]</td>
<td>A List of Record{ [[strings]]: List, [[array]]: Object }</td>
<td>Template objects are canonicalized separately for each Realm using its [[templateMap]]. Each [[strings]] value is a List containing in source code order the raw string values of a TemplateLiteral that has been evaluated. The associated [[array]] value is the corresponding template object that is passed to a tag function.</td>
</tr>
<tr>
<td>[[modules]]</td>
<td>A List of ModuleRecords</td>
<td>An initially empty List containing the ModuleRecord for each module that has been loaded by this Realm</td>
</tr>
</tbody>
</table>

8.2.1 CreateRealm ( ) Abstract Operation

The abstract operation CreateRealm with no arguments performs the following steps:

1. Let `realmRec` be a new Record.
2. Let `intrinsics` be `CreateIntrinsics(realmRec)`.
3. Set `realmRec`.[[globalThis]] to `undefined`.
4. Set `realmRec`.[[globalEnv]] to `undefined`.
5. Set `realmRec`.[[templateMap]] to a new empty List.
6. Set `realmRec`.[[modules]] to a new empty List.
7. Return `realmRec`.

8.2.2 CreateIntrinsics ( realmRec ) Abstract Operation

When the abstract operation CreateIntrinsics with argument `realmRec` performs the following steps:
1. Let **intrinsics** be a new Record.
2. Set `realmRec.[[intrinsics]]` to **intrinsics**.
3. Let `objProto` be ObjectCreate(null).
4. Set `intrinsics.[[ObjectPrototype]]` to `objProto`.
5. Let `throwerSteps` be the algorithm steps of the %ThrowTypeError% function (9.2.8.1).
6. Let `thrower` be CreateBuiltinFunction(realmRec, throwerSteps, null).
7. Set `intrinsics.[[%ThrowTypeError%]]` to `thrower`.
8. Let `noSteps` be an empty sequence of algorithm steps.
9. Let `funcProto` be the CreateBuiltinFunction(realmRec, noSteps, objProto).
10. Set `intrinsics.[[%FunctionPrototype%]]` to `funcProto`.
11. Call the [[SetPrototypeOf]] internal method of `thrower` with argument `funcProto`.
13. Set fields of `intrinsics` with the values listed in Table 7 that have not already been handled above. The field names are the names listed in column one of the table. The value of each field is a new object value fully and recursively populated with property values as defined by the specification of each object in clauses 18-26. All object property values are newly created object values. All values that are built-in function objects are created by performing CreateBuiltinFunction(realmRec, <steps>, <prototype>, <slots>) where <steps> is the definition of that function provided by this specification, <prototype> is the specified value of the function’s [[Prototype]] internal slot and <slots> is a list of the names, if any, of the functions specified internal slots. The creation of the intrinsics and their properties must be ordered to avoid any dependencies upon objects that have not yet been created.
14. Return **intrinsics**.

### 8.2.3 SetRealmGlobalObj ( realmRec, globalObj ) Abstract Operation

The abstract operation SetRealmGlobalObj with arguments `realmRec` and `globalObj` performs the following steps:

1. If `globalObj` is **undefined**, then
   a. Let **intrinsics** be `realmRec.[[intrinsics]]`.
   b. Let `globalObj` be ObjectCreate(intrinsics.[[ObjectPrototype]]).
2. Assert: Type(`globalObj`) is Object.
3. Set `realmRec.[[globalThis]]` to `newGlobal`.
5. Set `realmRec.[[globalEnv]]` to `newGlobalEnv`.
6. Return `realmRec`.

### 8.2.4 SetDefaultGlobalBindings ( realmRec ) Abstract Operation

The abstract operation SetDefaultGlobalBindings with argument `realmRec` performs the following steps:

1. Let `global` be `realmRec.[[globalThis]]`.
2. For each property of the Global Object specified in clause 18, do
   a. Let `name` be the string value of the property name.
   b. Let `desc` be the fully populated data property descriptor for the property containing the specified attributes for the property. For properties whose values are functions, the value of the [[Value]] attribute is the corresponding intrinsic function object from `realmRec`.
   c. Let `status` be DefinePropertyOrThrow(global, name, desc).
   d. ReturnIfAbrupt(status).
3. Return `global`.
8.3 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 at least the state components listed in Table 23.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>code evaluation state</td>
<td>Any state needed to perform, suspend, and resume evaluation of the code associated with this execution context.</td>
</tr>
<tr>
<td>Function</td>
<td>If this execution context is evaluating the code of a function object, then the value of this component is that function object. If the context is evaluating the code of a Script or Module, the value is null.</td>
</tr>
<tr>
<td>Realm</td>
<td>The Realm from which associated code accesses ECMAScript resources.</td>
</tr>
</tbody>
</table>

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 and converted into an execution context, it becomes the running execution context and commences evaluating its code. At some later 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 of the Realm component of the running execution context is also called the current Realm. The value of the Function component of the running execution context is also called the active function object.

Execution contexts for ECMAScript code have the additional state components listed in Table 24.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>LexicalEnvironment</td>
<td>Identifies the Lexical Environment used to resolve identifier references made by code within this execution context.</td>
</tr>
<tr>
<td>VariableEnvironment</td>
<td>Identifies the Lexical Environment whose environment record holds bindings created by VariableStatements within this execution context.</td>
</tr>
</tbody>
</table>

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.
Execution contexts representing the evaluation of generator objects have the additional state components listed in Table 25.

Table 25 — Additional State Components for Generator Execution Contexts

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator</td>
<td>The GeneratorObject that this execution context is evaluating.</td>
</tr>
</tbody>
</table>

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.

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

8.3.1 ResolveBinding ( name ) Abstract Operation

The ResolveBinding abstract operation is used to determine the binding of name passed as a string value using the LexicalEnvironment of the running execution context. During execution of ECMAScript code, ResolveBinding is performed using the following algorithm:

1. Let env be the running execution context’s LexicalEnvironment.
2. If the syntactic production that is being evaluated is contained in strict mode code, let strict be true, else let strict be false.
3. Return GetIdentifierReference(env, name, strict).

NOTE The result of ResolveBinding is always a Reference value with its referenced name component equal to the name argument.

8.3.2 GetThisEnvironment () Abstract Operation

The abstract operation GetThisEnvironment finds the environment record 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, 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.

8.3.3 ResolveThisBinding () Abstract Operation

The abstract operation ResolveThisBinding determines the binding of the keyword this using the LexicalEnvironment of the running execution context. ResolveThisBinding performs the following steps:

1. Let envRec be GetThisEnvironment().
2. Return the result of calling the GetThisBinding concrete method of envRec.
8.3.4 GetNewTarget () Abstract Operation

The abstract operation GetNewTarget determines the NewTarget value using the LexicalEnvironment of the running execution context. GetNewTarget performs the following steps:

1. Let envRec be GetThisEnvironment().
2. Assert: envRec has a [[NewTarget]] field.
3. Return envRec. [[NewTarget]].

8.3.5 GetGlobalObject () Abstract Operation

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]].

8.4 Jobs and Job Queues

A Job is an abstract operation that initiates an ECMAScript computation when no other ECMAScript computation is currently in progress. A Job abstract operation may be defined to accept an arbitrary set of job parameters.

Execution of a Job can be initiated only when there is no running execution context and the execution context stack is empty. A PendingJob is a request for the future execution of a Job. A PendingJob is an internal Record whose fields are specified in Table 26. Once execution of a Job is initiated, the Job always executes to completion. No other Job may be initiated until the currently running Job completes. However, the currently running Job or external events may cause the enqueuing of additional PendingJobs that may be initiated sometime after completion of the currently running Job.

Table 26 — PendingJob Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Job]]</td>
<td>The name of a Job abstract operation</td>
<td>This is the abstract operation that is performed when execution of this PendingJob is initiated. Jobs are abstract operations that use NextJob rather than Return to indicate that they have completed.</td>
</tr>
<tr>
<td>[[Arguments]]</td>
<td>A List</td>
<td>The List of argument values that are to be passed to [[Job]] when it is activated.</td>
</tr>
<tr>
<td>[[Realm]]</td>
<td>A Realm Record</td>
<td>The Realm for the initial execution context when this Pending Job is initiated.</td>
</tr>
<tr>
<td>[[HostDefined]]</td>
<td>Any, default value is undefined</td>
<td>Field reserved for use by host environments that need to associate additional information with a pending Job.</td>
</tr>
</tbody>
</table>

A Job Queue is a FIFO queue of PendingJob records. Each Job Queue has a name and the full set of available Job Queues are defined by an ECMAScript implementation. Every ECMAScript implementation has at least the Job Queues defined in Table 27.

Deleted: &lt;#&gt;IsThisInitialized () Abstract Operation

The abstract operation IsThisInitialized determines whether the visible binding of this has been initialized:

1. Let envRec be GetThisEnvironment() if envRec is not a Function Environment Record, return true; otherwise, return the value of envRec. [[thisInitializationState]].

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### Table 27 — Required Job Queues

<table>
<thead>
<tr>
<th>Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ScriptJobs</td>
<td>Jobs that validate and evaluate ECMAScript Script and Module code units. See clauses 10 and 15.</td>
</tr>
<tr>
<td>PromiseJobs</td>
<td>Jobs that are responses to the settlement of a Promise (see 25.4).</td>
</tr>
</tbody>
</table>

A request for the future execution of a Job is made by enqueueing, on a Job Queue, a PendingJob record that includes a Job abstract operation name and any necessary argument values. When there is no running execution context and the execution context stack is empty, the ECMAScript implementation removes the first PendingJob from a Job Queue and uses the information contained in it to create an execution context and starts execution of the associated Job abstract operation.

The PendingJob records from a single Job Queue are always initiated in FIFO order. This specification does not define the order in which multiple Job Queues are serviced. An ECMAScript implementation may interweave the FIFO evaluation of the PendingJob records of a Job Queue with the evaluation of the PendingJob records of one or more other Job Queues. An implementation must define what occurs when there are no running execution context and all Job Queues are empty.

**NOTE** Typically an ECMAScript implementation will have its Job Queues pre-initialized with at least one PendingJob and one of those Jobs will be the first to be executed. An implementation might choose to free all resources and terminate if the current Job completes and all Job Queues are empty. Alternatively, it might choose to wait for a some implementation specific agent or mechanism to enqueue new PendingJob requests.

The following abstract operations are used to create and manage Jobs and Job Queues:

#### 8.4.1 EnqueueJob (queueName, job, arguments) Abstract Operation

The EnqueueJob abstract operation requires three arguments: `queueName`, `job`, and `arguments`. It performs the following steps:

1. Assert: Type(`queueName`) is String and its value is the name of a Job Queue recognized by this implementation.
2. Assert: `job` is the name of a Job.
3. Assert: `arguments` is a List that has the same number of elements as the number of parameters required by `job`.
4. Let `callerContext` be the running execution context.
5. Let `callerRealm` be `callerContext`'s Realm.
6. Let `pending` be PendingJob[ [[Job]]: `job`, [[Arguments]]: `arguments`, [[Realm]]: `callerRealm`, [[HostDefined]]: `undefined` ].
7. Perform any implementation or host environment defined processing of `pending`. This may including modify the [[HostDefined]] field or any other field of `pending`.
8. Add `pending` at the back of the Job Queue named by `queueName`.
9. Return NormalCompletion( empty).

#### 8.4.2 NextJob result

An algorithm step such as:

1. `NextJob result`.

is used in Job abstract operations in place of:
1. Return result.

Job abstract operations must not contain a Return step or a ReturnIfAbrupt step. The NextJob result operation is equivalent to the following steps:

1. If result is an abrupt completion, perform implementation defined unhandled exception processing.
2. Suspend the running execution context and remove it from the execution context stack.
3. Assert: The execution context stack is now empty.
4. Let nextQueue be a non-empty Job Queue chosen in an implementation defined manner. If all Job Queues are empty, the result is implementation defined.
5. Let nextPending be the PendingJob record at the front of nextQueue. Remove that record from nextQueue.
6. Let newContext be a new execution context.
7. Set newContext's Realm to nextPending.\[[Realm]\].
8. Push newContext onto the execution context stack; newContext is now the running execution context.
9. Perform any implementation or host environment defined job initialization using nextPending.
10. Perform the abstract operation named by nextPending.\[[Job]\] using the elements of nextPending.\[[Arguments]\] as its arguments.

8.5 Initialization

An ECMAScript implementation performs the following steps prior to the execution of any Jobs or the evaluation of any ECMAScript code:

1. Let realm be CreateRealm().
2. Let newContext be a new execution context.
3. Set the Function of newContext to null.
4. Set the Realm of newContext to realm.
5. Push newContext onto the execution context stack; newContext is now the running execution context.
6. Let status be InitializeFirstRealm(realm).
7. If status is an abrupt completion, then
   a. Assert: The first realm could not be created.
   b. Terminate ECMAScript execution.
8. In an implementation dependent manner, obtain the sourceCodeId strings (see 8.6.1) for zero or more ECMAScript scripts and/or ECMAScript modules. For each such sourceCodeId do,
   a. If the sourceCodeId identifies the source code of a script, then
      i. Let source be the SourceCharacter sequence of the script.
      ii. EnqueueJob("ScriptJobs", ScriptEvaluationJob, \"sourceCodeId\")
   b. Else the sourceCodeId identifies the source code of a module,
      i. EnqueueJob("ScriptJobs", ModuleEvaluationJob, \"sourceCodeId\")
9. NextJob NormalCompletion(\texttt{undefined}).

8.5.1 InitializeFirstRealm (realm) Abstract Operation

The abstract operation InitializeFirstRealm with parameter realm performs the following steps:

1. Let intrinsics be CreateIntrinsics(realm).
2. If this implementation requires use of an exotic object to serve as realm’s global object, let global be such an object created in an implementation defined manner. Otherwise, let global be \texttt{undefined} indicating that an ordinary object should be created as the global object.
3. Perform SetRealmGlobalObject(realm, global).
4. Let `globalObj` be `SetDefaultGlobalBindings(realm)`.  
5. `ReturnIfAbrupt(globalObj)`.  
6. Create any implementation defined global object properties on `globalObj`.  
7. `Return NormalCompletion(undefined)`.  

### 8.6 Host Provided Services

Host provided services are abstract operations used by this specification to access resources of the host environment within which an ECMAScript implementation is operating. The specific semantics must be defined by the ECMAScript implementation.

#### 8.6.1 HostGetSource (sourceCodeId) Abstract Operation

A `sourceCodeId` is a host defined string value that identifies a specific source code resource. The abstract operation `HostGetSource` retrieves the `SourceCharacter` sequence (see clause 10) that is identified by the `String` `sourceCodeId`. The returned value is the `SourceCharacter` sequence. If `sourceCodeId` does not identify a `SourceCharacter` sequence or if the `SourceCharacter` sequence cannot be retrieved an abrupt completion value is returned.

The argument value passed to this operation is a `sourceCodeId` that was previously either directly provided by the host or returned from the `HostNormalizeModuleName` abstract operation.

#### 8.6.2 HostNormalizeModuleName (unnormalizedName, referrerId) Abstract Operation

The abstract operation `HostNormalizeModuleName` translates an unnormalized module name string to a host defined `sourceCodeId` that can be used to retrieve the source code for the named module. `unnormalizedName` is a `String` and is the name to be normalized, `referrerId` is a `String` and is the host supplied `sourceCodeId` of the module that referenced `unnormalizedName`. The returned value is either a `String` or `undefined`. If `undefined` is returned, the name cannot be normalized to a `sourceCodeId` that is usable to retrieve source code.

A host must supply a stable mapping of unnormalized names to `sourceCodeIds`. Multiple successive calls to `HostNormalizeModuleName`, with the same arguments, must return the same `String` value.

Many different unnormalized names may be mapped to the same `sourceCodeId`. The actual normalization mapping is implementation defined but typically includes processes such as alphabetic case normalization and expansion of relative and abbreviated file system paths.

**NOTE** The `referrerId` argument is intended to support relative naming syntax that might be used within an unnormalized name. The actual relative naming semantic, if any, are host defined.

### 9 Ordinary and Exotic Objects Behaviours

#### 9.1 Ordinary Object Internal Methods and Internal Slots

All ordinary objects have an internal slot called `[[Prototype]]`. The value of this internal slot 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 object has a Boolean-valued `[[Extensible]]` internal slot that controls whether or not properties may be added to the object. If the value of the `[[Extensible]]` internal slot is `false` then additional properties may not be added to the object. In addition, if `[[Extensible]]` is `false` the value of the
The [[Prototype]] internal slot of the object may not be modified. Once the value of an object’s [[Extensible]] internal slot has been set to false it may not be subsequently changed to true.

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

9.1.1 [[GetPrototypeOf]] ( )

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

1. Return the value of the [[Prototype]] internal slot of O.

9.1.2 [[SetPrototypeOf]] (V)

When the [[SetPrototypeOf]] 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 slot of O.
3. Let current be the value of the [[Prototype]] internal slot of O.
4. If SameValue(V, current), return true.
5. If extensible is false, 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, return false.
      ii. Let nextp be the result of calling the [[GetPrototypeOf]] internal method of p with no arguments.
      iii. ReturnIfAbrupt(nextp).
      iv. Let p be nextp.
6. Let extensible be the value of the [[Extensible]] internal slot of O.
8. If extensible is false, then
   a. Let current2 be the value of the [[Prototype]] internal slot of O.
   b. If SameValue(V, current2) is true, return true.
   c. Return false.
9. Set the value of the [[Prototype]] internal slot of O to V.
10. Return true.

9.1.3 [[IsExtensible]] ( )

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

1. Return the value of the [[Extensible]] internal slot of O.

9.1.4 [[PreventExtensions]] ( )

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

1. Set the value of the [[Extensible]] internal slot of O to false.
2. Return true.
9.1.5  [[GetOwnProperty]] (P)

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

1. Return OrdinaryGetOwnProperty(\( O, P \)).

9.1.5.1  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
   a. Set \( D.[[Get]] \) to the value of \( X \)'s [[Get]] attribute.
   b. Set \( D.[[Set]] \) to the value of \( X \)'s [[Set]] attribute.
7. Set \( D.[[Enumerable]] \) to the value of \( X \)'s [[Enumerable]] attribute.
8. Set \( D.[[Configurable]] \) to the value of \( X \)'s [[Configurable]] attribute.
9. Return \( D \).

9.1.6  [[DefineOwnProperty]] (P, Desc)

When the [[DefineOwnProperty]] internal method of \( O \) is called with property key \( P \) and Property Descriptor \( Desc \), the following steps are taken:

1. Return OrdinaryDefineOwnProperty(\( O, P, Desc \)).

9.1.6.1  OrdinaryDefineOwnProperty (O, P, Desc)

When the abstract operation OrdinaryDefineOwnProperty is called with Object \( O \), property key \( P \), 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. ReturnIfAbrupt(\( current \)).
3. Let \( extensible \) be the value of the [[Extensible]] internal slot of \( O \).
4. Return ValidateAndApplyPropertyDescriptor(\( O, P, extensible, Desc, current \)).

9.1.6.2  IsCompatiblePropertyDescriptor (Extensible, Desc, Current)

When the abstract operation IsCompatiblePropertyDescriptor is called with Boolean value \( Extensible \), and Property Descriptors \( Desc \), and \( Current \) the following steps are taken:

1. Return ValidateAndApplyPropertyDescriptor(\( undefined, undefined, Extensible, Desc, Current \)).

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

When the abstract operation 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 \( \text{Desc} \) for specific values. The fields that are tested in this manner need not actually exist in \( \text{Desc} \). If a field is absent then its value is considered to be \texttt{false}.

**NOTE**: If \texttt{undefined} is passed as the \( O \) argument only validation is performed and no object updates are performed.

1. Assert: If \( O \) is not \texttt{undefined} then \( P \) is a valid property key.
2. If \( \text{current} \) is \texttt{undefined}, then
   a. If \( \text{extensible} \) is \texttt{false}, return \texttt{false}.
   b. Assert: \( \text{extensible} \) is \texttt{true}.
   c. If \texttt{IsGenericDescriptor(\( \text{Desc} \))} or \texttt{IsDataDescriptor(\( \text{Desc} \))} is \texttt{true}, then
      i. If \( O \) is not \texttt{undefined}, create an own data property named \( P \) of object \( O \) whose [[Value]], [[Writable]], [[Enumerable]] and [[Configurable]] attribute values are described by \( \text{Desc} \). If the value of an attribute field of \( \text{Desc} \) is absent, the attribute of the newly created property is set to its default value.
   d. Else \( \text{Desc} \) must be an accessor Property Descriptor,
      i. If \( O \) is not \texttt{undefined}, create an own accessor property named \( P \) of object \( O \) whose [[Get]], [[Set]], [[Enumerable]] and [[Configurable]] attribute values are described by \( \text{Desc} \). If the value of an attribute field of \( \text{Desc} \) is absent, the attribute of the newly created property is set to its default value.
   e. Return \texttt{true}.
3. Return \texttt{true}, if every field in \( \text{Desc} \) is absent.
4. Return \texttt{true}, if every field in \( \text{Desc} \) also occurs in \( \text{current} \) and the value of every field in \( \text{Desc} \) is the same value as the corresponding field in \( \text{current} \) when compared using the SameValue algorithm.
5. If the [[Configurable]] field of \( \text{current} \) is \texttt{false}, then
   a. Return \texttt{false}, if the [[Configurable]] field of \( \text{Desc} \) is \texttt{true}.
   b. Return \texttt{false}, if the [[Enumerable]] field of \( \text{Desc} \) is present and the [[Enumerable]] fields of \( \text{current} \) and \( \text{Desc} \) are the Boolean negation of each other.
6. If \texttt{IsGenericDescriptor(\( \text{Desc} \))} is \texttt{true}, no further validation is required.
7. Else if \texttt{IsDataDescriptor(\( \text{current} \))} and \texttt{IsDataDescriptor(\( \text{Desc} \))} have different results, then
   a. Return \texttt{false}, if the [[Configurable]] field of \( \text{current} \) is \texttt{false}.
   b. If \texttt{IsDataDescriptor(\( \text{current} \))} is \texttt{true}, then
      i. If \( O \) is not \texttt{undefined}, 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 \texttt{undefined}, 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 \texttt{IsDataDescriptor(\( \text{current} \))} and \texttt{IsDataDescriptor(\( \text{Desc} \))} are both \texttt{true}, then
   a. If the [[Configurable]] field of \( \text{current} \) is \texttt{false}, then
      i. Return \texttt{false}, if the [[Writable]] field of \( \text{current} \) is \texttt{false} and the [[Writable]] field of \( \text{Desc} \) is \texttt{true}.
      ii. If the [[Writable]] field of \( \text{current} \) is \texttt{false}, then
           i. Return \texttt{false}, if the [[Value]] field of \( \text{Desc} \) is present and \( \text{SameValue(\( \text{Desc}.[[\text{Value}]],\( \text{current}.[[\text{Value}]] \))} \) is \texttt{false}.
   b. Else the [[Configurable]] field of \( \text{current} \) is \texttt{true}, so any change is acceptable.
9. Else \texttt{IsAccessorDescriptor(\( \text{current} \))} and \texttt{IsAccessorDescriptor(\( \text{Desc} \))} are both \texttt{true}, then
   a. If the [[Configurable]] field of \( \text{current} \) is \texttt{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 field of `Desc` that is present, set the corresponding 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`.

9.1.7 `[[HasProperty]](P)`

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

1. Return `OrdinaryHasProperty(O, P)`.

9.1.7.1 `OrdinaryHasProperty(O, P)`

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

1. Assert: `IsPropertyKey(P)` is `true`.
2. Let `hasOwn` be `OrdinaryGetOwnProperty(O, P)`.
3. ReturnIfAbrupt(`hasOwn`).
4. If `hasOwn` is not `undefined`, return `true`.
5. Let `parent` be the result of calling the `[[GetPrototypeOf]]` internal method of `O`.
6. ReturnIfAbrupt(`parent`).
7. If `parent` is not `null`, then
   a. Return the result of calling the `[[HasProperty]]` internal method of `parent` with argument `P`.
8. Return `false`.

9.1.8 `[[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`.
3. ReturnIfAbrupt(`desc`).
4. If `desc` is `undefined`, then
   a. Let `parent` be the result of calling the `[[GetPrototypeOf]]` internal method of `O`.
   b. ReturnIfAbrupt(`parent`).
   c. If `parent` is `null`, 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 `Call(getter, Receiver)`. 
9.1.9 [[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: \( \text{IsPropertyKey}(P) \) is \( \text{true} \).
2. Let \( ownDesc \) be the result of calling the [[GetOwnProperty]] internal method of \( O \) with argument \( P \).
3. ReturnIfAbrupt(ownDesc).
4. If \( ownDesc \) is \( \text{undefined} \), then
   a. Let \( parent \) be the result of calling the [[PrototypeOf]] 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. Let \( ownDesc \) be the PropertyDescriptor{[[Value]]: \( \text{undefined} \), [[Writable]]: \( \text{true} \), [[Enumerable]]: \( \text{true} \), [[Configurable]]: \( \text{true} \) }.
5. If IsDataDescriptor(ownDesc) is \( \text{true} \), then
   a. If \( ownDesc \).[[Writable]] is \( \text{false} \), return \( \text{false} \).
   b. If Type(Receiver) is not Object, return \( \text{false} \).
   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 \( \text{undefined} \), then
      i. Let \( valueDesc \) be the PropertyDescriptor{[[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 CreateDataProperty(Receiver, \( P \), \( V \)).
6. Assert: \( \text{IsAccessorDescriptor}(ownDesc) \) is \( \text{true} \).
7. Let \( setter \) be ownDesc.[[Set]].
8. If \( setter \) is \( \text{undefined} \), return \( \text{false} \).
9. Let \( setterResult \) be Call(setter, Receiver, «\( V \)>>).
10. ReturnIfAbrupt(setterResult).
11. Return \( \text{true} \).

9.1.10 [[Delete]] (P)

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

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

9.1.11 [[Enumerate]] ()

When the [[Enumerate]] internal method of \( O \) is called the following steps are taken:
1. Return an Iterator object (25.1.1.2) whose `next` method iterates over all the String-valued keys of enumerable properties of `O`. The Iterator object must inherit from `%IteratorPrototype%` (25.1.2). The mechanics and order of enumerating the properties is not specified but must conform to the rules specified below.

The iterator’s `next` method processes object properties to determine whether the property key should be returned as an iterator value. Processed properties do not include properties whose property key is a Symbol. Properties of the object being enumerated may be deleted during enumeration. A property that is deleted before it is processed by the iterator’s `next` method is ignored. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be processed in the active enumeration. A property name will be returned by the iterator’s `next` method at most once in any enumeration.

Enumerating the properties of an object includes processing properties of its prototype, and the prototype of the prototype, and so on, recursively; but a property of a prototype is not processed if it has the same name as a property that has already been processed by the iterator’s `next` method. The values of `[[Enumerable]]` attributes are not considered when determining if a property of a prototype object has already been processed.

The following is an informative definition of an ECMAScript generator function that conforms to these rules:

```javascript
function* enumerate(obj) {
  if (Object(obj)!== obj) return undefined;
  let visited = new Set;
  while (obj !== null) {
    for (let name of Object.getOwnPropertyNames(obj)) {
      // any new properties added to obj by visitor are ignored.
      if (!visited.has(name)) {
        let desc = Object.getOwnPropertyDescriptor(obj,name);
        if (desc) {
          visited.add(name);
          if (desc.enumerable) yield name;
        }
      }
    }
    obj = Object.getPrototypeOf(obj);
  }
}
```

### 9.1.12 `[[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` that is an integer index, in ascending numeric index order
   a. Add `P` as the last element of `keys`.
3. For each own property key `P` of `O` that is a String but is not an integer index, in property creation order
   a. Add `P` as the last element of `keys`.
4. For each own property key `P` of `O` that is a Symbol, in property creation order
   a. Add `P` as the last element of `keys`.
5. Return `keys`.
9.1.13 ObjectCreate(proto, internalSlotsList) 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 internalSlotsList is a List of the names of additional internal slots that must 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. If internalSlotsList was not provided, let internalSlotsList be an empty List.
2. Let obj be a newly created object with an internal slot for each name in internalSlotsList.
3. Set obj’s essential internal methods to the default ordinary object definitions specified in 9.1.
4. Set the [[Prototype]] internal slot of obj to proto.
5. Set the [[Extensible]] internal slot of obj to true.
6. Return obj.

9.1.14 OrdinaryCreateFromConstructor (constructor, intrinsicDefaultProto, internalSlotsList)

The abstract operation OrdinaryCreateFromConstructor creates an ordinary object whose [[Prototype]] value is retrieved from a constructor’s prototype property, if it exists. Otherwise the intrinsic named by intrinsicDefaultProto is used for [[Prototype]]. The optional internalSlotsList is a List of the names of additional internal slots that must 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 GetPrototypeFromConstructor(constructor, intrinsicDefaultProto).
3. ReturnIfAbrupt(proto).
4. Return ObjectCreate(proto, internalSlotsList).

9.1.15 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 intrinsic named by intrinsicDefaultProto is used for [[Prototype]]. 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. Assert: IsConstructor(constructor) is true.
3. Let proto be Get(constructor, "prototype").
4. ReturnIfAbrupt(proto).
5. If Type(proto) is not Object, then
   a. Let realm be GetFunctionRealm(constructor).
   b. Let proto be realm’s intrinsic object named intrinsicDefaultProto.
6. Return proto.

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.

9.2 ECMAScript Function Objects

ECMAScript function objects encapsulate parameterized ECMAScript code closed over a lexical environment and support the dynamic evaluation of that code. An ECMAScript function object is an
ordinary object and has the same internal slots and (except as noted below) and the same internal methods as other ordinary objects. The code of an ECMAScript function object may be either strict mode code (10.2.1) or non-strict mode code.

ECMAScript function objects have the additional internal slots listed in Table 28.

ECMAScript function objects whose code is not strict mode code (10.2.1) provide an alternative definition for the [[GetOwnProperty]] internal method. This alternative prevents the value of strict mode function from being revealed as the value of a function object property named "caller". The alternative definition exist solely 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 this alternative internal method for ECMAScript function objects. ECMAScript function objects are considered to be ordinary objects even though they may use the alternative definition of [[GetOwnProperty]].

### Table 28 — Internal Slots of ECMAScript Function Objects

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Environment]]</td>
<td>Lexical Environment</td>
<td>The Lexical Environment that the function was closed over. Used as the outer environment when evaluating the code of the function.</td>
</tr>
<tr>
<td>[[FormalParameters]]</td>
<td>Parse Node</td>
<td>The root parse node of the source code that defines the function's formal parameter list.</td>
</tr>
<tr>
<td>[[FunctionKind]]</td>
<td>String</td>
<td>Either &quot;normal&quot;, &quot;classConstructor&quot; or &quot;generator&quot;.</td>
</tr>
<tr>
<td>[[ECMAScriptCode]]</td>
<td>Parse Node</td>
<td>The root parse node of the source code that defines the function's body.</td>
</tr>
<tr>
<td>[[ConstructorKind]]</td>
<td>String</td>
<td>Either &quot;base&quot; or &quot;derived&quot;.</td>
</tr>
<tr>
<td>[[Realm]]</td>
<td>Realm Record</td>
<td>The Code Realm in which the function was created and which provides any intrinsic objects that are accessed when evaluating the function.</td>
</tr>
<tr>
<td>[[ThisMode]]</td>
<td>(lexical, strict, global)</td>
<td>Defines how this references are interpreted within the formal parameters and code body of the function. lexical means that this refers to the this value of a lexically enclosing function. strict means that the this value is used exactly as provided by an invocation of the function. global means that a this value of undefined is interpreted as a reference to the global object.</td>
</tr>
<tr>
<td>[[Strict]]</td>
<td>Boolean</td>
<td>true if this is a strict mode function, false if this is not a strict mode function.</td>
</tr>
<tr>
<td>[[NeedsSuper]]</td>
<td>Boolean</td>
<td>true if this function uses super.</td>
</tr>
<tr>
<td>[[HomeObject]]</td>
<td>Object</td>
<td>If the function uses super, this is the object whose [[GetPrototypeOf]] provides the object where super property lookups begin.</td>
</tr>
</tbody>
</table>

All ECMAScript function objects have the [[Call]] internal method defined here. ECMAScript functions that are also constructors in addition have the [[Construct]] internal method. ECMAScript function objects whose code is not strict mode code have the [[GetOwnProperty]] internal method defined here.
9.2.1 [[GetOwnProperty]] (P)

When the [[GetOwnProperty]] internal method of a non-strict ECMAScript function object \( F \) is called with property key \( P \), the following steps are taken:

1. Let \( v \) be OrdinaryGetOwnProperty(\( F \), \( P \)).
2. If IsDataDescriptor(\( v \)) is true, then
   a. If \( P \) is "caller", then
      i. Let \( callerValue \) be \( v.\[[\text{Value}]\]\).
      ii. If \( callerValue \) is an ECMAScript Function object, then
         i. If \( callerValue \)’s [[Strict]] internal slot is true, set \( v.\[[\text{Value}]\] \) to null.
3. Return \( v \).

If an implementation extends non-strict ECMAScript function objects with a built-in caller own property then it must use this definition of [[GetOwnProperty]]. If an implementation does not provide such an extension, the ordinary object [[GetOwnProperty]] internal method must be used.

9.2.2 [[Call]] (thisArgument, argumentsList)

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

1. Assert: \( F \) is an ECMAScript function object.
2. If \( F \)’s [[FunctionKind]] internal slot is classConstructor, throw a TypeError exception.
3. Let callerContext be the running execution context.
4. Let calleeContext be PrepareForOrdinaryCall(\( F \), null).
5. ReturnIfAbrupt(calleeContext).
6. Let status be OrdinaryCallBindThis(\( F \), calleeContext, thisArgument).
7. 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.
8. Let result be OrdinaryCallEvaluateBody(\( F \), calleeContext, argumentsList).
9. Remove calleeContext from the execution context stack and restore callerContext as the running execution context.
10. If result.[[type]] is return, return NormalCompletion(result.[[value]])
11. ReturnIfAbrupt(result).
12. Return NormalCompletion(undefined).

NOTE When calleeContext is removed from the execution context stack in step 8 it must not be destroyed if it is suspended and retained for later resumption by an accessible generator object.

9.2.2.1 PrepareForOrdinaryCall (F, newTarget)

When the abstract operation PrepareForOrdinaryCall is called with function object \( F \) and ECMAScript language value newTarget, the following steps are taken:

1. Assert: Type(newTarget) is Undefined or Object.
2. Let callerContext be the running execution context.
3. If callerContext is not already suspended, Suspend callerContext.
4. Let calleeContext be a new ECMAScript Code execution context.
5. Set the Function of calleeContext to \( F \).
6. Let calleeRealm be the value of \( F \)’s [[Realm]] internal slot.
7. Set the Realm of calleeContext to calleeRealm.

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9.2.2.2 OrdinaryCallBindThis (F, calleeContext, thisArgument)

When the abstract operation OrdinaryCallBindThis is called with function object F, execution context calleeContext, and ECMAScript value thisArgument the following steps are taken:

1. Let thisMode be the value of F’s [[ThisMode]] internal slot.
2. If thisMode is lexical, return NormalCompletion(undefined).
3. Let calleeRealm be the value of F’s [[Realm]] internal slot.
4. Let localEnv be the LexicalEnvironment of calleeContext.
5. If thisMode is strict, let thisValue be thisArgument.
6. Else
   a. if thisArgument is null or undefined, then
      i. Let thisValue be calleeRealm.[[globalThis]].
   b. Else
      i. Let thisValue be ToObject(thisArgument).
      ii. Assert: thisValue is not an abrupt completion.
      iii. NOTE ToObject produces wrapper objects using calleeRealm.
7. Let envRec be localEnv’s environment record.
8. Return the result of calling the BindThisValue concrete method of envRec with argument thisValue.

9.2.2.3 OrdinaryCallEvaluateBody (F, calleeContext, argumentsList)

When the abstract operation OrdinaryCallEvaluateBody is called with function object F, execution context calleeContext, and List argumentsList the following steps are taken:

1. Let localEnv be the LexicalEnvironment of calleeContext.
2. Let status be the result of performing FunctionDeclarationInstantiation using the function F, argumentsList, and localEnv as described in 9.2.13.
3. IfReturnIfAbrupt(status).
4. Return the result of EvaluateBody of the production that is the value of F’s [[ECMAScriptCode]] internal slot passing F as the argument.

9.2.3 [[Construct]] (argumentsList, newTarget)

The [[Construct]] internal method for an ECMAScript Function object F is called with parameters argumentsList and newTarget. argumentsList is a possibly empty List of ECMAScript language values. The following steps are taken:

1. Assert: F is an ECMAScript function object.
2. Assert: Type(newTarget) is Object.
3. Let calleeContext be the running execution context.
4. Let kind be F’s [[ConstructKind]] internal slot.
5. If kind is “base”, then

NOTE: Any exception objects produced by NewFunctionEnvironment are associated with calleeContext.
9.2.4 FunctionAllocate (functionPrototype, strict [functionKind]) Abstract Operation

The abstract operation FunctionAllocate requires the two arguments functionPrototype and strict. It also 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", "non-constructor" or "generator".
3. If functionKind is not present, let functionKind be "normal".
4. If functionKind is "non-constructor", then
   a. Let functionKind be "normal".
   b. Let needsConstruct be false.
5. Else let needsConstruct be true.
6. Let F be a newly created ECMAScript function object with the internal slots listed in Table 28. All of those internal slots are initialized to undefined.
7. Set F’s [[GetOwnProperty]] internal method to the default ordinary object definitions specified in 9.1.
8. If strict is true, set F’s [[GetOwnProperty]] internal method to the default ordinary object definition specified in 9.1.5.
10. Set F’s [[Call]] internal method to the definition specified in 9.2.2.
11. If needsConstruct is true, then
    a. Set F’s [[Construct]] internal method to the definition specified in 9.2.3.
    b. If functionKind is "generator", set the [[ConstructorKind]] internal slot of F to "derived".
    c. Else, set the [[ConstructorKind]] internal slot of F to "base".
    d. NOTE Generator functions are tagged as "derived" constructors to prevent [[Construct]] from preallocating a generator instance. Generator instance objects are allocated when EvaluateBody is applied to the GeneratorBody of a generator function.
12. Set the [[Strict]] internal slot of F to strict.
13. Set the [[FunctionKind]] internal slot of F to functionKind.
14. Set the [[Prototype]] internal slot of F to functionPrototype.
15. Set the [[Extensible]] internal slot of F to true.
16. Set the [[Realm]] internal slot of F to the running execution context’s Realm.
17. Return F.

9.2.5 FunctionInitialize (F, kind, Strict, ParameterList, Body, Scope) Abstract Operation

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

1. Assert: F is an extensible object that does not have a length own property.
2. Let len be the ExpectedArgumentCount of ParameterList.
3. Let realm be the value of F’s [[Realm]] internal slot.
4. Let status be DefinePropertyOrThrow(F, "length", PropertyDescriptor{[[Value]]: len, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true}).
5. Assert: status is not an abrupt completion.
6. Set the [[Length]] internal slot of F to Strict.
7. Set the [[Environment]] internal slot of F to the value of Scope.
8. Set the [[FormalParameters]] internal slot of F to ParameterList.
9. Set the [[ECMAScriptCode]] internal slot of F to Body.
10. If kind is Arrow, set the [[ThisMode]] internal slot of F to lexical.
11. Else if Strict is true, set the [[ThisMode]] internal slot of F to strict.
12. Else set the [[ThisMode]] internal slot of F to global.
13. Return F.

9.2.6 FunctionCreate (kind, ParameterList, Body, Scope, Strict) Abstract Operation

The abstract operation FunctionCreate requires the arguments: kind which is one of (Normal, Method, Arrow), a 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. FunctionCreate performs the following steps:

1. If the functionPrototype argument was not passed, then
   a. Let functionPrototype be the intrinsic object %FunctionPrototype%.
2. If kind is not Normal, let allocKind be "non-constructor".
3. Else let allocKind be "normal".
4. Let F be FunctionAllocate(functionPrototype, Strict, allocKind).
5. Return FunctionInitialize(F, kind, Strict, ParameterList, Body, Scope).

9.2.7 GeneratorFunctionCreate (kind, ParameterList, Body, Scope, Strict) Abstract Operation

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

1. Let functionPrototype be the intrinsic object %Generator%.
2. Let F be FunctionAllocate(functionPrototype, Strict, "generator").
3. Return FunctionInitialize(F, kind, Strict, ParameterList, Body, Scope).
9.2.8 AddRestrictedFunctionProperties (F, realm) Abstract Operation

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

1. Assert: realm.[[intrinsic]].[[%ThrowTypeError%]] exists and has been initialized.
2. Let thrower be realm.[[intrinsic]].[[%ThrowTypeError%]].
3. Let status be DefinePropertyOrThrow(F, "caller", PropertyDescriptor [[Get]: thrower, [[Configurable]]: true]).
4. Assert: status is not an abrupt completion.
5. Return DefinePropertyOrThrow(F, "arguments", PropertyDescriptor [[Get]: thrower, [[Configurable]]: true]).
6. Assert: The above returned value is not an abrupt completion.

9.2.8.1 %ThrowTypeError%()

The %ThrowTypeError% intrinsic is an anonymous built-in function object that is defined once for each Realm. When %ThrowTypeError% is called it performs the following steps:

1. Throw a TypeError exception.

The value of the [[Extensible]] internal slot of a %ThrowTypeError% function is false.

The length property of a %ThrowTypeError% function has the attributes {[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}.

9.2.9 MakeConstructor (F, writablePrototype, prototype) 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. Assert: F is an ECMA-Script function object.
2. Assert: F has a [[Constructor]] internal method.
3. Assert: F is an extensible object that does not have a prototype own property.
4. Assert: If the prototype argument was provided it is an extensible object that does not have a constructor own property.
5. Let installNeeded be false.
6. If the prototype argument was not provided, then
   a. Let installNeeded be true.
   b. Let prototype be ObjectCreate(%ObjectPrototype%).
7. If the writablePrototype argument was not provided, then
   a. Let writablePrototype be true.
8. If installNeeded, then
   a. Let status be DefinePropertyOrThrow(prototype, "constructor", PropertyDescriptor [[Value]: F, [[Writable]]: writablePrototype, [[Enumerable]]: false, [[Configurable]]: writablePrototype)).
   b. Assert: status is not an abrupt completion.
9. Let status be DefinePropertyOrThrow(F, "prototype", PropertyDescriptor [[Value]: prototype, [[Writable]]: writablePrototype, [[Enumerable]]: false, [[Configurable]]: false)).
10. Assert: status is not an abrupt completion.
11. Return NormalCompletion(undefined).
9.2.10 MakeClassConstructor (F) Abstract Operation

The abstract operation MakeClassConstructor with argument F performs the following steps:

1. Assert: F is an ECMAScript function object.
2. Assert: F’s [[FunctionKind]] internal slot is “normal”.
3. Set F’s [[FunctionKind]] internal slot to “classConstructor”.
4. Return NormalCompletion(undefined).

9.2.11 MakeMethod (F, homeObject) Abstract Operation

The abstract operation MakeMethod with arguments F and homeObject configures F as a method by performing the following steps:

1. Assert: F is an ECMAScript function object.
2. Assert: Type(homeObject) is either Undefined or Object.
3. Set the [[NeedsSuper]] internal slot of F to true.
4. Set the [[HomeObject]] internal slot of F to homeObject.
5. Return NormalCompletion(undefined).

9.2.12 SetFunctionName (F, name, prefix) Abstract Operation

The abstract operation SetFunctionName requires a Function argument F, a String or Symbol argument name and optionally a String argument prefix. This operation adds a name property to F by performing the following steps:

1. Assert: F is an extensible object that does not have a name own property.
2. Assert: Type(name) is either Symbol or String.
3. Assert: If prefix was passed then Type(prefix) is String.
4. If Type(name) is Symbol, then
   a. Let description be name’s [[Description]] value.
   b. If description is undefined, let name be the empty String.
   c. Else, let name be the concatenation of “ “, description, and “ “.
5. If prefix was passed, then
   a. Let name be the concatenation of prefix, Unicode code point U+0020 (Space), and name.
6. Return DefinePropertyOrThrow(F, “name”, PropertyDescriptor{[[Value]]: name, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true}).
7. Assert: the result is never an abrupt completion.

9.2.13 FunctionDeclarationInstantiation(func, argumentsList, env) Abstract Operation

NOTE When an execution context is established for evaluating an ECMAScript function a new Function Environment Record is created and bindings for each formal parameter are instantiated in that environment record. Each declaration in the function body is also instantiated. If the function’s formal parameters do not include any default value initializers then the body declarations are instantiated in the same environment record as the parameters. If default value parameter initializers exist, a second environment record is created for the body declarations. Formal parameters and functions are initialized as part of FunctionDeclarationInstantiation. All other bindings are initialized during evaluation of the function body.

FunctionDeclarationInstantiation 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 lexical environment in which formal parameter bindings are to be created.

Deleted: <#> CloneMethod(function, newHome, newName) Abstract Operation

The abstract operation CloneMethod is called with a function object function, and an object newHome, and a property key newName as its arguments. It performs the following steps:

1. Assert: function is an ECMAScript function object or an exotic Built-in function object.
2. Assert: Type(newHome) is Object.
3. Assert: Type(newName) is one of Undefined, String, or Symbol.
4. If function is an ECMAScript function, then
   a. Let new be a new ECMAScript function object that has all of the same internal methods and internal slots as function.
   b. Else
      a. Let new be an exotic Built-in function object.
      b. If newName is symbol, then
         a. Set new’s [[Extensible]] internal slot to true.
      c. Else, Let new be a new exotic Built-in function object that has all of the same internal methods and internal slots as function.
      d. If the value of each of new’s internal slots, except for [[NeedsSuper]], and [[HomeObject]], and [[MethodName]] to the value of function’s corresponding internal slot.
      e. Else
         a. Set new’s [[Extensible]] internal slot to true.
         b. If the value of function’s [[NeedsSuper]] internal slot is true, then
            a. Set the value of new’s [[HomeObject]] internal slot to newHome.
            b. If newName is not undefined, then
               a. Set the value of new’s [[MethodName]] internal slot to newName.
               b.Else
                  a. Set the value of new’s [[MethodName]] internal slot to the value of function’s [[MethodName]] internal slot.
                  b. If function is an exotic Built-in function object or if function’s [[Strict]] internal slot is true, then
                     a. Let realm be GetFunctionRealm(new’s [[Realm]] internal slot).
                     b. Let status be AddRestrictedFunctionProperties(new, realm).
                     c. ReturnIfAbrupt(status).
                     d. Else
                        a. Set new’s [[NeedsSuper]] internal slot to true.
                        b. If the value of each of new’s internal slots, except for its identity and the value of its [[HomeObject]] internal slot, is always except for its identity and the value of its [[HomeObject]] internal slot, however, own properties of the argument function object, except for the restricted function properties, are not created or copied.

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1. Let envRec be env’s environment record.
2. Let calleeContext be the running execution context.
3. Let code be the value of the [[ECMAScriptCode]] internal slot of func.
4. Let strict be the value of the [[Strict]] internal slot of func.
5. Let formals be the value of the [[FormalParameters]] internal slot of func.
6. Let parameterNames be the BoundNames of formals.
7. If parameterNames has any duplicate entries, let hasDuplicates be true. Otherwise, let hasDuplicates be false.
8. Let simpleParameterList be IsSimpleParameterList of formals.
9. Let hasParameterExpressions be ContainsExpression of formals.
10. Let varNames be the VarDeclaredNames of code.
11. Let varDeclarations be the VarScopedDeclarations of code.
12. Let lexicalNames be the LexicallyDeclaredNames of code.
13. Let functionNames be an empty List.
14. Let functionsToInitialize be an empty List.
15. For each d in varDeclarations, in reverse list order do
   a. If d is neither a VariableDeclaration or a ForBinding, then
      i. Assert: d is either a FunctionDeclaration or a GeneratorDeclaration.
      ii. Let fn be the sole element of the BoundNames of d.
      iii. If fn is not an element of functionNames, then
         1. Insert fn as the first element of functionNames.
         2. NOTE If there are multiple FunctionDeclarations or GeneratorDeclarations for the same name, the last declaration is used.
         3. Insert d as the first element of functionsToInitialize.
16. Let argumentsObjectNeeded be true.
17. If the value of the [[ThisMode]] internal slot of func is lexical, then
   a. NOTE Arrow functions never have an arguments object.
   b. Let argumentsObjectNeeded be false.
18. Else if “arguments” is an element of parameterNames, then
   a. Let argumentsObjectNeeded be false.
19. Else if hasParameterExpressions is false, then
   a. If “arguments” is an element of functionNames or if “arguments” is an element of lexicalNames, then
      i. Let argumentsObjectNeeded be false.
20. For each String paramName in parameterNames, do
   a. Let alreadyDeclared be the result of calling envRec’s HasBinding concrete method passing paramName as the argument.
   b. NOTE Early errors ensure that duplicate parameter names can only occur in non-strict functions that do not have parameter default values or rest parameters.
   c. If alreadyDeclared is false, then
      i. Let status be the result of calling envRec’s CreateMutableBinding concrete method passing paramName as the argument.
      ii. If hasDuplicates is true, then
         1. Let status be the result of calling envRec’s InitializeBinding concrete method passing paramName and undefined as the argument.
         iii. Assert: status is never an abrupt completion for either of the above operations.
21. If argumentsObjectNeeded is true, then
   a. If strict is true or if simpleParameterList is false, then
      i. Let ao be CreateUnmappedArgumentsObject(argumentsList).
   b. Else,
      i. NOTE mapped argument object is only provided for non-strict functions that don’t have a rest parameter, any parameter default value initializers, or any destructured parameters.
      ii. Let ao be CreateMappedArgumentsObject(func, formals, argumentsList, env).
c. ReturnIfAbrupt(ao).

d. If strict is true, then
   i. Let status be the result of calling envRec’s CreateImmutableBinding concrete method
      passing "arguments" as the argument.
   Else,
   i. Let status be the result of calling envRec’s CreateMutableBinding concrete method passing
      "arguments" as the argument.
   f. Assert: status is never an abrupt completion.
   g. Call envRec’s InitializeBinding concrete method passing "arguments" and ao as arguments.

22. If hasDuplicates is true, then
   a. Let formalStatus be the result of performing IteratorBindingInitialization for formals with
      CreateListIterator(argumentsList) and undefined as arguments.
   Else,
   a. Let formalStatus be the result of performing IteratorBindingInitialization for formals with
      CreateListIterator(argumentsList) and envRec as arguments.
   23. ReturnIfAbrupt(formalStatus).

24. If hasParameterExpressions is false, then
   a. NOTE Only a single lexical environment is needed for the parameters and top-level vars.
   b. Let instantiatedVarNames be a copy of the List parameterNames.
   c. For each n in varNames, do
      i. If n is not an element of instantiatedVarNames, then
         1. Append n to instantiatedVarNames.
         2. Let status be the result of calling envRec’s CreateMutableBinding concrete method
            passing n as the argument.
         3. Assert: status is never an abrupt completion.
         4. Call envRec’s InitializeBinding concrete method passing n and undefined as arguments.
      d. Let varEnv be env.
      e. Let varEnvRec be envRec.
   26. Else,
      a. NOTE A separate environment record is needed to ensure that closures created by expressions
         in the formal parameter list do not have visibility of declarations in the function body.
      b. Let varEnv be NewDeclarativeEnvironment(env).
      c. Let varEnvRec be varEnv’s environment record.
      d. Set the VariableEnvironment of calleeContext to varEnv.
      e. Let instantiatedVarNames be a new emptyList.
      f. For each n in varNames, do
         i. If n is not an element of instantiatedVarNames, then
            1. Append n to instantiatedVarNames.
            2. Let status be the result of calling varEnvRec’s CreateMutableBinding concrete method
               passing n as the argument.
            3. Assert: status is never an abrupt completion.
            4. If n is not an element of parameterNames or if n is an element of functionNames, let
               initialValue be undefined.
            5. Else,
               a. Let initialValue be the result of calling envRec’s GetBindingValue concrete
                  method passing n and false as the arguments.
               b. ReturnIfAbrupt(initialValue).
            6. Call varEnvRec’s InitializeBinding concrete method passing n and initialValue as arguments.
      7. NOTE vars whose names are the same as a formal parameter, initially have the same
         value as the corresponding initialized parameter.
27. If `strict` is `false`, then
   a. Let `lexEnv` be `NewDeclarativeEnvironment(varEnv)`.
   b. NOTE: Non-strict functions use a separate lexical environment record for top-level
      lexical declarations so that a direct `eval` (see 12.3.4.1) can determine whether any var-
      scoped declarations introduced by the eval code conflict with pre-existing top-level
      lexically scoped declarations. This is not needed for strict functions because a strict
      direct `eval` always places all declarations into a new environment record.

28. Else, let `lexEnv` be `varEnv`.
29. Let `lexEnvRec` be `lexEnv`'s environment record.
30. Set `envRec.[[topLex]]` to `lexEnvRec`.
31. Set the LexicalEnvironment of `calleeContext` to `lexEnv`.
32. Let `lexDeclarations` be the LexicallyScopedDeclarations of `code`.
33. For each element `d` in `lexDeclarations` do
   a. NOTE A lexically declared name cannot be the same as a function/generator 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. Let `status` be the result of calling `lexEnvRec`'s `CreateImmutableBinding` concrete
            method passing `dn` and `true` as the arguments.
      ii. Else,
         1. Let `status` be the result of calling `lexEnvRec`'s `CreateMutableBinding` concrete
            method passing `dn` and `false` as the arguments.
   c. Assert: `status` is never an abrupt completion.
34. 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 `lexEnv`.
   c. Let `status` be the result of calling `varEnvRec`'s `SetMutableBinding` concrete method passing `fn`,
      `fo` and `false` as the arguments.
   d. Assert: `status` is never an abrupt completion.
35. Return `NormalCompletion(empty)`.

NOTE  B.3.2 provides an extension to the above algorithm that is necessary for backwards compatibility with
web browser implementations of ECMAScript that predate the sixth edition of ECMA-262.

9.3 Built-in Function Objects

The built-in function objects defined in this specification may be implemented as either ECMAScript
function objects (9.3) 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 conform to their specifications. An implementation may also provide additional
built-in function objects that are not defined in this specification.

If a built-in function object is implemented as an exotic object it must have the ordinary object behaviour
specified in 9.1 except `[[GetOwnProperty]]` which must be as specified in 9.2.1. All such exotic function
objects also have `[[Prototype]]`, `[[Extensible]]`, and `[[Realm]]` internal slots.

Unless otherwise specified every built-in function object initially has the `%FunctionPrototype%` object
(19.2.3) as the initial value of its `[[Prototype]]` internal slot.

The behaviour specified for each built-in function via algorithm steps or other means is the specification of
the function body behaviour for both `[[Call]]` and `[[Construct]]` invoking of the function. For each built-in
function, when invoked with `[[Call]]`, the `[[Call]]` thisArgument provides the this value, the `[[Call]]`
argumentsList provides the named parameters, and the NewTarget value is **undefined.** When invoked with

[[Construct]], the this value is uninitialized, the [[Construct]] argumentsList provides the named parameters,

and the [[Construct]] newTarget parameter provides the NewTarget value. If the built-in function is

implemented as an ECMAScript function object then this specified behaviour must be implemented by the

ECMAScript code that is the body of the function. Built-in functions that are ECMAScript function objects

must be strict mode functions. If a built-in constructor has any [[Call]] behaviour other than throwing a

TypeError exception, an ECMAScript implementation of the function must be done in a manner that does

not cause the function’s [FunctionKind] internal slot to have the value "classConstructor".

Built-in function objects that are not identified as constructors do not implement the [[Construct]] internal

method unless otherwise specified in the description of a particular function. When a built-in constructor is
called as part of a new expression the argumentsList parameter of the invoked [[Construct]] internal

method provides the values for the built-in constructor’s named parameters.

Built-in functions that are not constructors do not have a prototype property unless otherwise specified
in the description of a particular function.

If a built-in function object is not implemented as an ECMAScript function it must provide [[Call]] and

[[Construct]] internal methods that conforms to the following definitions:

### 9.3.1 [[Call]] (thisArgument, argumentsList)

The [[Call]] internal method for a built-in 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, suspend callerContext.
3. Let calleeContext be a new execution context.
4. Set the Function of calleeContext to F.
5. Let calleeRealm be the value of F’s [[Realm]] internal slot.
6. Set the Realm of calleeContext to calleeRealm.
7. Perform any necessary implementation defined initialization of calleeContext.
8. Push calleeContext onto the execution context stack; calleeContext is now the running execution

context.
9. Let result be the Completion Record that is the result of evaluating F in an implementation defined

manner that conforms to the specification of F. thisArgument is the this value, argumentsList

provides the named parameters, and the NewTarget value is **undefined.**
10. Remove calleeContext from the execution context stack and restore callerContext as the running

execution context.
11. Return result.

NOTE 1. When calleeContext is removed from the execution context stack it must not be destroyed if it has been

suspended and retained by an accessible generator object for later resumption.

### 9.3.2 [[Construct]] (argumentsList, newTarget)

The [[Construct]] internal method for built-in function object F is called with parameters argumentsList and

newTarget. The steps performed as the same as [[Call]] (see 9.3.1) except that step 9 is replaced by:

9. Let result be the Completion Record that is the result of evaluating F in an implementation defined

manner that conforms to the specification of F. The this value is uninitialized, argumentsList

provides the named parameters, and newTarget provides the NewTarget value.
9.3.3 CreateBuiltinFunction(realm, steps, prototype, internalSlotsList) Abstract Operation

The abstract operation CreateBuiltinFunction takes arguments realm, prototype, and steps. The optional argument internalSlotsList is a List of the names of additional internal slot that must be defined as part of the object. If the list is not provided, an empty List is used. CreateBuiltinFunction returns a built-in function object created by the following steps:

1. Assert: realm is a Realm Record.
2. Assert: steps is either a set of algorithm steps or other definition of a functions behaviour provided in this specification.
3. Let func be a new built-in function object that when called performs the action described by steps.
   The new function object has internal slots whose names are the elements of internalSlotsList. The initial value of each of those internal slots is undefined.
4. Set the [[Realm]] internal slot of func to realm.
5. Set the [[Prototype]] internal slot of func to prototype.
6. Return func.

9.4 Built-in Exotic Object Internal Methods and Slots

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:

9.4.1 Bound Function Exotic Objects

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

Bound function objects do not have the internal slots of ECMAScript function objects defined in Table 28. Instead they have the internal slots defined in Table 29.

Table 29 — Internal Slots of Exotic Bound Function Objects

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[BoundTargetFunction]]</td>
<td>Callable Object</td>
<td>The wrapped function object.</td>
</tr>
<tr>
<td>[[BoundThis]]</td>
<td>Any</td>
<td>The value that is always passed as the this value when calling the wrapped function.</td>
</tr>
<tr>
<td>[[BoundArguments]]</td>
<td>List of Any</td>
<td>A list of values whose elements are used as the first arguments to any call to the wrapped function.</td>
</tr>
</tbody>
</table>

Unlike ECMAScript function objects, bound function objects do not use an alternative definition of the [[GetOwnProperty]] internal methods. Bound function objects provide all of the essential internal methods as specified in 9.1. However, they use the following definitions for the essential internal methods of function objects.

9.4.1.1 [[Call]] (thisArgument, argumentsList)

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 target be the value of F’s [[BoundTargetFunction]] internal slot.

Deleted: <#>Let boundArgs be the value of F’s [[BoundArguments]] internal slot;
2. Let `boundThis` be the value of `F`’s `[[BoundThis]]` internal slot.
3. Let `boundArgs` be the value of `F`’s `[[BoundArguments]]` internal slot.
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 `Call(target, boundThis, args)`.

9.4.1.2 `[[Construct]]`(argumentsList, newTarget)

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 `argumentsList` and `newTarget`, the following steps are taken:

1. Let `target` be the value of `F`’s `[[BoundTargetFunction]]` internal slot.
2. Assert: `target` has a `[[Construct]]` internal method.
3. Let `boundArgs` be the value of `F`’s `[[BoundArguments]]` internal slot.
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. If `SameValue(F, newTarget)` is true, let `newTarget` be `target`.
6. Return `Construct(target, args, newTarget)`.

9.4.1.3 `BoundFunctionCreate`(targetFunction, boundThis, boundArgs)

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 object.
3. Set `obj`’s essential internal methods to the default ordinary object definitions specified in 9.1.
4. Set the `[[Call]]` internal method of `obj` as described in 9.4.1.1.
5. If `targetFunction` has a `[[Construct]]` internal method, then
   a. Set the `[[Construct]]` internal method of `obj` as described in 9.4.1.2.
6. Set the `[[Prototype]]` internal slot of `obj` to `proto`.
7. Set the `[[Extensible]]` internal slot of `obj` to `true`.
8. Set the `[[BoundTargetFunction]]` internal slot of `obj` to `targetFunction`.
9. Set the `[[BoundThis]]` internal slot of `obj` to the value of `boundThis`.
10. Set the `[[BoundArguments]]` internal slot of `obj` to `boundArgs`.
11. Return `obj`.

9.4.1.4 `BoundFunctionClone`(function)

The abstract operation `BoundFunctionClone` is called with argument `function` it performs the following steps:

1. Assert: `function` is a Bound Function exotic object.
2. Let `new` be a new Bound Function exotic object that has all of the same internal methods and internal slots as `function`.
3. Set the value of each of `new`’s internal slots, except for `[[Extensible]]` to the value of `function`’s corresponding internal slot.
4. Set `new`’s `[[Extensible]]` internal slot to `true`.
5. Return `new`.

9.4.2 Array Exotic Objects

An Array object is an exotic object that gives special treatment to array index property keys (see 6.1.7). 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 own property whose name is an array index; whenever an own property of an Array object is created or changed, other properties are adjusted as necessary to maintain this invariant. Specifically, whenever an own property is added whose name is an array index, the value of the **length** property is changed, if necessary, to be one more than the numeric value of that array index; and whenever the value of the **length** property is changed, every own property whose name is an array index whose value is not smaller than the new length is 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.

NOTE A String property name $P$ is an array index if and only if $\text{ToString(ToUint32(P))}$ is equal to $P$ and $\text{ToUint32(P)}$ is not equal to $2^{32}-1$.

Array exotic objects always have a non-configurable property named "**length**".

Array exotic objects provide an alternative definition for the [[DefineOwnProperty]] internal method. Except for that internal method, Array exotic objects provide all of the other essential internal methods as specified in 9.1.

### 9.4.2.1 [[DefineOwnProperty]] (P, Desc)

When the [[DefineOwnProperty]] internal method of an Array exotic object $A$ is called with property key $P$, and Property Descriptor $\text{Desc}$ the following steps are taken:

1. Assert: $\text{IsPropertyKey(P)}$ is true.
2. If $P$ is **"length"**, then
   a. Return $\text{ArraySetLength}(A, \text{Desc})$.
3. Else if $P$ is an array index, then
   a. Let $\text{oldLenDesc}$ be $\text{OrdinaryGetOwnProperty}(A, \text{"length"})$.
   b. Assert: $\text{oldLenDesc}$ will never be **undefined** or an accessor descriptor because Array objects are created with a length data property that cannot be deleted or reconfigured.
   c. Let $\text{oldLen}$ be $\text{oldLenDesc}.\text{[[Value]]}$.
   d. Let $\text{index}$ be $\text{ToUint32(P)}$.
   e. Assert: $\text{index}$ will never be an abrupt completion.
   f. If $\text{index} \geq \text{oldLen}$ and $\text{oldLenDesc}.\text{[[Writable]]}$ is false, return false.
   g. Let $\text{succeeded}$ be $\text{OrdinaryDefineOwnProperty}(A, P, \text{Desc})$.
   h. Assert: $\text{succeeded}$ is not an abrupt completion.
   i. If $\text{succeeded}$ is false, return false.
   j. If $\text{index} \geq \text{oldLen}$.
      i. Set $\text{oldLenDesc}.\text{[[Value]]}$ to $\text{index} + 1$.
      ii. Let $\text{succeeded}$ be $\text{OrdinaryDefineOwnProperty}(A, \text{"length"}, \text{oldLenDesc})$.
   k. Assert: $\text{succeeded}$ is true.
4. Return true.

### 9.4.2.2 ArrayCreate(length, proto) Abstract Operation

The abstract operation ArrayCreate with argument $\text{length}$ (a positive integer) and optional argument $\text{proto}$ is used to specify the creation of new Array exotic objects. It performs the following steps:

1. Assert: $\text{length}$ is an integer Number $\geq 0$.
2. If $\text{length}$ is $-0$, let $\text{length}$ be $+0$.
3. If $\text{length} > 2^{32}-1$, throw a **RangeError** exception.
4. If the `proto` argument was not passed, let `proto` be the intrinsic object `%ArrayPrototype%.
5. Let `A` be a newly created Array exotic object.
6. Set `A`'s essential internal methods except for [[DefineOwnProperty]] to the default ordinary object definitions specified in 9.1.
7. Set the [[DefineOwnProperty]] internal method of `A` as specified in 9.4.2.1.
8. Set the [[Prototype]] internal slot of `A` to `proto`.
9. Set the [[Extensible]] internal slot of `A` to `true`.
10. Call OrdinaryDefineOwnProperty with arguments `A`, "length" and Property Descriptor{[[Value]]: length, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false}.
11. Return `A`.

9.4.2.3 ArraySpeciesCreate(originalArray, length) Abstract Operation

The abstract operation ArraySpeciesCreate with arguments `originalArray` and `length` is used to specify the creation of a new Array object using a constructor function that is derived from `originalArray`. It performs the following steps:

1. Assert: `length` is an integer Number ≥ 0.
2. If `length` is −0, let `length` be +0.
3. Let `C` be undefined.
4. If IsArray(`originalArray`) is true, then
   a. Let `C` be Get(`originalArray`, "constructor").
   b. ReturnIfAbrupt(`C`).
   c. If IsConstructor(`C`) is true, then
      i. Let `thisRealm` be the running execution context’s Realm.
      ii. Let `realmC` be GetFunctionRealm(`C`).
      iii. If `thisRealm` and `realmC` are not the same Realm Record, then
         i. If SameValue(`C`, `realmC`. [%intrinsic%]. [%Array%]) is true, let `C` be undefined.
   d. If Type(`C`) is Object, then
      i. Let `C` be Get(`C`, @@species).
      ii. ReturnIfAbrupt(`C`).
5. If `C` is undefined, return ArrayCreate(`length`).
6. If IsConstructor(`C`) is false, throw a TypeError exception.

NOTE: If `originalArray` was created using the standard built-in Array constructor for a Realm that is not the Realm of the running execution context, then a new Array is created using the Realm of the running execution context. This maintains compatibility with Web browsers that have historically had that behaviour for the Array prototype methods that now are defined using ArraySpeciesCreate.

9.4.2.4 ArraySetLength(A, Desc) Abstract Operation

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

1. If the [[Value]] field of `Desc` is absent, then
2. Let `newLenDesc` be a copy of `Desc`.
3. Let `newLen` be ToUint32(`Desc`. [[Value]]).
4. ReturnIfAbrupt(`newLen`).
5. Let `numberLen` be ToNumber(`Desc`. [[Value]]).
6. ReturnIfAbrupt(`newLen`).
7. If `newLen` ≠ `numberLen` throw a RangeError exception.
8. Set `newLenDesc`.[[Value]] to `newLen`.
9. Let `oldLenDesc` be `OrdinaryGetOwnProperty(A, "length")`.
10. Assert: `oldLenDesc` is not an abrupt completion.
11. Assert: `oldLenDesc` will never be `undefined` or an accessor descriptor because Array objects are created with a length data property that cannot be deleted or reconfigured.
12. Let `oldLen` be `oldLenDesc`.[[Value]].
13. If `newLen` ≥ `oldLen`, then
   a. Return `OrdinaryDefineOwnProperty(A, "length", newLenDesc)`.
14. If `oldLenDesc`.[[Writable]] is `false`, return `false`.
15. If `newLenDesc`.[[Writable]] is absent or has the value `true`, let `newWritable` be `true`.
16. 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`.
17. Let `succeeded` be `OrdinaryDefineOwnProperty(A, "length", newLenDesc)`.
18. If `succeeded` is `false`, return `false`.
19. 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. Assert: `deleteSucceeded` is not an abrupt completion.
   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 `OrdinaryDefineOwnProperty(A, "length", newLenDesc)`.
   e. Assert: `succeeded` is not an abrupt completion.
   f. Return `false`.
20. If `newWritable` is `false`, then
    a. Return `OrdinaryDefineOwnProperty(A, "length", PropertyDescriptor{[[Writable]]: false})`.
    This call will always return `true`.

NOTE In steps 3 and 4, if `Desc`.[[Value]] is an object then its `valueOf` method is called twice. This is legacy behaviour that was specified with this effect starting with the 2nd Edition of this specification.

### 9.4.3 String Exotic Objects

A `String` object is an exotic object that encapsulates a String value and exposes virtual integer indexed 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 slots as ordinary objects. They also have a `[[StringData]]` internal slot.

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 9.1.
9.4.3.1 \texttt{[[GetOwnProperty]]}(P)

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

1. Assert: \(\text{IsPropertyKey}(P)\) is \texttt{true}.
2. Let \(\text{desc} \) be \text{OrdinaryGetOwnProperty}(S, \(P\)).
3. If \(\text{desc} \) is not \texttt{undefined} return \(\text{desc} \).
4. Return \text{StringGetIndexProperty}(S, \(P\)).

9.4.3.1.1 \texttt{StringGetIndexProperty}(S, P)

When the abstract operation \texttt{StringGetIndexProperty} is called with an exotic String object \(S\) and with property key \(P\), the following steps are taken:

1. If \(\text{Type}(P)\) is not String, return \texttt{undefined}.
2. Let \(\text{index} \) be \texttt{CanonicalNumericIndexString}(\(P\)).
3. Assert: \(\text{index}\) is not an abrupt completion.
4. If \(\text{index} \) is \texttt{undefined}, return \texttt{undefined}.
5. If \(\text{IsInteger}(\text{index})\) is \texttt{false}, return \texttt{undefined}.
6. If \(\text{index} = -0\), return \texttt{undefined}.
7. Let \(\text{str} \) be the String value of the \texttt{[[StringData]]} internal slot of \(S\).
8. Let \(\text{len} \) be the number of elements in \(\text{str}\).
9. If \(\text{index} < 0\) or \(\text{len} \leq \text{index}\), return \texttt{undefined}.
10. Let \(\text{resultStr} \) be a String value of length 1, containing one code unit from \(\text{str}\), specifically the code unit at index \(\text{index}\).
11. Return a PropertyDescriptor:\{ \texttt{[[Value]]}: \(\text{resultStr} \), \texttt{[[Enumerable]]}: \texttt{true}, \texttt{[[Writable]]}: \texttt{false}, \texttt{[[Configurable]]}: \texttt{false} \}.

9.4.3.2 \texttt{[[HasProperty]]}(P)

When the \texttt{[[HasProperty]]} internal method of an exotic String object \(S\) is called with property key \(P\), the following steps are taken:

1. Let \(\text{hasOrdinary} \) be \text{OrdinaryHasProperty}(S, \(P\)).
2. If \(\text{hasOrdinary} \) is \texttt{true}, return \texttt{true}.
3. Let \(\text{desc} \) be \text{StringGetIndexProperty}(S, \(P\)).
4. If \(\text{desc} \) is \texttt{undefined}, return \texttt{false}; otherwise, return \texttt{true}.

9.4.3.3 \texttt{[[Enumerate]]}()

When the \texttt{[[Enumerate]]} internal method of an exotic String object \(O\) is called the following steps are taken:

1. Let \(\text{indexKeys} \) be a new empty List.
2. Let \(\text{str} \) be the String value of the \texttt{[[StringData]]} internal slot of \(O\).
3. Let \(\text{len} \) be the number of elements in \(\text{str}\).
4. For each integer \(i\) starting with 0 such that \(i < \text{len}\), in ascending order,
   a. Add \(\text{ToString}(i)\) as the last element of \(\text{indexKeys}\)
5. Let \(\text{ordinary} \) be the result of calling the default ordinary object \texttt{[[Enumerate]]} internal method (9.1.11) on \(O\).
6. ReturnIfAbrupt(\(\text{ordinary}\)).
7. Return \text{CreateCompoundIterator}(\text{CreateListIterator}(\text{indexKeys}), \text{ordinary}).
9.4.3.4 [[OwnPropertyKeys]]()

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

1. Let keys be a new empty List.
2. Let str be the String value of the [[StringData]] internal slot of O.
3. Let len be the number of elements in str.
4. For each integer i starting with 0 such that $i < len$, in ascending order,
   a. Add ToString(i) as the last element of keys
5. For each own property key $P$ of O such that $P$ is an integer index and ToInteger($P$) ≥ len, in ascending numeric index order,
   a. Add P as the last element of keys.
6. For each own property key $P$ of O such that Type($P$) is String and $P$ is not an integer index, in property creation order,
   a. Add P as the last element of keys.
7. Return keys.

9.4.3.5 StringCreate(value, prototype) Abstract Operation

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

1. ReturnIfAbrupt(prototype).

2. Assert: Type(value) is String.
3. Let S be a newly created String exotic object.
4. Set the [[StringData]] internal slot of S to value.
5. Set the [[GetOwnProperty]] internal method of S as specified in 9.4.3.1.
6. Set the [[Enumerate]] internal method of S as specified in 9.4.3.2.
7. Set the [[OwnPropertyKeys]] internal method of S as specified in 9.4.3.3.
8. Set the [[Prototype]] internal slot of S to prototype.
9. Set the [[Extensible]] internal slot of S to true.
10. Let length be the number of code unit elements in value.
11. Let status be DefinePropertyOrThrow(S, "length", PropertyDescriptor{[[Value]]: length, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}).
12. Assert: status is not an abrupt completion.
13. Return S.

9.4.4 Arguments Exotic Objects

Most ECMAScript functions make an arguments objects available to their code. Depending upon the characteristics of the function definition, its argument object is either an ordinary object or an arguments exotic object. An arguments exotic object is an exotic object whose array index properties map to the formal parameters bindings of an invocation of its associated ECMAScript function.

Arguments exotic objects have the same internal slots as ordinary objects. They also have a [[ParameterMap]] internal slot. Ordinary arguments objects also have a [[ParameterMap]] internal slot whose value is always undefined. For ordinary argument objects the [[ParameterMap]] internal slot is only used by Object.prototype.toString (19.1.3.6) to identify them as such.
Arguments exotic 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 9.1

**NOTE 1** For non-strict mode functions the integer indexed 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 observable 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.

### 9.4.4.1 [[GetOwnProperty]] (P)

The [[GetOwnProperty]] internal method of an arguments exotic object when called with a property name P performs the following steps:

1. Let args be the arguments object.
2. Let desc be OrdinaryGetOwnProperty(args, P).
3. If desc is undefined, return desc.
4. Let map be the value of the [[ParameterMap]] internal slot of the arguments object.
5. Let isMapped be HasOwnProperty(map, P).
6. Assert: isMapped is never an abrupt completion.
7. If the value of isMapped is true, then
   a. Set desc.[[Value]] to Get(map, P).
8. If IsDataDescriptor(desc) is true and P is "caller" and desc.[[Value]] is a strict mode Function object, throw a TypeError exception.
9. Return desc.

If an implementation does not provide a built-in caller property for argument exotic objects then step 8 of this algorithm is must be skipped.

### 9.4.4.2 [[DefineOwnProperty]] (P, Desc)

The [[DefineOwnProperty]] internal method of an arguments exotic object when called with a property name P and Property Descriptor Desc performs the following steps:

1. Let args be the arguments object.
2. Let map be the value of the [[ParameterMap]] internal slot of the arguments object.
3. Let isMapped be HasOwnProperty(map, P).
4. Let allowed be OrdinaryDefineOwnProperty(args, P, Desc).
5. ReturnIfAbrupt(allowed).
6. If allowed is false, return false.
7. If the value of `isMapped` is `true`, 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. Let `putStatus` be `Put(map, P, Desc.[[Value]], false)`.
         2. Assert: `putStatus` is `true` because formal parameters mapped by argument objects are always writable.
      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.
8. Return `true`.

9.4.4.3 `[[Get]] (P, Receiver)`

The `[[Get]]` internal method of an arguments exotic object when called with a property name `P` and ECMAScript language value `Receiver` performs the following steps:

1. Let `args` be the arguments object.
2. Let `map` be the value of the `[[ParameterMap]]` internal slot of the arguments object.
3. Let `isMapped` be `HasOwnProperty(map, P)`.
4. Assert: `isMapped` is not an abrupt completion.
5. If the value of `isMapped` is `false`, then
   a. Let `v` be the result of calling the default ordinary object `[[Get]]` internal method (9.1.8) on `args` passing `P` and `Receiver` as the arguments.
6. Else `map` contains a formal parameter mapping for `P`,
   a. Let `v` be `Get(map, P)`.
7. ReturnIfAbrupt(`v`).
8. Return `v`.

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

The `[[Set]]` internal method of an arguments exotic object when called with property key `P`, value `V`, and ECMAScript language value `Receiver` performs the following steps:

1. Let `args` be the arguments object.
2. If `SameValue(args, Receiver)` is `false`, then
   a. Let `isMapped` be `undefined`.
3. Else,
   a. Let `map` be the value of the `[[ParameterMap]]` internal slot of the arguments object.
   b. Let `isMapped` be `HasOwnProperty(map, P)`.
   c. Assert: `isMapped` is not an abrupt completion.
4. If the value of `isMapped` is `false`, then
   a. Return the result of calling the default ordinary object `[[Set]]` internal method (9.1.9) on `args` passing `P`, `V` and `Receiver` as the arguments.
5. Else `map` contains a formal parameter mapping for `P`,
   a. Return `Put(map, P, V, false)`.

9.4.4.5 `[[Delete]] (P)`

The `[[Delete]]` internal method of an arguments exotic object when called with a property key `P` performs the following steps:

1. Let `map` be the value of the `[[ParameterMap]]` internal slot of the arguments object.
2. Let isMapped be HasOwnProperty(map, P).
3. Assert: isMapped is not an abrupt completion.
4. Let result be the result of calling the default [[Delete]] internal method for ordinary objects (9.1.10) on the arguments object passing P as the argument.
5. ReturnIfAbrupt(result).
6. If result is true and the value of isMapped is true, then
   a. Call the [[Delete]] internal method of map passing P as the argument.
7. Return result.

9.4.4.6 CreateUnmappedArgumentsObject(ArgumentsList) Abstract Operation

The abstract operation CreateUnmappedArgumentsObject called with an argument argumentsList performs the following steps:

1. Let len be the number of elements in argumentsList.
2. Let obj be ObjectCreate(%ObjectPrototype%, %[[ParameterMap]]%).
3. Set obj’s [[ParameterMap]] internal slot to undefined.
4. Perform DefinePropertyOrThrow(obj, "length", PropertyDescriptor(%[[Value]]: len, %[[Writable]]: true, %[[Enumerable]]: false, %[[Configurable]]: true)).
5. Let index be 0.
6. Repeat while index < len,
   a. Let val be the element of argumentsList[index].
   b. Perform CreateDataProperty(obj, ToString(index), val).
   c. Let index be index + 1
7. Perform DefinePropertyOrThrow(obj, @@iterator, PropertyDescriptor(%[[Value]]: %ArrayProto_values%, %[[Writable]]: true, %[[Enumerable]]: false, %[[Configurable]]: true)).
8. Perform DefinePropertyOrThrow(obj, "callee", PropertyDescriptor(%[[Get]]: %ThrowTypeError%, %[[Set]]: %ThrowTypeError%, %[[Enumerable]]: false, %[[Configurable]]: false)).
9. Perform DefinePropertyOrThrow(obj, "calleee", PropertyDescriptor(%[[Get]]: %ThrowTypeError%, %[[Set]]: %ThrowTypeError%, %[[Enumerable]]: false, %[[Configurable]]: false)).
10. Assert: the above property definitions will not produce an abrupt completion.
11. Return obj

9.4.4.7 CreateMappedArgumentsObject (func, formals, argumentsList, env) Abstract Operation

The abstract operation CreateMappedArgumentsObject is called with object func, grammar production formals, List argumentsList, and environment record env. The following steps are performed:

1. Assert: formals does not contain a rest parameter, any binding patterns, or any initializers. It may contain duplicate identifiers.
2. Let len be the number of elements in argumentsList.
3. Let obj be a newly created arguments exotic object with a [[ParameterMap]] internal slot.
4. Set the [[GetOwnProperty]] internal method of obj as specified in 9.4.4.1.
5. Set the [[DefineOwnProperty]] internal method of obj as specified in 9.4.4.2.
6. Set the [[Get]] internal method of obj as specified in 9.4.4.3.
7. Set the [[Set]] internal method of obj as specified in 9.4.4.4.
8. Set the [[Delete]] internal method of obj as specified in 9.4.4.5.
9. Set the remainder of obj’s essential internal methods to the default ordinary object definitions specified in 9.1.
10. Set the [[Prototype]] internal slot of obj to %ObjectPrototype%.
11. Set the [[Extensible]] internal slot of obj to true.
12. Let `parameterNames` be the `BoundNames of formals`.
13. Let `numberOfParameters` be the number of elements in `parameterNames`.
14. Let `index` be 0.
15. Repeat while `index < len`:
   a. Let `val` be the element of `argumentsList[index]`.
   b. Perform `CreateDataProperty(obj, ToString(index), val)`.
   c. Let `index` be `index + 1`.
16. Perform `DefinePropertyOrThrow(obj, "length", PropertyDescriptor{[[Value]]: len, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true})`.
17. Let `map` be `ObjectCreate(null)`.
18. Let `mappedNames` be an empty `List`.
19. Let `index` be `numberOfParameters - 1`.
20. Repeat while `index ≥ 0`:
   a. Let `name` be the element of `parameterNames[index]`.
   b. If `name` is not an element of `mappedNames`, then
      i. Add `name` as an element of the list `mappedNames`.
      ii. If `index < len`, then
          1. Let `g` be `MakeArgGetter(name, env)`.
          2. Let `p` be `MakeArgSetter(name, env)`.
          3. Call the `[[DefineOwnProperty]]` internal method of `map` passing `ToString(index)` and the `PropertyDescriptor{[[Set]]: p, [[Get]]: g, [[Enumerable]]: false, [[Configurable]]: true}` as arguments.
   c. Let `index` be `index - 1`.
21. Set the `[[ParameterMap]] internal slot of `obj` to `map`.
22. Perform `DefinePropertyOrThrow(obj, @@iterator, PropertyDescriptor{[[Value]]: %ArrayProto_values%, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true})`.
23. Perform `DefinePropertyOrThrow(obj, "callee", PropertyDescriptor{[[Value]]: func, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true})`.
24. Assert: the above property definitions will not produce an abrupt completion.
25. Return `obj`.

### 9.4.4.7.1 MakeArgGetter (name, env) Abstract Operation

The abstract operation `MakeArgGetter` called with `String name` and `environment record env` creates a built-in function object that when executed returns the value bound for `name` in `env`. It performs the following steps:

1. Let `realm` be the current Realm.
2. Let `steps` be the steps of an ArgGetter function as specified below.
3. Let `getter` be `CreateBuiltInFunction(realm, steps, %FunctionPrototype%, «[name], [env]»)`.
4. Set `getter`'s `[[name]]` internal slot to `name`.
5. Set `getter`'s `[[env]]` internal slot to `env`.
6. Return `getter`.

An ArgGetter function is an anonymous built-in function with `[[name]]` and `[[env]]` internal slots. When an ArgGetter function `f` that expects no arguments is called it performs the following steps:

1. Let `name` be the value of `f`'s `[[name]]` internal slot.
2. Let `env` be the value of `f`'s `[[env]]` internal slot.
3. Return the result of calling the `GetBindingValue` concrete method of `env` with arguments `name` and `false`.

**NOTE** ArgGetter functions are never directly accessible to ECMAScript code.
9.4.4.7.2 MakeArgSetter (name, env) Abstract Operation

The abstract operation MakeArgSetter called with String name and environment record env creates a built-in function object that when executed sets the value bound for name in env. It performs the following steps:

1. Let realm be the current Realm.
2. Let steps be the steps of an ArgSetter function as specified below.
3. Let setter be CreateBuiltinFunction(realm, steps, %FunctionPrototype%, «[[name]], [[env]]»).
4. Set setter’s [[name]] internal slot to name.
5. Set setter’s [[env]] internal slot to env.
6. Return setter.

An ArgSetter function is an anonymous built-in function with [[name]] and [[env]] internal slots. When an ArgSetter function f is called with argument value it performs the following steps:

1. Let name be the value of f’s [[name]] internal slot.
2. Let env be the value of f’s [[env]] internal slot.
3. Return the result of calling the SetMutableBinding concrete method of env with arguments name, value, and false.

NOTE ArgSetter functions are never directly accessible to ECMAScript code.

9.4.5 Integer Indexed Exotic Objects

An Integer Indexed object is an exotic object that performs special handling of integer index property keys.

Integer Indexed exotic objects have the same internal slots as ordinary objects additionally [[ViewedArrayBuffer]], [[ArrayLength]], [[ByteOffset]], and [[TypedArrayName]] internal slots.

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 9.1.

9.4.5.1 [[GetOwnProperty]] (P)

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

1. Assert: IsPropertyKey(P) is true.
2. Assert: O is an Object that has a [[ViewedArrayBuffer]] internal slot.
3. If Type(P) is String, then
   a. Let numericIndex be CanonicalNumericIndexString(P).
   b. Assert: numericIndex is not an abrupt completion.
   c. If numericIndex is not undefined, then
      i. Let value be IntegerIndexedElementGet(O, numericIndex).
      ii. ReturnIfAbrupt(value).
      iii. If value is undefined, return undefined.
      iv. Return a PropertyDescriptor{ [[Value]]: value, [[Enumerable]]: true, [[Writable]]: true, [[Configurable]]: false }.
4. Return OrdinaryGetOwnProperty(O, P).
9.4.5.2 [[HasProperty]](P)

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

1. Assert: IsPropertyKey(P) is true.
2. Assert: O is an Object that has a [[ViewedArrayBuffer]] internal slot.
3. If Type(P) is String, then
   a. Let numericIndex be CanonicalNumericIndexString(P).
   b. Assert: numericIndex is not an abrupt completion.
   c. If numericIndex is not undefined, then
      i. Let buffer be the value of O's [[ViewedArrayBuffer]] internal slot.
      ii. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
      iii. If IsInteger(index) is false, return false.
      iv. If index = −0, return false.
      v. Return true.
4. Return OrdinaryHasProperty(O, P).

9.4.5.3 [[DefineOwnProperty]] (P, Desc)

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

1. Assert: IsPropertyKey(P) is true.
2. Assert: O is an Object that has a [[ViewedArrayBuffer]] internal slot.
3. If Type(P) is String, then
   a. Let numericIndex be CanonicalNumericIndexString(P).
   b. Assert: numericIndex is not an abrupt completion.
   c. If numericIndex is not undefined, then
      i. If IsInteger(numericIndex) is false, return false.
      ii. Let intIndex be numericIndex.
      iii. If intIndex = −0, return false.
      iv. If intIndex < 0, return false.
      v. Let length be the value of O's [[ArrayLength]] internal slot.
      vi. If intIndex ≥ length, return false.
      vii. If IsAccessorDescriptor(Desc) is true, return false.
      viii. If Desc has a [[Configurable]] field and if Desc.[[Configurable]] is true, return false.
      ix. If Desc has an [[Enumerable]] field and if Desc.[[Enumerable]] is false, return false.
      x. If Desc has a [[Writable]] field and if Desc.[[Writable]] is false, return false.
      xi. If Desc has a [[Value]] field, then
         1. Let value be Desc.[[Value]].
         2. Let status be IntegerIndexedElementSet(O, intIndex, value).
         3. ReturnIfAbrupt(status).
      xii. Return true.
4. Return OrdinaryDefineOwnProperty(O, P, Desc).

9.4.5.4 [[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. Assert: IsPropertyKey(P) is true.
2. If Type(P) is String and if SameValue(O, Receiver) is true, then
   a. Let numericIndex be CanonicalNumericIndexString(P).
b. Assert: \( numericIndex \) is not an abrupt completion.

   c. If \( numericIndex \) is not \( undefined \), then
      i. Return \( \text{IntegerIndexedElementGet}(O, numericIndex) \).

3. Return the result of calling the default ordinary object \([\text{Get}]\) internal method (9.1.8) on \( O \) passing \( P \) and \( Receiver \) as arguments.

### 9.4.5.5 \([\text{Set}]\) (\( P, V, Receiver \))

When the \([\text{Set}]\) internal method of an Integer Indexed exotic object \( O \) is called with property key \( P \), value \( V \), and ECMAScript language value \( Receiver \), the following steps are taken:

1. Assert: \( \text{IsPropertyKey}(P) \) is \( true \).
2. If Type(\( P \)) is String and if SameValue(\( O, Receiver \)) is \( true \), then
   a. Let \( numericIndex \) be CanonicalNumericIndexString(\( P \)).
   b. Assert: \( numericIndex \) is not an abrupt completion.
   c. If \( numericIndex \) is not \( undefined \), then
      i. Return \( \text{IntegerIndexedElementSet}(O, numericIndex, V) \).
3. Return the result of calling the default ordinary object \([\text{Set}]\) internal method (9.1.8) on \( O \) passing \( P, V, \) and \( Receiver \) as arguments.

### 9.4.5.6 \([\text{Enumerate}]\) ()

When the \([\text{Enumerate}]\) internal method of an Integer Indexed exotic object \( O \) is called the following steps are taken:

1. Let \( indexKeys \) be a new empty List.
2. Assert: \( O \) is an Object that has \([\text{ViewedArrayBuffer}]\), \([\text{ArrayLength}]\), \([\text{ByteOffset}]\), and \([\text{TypedArrayName}]\) internal slots.
3. Let \( len \) be the value of \( O \)'s \([\text{ArrayLength}]\) internal slot.
4. For each integer \( i \) starting with 0 such that \( i < len \), in ascending order,
   a. Add \( \text{ToString}(i) \) as the last element of \( indexKeys \).
5. Let \( ordinary \) be the result of calling the default ordinary object \([\text{Enumerate}]\) internal method (9.1.11) on \( O \).
6. ReturnIfAbrupt(\( ordinary \)).
7. Return \( \text{CreateCompoundIterator}(\text{CreateListIterator}(indexKeys), ordinary) \).

### 9.4.5.7 \([\text{OwnPropertyKeys}]\) ()

When the \([\text{OwnPropertyKeys}]\) internal method of an Integer Indexed exotic object \( O \) is called the following steps are taken:

1. Let \( keys \) be a new empty List.
2. Assert: \( O \) is an Object that has \([\text{ViewedArrayBuffer}]\), \([\text{ArrayLength}]\), \([\text{ByteOffset}]\), and \([\text{TypedArrayName}]\) internal slots.
3. Let \( len \) be the value of \( O \)'s \([\text{ArrayLength}]\) internal slot.
4. For each integer \( i \) starting with 0 such that \( i < len \), in ascending order,
   a. Add \( \text{ToString}(i) \) as the last element of \( keys \).
5. For each own property key \( P \) of \( O \) such that Type(\( P \)) is String and \( P \) is not an integer index, in property creation order
   a. Add \( P \) as the last element of \( keys \).
6. For each own property key \( P \) of \( O \) such that Type(\( P \)) is Symbol, in property creation order
   a. Add \( P \) as the last element of \( keys \).
7. Return keys.

9.4.5.8 IntegerIndexedObjectCreate (prototype, internalSlotsList) Abstract Operation

The abstract operation IntegerIndexedObjectCreate with arguments prototype and internalSlotsList is used to specify the creation of new Integer Indexed exotic objects. The argument internalSlotsList is a List of the names of additional internal slots that must be defined as part of the object. IntegerIndexedObjectCreate performs the following steps:

1. Let A be a newly created object with an internal slot for each name in internalSlotsList.
2. Set A’s essential internal methods to the default ordinary object definitions specified in 9.1.
3. Set the [[GetOwnProperty]] internal method of A as specified in 9.4.5.2.
4. Set the [[Set]] internal method of A as specified in 9.4.5.3.
5. Set the [[Enumerate]] internal method of A as specified in 9.4.5.4.
6. Set the [[Prototype]] internal slot of A to prototype.
7. Set the [[Extensible]] internal slot of A to true.
8. Return A.

9.4.5.9 IntegerIndexedElementGet (O, index) Abstract Operation

The abstract operation IntegerIndexedElementGet with arguments O and index performs the following steps:

1. Assert: Type(index) is Number.
2. Assert: O is an Object that has [[ViewedArrayBuffer]], [[ArrayLength]], [[ByteOffset]], and [[TypedArrayName]] internal slots.
3. Let buffer be the value of O’s [[ViewedArrayBuffer]] internal slot.
4. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
5. If IsInteger(index) is false, return undefined.
6. If index = 0, return undefined.
7. Let length be the value of O’s [[ArrayLength]] internal slot.
8. If index < 0 or index ≥ length, return undefined.
9. Let offset be the value of O’s [[ByteOffset]] internal slot.
10. Let arrayTypeName be the string value of O’s [[TypedArrayName]] internal slot.
11. Let elementSize be the Number value of the Element Size value specified in Table 46 for arrayTypeName.
12. Let indexedPosition = (index × elementSize) + offset.
13. Let elementType be the string value of the Element Type value in Table 46 for arrayTypeName.

9.4.5.10 IntegerIndexedElementSet (O, index, value) Abstract Operation

The abstract operation IntegerIndexedElementSet with arguments O, index, and value performs the following steps:

1. Assert: Type(index) is Number.
2. Assert: O is an Object that has [[ViewedArrayBuffer]], [[ArrayLength]], [[ByteOffset]], and [[TypedArrayName]] internal slots.
3. Let numValue be ToNumber(value).
4. ReturnIfAbrupt(numValue).
5. Let buffer be the value of O’s [[ViewedArrayBuffer]] internal slot.
6. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
7. If `IsInteger(index)` is `false`, return `false`.
8. If `index = -0`, return `false`.
9. Let `length` be the value of `O`'s `[[ArrayLength]]` internal slot.
10. If `index < 0` or `index ≥ length`, return `false`.
11. Let `offset` be the value of `O`'s `[[ByteOffset]]` internal slot.
12. Let `arrayTypeName` be the string value of `O`'s `[[TypedArrayName]]` internal slot.
13. Let `elementSize` be the Number value of the Element Size value specified in Table 46 for `arrayTypeName`.
15. Let `elementType` be the string value of the Element Type value in Table 46 for `arrayTypeName`.
16. Let `status` be `SetValueInBuffer(buffer, indexedPosition, elementType, numValue)`.
17. ReturnIfAbrupt(`status`).
18. Return `true`.

### 9.4.6 Module Namespace Exotic Objects

A *module namespace object* is an exotic object that exposes the bindings exported from an ECMAScript `Module` (See 15.2.3). There is a one-to-one correspondence between the String-keyed own properties of a module namespace exotic object and the binding names exported by the `Module`. The exported bindings include any bindings that are indirectly exported using `export *` export items. Each String-valued own property key is the StringValue of the corresponding exported binding name. These are the only String-keyed properties of a module namespace exotic object. Each such property has the attributes `[[Configurable]]: false, [[Enumerable]]: true`. Module namespace objects are not extensible.

Module namespace objects have the internal slots defined in Table 30.

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Module]]</code></td>
<td>Module Record</td>
<td>The Module Record whose exports this namespace exposes.</td>
</tr>
<tr>
<td><code>[[Exports]]</code></td>
<td>List of String</td>
<td>A List containing the String values of the exported names exposed as own properties of this object. The list is ordered as if an Array of those string values had been sorted using <code>Array.prototype.sort</code> using SortCompare as comparefn.</td>
</tr>
</tbody>
</table>

Module namespace exotic objects provide alternative definitions for all of the internal methods.

#### 9.4.6.1 `[[GetPrototypeOf]]()`

When the `[[GetPrototypeOf]]` internal method of a module namespace exotic object `O` is called the following steps are taken:

1. Return `null`.

#### 9.4.6.2 `[[SetPrototypeOf]](V)`

When the `[[SetPrototypeOf]]` internal method of a module namespace exotic 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`.
9.4.6.3 [[IsExtensible]] ( )

When the [[IsExtensible]] internal method of a module namespace exotic object \( O \) is called the following steps are taken:

1. Return false.

9.4.6.4 [[PreventExtensions]] ( )

When the [[PreventExtensions]] internal method of a module namespace exotic object \( O \) is called the following steps are taken:

1. Return true.

9.4.6.5 [[GetOwnProperty]] (P)

When the [[GetOwnProperty]] internal method of a module namespace exotic object \( O \) is called with property key \( P \), the following steps are taken:

1. If Type(\( P \)) is Symbol, return OrdinaryGetOwnProperty(\( O \), \( P \)).
2. Throw a TypeError exception.

9.4.6.6 [[DefineOwnProperty]] (P, Desc)

When the [[DefineOwnProperty]] internal method of a module namespace exotic object \( O \) is called with property key \( P \) and Property Descriptor \( Desc \), the following steps are taken:

1. Return false.

9.4.6.7 [[HasProperty]] (P)

When the [[HasProperty]] internal method of a module namespace exotic object \( O \) is called with property key \( P \), the following steps are taken:

1. If Type(\( P \)) is Symbol, return OrdinaryHasProperty(\( O \), \( P \)).
2. Let \( exports \) be the value of \( O \)'s [[Exports]] internal slot.
3. If \( P \) is an element of \( exports \), return true.
4. Return false.

9.4.6.8 [[Get]] (P, Receiver)

When the [[Get]] internal method of a module namespace exotic 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 Type(\( P \)) is Symbol, then
   a. Return the result of calling the default ordinary object [[Get]] internal method (9.1.8) on \( O \) passing \( P \) and \( Receiver \) as arguments.
3. Let \( exports \) be the value of \( O \)'s [[Exports]] internal slot.
4. If \( P \) is not an element of \( exports \), return undefined.
5. Let \( m \) be the value of \( O \)'s [[Module]] internal slot.
6. Let binding be ResolveExport(\( m \), \( P \), «»).
7. If binding is an abrupt completion, then
   a. Assert: The binding for \( P \) exported by the module is ambiguous.
   b. Throw a ReferenceError exception.

Deleted: <#>Let realm be value of \( O \)'s [[Realm]] internal slot
8. Let \( binding \) be \( binding.[[value]] \).
9. Assert: \( binding \) is not \( null \).
10. Let \( targetModule \) be \( binding.[[module]] \).
11. Assert: \( targetModule \) is not \( undefined \).
12. Let \( targetEnvRec \) be \( targetModule.[[Environment]] \)’s environment record.
13. Return the result of calling the GetBindingValue concrete method of \( targetEnvRec \) with arguments \( binding.[[bindingName]] \) and \( true \).

NOTE ResolveExport is idempotent and side-effect free. An implementation might choose to pre-compute or cache the ResolveExport results for the [[Exports]] of each module namespace exotic object.

9.4.6.9 [[Set]] ( \( P, V, Receiver \))

When the [[Set]] internal method of a module namespace exotic object \( O \) is called with property key \( P \), value \( V \), and ECMAScript language value \( Receiver \), the following steps are taken:

1. Return \( false \).

9.4.6.10 [[Delete]] ( \( P \))

When the [[Delete]] internal method of a module namespace exotic object \( O \) is called with property key \( P \) the following steps are taken:

1. Assert: IsPropertyKey(\( P \)) is \( true \).
2. Let \( exports \) be the value of \( O \)’s [[Exports]] internal slot.
3. If \( P \) is an element of \( exports \), return \( false \).
4. Return \( true \).

9.4.6.11 [[Enumerate]] ()

When the [[Enumerate]] internal method of a module namespace exotic object \( O \) is called the following steps are taken:

1. Let \( exports \) be the value of \( O \)’s [[Exports]] internal slot.
2. Return CreateListIterator(\( exports \)).

9.4.6.12 [[OwnPropertyKeys]] ()

When the [[OwnPropertyKeys]] internal method of a namespace module exotic object \( O \) is called the following steps are taken:

1. Let \( exports \) be a copy of the value of \( O \)’s [[Exports]] internal slot.
2. Let \( symbolKeys \) the result of calling the default ordinary object [[OwnPropertyKeys]] internal method (9.1.12) on \( O \) passing no arguments.
3. Append all the entries of \( symbolKeys \) to the end of \( exports \).
4. Return \( exports \).

9.4.6.13 ModuleNamespaceCreate (\( module, exports \))

The abstract operation ModuleNamespaceCreate with arguments \( module \), and \( exports \) is used to specify the creation of new module namespace exotic objects. It performs the following steps:

1. Assert: \( module \) is a Module Record (see 15.2.1.15).
2. Assert: \( module.[[Namespace]] \) is \( undefined \).
3. Assert: \( realm \) is a Realm Record.
4. Assert: `exports` is a List of string values.
5. Let `M` be a newly created object.
6. Set `M`'s essential internal methods to the definitions specified in 9.4.6.
7. Set `M`'s `[[Module]]` internal slot to `module`.
8. Set `M`'s `[[Exports]]` internal slot to `exports`.
9. Create own properties of `M` corresponding to the definitions in 26.3.
10. Set `module.[[Namespace]]` to `M`.
11. Return `M`.

### 9.5 Proxy Object Internal Methods and Internal Slots

A proxy object is an exotic object whose essential internal methods are partially implemented using ECMAScript code. Every proxy object has an internal slot called `[[ProxyHandler]]`. The value of `[[ProxyHandler]]` is an object, called the proxy's handler object, or null. Methods (see Table 31) 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 slot called `[[ProxyTarget]]` whose value is either an object or the `null` value. This object is called the proxy's target object.

<table>
<thead>
<tr>
<th>Internal Method</th>
<th>Handler Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[GetPrototypeOf]]</code></td>
<td><code>getPrototypeOf</code></td>
</tr>
<tr>
<td><code>[[SetPrototypeOf]]</code></td>
<td><code>setPrototypeOf</code></td>
</tr>
<tr>
<td><code>[[IsExtensible]]</code></td>
<td><code>isExtensible</code></td>
</tr>
<tr>
<td><code>[[PreventExtensions]]</code></td>
<td><code>preventExtensions</code></td>
</tr>
<tr>
<td><code>[[GetOwnProperty]]</code></td>
<td><code>getOwnPropertyDescriptor</code></td>
</tr>
<tr>
<td><code>[[HasProperty]]</code></td>
<td><code>has</code></td>
</tr>
<tr>
<td><code>[[Get]]</code></td>
<td><code>get</code></td>
</tr>
<tr>
<td><code>[[Set]]</code></td>
<td><code>set</code></td>
</tr>
<tr>
<td><code>[[Delete]]</code></td>
<td><code>deleteProperty</code></td>
</tr>
<tr>
<td><code>[[DefineOwnProperty]]</code></td>
<td><code>defineProperty</code></td>
</tr>
<tr>
<td><code>[[Enumerate]]</code></td>
<td><code>enumerate</code></td>
</tr>
<tr>
<td><code>[[OwnPropertyKeys]]</code></td>
<td><code>ownKeys</code></td>
</tr>
<tr>
<td><code>[[Call]]</code></td>
<td><code>apply</code></td>
</tr>
<tr>
<td><code>[[Construct]]</code></td>
<td><code>construct</code></td>
</tr>
</tbody>
</table>

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 slots 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]]` and `[[ProxyTarget]]` internal slots are set to `null` causing subsequent invocations of internal methods on that proxy object to throw a `TypeError` exception.

Because proxy objects permit the implementation of internal methods to be provided by arbitrary ECMAScript code, it is possible to define a proxy object whose handler methods violates the invariants defined in 6.1.7.3. Some of the internal method invariants defined in 6.1.7.3 are essential integrity
invariants. These invariants are explicitly enforced by the proxy object internal methods specified in this section. An ECMAScript implementation must be robust in the presence of all possible invariant violations.

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

9.5.1 [[GetPrototypeOf]] ( )

When the [[GetPrototypeOf]] 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 slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "getPrototypeOf").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
   a. Return the result of calling the [[GetPrototypeOf]] internal method of target.
8. Let handlerProto be Call(trap, handler, «target»).
9. ReturnIfAbrupt(handlerProto).
10. If Type(handlerProto) is neither Object nor Null, throw a TypeError exception.
11. Let extensibleTarget be IsExtensible(target).
12. ReturnIfAbrupt(extensibleTarget).
13. If extensibleTarget is true, return handlerProto.
14. Let targetProto be the result of calling the [[GetPrototypeOf]] internal method of target.
15. ReturnIfAbrupt(targetProto).
16. If SameValue(handlerProto, targetProto) is false, throw a TypeError exception.
17. Return handlerProto.

NOTE [[GetPrototypeOf]] for proxy objects enforces the following invariant:
- The result of [[GetPrototypeOf]] must be either an Object or null.
- If the target object is not extensible, [[GetPrototypeOf]] applied to the proxy object must return the same value as [[GetPrototypeOf]] applied to the proxy object's target object.

9.5.2 [[SetPrototypeOf]] (V)

When the [[SetPrototypeOf]] internal method of an exotic Proxy 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. Let handler be the value of the [[ProxyHandler]] internal slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
6. Let trap be GetMethod(handler, "setPrototypeOf").
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[SetPrototypeOf]] internal method of target with argument V.
9. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target, V»)).
10. ReturnIfAbrupt(booleanTrapResult).
11. Let extensibleTarget be IsExtensible(target).
12. ReturnIfAbrupt(extensibleTarget).
13. If extensibleTarget is true, return booleanTrapResult.
14. Let targetProto be the result of calling the [[GetPrototypeOf]] internal method of target.
15. ReturnIfAbrupt(targetProto).
16. If booleanTrapResult is true and SameValue(V, targetProto) is false, throw a TypeError exception.
17. Return booleanTrapResult.

NOTE [[SetPrototypeOf]] 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 [[GetPrototypeOf]] applied to target object.

9.5.3 [[IsExtensible]] ()

When the [[IsExtensible]] 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 slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "isExtensible").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
   a. Return the result of calling the [[IsExtensible]] internal method of target.
8. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target»)).
9. ReturnIfAbrupt(booleanTrapResult).
10. Let targetResult be the result of calling the [[IsExtensible]] internal method of target.
11. ReturnIfAbrupt(targetResult).
12. If SameValue(booleanTrapResult, targetResult) is false, throw a TypeError exception.
13. Return booleanTrapResult.

NOTE [[IsExtensible]] for proxy objects enforces the following invariant:
- [[IsExtensible]] applied to the proxy object must return the same value as [[IsExtensible]] applied to the proxy object's target object with the same argument.

9.5.4 [[PreventExtensions]] ()

When the [[PreventExtensions]] 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 slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "preventExtensions").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
   a. Return the result of calling the [[PreventExtensions]] internal method of target.
8. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target»)).
9. ReturnIfAbrupt(booleanTrapResult).
10. If booleanTrapResult is true, then
    a. Let targetIsExtensible be the result of calling the [[IsExtensible]] internal method of target.
    b. ReturnIfAbrupt(targetIsExtensible).
If targetIsExtensible is true, throw a TypeError exception.

11. Return booleanTrapResult.

NOTE

[[PreventExtensions]] for proxy objects enforces the following invariant:

- [[PreventExtensions]] applied to the proxy object only returns true if [[IsExtensible]] applied to the proxy object's target object is false.

9.5.5 [[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 slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[GetOwnProperty]] internal method of target with argument P.
9. Let trapResultObj be Call(trap, handler, «target, P»).
10. ReturnIfAbrupt(trapResultObj).
11. If Type(trapResultObj) is neither Object nor Undefined, throw a TypeError exception.
12. Let targetDesc be the result of calling the [[GetOwnProperty]] internal method of target with argument P.
13. ReturnIfAbrupt(targetDesc).
14. If trapResultObj is undefined, then
   a. If targetDesc is undefined, return undefined.
   b. If targetDesc.[[Configurable]] is false, throw a TypeError exception.
   c. Let extensibleTarget be IsExtensible(target).
   d. ReturnIfAbrupt(extensibleTarget).
   e. If ToBoolean(extensibleTarget) is false, throw a TypeError exception.
   f. Return undefined.
15. Let extensibleTarget be IsExtensible(target).
16. ReturnIfAbrupt(extensibleTarget).
17. Let resultDesc be ToPropertyDescriptor(trapResultObj).
18. ReturnIfAbrupt(resultDesc).
19. Call CompletePropertyDescriptor(resultDesc).
20. Let valid be IsCompatiblePropertyDescriptor(extensibleTarget, resultDesc, targetDesc).
21. If valid is false, throw a TypeError exception.
22. If resultDesc.[[Configurable]] is false, then
   a. If targetDesc is undefined or targetDesc.[[Configurable]] is true, then
      i. Throw a TypeError exception.
23. 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 an 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 an 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 an 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.

9.5.6 `[[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 slot of `O`.
3. If `handler` is `null`, throw a `TypeError` exception.
4. Assert: `Type(handler)` is `Object`.
5. Let `target` be the value of the `[[ProxyTarget]]` internal slot of `O`.
7. ReturnIfAbrupt(trap).
8. If `trap` is `undefined`, then
   a. Return the result of calling the `[[DefineOwnProperty]]` internal method of `target` with arguments `P` and `Desc`.
9. Let `descObj` be `FromPropertyDescriptor(Desc)`.
10. Let `booleanTrapResult` be `ToBoolean(Call(trap, handler, «target, P, descObj»))`.
11. ReturnIfAbrupt(booleanTrapResult).
12. If `booleanTrapResult` is `false`, return `false`.
13. Let `targetDesc` be the result of calling the `[[GetOwnProperty]]` internal method of `target` with argument `P`.
14. ReturnIfAbrupt(targetDesc).
15. Let `extensibleTarget` be `IsExtensible(target)`.
16. ReturnIfAbrupt(extensibleTarget).
17. If `Desc` has a `[[Configurable]]` field and if `Desc.[[Configurable]]` is `false`, then
   a. Let `settingConfigFalse` be `true`.
18. Else let `settingConfigFalse` be `false`.
19. If `targetDesc` is `undefined`, then
   a. If `extensibleTarget` is `false`, throw a `TypeError` exception.
   b. If `settingConfigFalse` is `true`, throw a `TypeError` exception.
20. Else `targetDesc` is not `undefined`,
   a. If `IsCompatiblePropertyDescriptor(extensibleTarget, Desc, targetDesc)` is `false`, throw a `TypeError` exception.
   b. If `settingConfigFalse` is `true` and `targetDesc.[[Configurable]]` is `true`, throw a `TypeError` exception.

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 exists 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.
9.5.7 [[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 slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
6. Let trap be GetMethod(handler, "has").
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[HasProperty]] internal method of target with argument P.
9. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target, P»)).
10. ReturnIfAbrupt(booleanTrapResult).
11. If booleanTrapResult 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, throw a TypeError exception.
       ii. Let extensibleTarget be IsExtensible(target).
       iii. ReturnIfAbrupt(extensibleTarget).
       iv. If extensibleTarget is false, throw a TypeError exception.
12. Return booleanTrapResult.

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 an own property of the target object and the target object is not extensible.

9.5.8 [[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 slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
6. Let trap be GetMethod(handler, "get").
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[Get]] internal method of target with arguments P and Receiver.
9. Let trapResult be Call(trap, handler, «target, P, Receiver»).
10. ReturnIfAbrupt(trapResult).
11. Let targetDesc be the result of calling the [[GetOwnProperty]] internal method of target with argument P.
12. ReturnIfAbrupt(targetDesc).
13. 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, throw a TypeError exception.

b. If IsAccessorDescriptor(targetDesc) and targetDesc.[[Configurable]] is false and targetDesc.[[Set]] is undefined, then
   i. If trapResult is not undefined, throw a TypeError exception.


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 target object property is non-configurable accessor property that has undefined as its [[Get]] attribute.

9.5.9 [[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 slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
6. Let trap be GetMethod(handler, "set").
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[Set]] internal method of target with arguments P, V, and Receiver.
9. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target, P, V, Receiver»)).
10. ReturnIfAbrupt(booleanTrapResult).
11. If booleanTrapResult is false, return false.
12. Let targetDesc be the result of calling the [[GetOwnProperty]] internal method of target with argument P.
13. ReturnIfAbrupt(targetDesc).
14. 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, throw a TypeError exception.
   b. If IsAccessorDescriptor(targetDesc) and targetDesc.[[Configurable]] is false, then
      i. If targetDesc.[[Set]] is undefined, throw a TypeError exception.
15. 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 target object property is a non-configurable accessor property that has undefined as its [[Set]] attribute.

9.5.10 [[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 slot of O.
3. If handler is null, throw a TypeError exception.
4. Assert: Type(handler) is Object.
5. Let target be the value of the [[ProxyTarget]] internal slot of O.
6. Let trap be GetMethod(handler, "deleteProperty").
7. ReturnIfAbrupt(trap).
8. If trap is undefined, then
   a. Return the result of calling the [[Delete]] internal method of target with argument P.
9. Let booleanTrapResult be ToBoolean(Call(trap, handler, «target, P»)).
10. ReturnIfAbrupt(booleanTrapResult).
11. If booleanTrapResult is false, return false.
12. Let targetDesc be the result of calling the [[GetOwnProperty]] internal method of target with argument P.
13. ReturnIfAbrupt(targetDesc).
14. If targetDesc is undefined, return true.
15. If targetDesc.[[Configurable]] is false, throw a TypeError exception.
16. 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.

9.5.11 [[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 slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "enumerate").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
   a. Return the result of calling the [[Enumerate]] internal method of target.
8. Let trapResult be Call(trap, handler, «target»).
9. ReturnIfAbrupt(trapResult).
10. If Type(trapResult) is not Object, throw a TypeError exception.
11. Return trapResult.

NOTE [[Enumerate]] for proxy objects enforces the following invariants:
   • The result of [[Enumerate]] must be an Object.

9.5.12 [[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 slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "ownKeys").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
   a. Return the result of calling the [[OwnPropertyKeys]] internal method of target.
8. Let trapResultArray be Call(trap, handler, «target»).
9. Let trapResult be CreateListFromArrayLike(trapResultArray, «String, Symbol»).
10. ReturnIfAbrupt(trapResult).
11. Let extensibleTarget be IsExtensible(target).
12. ReturnIfAbrupt(extensibleTarget).
13. Let targetKeys be the result of calling the [[OwnPropertyKeys]] internal method of target.
14. ReturnIfAbrupt(targetKeys).
15. Assert: targetKeys is a List containing only String and Symbol values.
16. Let targetConfigurableKeys be an empty List.
17. Let targetNonconfigurableKeys be an empty List.
18. Repeat, for each element key of targetKeys,
   a. Let desc the result of calling the [[GetOwnProperty]] internal method of target with argument key.
   b. ReturnIfAbrupt(desc).
   c. If desc is not undefined and desc.[[Configurable]] is false, then
      i. Append key as an element of targetNonconfigurableKeys.
   d. Else,
      i. Append key as an element of targetConfigurableKeys.
19. If extensibleTarget is true and targetNonconfigurableKeys is empty, then
   a. Return trapResult.
20. Let uncheckedResultKeys be a new List which is a copy of trapResult.
21. Repeat, for each key that is an element of targetNonconfigurableKeys,
   a. If key is not an element of uncheckedResultKeys, throw a TypeError exception.
   b. Remove key from uncheckedResultKeys.
22. If extensibleTarget is true, return trapResult.
23. Repeat, for each key that is an element of targetConfigurableKeys,
   a. If key is not an element of uncheckedResultKeys, throw a TypeError exception.
   b. Remove key from uncheckedResultKeys.
24. If uncheckedResultKeys is not empty, throw a TypeError exception.
25. Return trapResult.

NOTE [[OwnPropertyKeys]] for proxy objects enforces the following invariants:
- The result of [[OwnPropertyKeys]] is a List.
- The Type of each result List element is either String or Symbol.
- The result List must contain the keys of all non-configurable own properties of the target object.
- If the target object is not extensible, then the result List must contain all the keys of the own properties of the target object and no other values.

9.5.13 [[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:
1. Let handler be the value of the [[ProxyHandler]] internal slot of O.
2. If handler is null, throw a TypeError exception.
3. Assert: Type(handler) is Object.
4. Let target be the value of the [[ProxyTarget]] internal slot of O.
5. Let trap be GetMethod(handler, "apply").
6. ReturnIfAbrupt(trap).
7. If trap is undefined, then
8. Let `argArray` be `CreateArrayFromList(argumentsList)`.
9. Return `Call(trap, handler, «target, thisArgument, argArray»).

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

**9.5.14 [[Construct]] (argumentsList, newTarget)**

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

1. Let `handler` be the value of the `[[ProxyHandler]]` internal slot of `O`.
2. If `handler` is `null`, throw a `TypeError` exception.
3. Assert: Type(`handler`) is `Object`.
4. Let `target` be the value of the `[[ProxyTarget]]` internal slot of `O`.
5. Let `trap` be `GetMethod(handler, "construct")`.
6. ReturnIfAbrupt(`trap`).
7. If `trap` is `undefined`, then
   a. Assert: `target` has a `[[Construct]]` internal method.
   b. Return `Construct(target, argumentsList, newTarget)`.
8. Let `argArray` be `CreateArrayFromList(argumentsList)`.
9. Let `newObj` be `Call(trap, handler, «target, argArray, newTarget»)`.
10. ReturnIfAbrupt(`newObj`).
11. If Type(`newObj`) is not `Object`, throw a `TypeError` exception.
12. Return `newObj`.

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

***NOTE 2***

- The result of `[[Construct]]` for proxy objects enforces the following invariants:
  - The result of `[[Construct]]` must be an `Object`.

**9.5.15 ProxyCreate(target, handler) Abstract Operation**

The abstract operation `ProxyCreate` with arguments `target` and `handler` is used to specify the creation of new Proxy exotic objects. It performs the following steps:

1. If Type(`target`) is not `Object`, throw a `TypeError` Exception.
2. If Type(`handler`) is not `Object`, throw a `TypeError` Exception.
3. Let `P` be a newly created object.
4. Set `P`'s essential internal methods (except for `[[Call]]` and `[[Construct]]`) to the definitions specified in 9.5.
5. If IsCallable(`target`) is `true`, then
   a. Set the `[[Call]]` internal method of `P` as specified in 9.5.13.
   b. If `target` has a `[[Construct]]` internal method, then
      i. Set the `[[Construct]]` internal method of `P` as specified in 9.5.14.
5. Set the `[[ProxyTarget]]` internal slot of `P` to `target`.
7. Set the `[[ProxyHandler]]` internal slot of `P` to `handler`.
8. Return `P`.
10  ECMAScript Language: Source Code

10.1  Source Text

Syntax

SourceCharacter ::
  any Unicode code point

The ECMAScript code is expressed using Unicode, version 5.1 or later. ECMAScript source text is a sequence of code points. All Unicode code point values from U+0000 to U+10FFFF, including surrogate code points, may occur in source text where permitted by the ECMAScript grammars. The actual encodings used to store and interchange ECMAScript source text is not relevant to this specification.

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 a Unicode code point. Conforming ECMAScript implementations are not required to perform any normalization of text, or behave as though they were performing normalization of text.

The components of a combining character sequence are treated as individual Unicode code points even though a user might think of the whole sequence as a single character.

NOTE In string literals, regular expression literals, template literals and identifiers, any Unicode code point may also be expressed using Unicode escape sequences that explicitly express a code point's numeric value. Within a comment, such an escape sequence is effectively ignored as part of the comment.

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 code point U+000A is LINE FEED (LF)) and therefore the next code point 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 (LF) 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 to the literal and is never interpreted as a line terminator or as a code point that might terminate the string literal.

10.1.1  Static Semantics: UTF-16Encoding

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

1. Assert: 0 ≤ cp ≤ 0x10FFFF.
2. If cp ≤ 65535, return cp.
3. Let cu1 be floor((cp – 65536) / 1024) + 0xD800.
4. Let cu2 be ((cp – 65536) modulo 1024) + 0xDC00.
5. Return the code unit sequence consisting of cu1 followed by cu2.

10.1.2  Static Semantics: UTF16Decode(lead, trail)

Two code units, lead and trail, that form a UTF-16 surrogate pair are converted to a code point by performing the following steps:

1. Assert: 0xD800 ≤ lead ≤ 0xDBFF and 0xDC00 ≤ trail ≤ 0xDFFF.
2. Let cp be (lead–0xD800)x1024+( trail–0xDC00)+0x10000.
3. Return the code point \( cp \).

10.2 Types of Source Code

There are four types of ECMAScript 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 `FunctionDeclaration`, `FunctionExpression`, `GeneratorDeclaration`, `GeneratorExpression`, `MethodDefinition`, `ArrowFunction`, `ClassDeclaration`, or `ClassExpression`.

- **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 `[[ECMAScriptCode]]` internal slot (see 9.1.14) of function and generator objects. It also includes the code that defines and initializes the formal parameters of the function. 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 `FunctionDeclaration`, `FunctionExpression`, `GeneratorDeclaration`, `GeneratorExpression`, `MethodDefinition`, `ArrowFunction`, `ClassDeclaration`, or `ClassExpression`.

- **Module code** is source text that is 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 `FunctionDeclaration`, `FunctionExpression`, `GeneratorDeclaration`, `GeneratorExpression`, `MethodDefinition`, `ArrowFunction`, `ClassDeclaration`, or `ClassExpression`.

**NOTE**  Function code is generally provided as the bodies of Function Definitions (14.1), Arrow Function Definitions (14.2), Method Definitions (14.3) and Generator Definitions (14.4). Function code is also derived from the last argument to the Function constructor (19.2.1.1) and the GeneratorFunction constructor (25.2.1.1).

10.2.1 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 14.1.1).

- **Module code** is always strict code.

- All parts of a `ClassDeclaration` or a `ClassExpression` are 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 12.3.4.1) to the eval function that is contained in strict mode code.

- **Function code** is strict function code if its `FunctionDeclaration`, `FunctionExpression`, `GeneratorDeclaration`, `GeneratorExpression`, `MethodDefinition`, or `ArrowFunction` is contained in strict
mode code or if it is within a `FunctionBody` that 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.

10.2.2 Non-ECMAScript Functions

An ECMAScript implementation may support the evaluation of exotic 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.

11 ECMAScript Language: Lexical Grammar

The source text of an ECMAScript `Script` or `Module` 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 code units as the next input element.

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.

**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 11.9); in examples such as the following:

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

where the first non-whitespace, non-comment code point after a `LineTerminator` is SOLIDUS (`/`) 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:

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

**Syntax**

```
InputElementDiv ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator
  RightBracePunctuator
```

[Deleted: script]

[Comment [AWB96]: May need to also say something about TemplateSubstitution tail. Also need to consider with there are any ASI issues concerning it.]
InputElementRegExp ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  RightBracePunctuator
  RegularExpressionLiteral

InputElementTemplateTail ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator
  TemplateSubstitutionTail

11.1 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.

U+200C (ZERO WIDTH NON-JOINER) and U+200D (ZERO WIDTH JOINER) are format-control characters that are used to make necessary distinctions when forming words or phrases in certain languages. In ECMAScript source text these code points may also be used in an IdentifierName (see 11.6.1) after the first character.

U+FEFF (ZERO WIDTH NO-BREAK SPACE) 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. <ZWNBSP> characters intended for this purpose can sometimes also appear after the start of a text, for example as a result of concatenating files. In ECMAScript source text <ZWNBSP> code points are treated as white space characters (see 11.2).

The special treatment of certain format-control characters outside of comments, string literals, and regular expression literals is summarized in Table 32.

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Name</th>
<th>Abbreviation</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+200C</td>
<td>ZERO WIDTH NON-JOINER</td>
<td>&lt;ZWNJ&gt;</td>
<td>IdentifierPart</td>
</tr>
<tr>
<td>U+200D</td>
<td>ZERO WIDTH JOINER</td>
<td>&lt;ZWJ&gt;</td>
<td>IdentifierPart</td>
</tr>
<tr>
<td>U+FEFF</td>
<td>ZERO WIDTH NO-BREAK SPACE</td>
<td>&lt;ZWNBSP&gt;</td>
<td>WhiteSpace</td>
</tr>
</tbody>
</table>

11.2 White Space

White space code points are used to improve source text readability and to separate tokens (indivisible lexical units) from each other, but are otherwise insignificant. White space code points may occur
between any two tokens and at the start or end of input. White space code points may occur within a StringLiteral, a RegularExpressionLiteral, a Template, or a TemplateSubstitutionTail where they are considered significant code points 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 code points are listed in Table 33.

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Name</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+0009</td>
<td>CHARACTER TABULATION</td>
<td>&lt;TAB&gt;</td>
</tr>
<tr>
<td>U+000B</td>
<td>LINE TABULATION</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>U+000C</td>
<td>FORM FEED (FF)</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>U+0020</td>
<td>SPACE</td>
<td>&lt;SP&gt;</td>
</tr>
<tr>
<td>U+00A0</td>
<td>NO-BREAK SPACE</td>
<td>&lt;NBSP&gt;</td>
</tr>
<tr>
<td>U+FEFF</td>
<td>ZERO WIDTH NO-BREAK SPACE</td>
<td>&lt;ZWNBSP&gt;</td>
</tr>
<tr>
<td>Other category “Zs”</td>
<td>Any other Unicode “Separator, space” code point</td>
<td>&lt;USP&gt;</td>
</tr>
</tbody>
</table>

ECMAScript implementations must recognize as Whitespace code points listed in the “Separator, space” (Zs) category by Unicode 5.1. ECMAScript implementations may also recognize as Whitespace additional category Zs code points from subsequent editions of the Unicode Standard.

NOTE Other than for the code points listed in Table 33, ECMAScript Whitespace intentionally excludes all code points that have the Unicode “White_Space” property but which are not classified in category “Zs”.

Syntax

WhiteSpace ::=
  <TAB>
  <VT>
  <FF>
  <SP>
  <NBSP>
  <ZWNBSP>
  <USP>

11.3 Line Terminators

Like white space code points, line terminator code points are used to improve source text readability and to separate tokens (indivisible lexical units) from each other. However, unlike white space code points, 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 (11.9). 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.

A line terminator can occur within a MultiLineComment (11.4) but cannot occur within a SingleLineComment.

Line terminators are included in the set of white space code points that are matched by the \s class in regular expressions.
The ECMAScript line terminator code points are listed in Table 34.

**Table 34 — Line Terminator Code Points**

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Unicode Name</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+000A</td>
<td>LINE FEED (LF)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>U+000D</td>
<td>CARRIAGE RETURN (CR)</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>U+2028</td>
<td>LINE SEPARATOR</td>
<td>&lt;LS&gt;</td>
</tr>
<tr>
<td>U+2029</td>
<td>PARAGRAPH SEPARATOR</td>
<td>&lt;PS&gt;</td>
</tr>
</tbody>
</table>

Only the Unicode code points in Table 34 are treated as line terminators. Other new line or line breaking Unicode code points are not treated as line terminators but are treated as white space if they meet the requirements listed in Table 33. 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>`  
  `<LS>`  
  `<PS>`  
  `<CR>` `<LF>`

**11.4 Comments**

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

Because a single-line comment can contain any Unicode code point except a `LineTerminator` code point, and because of the general rule that a token is always as long as possible, a single-line comment always consists of all code points from the // marker to the end of the line. However, the `LineTerminator` at the end of the line is not considered to be part of the single-line comment; it is recognized separately by the lexical grammar and becomes part of the stream of input elements for the syntactic grammar. This point is very important, because it implies that the presence or absence of single-line comments does not affect the process of automatic semicolon insertion (see 11.9).

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

**Syntax**

- `Comment ::`  
  `MultiLineComment`  
  `SingleLineComment`
MultiLineComment ::
    /* MultiLineCommentChars opt */

MultiLineCommentChars ::
    MultiLineNotAsteriskChar MultiLineCommentChars opt
    * PostAsteriskCommentChars opt

PostAsteriskCommentChars ::
    MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentChars opt
    * PostAsteriskCommentChars opt

MultiLineNotAsteriskChar ::
    SourceCharacter but not *

MultiLineNotForwardSlashOrAsteriskChar ::
    SourceCharacter but not one of / or *

SingleLineComment ::
    // SingleLineCommentChars opt

SingleLineCommentChars ::
    SingleLineCommentChar SingleLineCommentChars opt

SingleLineCommentChar ::
    SourceCharacter but not LineTerminator

11.5 Tokens

Syntax

Token ::
    IdentifierName
    Punctuator
    NumericLiteral
    StringLiteral
    Template

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

11.6 Names and Keywords

IdentifierName 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. The syntactic grammar defines Identifier as an IdentifierName that is not a ReservedWord (see 11.6.2). The Unicode identifier grammar is based on character properties specified by the Unicode Standard. The Unicode code points 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 recognize identifier code points defined in later editions of the Unicode Standard.
NOTE 1 This standard specifies specific code point additions: \u2400 (DOLLAR SIGN) and \u005F (LOW LINE) are permitted anywhere in an IdentifierName, and the characters \u200C (ZERO-WIDTH NON-JOINER) and \u200D (ZERO-WIDTH JOINER) are permitted anywhere after the first code unit of an IdentifierName.

Unicode escape sequences are permitted in an IdentifierName, where they contribute a single Unicode code point to the IdentifierName. The code point is expressed by the HexDigits of the UnicodeEscapeSequence (see 11.8.4). The \ preceding the UnicodeEscapeSequence and the u and \{ } code units, if they appear, do not contribute code points to the IdentifierName. A UnicodeEscapeSequence cannot be used to put a code point into an IdentifierName that would otherwise be illegal. In other words, if a UnicodeEscapeSequence sequence were replaced by the SourceCharacter it contributes, the result must still be a valid IdentifierName that has the exact same sequence of SourceCharacter elements as the original IdentifierName. All interpretations of IdentifierName within this specification are based upon their actual code points regardless of whether or not an escape sequence was used to contribute any particular code point.

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 points (in other words, conforming ECMAScript implementations are only required to do bitwise comparison on IdentifierName values).

Syntax

IdentifierName ::
  IdentifierStart IdentifierName IdentifierPart

IdentifierStart ::
  UnicodeIDStart
  $\$
  UnicodeEscapeSequence

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

UnicodeIDStart ::
  any Unicode code point with the Unicode property “ID_Start” or “Other_ID_Start”

UnicodeIDContinue ::
  any Unicode code point with the Unicode property “ID_Continue”, “Other_ID_Continue”, or “Other_ID_Start”

The definitions of the nonterminal UnicodeEscapeSequence is given in 11.8.4.
11.6.1 Identifier Names

11.6.1.1 Static Semantics: Early Errors

IdentifierStart :: UnicodeEscapeSequence

- It is a Syntax Error if SV(UnicodeEscapeSequence) is neither the UTF-16 Encoding (10.1.1) of a single Unicode code point with the Unicode property "ID_Start" nor "$" or "_".

IdentifierPart :: UnicodeEscapeSequence

- It is a Syntax Error if SV(UnicodeEscapeSequence) is neither the UTF-16 Encoding (10.1.1) of a single Unicode code point with the Unicode property "ID_Continue" nor "$" or "_" nor the UTF-16 Encoding of either <ZWNJ> or <ZWJ>.

11.6.1.2 Static Semantics: StringValue

See also: 11.8.4.2, 12.1.4.

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 (10.1.1) each code point.

11.6.2 Reserved Words

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

Syntax

ReservedWord ::
  Keyword
  FutureReservedWord
  NullLiteral
  BooleanLiteral

NOTE The ReservedWord definitions are specified as literal sequences of specific SourceCharacter elements. A code point in a ReservedWord cannot be expressed by a UnicodeEscapeSequence.

11.6.2.1 Keywords

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

Keyword :: one of

break   do   in   typeof
case    else  instanceof var
catch   export new  void
class   extends return while
const   finally super with
continue for   switch yield
debugger function this
default if    throw
delete  import try

NOTE In some contexts yield is given the semantics of an Identifier. See 12.1.1. In strict mode code, let and static are treated as reserved keywords through static semantic restrictions (see 12.1.1, 13.2.1.1, 13.6.4.1, and 14.5.1) rather than the lexical grammar.

11.6.2.2 Future Reserved Words

The following tokens are reserved for use as keywords in future language extensions.

Syntax

FutureReservedWord ::

enum
await

await is only treated as a FutureReservedWord when Module is the goal symbol of the syntactic grammar.

NOTE Use of the following tokens within strict mode code (see 10.2.1) is also reserved. That usage is restricted using static semantic restrictions (see 12.1.1) rather than the lexical grammar:

implements package protected
interface private public

11.7 Punctuators

Syntax

Punctuator :: one of

{   }   [   ]   .
... ;   ,   <   >   <=
>=   ==   !=   ===  !==
+    -    *    %    m   m   m
<<<  >>>  >>>>  &   |   ^
!    ~    &&   ||   ?   :
==   +=   -=   *=   %=   <<=
>>=  >>=  >=  |=  ^=  =>
DivPunctuator :: one of
   /   /=

RightBracePunctuator ::
}

11.8 Literals
11.8.1 Null Literals

Syntax
NullLiteral ::
   null

11.8.2 Boolean Literals

Syntax
BooleanLiteral ::
   true
   false

11.8.3 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

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
ExponentIndicator :: one of
e E

SignedInteger ::
   DecimalDigits
   + DecimalDigits
   - DecimalDigits

BinaryIntegerLiteral ::
   0b BinaryDigits
   0B BinaryDigits

BinaryDigits ::
   BinaryDigit
   BinaryDigits BinaryDigit

BinaryDigit :: one of
   0 1

OctalIntegerLiteral ::
   0o OctalDigits
   0O OctalDigits

OctalDigits ::
   OctalDigit
   OctalDigits OctalDigit

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

HexIntegerLiteral ::
   0x HexDigits
   0X HexDigits

HexDigits ::
   HexDigit
   HexDigits 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

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

NOTE For example:

   3in

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

A conforming implementation, when processing strict mode code (see 10.2.1), must not extend, as described in B.1.1, the syntax of NumericLiteral to include LegacyOctalIntegerLiteral, nor extend the syntax of DecimalIntegerLiteral to include NonOctalDecimalIntegerLiteral.
11.8.3.1 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 × 10^n), where n is the number of code points in DecimalDigits.
- The MV of DecimalLiteral :: DecimalIntegerLiteral . ExponentPart is the MV of DecimalIntegerLiteral × 10^n, where e is the MV of ExponentPart.
- The MV of DecimalLiteral :: DecimalIntegerLiteral . DecimalsepDigits ExponentPart is (the MV of DecimalIntegerLiteral plus (the MV of DecimalDigits × 10^n)) × 10^n, where n is the number of code points in DecimalDigits and e is the MV of ExponentPart.
- The MV of DecimalLiteral :: . DecimalDigits is the MV of DecimalDigits × 10^n, where n is the number of code points in DecimalDigits.
- The MV of DecimalLiteral :: . DecimalDigits ExponentPart is the MV of DecimalDigits × 10^n, where n is the number of code points 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 × 10^n, 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 × 10^n) plus the MV of DecimalDigits, where n is the number of code points in DecimalDigits.
- The MV of DecimalIntegerLiteral :: DecimalDigit is the MV of DecimalDigit.
- The MV of DecimalIntegerLiteral :: DecimalDigits ExponentPart is (the MV of DecimalDigits × 10^n) 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 Decrease is the MV of DecimalDigits.
- The MV of SignedInteger :: Decrease 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.
- 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 BinaryDigits is the MV of BinaryDigits.

The MV of BinaryIntegerLiteral :: 0B BinaryDigits is the MV of BinaryDigits.

The MV of BinaryDigits :: BinaryDigit is the MV of BinaryDigit.

The MV of BinaryDigits :: BinaryDigits BinaryDigit is (the MV of BinaryDigits × 2) plus the MV of BinaryDigit.

The MV of OctalIntegerLiteral :: 0o OctalDigits is the MV of OctalDigits.

The MV of OctalIntegerLiteral :: 0O OctalDigits is the MV of OctalDigits.

The MV of OctalDigits :: OctalDigit is the MV of OctalDigit.

The MV of OctalDigits :: OctalDigits OctalDigit is (the MV of OctalDigits × 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 × 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 6.1.6), 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.

11.8.4 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 code points may appear literally in a string literal except for the closing quote code points, REVERSE SOLIDUS (\), CARRIAGE RETURN (CR), LINE SEPARATOR, PARAGRAPH SEPARATOR, and LINE FEED (LF). Any code points may appear in the form of an escape sequence. String literals evaluate to ECMAScript String values. When generating these string values Unicode code points are UTF-16 encoded as defined in 10.1.1. 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.

Syntax

StringLiteral ::

" DoubleStringCharactersopt "

' SingleStringCharactersopt '
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 a DecimalDigit]
  HexEscapeSequence
  UnicodeEscapeSequence

A conforming implementation, when processing strict mode code (see 10.2.1), must not extend the syntax of EscapeSequence to include LegacyOctalEscapeSequence 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 Hex4Digits
  u{ HexDigits }
HexDigit ::
  HexDigit HexDigit HexDigit HexDigit

The definition of the nonterminal \textit{HexDigit} is given in 11.8.3. \textit{SourceCharacter} is defined in 10.1.

\textbf{NOTE} \ A line terminator code point cannot appear in a string literal, except as part of a \textit{LineContinuation} to produce the empty code points sequence. The proper way to cause a line terminator code point to be part of the String value of a string literal is to use an escape sequence such as \texttt{\textbackslash n} or \texttt{\textbackslash u000A}.

\subsection*{11.8.4.1 \ Static Semantics: Early Errors}

\textsl{UnicodeEscapeSequence} :: \texttt{u\{HexDigits\}}

- It is a Syntax Error if the MV of \textsl{HexDigits} > 114111.

\subsection*{11.8.4.2 \ Static Semantics: StringValue}

See also: 11.6.1.2, 12.1.4.

\textsl{StringValue}

\textbf{Note} \ A line terminator code point cannot appear in a string literal, except as part of a \textit{LineContinuation} to produce the empty code points sequence. The proper way to cause a line terminator code point to be part of the String value of a string literal is to use an escape sequence such as \texttt{\textbackslash n} or \texttt{\textbackslash u000A}.

\textbf{Static Semantics: \textit{SV}'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 contributed by the various parts of the string literal. As part of this process, some Unicode code points within the string literal are interpreted as having a mathematical value (MV), as described below or in 11.8.3.

- The SV of \textsl{StringLiteral} :: " is the empty code unit sequence.
- The SV of \textsl{StringLiteral} :: ' is the empty code unit sequence.
- The SV of \textsl{StringLiteral} :: " \textsl{DoubleStringCharacters} " is the SV of \textsl{DoubleStringCharacters}.
- The SV of \textsl{StringLiteral} :: ' \textsl{SingleStringCharacters} ' is the SV of \textsl{SingleStringCharacters}.
- The SV of \textsl{DoubleStringCharacters} :: \textsl{DoubleStringCharacter} \textsl{DoubleStringCharacters} is a sequence of one or two code units that is the SV of \textsl{DoubleStringCharacter} in order.
- The SV of \textsl{DoubleStringCharacters} :: \textsl{SingleStringCharacter} \textsl{SingleStringCharacters} is a sequence of one or two code units that is the SV of \textsl{SingleStringCharacter} followed by all the code units in the SV of \textsl{SingleStringCharacters} in order.
- The SV of \textsl{DoubleStringCharacter} :: \texttt{\textbackslash EscapeSequence} is the SV of the \texttt{\textbackslash EscapeSequence}.
- The SV of \textsl{DoubleStringCharacter} :: \texttt{\textbackslash LineContinuation} is the empty code unit sequence.

\section*{Deleted: correct}

\section*{Deleted: s}
The SV of SingleStringCharacter :: SourceCharacter but not one of ' or \ or LineTerminator is the UTF-16Encoding (10.1.1) of the code point value of SourceCharacter.

The SV of SingleStringCharacter :: \ EscapeSequence is the SV of the EscapeSequence.

The SV of SingleStringCharacter :: LineContinuation is the empty code unit sequence.

The SV of EscapeSequence :: CharacterEscapeSequence is the SV of the CharacterEscapeSequence.

The SV of EscapeSequence :: 0 is the code unit value 0.

The SV of EscapeSequence :: HexEscapeSequence is the SV of the HexEscapeSequence.

The SV of EscapeSequence :: UnicodeEscapeSequence is the SV of the UnicodeEscapeSequence.

The SV of CharacterEscapeSequence :: SingleEscapeCharacter is the code unit whose value is determined by the SingleEscapeCharacter according to Table 35.

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Code Unit Value</th>
<th>Unicode Character Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>\b</td>
<td>0x0008</td>
<td>BACKSPACE</td>
<td>&lt;BS&gt;</td>
</tr>
<tr>
<td>\t</td>
<td>0x0009</td>
<td>CHARACTER TABULATION</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>\n</td>
<td>0x000A</td>
<td>LINE FEED (LF)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>\v</td>
<td>0x000B</td>
<td>LINE TABULATION</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>\f</td>
<td>0x000C</td>
<td>FORM FEED (FF)</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>\r</td>
<td>0x000D</td>
<td>CARRIAGE RETURN (CR)</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>&quot;</td>
<td>0x0022</td>
<td>QUOTATION MARK</td>
<td>&quot;</td>
</tr>
<tr>
<td>'</td>
<td>0x0027</td>
<td>APOSTROPHE</td>
<td>'</td>
</tr>
<tr>
<td>\</td>
<td>0x005C</td>
<td>REVERSE SOLIDUS</td>
<td>\</td>
</tr>
</tbody>
</table>

The SV of CharacterEscapeSequence :: NonEscapeCharacter is the SV of the NonEscapeCharacter.

The SV of NonEscapeCharacter :: SourceCharacter but not one of EscapeCharacter or LineTerminator is the UTF-16Encoding (10.1.1) of the code point value of SourceCharacter.

The SV of HexEscapeSequence :: \ 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 SV of UnicodeEscapeSequence :: \ Hex4Digits is the SV of Hex4Digits.

The SV of Hex4Digits :: 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 SV of UnicodeEscapeSequence :: u{ HexDigits } is the UTF-16Encoding (10.1.1) of the MV of HexDigits.

### 11.8.5 Regular Expression Literals

**NOTE** A regular expression literal is an input element that is converted to a RegExp object (see 21.2) 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 21.2.3.2) or calling the RegExp constructor as a function (21.2.3.1).

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 (21.2.1).
An implementation may extend the ECMAScript Regular Expression grammar defined in 21.2.1, but it must not extend the `RegularExpressionBody` and `RegularExpressionFlags` productions defined below or the productions used by these productions.

**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 code unit sequence `//` starts a single-line comment. To specify an empty regular expression, use: `/(?::)/`. 
11.8.5.1 Static Semantics: Early Errors

RegularExpressionFlags :: RegularExpressionFlags IdentifierPart

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

11.8.5.2 Static Semantics: BodyText

RegularExpressionLiteral :: / RegularExpressionBody / RegularExpressionFlags

1. Return the source code that was recognized as RegularExpressionBody.

11.8.5.3 Static Semantics: FlagText

RegularExpressionLiteral :: / RegularExpressionBody / RegularExpressionFlags

1. Return the source code that was recognized as RegularExpressionFlags.

11.8.6 Template Literal Lexical Components

Syntax

Template ::
  NoSubstitutionTemplate
  TemplateHead

NoSubstitutionTemplate ::
  ` TemplateCharactersopt ` 

TemplateHead ::
  ` TemplateCharactersopt $ { 

TemplateMiddle ::
  } TemplateCharactersopt $ { 

TemplateTail ::
  } TemplateCharactersopt ` 

TemplateCharacters ::
  TemplateCharacter TemplateCharactersopt

TemplateCharacter ::
  $ [lookahead ≠ { ] 
  \ EscapeSequence 
  LineContinuation 
  LineTerminatorSequence 
  SourceCharacter but not one of \ or \$ or LineTerminator 

A conforming implementation must not use the extended definition of EscapeSequence described in B.1.2 when parsing a TemplateCharacter.
NOTE TemplateSubstitutionTail is used by the InputElementTemplateTail alternative lexical goal.

11.8.6.1 Static Semantics: TV's and TRV's

A template literal component is interpreted as a sequence of Unicode code points. The Template Value (TV) of a literal component is described in terms of code unit values (SV, 11.8.4) contributed by the various parts of the template literal component. As part of this process, some Unicode code points within the template component are interpreted as having a mathematical value (MV, 11.8.3). In determining a TV, escape sequences are replaced by the UTF-16 code unit(s) of the Unicode code point 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.
- The TV of TemplateCharacter :: SourceCharacter but not one of ` ` or \ or $ or LineTerminator is the UTF-16Encoding (10.1.1) of the code point value of SourceCharacter.
- The TV of TemplateCharacter :: ` is the code unit value 0x0022.
- The TV of TemplateCharacter :: \ EscapeSequence is the SV of EscapeSequence.
- The TV of TemplateCharacter :: LineTerminator is the TV of LineTerminator.
- The TV of TemplateCharacter :: LineTerminatorSequence is the TV of LineTerminatorSequence.
- The TV of LineTerminator :: ` LineTerminatorSequence 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 TRV of TemplateCharacter.
- The TV of TemplateCharacters :: TemplateCharacter TemplateCharacters is a sequence consisting of the code units in the TRV of TemplateCharacter followed by all the code units in the TRV of TemplateCharacters in order.
- The TRV of TemplateCharacter :: SourceCharacter but not one of ` ` or \ or $ or LineTerminator is the UTF-16Encoding (10.1.1) of the code point value of SourceCharacter.
- The TRV of TemplateCharacter :: ` is the code unit value 0x0022.
- The TRV of TemplateCharacter :: \ EscapeSequence is the sequence consisting of the code unit value 0x0022 followed by the code units of TV of EscapeSequence.
- The TRV of TemplateCharacter :: LineContinuation is the TV of LineContinuation.
- The TRV of TemplateCharacter :: LineTerminatorSequence is the TV of LineTerminatorSequence.
- The TRV of EscapeSequence :: CharacterEscapeSequence is the TRV of the CharacterEscapeSequence.
There are three basic rules of semicolon insertion:

- The TRV of `EscapeSequence :: 0` is the code unit value 0x0030.
- The TRV of `EscapeSequence :: HexEscapeSequence` is the TRV of the `HexEscapeSequence`.
- The TRV of `EscapeSequence :: UnaryEscapeSequence` is the TRV of the `UnaryEscapeSequence`.
- The TRV of `CharacterEscapeSequence :: SingleEscapeCharacter` is the TRV of the `SingleEscapeCharacter`.
- The TRV of `CharacterEscapeSequence :: NonEscapeCharacter` is the SV of the `NonEscapeCharacter`.
- The TRV of `SingleEscapeCharacter :: one of ' ' " \ b f n r t v \ is the SV of the `SourceCharacter` that is that single code point.
- The TRV of `HexEscapeSequence :: x HexDigit HexDigit` is the sequence consisting of code unit value 0x0078 followed by TRV of the first `HexDigit` followed by the TRV of the second `HexDigit`.
- The TRV of `UnicodeEscapeSequence :: u Hex4Digits` is the sequence consisting of code unit value 0x0075 followed by TRV of `Hex4Digits`.
- The TRV of `UnicodeEscapeSequence :: u{ HexDigits }` is the sequence consisting of code unit value 0x0075 followed by code unit value 0x007B followed by TRV of `HexDigits` followed by code unit value 0x007D.
- The TRV of `Hex4Digits :: HexDigit HexDigit HexDigit HexDigit` is the sequence consisting of the TRV of the first `HexDigit` followed by the TRV of the second `HexDigit` followed by the TRV of the third `HexDigit` followed by the TRV of the fourth `HexDigit`.
- The TRV of `HexDigits :: HexDigit` is the TRV of `HexDigit`.
- The TRV of `HexDigits :: HexDigits HexDigit` is the sequence consisting of TRV of `HexDigits` followed by TRV of `HexDigit`.
- The TRV of `HexDigit is the SV of the SourceCharacter that is that `HexDigit`.
- The TRV of `LineContinuation :: \ LineTerminatorSequence` is the sequence consisting of the code unit value 0x000C followed by the code units of TRV of `LineTerminatorSequence`.
- The TRV of `LineTerminatorSequence :: <LF>` is the code unit value 0x000A.
- The TRV of `LineTerminatorSequence :: <CR>` is the code unit value 0x000A.
- The TRV of `LineTerminatorSequence :: <LS>` is the code unit value 0x0028.
- The TRV of `LineTerminatorSequence :: <PS>` is the code unit value 0x0029.
- The TRV of `LineTerminatorSequence :: <CR><LF>` is the sequence consisting of the code unit value 0x000A.

NOTE TV excludes the code units of `LineContinuation` while TRV includes them. `<CR><LF>` and `<CR>` `LineTerminatorSequence`s are normalized to `<LF>` for both TV and TRV. An explicit `EscapeSequence` is needed to include a `<CR>` or `<CR><LF>` sequence.

11.9 Automatic Semicolon Insertion

Certain ECMAScript statements (empty statement, `let`, `const`, `import`, `and` `export` declarations, `variable` statement, `expression` statement, `debugger` 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.

11.9.1 Rules of Automatic Semicolon Insertion

There are three basic rules of semicolon insertion:
1. When, as a Script or Module 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 }.

2. When, as the Script or Module 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 or Module, then a semicolon is automatically inserted at the end of the input stream.

3. When, as the Script or Module is parsed from left to right, a token is encountered that is allowed by some production of the grammar, but the production is a restricted production and the token would be the first token for a terminal or nonterminal immediately following the annotation "[no LineTerminator here]" within the restricted production (and therefore such a token is called a restricted token), and the restricted token is separated from the previous token by at least one LineTerminator, then a semicolon is automatically inserted before the restricted token.

However, there is an additional overriding condition on the preceding rules: a semicolon is never inserted automatically if the semicolon would then be parsed as an empty statement or if that semicolon would become one of the two semicolons in the header of a for statement (see 13.6.3).

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

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

- **ContinueStatement[Yield]**:
  - `continue [no LineTerminator here] LabelIdentifier[Yield] ;`

- **BreakStatement[Yield]**:
  - `break ;`

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

- **ThrowStatement[Yield]**:

- **ArrowFunction[Yield]**:
  - `ArrowParameters[Yield] [no LineTerminator here] => ConciseBody[Yield]`

- **YieldExpression[Yield]**:

The practical effect of these restricted productions is as follows:

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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, throw, or yield token is encountered and a LineTerminator is encountered before the next token, a semicolon is automatically inserted after the continue, break, return, throw, or yield 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 or an AssignmentExpression in a yield expression should start on the same line as the return, throw, or yield token.

An IdentifierReference in a break or continue statement should be on the same line as the break or continue token.

11.9.2 Examples of Automatic Semicolon Insertion

The source

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

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

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

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

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

which is a valid ECMAScript sentence.

The source

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

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

The source

```javascript
return
  a + b
```

is transformed by automatic semicolon insertion into the following:

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

NOTE    The expression a + b is not treated as a value to be returned by the return statement, because a LineTerminator separates it from the token return.
The source

\[
\text{a} = \text{b} \\
\text{++c}
\]

is transformed by automatic semicolon insertion into the following:

\[
\text{a} = \text{b}; \\
\text{++c};
\]

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

The source

\[
\text{if} \ (\text{a} > \text{b}) \\
\text{else} \ 	ext{c} = \text{d}
\]

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

\[
\text{a} = \text{b} + \text{c} \\
\text{(d + e).print()}
\]

is not transformed by automatic semicolon insertion, because the parenthesized expression that begins the second line can be interpreted as an argument list for a function call:

\[
\text{a} = \text{b} + \text{c(d + e).print()}
\]

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.

12 ECMAScript Language: Expressions

12.1 Identifiers

**Syntax**

- `IdentifierReference`:
  - `Identifier`
  - `[-Yield] yield`

- `BindingIdentifier`:
  - `Identifier`
  - `[-Yield] yield`

- `LabelIdentifier`:
  - `Identifier`
  - `[-Yield] yield`

- `Identifier`:
  - `IdentifierName` **but not** `ReservedWord`
12.1.1 Static Semantics: Early Errors

**BindingIdentifier : Identifier**

- It is a Syntax Error if this production is contained in strict code and the StringValue of `Identifier` is "arguments" or "eval".

**IdentifierReference[Yield] : yield**

**BindingIdentifier[Yield] : yield**

**LabelIdentifier[Yield] : yield**

- It is a Syntax Error if this production has a `Yield` parameter.
- It is a Syntax Error if this production is contained in strict code.
- It is a Syntax Error if this production is within the `GeneratorBody` of a `GeneratorMethod`, `GeneratorDeclaration`, or `GeneratorExpression`.

**IdentifierReference[Yield] : Identifier**

**BindingIdentifier[Yield] : Identifier**

**LabelIdentifier[Yield] : Identifier**

- It is a Syntax Error if this production has a `Yield` parameter and StringValue of `Identifier` is "yield".

**Identifier :: IdentifierName but not ReservedWord**

- It is a Syntax Error if this phrase is contained in strict code and the StringValue of `IdentifierName` is: "implements", "interface", "let", "package", "private", "protected", "public", "static", or "yield".
- It is a Syntax Error if StringValue of `IdentifierName` is the same string value as the StringValue of any `ReservedWord` except for `yield`.

**NOTE** StringValue of `IdentifierName` normalizes any Unicode escape sequences in `IdentifierName` hence such escapes cannot be used to write an `Identifier` whose code point sequence is the same as a `ReservedWord`.

12.1.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

**BindingIdentifier : Identifier**

1. Return a new List containing the StringValue of `Identifier`.

**BindingIdentifier : yield**

1. Return a new List containing "yield".

12.1.3 Static Semantics: IsValidSimpleAssignmentTarget

IdentifierReference : Identifier

1. If this IdentifierReference is contained in strict code and StringValue of Identifier is "eval" or "arguments", return false.
2. Return true.

IdentifierReference : yield

1. Return true.

12.1.4 Static Semantics: StringValue

See also: 11.6.1.2, 11.8.4.2.

IdentifierReference : yield
BindingIdentifier : yield
LabelIdentifier : yield

1. Return "yield".

Identifier : IdentifierName but not ReservedWord

1. Return the StringValue of IdentifierName.

12.1.5 Runtime Semantics: BindingInitialization

With arguments value and environment.

See also: 13.2.3.5, 13.6.4.8.

NOTE undefined is passed for environment to indicate that a PutValue operation should be used to assign the initialization value. This is the case for var statements and formal parameter lists of some non-strict functions (See 9.2.13). In those cases a lexical binding is hoisted and preinitialized prior to evaluation of its initializer.

BindingIdentifier : Identifier

1. Let name be StringValue of Identifier.
2. Return InitializeBoundName(name, value, environment).

BindingIdentifier : yield

1. Return InitializeBoundName("yield", value, environment).

12.1.5.1 Runtime Semantics: InitializeBoundName(name, value, environment)

1. Assert: Type(name) is String.
2. If environment is not undefined, then
   a. Let env be the environment record component of environment.
   b. Call the InitializeBinding concrete method of env passing name and value as the arguments.
   c. Return NormalCompletion(undefined).
3. Else
   a. Let lhs be ResolveBinding(name).
   b. Return PutValue(lhs, value).
12.1.6 Runtime Semantics: Evaluation

IdentifierReference : Identifier
  1. Return ResolveBinding(StringValue of Identifier).

IdentifierReference : yield
  1. Return ResolveBinding("yield").

NOTE 1: The result of evaluating an IdentifierReference is always a value of type Reference.

NOTE 2: In non-strict code, the keyword yield may be used as an identifier. Evaluating the IdentifierReference production resolves the binding of yield as if it was an Identifier. Early Error restriction ensures that such an evaluation only can occur for non-strict code. See 13.2.1 for the handling of yield in binding creation contexts.

12.2 Primary Expression

Syntax

PrimaryExpression[Yield] :
  this
  IdentifierReference[Yield]
  Literal
  ArrayLiteral[Yield]
  ObjectLiteral[Yield]
  FunctionExpression
  ClassExpression
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral
  CoverParenthesizedExpressionAndArrowParameterList[Yield]

CoverParenthesizedExpressionAndArrowParameterList[Yield] :
  ( Expression[Yield, Yield] )
  ( )
  ( ... BindingIdentifier[Yield] )
  ( Expression[Yield, Yield], ... BindingIdentifier[Yield] )

Supplemental Syntax

When processing the production

PrimaryExpression[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

the interpretation of CoverParenthesizedExpressionAndArrowParameterList is refined using the following grammar:
ParenthesizedExpression_{Yield}:
    ( Expression_{In}, _{Yield} )

12.2.0 Semantics

12.2.0.1 Static Semantics: CoveredParenthesizedExpression

CoverParenthesizedExpressionAndArrowParameterList_{Yield}:
    ( Expression_{In}, _{Yield} )

1. Return the result of parsing the lexical token stream matched by CoverParenthesizedExpressionAndArrowParameterList_{Yield} using either ParenthesizedExpression or ParenthesizedExpression_{Yield} as the goal symbol depending upon whether the _{Yield} grammar parameter was present when CoverParenthesizedExpressionAndArrowParameterList was matched.

12.2.0.2 Static Semantics: IsFunctionDefinition

See also: 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.9, 14.5.8.

PrimaryExpression:
    this
    IdentifierReference
    Literal
    ArrayLiteral
    ObjectLiteral
    RegularExpressionLiteral
    TemplateLiteral

1. Return false.

PrimaryExpression: CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoveredParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return IsFunctionDefinition of expr.

12.2.0.3 Static Semantics: IsIdentifierRef

See also: 12.3.1.3.

PrimaryExpression:
    IdentifierReference

1. Return true.
PrimaryExpression :
  this
  Literal
  ArrayLiteral
  ObjectLiteral
  FunctionExpression
  ClassExpression
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral
  CoverParenthesizedExpressionAndArrowParameterList

1. Return false.

12.2.0.4 Static Semantics: IsValidSimpleAssignmentTarget

See also: 12.1.3, 12.2.9.3, 12.3.1.3, 12.4.3, 12.5.3, 12.6.2, 12.7.2, 12.8.2, 12.9.2, 12.10.2, 12.11.2,

PrimaryExpression :
  this
  Literal
  ArrayLiteral
  ObjectLiteral
  FunctionExpression
  ClassExpression
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral
  CoverParenthesizedExpressionAndArrowParameterList

1. Return false.

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoverParenthesizedExpression of
   CoverParenthesizedExpressionAndArrowParameterList.
2. Return IsValidSimpleAssignmentTarget of expr.

12.2.1 The this Keyword

12.2.1.1 Runtime Semantics: Evaluation

PrimaryExpression : this

1. Return ResolveThisBinding() .

12.2.2 Identifier Reference

See 12.1 for IdentifierReference.
12.2.3 Literals

Syntax

Literal :
  NullLiteral
  BooleanLiteral
  NumericLiteral
  StringLiteral

12.2.3.1 Runtime Semantics: Evaluation

Literal : NullLiteral
  1. Return null.

Literal : BooleanLiteral
  1. Return false if BooleanLiteral is the token false.
  2. Return true if BooleanLiteral is the token true.

Literal : NumericLiteral
  1. Return the number whose value is MV of NumericLiteral as defined in 11.8.3.

Literal : StringLiteral
  1. Return the StringValue of StringLiteral as defined in 11.8.4.2.

12.2.4 Array Initializer

NOTE An ArrayLiteral is an expression describing the initialization 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 initializer is evaluated.

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

Syntax

ArrayLiteral: [ Elision, ElementList ]
  [ Elision, ElementList, Elision ]

ElementList: Elision, AssignmentExpression, SpreadElement

Elision, ElementList, Elision, AssignmentExpression
Elision, ElementList, SpreadElement
Elision, ElementList, Elision, AssignmentExpression
Elision, ElementList, Elision, SpreadElement
Elision:

Elision,

SpreadElement:

... AssignmentExpression

12.2.4.1 Static Semantics: ElisionWidth

Elision:

1. Return the numeric value 1.

Elision:

1. Let preceding be the ElisionWidth of Elision.
2. Return preceding+1.

12.2.4.2 Runtime Semantics: ArrayAccumulation

With parameters array and nextIndex.

ElementList : Elision, AssignmentExpression

1. Let padding be the ElisionWidth 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. Let created be CreateDataProperty(array, ToString(ToUint32(nextIndex+padding)), initValue).
6. Assert: created is true.
7. Return nextIndex+padding+1.

ElementList : Elision, SpreadElement

1. Let padding be the ElisionWidth of Elision; if Elision is not present, use the numeric value zero.
2. Return the result of performing ArrayAccumulation for SpreadElement with arguments array and nextIndex+padding.

ElementList : ElementList, Elision, AssignmentExpression

1. Let postIndex be the result of performing ArrayAccumulation for ElementList with arguments array and nextIndex.
2. ReturnIfAbrupt(postIndex).
3. Let padding be the ElisionWidth 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. Let created be CreateDataProperty(array, ToString(ToUint32(postIndex+padding)), initValue).
8. Assert: created is true.
9. Return postIndex+padding+1.

ElementList : ElementList, Elision, SpreadElement

1. Let postIndex be the result of performing ArrayAccumulation for ElementList with arguments array and nextIndex.
2. ReturnIfAbrupt(postIndex).
3. Let padding be the ElisionWidth of Elision; if Elision is not present, use the numeric value zero.
4. Return the result of performing ArrayAccumulation for SpreadElement with arguments array and postIndex+padding.

SpreadElement: ... AssignmentExpression
1. Let spreadRef be the result of evaluating AssignmentExpression.
2. Let spreadObj be GetValue(spreadRef).
3. Let iterator be GetIterator(spreadObj).
4. ReturnIfAbrupt(iterator).
5. Repeat
   a. Let next be IteratorStep(iterator).
   b. ReturnIfAbrupt(next).
   c. If next is false, return nextIndex.
   d. Let nextValue be IteratorValue(next).
   e. ReturnIfAbrupt(nextValue).
   f. Let status be CreateDataProperty(array, [ToString(ToUint32(nextIndex))], nextValue).
   g. Assert: status is true.
   h. Let nextIndex be nextIndex + 1.

NOTE CreateDataProperty 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]].

12.2.4.3 Runtime Semantics: Evaluation

ArrayLiteral: [ Elisionopt ]
1. Let array be ArrayCreate(0).
2. Let pad be the ElisionWidth of Elision; if Elision is not present, use the numeric value zero.
4. NOTE: The above Put cannot fail because of the nature of the object returned by ArrayCreate.
5. Return array.

ArrayLiteral: [ ElementList ]
1. Let array be ArrayCreate(0).
2. Let len be the result of performing ArrayAccumulation for ElementList with arguments array and 0.
3. ReturnIfAbrupt(len).
5. NOTE: The above Put cannot fail because of the nature of the object returned by ArrayCreate.
6. Return array.

ArrayLiteral: [ ElementList, Elisionopt ]
1. Let array be ArrayCreate(0).
2. Let len be the result of performing ArrayAccumulation for ElementList with arguments array and 0.
3. ReturnIfAbrupt(len).
4. Let padding be the ElisionWidth of Elision; if Elision is not present, use the numeric value zero.
5. Perform Put(array, "length", ToUint32(padding+len), false).
6. NOTE: The above Put cannot fail because of the nature of the object returned by ArrayCreate.
7. Return array.
12.2.5 Object Initializer

NOTE 1 An object initializer is an expression describing the initialization 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 brackets. The values need not be literals; they are evaluated each time the object initializer is evaluated.

Syntax

ObjectLiteral[Yield]:
  { }
  { PropertyDefinitionList[Yield] }
  { PropertyDefinitionList[Yield] , }

PropertyDefinitionList[Yield]:
  PropertyDefinition[Yield] PropertyDefinitionList[Yield] , PropertyDefinition[Yield]

PropertyDefinition[Yield]:
  IdentifierReference[Yield]
  CoverInitializedName[Yield]
  PropertyName[Yield] : AssignmentExpression[Yield, Yield]
  MethodDefinition[Yield]

PropertyName[Yield, GeneratorParameter]:
  LiteralPropertyName
  [~GeneratorParameter] ComputedPropertyName
  [~GeneratorParameter] ComputedPropertyName[Yield]

LiteralPropertyName:
  IdentifierName
  StringLiteral
  NumericLiteral

ComputedPropertyName[Yield]:
  [ AssignmentExpression[Yield, Yield] ]

CoverInitializedName[Yield]:
  IdentifierReference[Yield] Initialize[Yield]

Initialize[Yield]:
  = AssignmentExpression[Yield, Yield]

NOTE 2 MethodDefinition is defined in 14.3.

NOTE 3 In certain contexts, ObjectLiteral is used as a cover grammar for a more restricted secondary grammar. The CoverInitializedName 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.

12.2.5.1 Static Semantics: Early Errors

PropertyDefinition : MethodDefinition
  • It is a Syntax Error if HasDirectSuper(MethodDefinition) is true.
In addition to describing an actual object initializer the `ObjectLiteral` productions are also used as a cover grammar for `ObjectAssignmentPattern` (12.14.5), and may be recognized as part of a `CoverParenthesizedExpressionAndArrowParameterList`. When `ObjectLiteral` appears in a context where `ObjectAssignmentPattern` is required the following Early Error rules are not applied. In addition, they are not applied when initially parsing a `CoverParenthesizedExpressionAndArrowParameterList`.

**PropertyDefinition : CoverInitializedName**

- 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` (12.14.5). It cannot occur in an actual object initializer.

**12.2.5.2 Static Semantics: ComputedPropertyContains**

With parameter `symbol`.

See also: 14.3.2, 14.4.3, 14.5.5.

**PropertyName : LiteralPropertyName**

1. Return `false`.

**PropertyName : ComputedPropertyName**

1. Return the result of `ComputedPropertyName` Contains `symbol`.

**12.2.5.3 Static Semantics: Contains**

With parameter `symbol`.

See also: 5.3, 12.3.1.1, 14.1.4, 14.2.3, 14.4.4, 14.5.4.

**PropertyDefinition : MethodDefinition**

1. If `symbol` is `MethodDefinition`, return `true`.
2. Return the result of `ComputedPropertyContains` for `MethodDefinition` with argument `symbol`.

**NOTE** Static semantic rules that depend upon substructure generally do not look into function definitions.

**LiteralPropertyName : 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`.

**12.2.5.4 Static Semantics: HasComputedPropertyKey**

See also: 14.3.4, 14.4.5

**PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition**

1. If `HasComputedPropertyKey` of `PropertyDefinitionList` is `true`, return `true`.
2. Return `HasComputedPropertyKey` of `PropertyDefinition`.
PropertyDefinition : IdentifierReference
  1. Return false.

PropertyDefinition : PropertyName : AssignmentExpression
  1. Return IsComputedPropertyKey of PropertyName.

12.2.5.5 Static Semantics: IsComputedPropertyKey

PropertyName : LiteralPropertyName
  1. Return false.

PropertyName : ComputedPropertyName
  1. Return true.

12.2.5.6 Static Semantics: PropName

See also: 14.3.5, 14.4.9, 14.5.12

PropertyDefinition : IdentifierReference
  1. Return StringValue of IdentifierReference.

PropertyDefinition : PropertyName : AssignmentExpression
  1. Return PropName of PropertyName.

LiteralPropertyName : IdentifierName
  1. Return StringValue of IdentifierName.

LiteralPropertyName : StringLiteral
  1. Return a String value whose code units are the SV of the StringLiteral.

LiteralPropertyName : NumericLiteral
  1. Let \( nbr \) be the result of forming the value of the NumericLiteral.
  2. Return ToString(nbr).

ComputedPropertyName : [ AssignmentExpression ]
  1. Return empty.

12.2.5.7 Static Semantics: PropertyNameList

PropertyDefinitionList : PropertyDefinition
  1. If PropName of PropertyDefinition is empty, return a new empty List.
  2. Return a new List containing PropName of PropertyDefinition.

PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition
  1. Let list be PropertyNameList of PropertyDefinitionList.
2. If PropName of PropertyDefinition is empty, return list.
3. Append PropName of PropertyDefinition to the end of list.
4. Return list.

12.2.5.8 Runtime Semantics: Evaluation

ObjectLiteral : { }
1. Return ObjectCreate(%ObjectPrototype%).

ObjectLiteral :
   { PropertyDefinitionList }
   { PropertyDefinitionList , }
1. Let obj be ObjectCreate(%ObjectPrototype%).
2. Let status be the result of performing PropertyDefinitionEvaluation of PropertyDefinitionList with arguments obj and true.
3. ReturnIfAbrupt(status).
4. Return obj.

LiteralPropertyName : IdentifierName
1. Return StringValue of IdentifierName.

LiteralPropertyName : StringLiteral
1. Return a String value whose code units are the SV of the StringLiteral.

LiteralPropertyName : NumericLiteral
1. Let nbr be the result of forming the value of the NumericLiteral.
2. Return ToString(nbr).

ComputedPropertyName : [ AssignmentExpression ]
1. Let exprValue be the result of evaluating AssignmentExpression.
2. Let propName be GetValue(exprValue).
3. ReturnIfAbrupt(propName).
4. Return ToPropertyKey(propName).

12.2.5.9 Runtime Semantics: PropertyDefinitionEvaluation

With parameter object and enumerable.

See also: 14.3.10, 14.4.14, B.3.1

PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition
1. Let status be the result of performing PropertyDefinitionEvaluation of PropertyDefinitionList with arguments object and enumerable.
2. ReturnIfAbrupt(status).
3. Return the result of performing PropertyDefinitionEvaluation of PropertyDefinition with arguments object and enumerable.
PropertyDefinition : IdentifierReference
1. Let propName be StringValue of IdentifierReference.
2. Let exprValue be the result of evaluating IdentifierReference.
3. ReturnIfAbrupt(exprValue).
4. Let propValue be GetValue(exprValue).
5. ReturnIfAbrupt(propValue).
6. Assert: enumerable is true.
7. Return CreateDataPropertyOrThrow(object, propName, propValue).

PropertyDefinition : PropertyName : AssignmentExpression
1. Let propKey be the result of evaluating PropertyName.
2. ReturnIfAbrupt(propKey).
3. Let exprValueRef be the result of evaluating AssignmentExpression.
4. Let propValue be GetValue(exprValueRef).
5. ReturnIfAbrupt(propValue).
6. If IsFunctionDefinition of AssignmentExpression is true, then
   a. Assert: propValue is an ECMAScript function object.
   b. Let referencesSuper be the value of propValue’s [[NeedsSuper]] internal slot.
   c. Let thisMode be the value of propValue’s [[ThisMode]] internal slot.
   d. If thisMode is not lexical and referencesSuper is true, then
      i. If propValue’s [[HomeObject]] internal slot is undefined, then
         1. Assert: AssignmentExpression is not a class definition whose constructor references super.
      ii. Set propValue’s [[HomeObject]] internal slot to object.
   e. If IsAnonymousFunctionDefinition(AssignmentExpression) is true, then
      i. Let hasNameProperty be HasOwnProperty(propValue, "name").
      ii. ReturnIfAbrupt(hasNameProperty).
      iii. If hasNameProperty is false, perform SetFunctionName(propValue, propKey).
7. Assert: enumerable is true.
8. Return CreateDataPropertyOrThrow(object, propKey, propValue).

NOTE An alternative semantics for this production is given in 8.3.1.

12.2.6 Function Defining Expressions
See 14.1 for PrimaryExpression : FunctionExpression.
See 14.4 for PrimaryExpression : GeneratorExpression.
See 14.5 for PrimaryExpression : ClassExpression.

12.2.7 Regular Expression Literals
Syntax
See 11.8.4.
12.2.7.1 Static Semantics: Early Errors

PrimaryExpression : RegularExpressionLiteral

- It is a Syntax Error if BodyText of RegularExpressionLiteral cannot be recognized using the goal symbol Pattern of the ECMAScript RegExp grammar specified in 21.2.1.
- It is a Syntax Error if FlagText of RegularExpressionLiteral contains any code points other than "g", "i", "m", "u", or "y", or if it contains the same code point more than once.

12.2.7.2 Runtime Semantics: Evaluation

PrimaryExpression : RegularExpressionLiteral

1. Let pattern be the string value consisting of the UTF-16Encoding of each code point of BodyText of RegularExpressionLiteral.
2. Let flags be the string value consisting of the UTF-16Encoding of each code point of FlagText of RegularExpressionLiteral.
3. Return RegExpCreate(pattern, flags).

12.2.8 Template Literals

Syntax

TemplateLiteral{raw} : 
  NoSubstitutionTemplate
    TemplateHead Expression{In, ?} [Lexical goal InputElementTemplateTail] TemplateSpans{Yield}

TemplateSpans{raw} : 
  TemplateTail
    TemplateMiddleList{In, ?} [Lexical goal InputElementTemplateTail] TemplateTail

TemplateMiddleList{raw} : 
  TemplateMiddle Expression{In, ?} 
    TemplateMiddleList{In, ?} [Lexical goal InputElementTemplateTail] TemplateMiddle Expression{In, ?}

12.2.8.1 Static Semantics

12.2.8.1.1 Static Semantics: TemplateStrings

With parameter raw.

TemplateLiteral : NoSubstitutionTemplate

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.

TemplateLiteral : TemplateHead Expression TemplateSpans

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.

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.

TemplateSpans : TemplateMiddleList TemplateTail
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.

TemplateMiddleList : TemplateMiddle  Expression
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.

TemplateMiddleList : TemplateMiddleList 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.

12.2.8.2 Runtime Semantics
12.2.8.2.1 Runtime Semantics: ArgumentListEvaluation

See also: 12.3.6.1

TemplateLiteral : NoSubstitutionTemplate
1. Let siteObj be the result of the abstract operation GetTemplateObject passing this TemplateLiteral production as the argument.
2. Return a List containing the one element which is siteObj.

TemplateLiteral : TemplateHead Expression  TemplateSpans
1. Let siteObj be the result of the abstract operation GetTemplateObject 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.

12.2.8.2.2 Runtime Semantics: GetTemplateObject ( templateLiteral )

The abstract operation GetTemplateObject is called with a grammar production, templateLiteral, as an argument. It performs the following steps:

1. Let rawStrings be TemplateStrings of templateLiteral with argument true.
2. Let ctx be the running execution context.
3. Let realm be the ctx's Realm.
4. Let templateRegistry be realm.[[templateMap]].
5. For each element e of templateRegistry, do
   a. If e.[[strings]] and rawStrings contain the same values in the same order, then
      i. Return e.[[array]].
6. Let cookedStrings be TemplateStrings of templateLiteral with argument false.
7. Let count be the number of elements in the List cookedStrings.
8. Let template be ArrayCreate(count).
9. Let rawObj be ArrayCreate(count).
10. Let index be 0.
11. Repeat while index < count
   a. Let prop be ToString(index).
   b. Let cookedValue be the string value List cookedStrings[index].
   c. Call the [[DefineOwnProperty]] internal method of template with arguments prop and PropertyDescriptor{[[Value]]; cookedValue, [[Enumerable]]; true, [[Writable]]; false, [[Configurable]]; false}.
   d. Let rawValue be the string value rawStrings[index].
   e. Call the [[DefineOwnProperty]] internal method of rawObj with arguments prop and PropertyDescriptor{[[Value]]; rawValue, [[Enumerable]]; true, [[Writable]]; false, [[Configurable]]; false}.
   f. Let index be index + 1.
12. Perform SetIntegrityLevel(rawObj, "frozen").
13. Call the [[DefineOwnProperty]] internal method of template with arguments "raw" and PropertyDescriptor{[[Value]]; rawObj, [[Writable]]; false, [[Enumerable]]; false, [[Configurable]]; false}.
14. Perform SetIntegrityLevel(template, "frozen").
15. Append the Record{[[strings]]; rawStrings, [[array]]; template} to templateRegistry.
16. Return template.

NOTE 1 The creation of a template object cannot result in an abrupt completion.

NOTE 2 Each TemplateLiteral in the program code of a Realm is associated with a unique template object that is used in the evaluation of tagged Templates (12.2.8.4). The template objects are frozen and the same template object is used each time a specific tagged Template is evaluated. Whether template 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.

NOTE 3 Future editions of this specification may define additional non-enumerable properties of template objects.
12.2.8.2.3 Runtime Semantics: SubstitutionEvaluation

TemplateSpans : TemplateTail
  1. Return an empty List.

TemplateSpans : TemplateMiddleList 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 TemplateMiddle Expression
  1. Let preceding be the result of SubstitutionEvaluation of TemplateMiddleList.
  2. ReturnIfAbrupt(preceding).
  3. Let next be the result of evaluating Expression.
  4. ReturnIfAbrupt(next).
  5. Append next as the last element of the List preceding.

12.2.8.2.4 Runtime Semantics: Evaluation

TemplateLiteral : NoSubstitutionTemplate
  1. Return the string value whose code units are the elements of the TV of NoSubstitutionTemplate as defined in 11.8.6.

TemplateLiteral : TemplateHead Expression TemplateSpans
  1. Let head be the TV of TemplateHead as defined in 11.8.6.
  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 code units are the elements of head followed by the elements of middle followed by the elements of tail.

NOTE The string conversion semantics applied to the Expression value are like String.prototype.concat rather than the + operator.

TemplateSpans : TemplateTail
  1. Let tail be the TV of TemplateTail as defined in 11.8.6.
  2. Return the string consisting of the code units of tail.

TemplateSpans : TemplateMiddleList TemplateTail
  1. Let head be the result of evaluating TemplateMiddleList.
  2. ReturnIfAbrupt(head).
3. Let tail be the TV of TemplateTail as defined in 11.8.6.
4. Return the string whose code units are the elements of head followed by the elements of tail.

TemplateMiddleList : TemplateMiddle Expression
1. Let head be the TV of TemplateMiddle as defined in 11.8.6.
2. Let sub be the result of evaluating Expression.
3. Let middle be ToString(sub).
4. ReturnIfAbrupt(middle).
5. Return the sequence of code units consisting of the code units of head followed by the elements of middle.

NOTE The string conversion semantics applied to the Expression value are like `String.prototype.concat` rather than the + operator.

TemplateMiddleList : TemplateMiddleList 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 11.8.6.
4. Let sub be the result of evaluating Expression.
5. Let last be ToString(sub).
6. ReturnIfAbrupt(last).
7. Return the sequence of code units consisting of the elements of rest followed by the code units of middle followed by the elements of last.

NOTE The string conversion semantics applied to the Expression value are like `String.prototype.concat` rather than the + operator.

12.2.9 The Grouping Operator

12.2.9.1 Static Semantics: Early Errors

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList
- It is a Syntax Error if the lexical token sequence matched by CoverParenthesizedExpressionAndArrowParameterList 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 CoverParenthesizedExpression and its derived productions.

12.2.9.2 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.9, 14.5.8.

ParenthesizedExpression : ( Expression )
- Return IsFunctionDefinition of Expression.

12.2.9.3 Static Semantics: IsValidSimpleAssignmentTarget

ParenthesizedExpression : ( Expression )

1. Return IsValidSimpleAssignmentTarget of Expression.

12.2.9.4 Runtime Semantics: Evaluation

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoverParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return the result of evaluating expr.

ParenthesizedExpression : ( 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 parenthesized expressions.

12.3 Left-Hand-Side Expressions

Syntax

MemberExpression {Yield}:
[Lexical goal InputElementRegExp] PrimaryExpression {Yield}
MemberExpression {Yield} [ Expression {Yield} ]
MemberExpression {Yield} . IdentifierName
MemberExpression {Yield} TemplateLiteral {Yield}
SuperProperty {Yield}
MetaProperty
new MemberExpression {Yield} Arguments {Yield}

SuperProperty {Yield}:
super [ Expression {Yield} ]
super . IdentifierName

NewExpression {Yield}:
MemberExpression {Yield}
new NewExpression {Yield}

MetaProperty :
NewTarget

NewTarget:
new . target

NewExpression {Yield}:
MemberExpression {Yield}
new NewExpression {Yield}
12.3.1 Static Semantics

12.3.1.1 Static Semantics: Contains

With parameter symbol.

See also: 5.3, 12.2.5.2, 14.1.4, 14.2.3, 14.4.4, 14.5.4

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.

SuperProperty : 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.

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`.

12.3.1.2 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

`MemberExpression`:
- `MemberExpression [ Expression ]`
- `MemberExpression . IdentifierName`
- `MemberExpression TemplateLiteral`
- `SuperProperty`
- `MetaProperty`
- `new MemberExpression Arguments`

`NewExpression`:
- `new NewExpression`

`CallExpression`:
- `MemberExpression Arguments`
- `SuperCall`
- `CallExpression Arguments`
- `CallExpression [ Expression ]`
- `CallExpression . IdentifierName`
- `CallExpression TemplateLiteral`

1. Return `false`.

12.3.1.3 Static Semantics: IsDestructuring

See also: 13.6.4.5.

`MemberExpression`:
- `PrimaryExpression`
  1. If `PrimaryExpression` is either an `ObjectLiteral` or an `ArrayLiteral`, return `true`.
  2. Return `false`.

`MemberExpression`:
- `MemberExpression [ Expression ]`
- `MemberExpression . IdentifierName`
- `MemberExpression TemplateLiteral`
- `SuperProperty`
- `MetaProperty`
- `new MemberExpression Arguments`

`NewExpression`:
- `new NewExpression`

Deleted: `NewSuper`
Deleted: `Arguments`
Deleted: `Arguments`
Deleted: `Arguments`
CallExpression:
  MemberExpression Arguments
SuperCall
CallExpression Arguments
CallExpression [ Expression ]
CallExpression . IdentifierName
CallExpression TemplateLiteral

1. Return false.

12.3.1.4 Static Semantics: IsIdentifierRef

See also: 12.2.0.3.

LeftHandSideExpression:
  CallExpression

MemberExpression:
  MemberExpression [ Expression ]
MemberExpression . IdentifierName
MemberExpression TemplateLiteral
SuperProperty
MetaProperty
new MemberExpression Arguments

NewExpression:
  new NewExpression

1. Return false.

12.3.1.5 Static Semantics: IsValidSimpleAssignmentTarget

See also: 12.1.3, 12.2.0.3, 12.2.9.3, 12.4.3, 12.5.3, 12.6.2, 12.7.2, 12.8.2, 12.9.2, 12.10.2, 12.11.2,

CallExpression:
  CallExpression [ Expression ]
CallExpression . IdentifierName

MemberExpression:
  MemberExpression [ Expression ]
MemberExpression . IdentifierName
SuperProperty

1. Return true.

CallExpression:
  MemberExpression Arguments
SuperCall
CallExpression Arguments
CallExpression TemplateLiteral

NewExpression:
  new NewExpression

Deleted: NewSuper
Deleted: NewSuper New super Arguments
Deleted: NewSuper
Deleted: NewSuper

12.3.2 Property Accessors

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

```
MemberExpression . IdentifierName
CallExpression . IdentifierName
```
or the bracket notation:

```
MemberExpression [ Expression ]
CallExpression [ Expression ]
```
The dot notation is explained by the following syntactic conversion:

```
MemberExpression . IdentifierName
```
is identical in its behaviour to

```
MemberExpression [ <identifier-name-string> ]
```
and similarly

```
CallExpression . IdentifierName
```
is identical in its behaviour to

```
CallExpression [ <identifier-name-string> ]
```
where `<identifier-name-string>` is the result of evaluating StringValue of IdentifierName.

12.3.2.1 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 RequireObjectCoercible(`baseValue`).
8. ReturnIfAbrupt(`bv`).
9. Let `propertyKey` be ToPropertyKey(`propertyNameValue`).
10. ReturnIfAbrupt(`propertyKey`).
11. 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`.
12. Return a value of type Reference whose base value is `bv` and whose referenced name is `propertyKey`, and whose strict reference flag is `strict`. 
MemberExpression : MemberExpression . IdentifierName

1. Let baseReference be the result of evaluating MemberExpression.
2. Let baseValue be GetValue(baseReference).
3. ReturnIfAbrupt(baseValue).
4. Let bv be RequireObjectCoercible(baseValue).
5. ReturnIfAbrupt(bv).
6. Let propertyNameString be StringValue of IdentifierName.
7. 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.
8. 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.

CallExpression : CallExpression . IdentifierName

Is evaluated in exactly the same manner as MemberExpression : MemberExpression . IdentifierName except that the contained CallExpression is evaluated in step 1.

12.3.3 The new Operator

12.3.3.1 Runtime Semantics: Evaluation

NewExpression : new NewExpression

1. Let thisNewExpression be this NewExpression.
2. Return EvaluateNew(thisNewExpression, NewExpression, empty).

MemberExpression : new MemberExpression Arguments

1. Let thisMemberExpression be this MemberExpression.
2. Return EvaluateNew(thisMemberExpression, MemberExpression, Arguments).

12.3.3.1.1 Runtime Semantics: EvaluateNew(thisCall, constructProduction, arguments)

The abstract operation EvaluateNew with arguments production and arguments performs the following steps:

1. Assert: thisCall is either a NewExpression or a MemberExpression.
2. Assert: constructProduction is either a NewExpression or a MemberExpression.
3. Assert: arguments is either empty or an Arguments production.
4. Let ref be the result of evaluating constructProduction.
5. Let constructor be GetValue(ref).
6. ReturnIfAbrupt(constructor).
7. If arguments is empty, let argList be an empty List.
8. Else,
   b. ReturnIfAbrupt(argList).
9. If IsConstructor(constructor) is false, throw a TypeError exception.
10. Let tailCall be IsInTailPosition(thisCall). (See 14.6.1)
11. If tailCall is true, perform the PrepareForTailCall abstract operation.
12. Let result be Construct(constructor, argList).
13. Assert: If tailCall is true, the above call of Construct will not return here, but instead evaluation will continue as if the following return has already occurred.
14. Return result.

12.3.4 Function Calls

12.3.4.1 Runtime Semantics: Evaluation

CallExpression : MemberExpression Arguments

1. Let ref be the result of evaluating MemberExpression.
2. Let func be GetValue(ref).
3. ReturnIfAbrupt(func).
4. If Type(ref) is Reference and IsPropertyReference(ref) is false and GetReferencedName(ref) is "eval", then
   a. If SameValue(func, %eval%) is true, then
      i. Let argList be ArgumentListEvaluation(Arguments).
      ii. ReturnIfAbrupt(argList).
      iii. If argList has no elements, return undefined.
      iv. Let evalText be the first element of argList.
      v. If the source code matching this CallExpression is strict code, let strictCaller be true. Otherwise let strictCaller be false.
      vi. Let evalRealm be the running execution context's Realm.
      vii. Return PerformEval(evalText, evalRealm, strictCaller, true).
5. If Type(ref) is Reference, then
   a. If IsPropertyReference(ref) is true, then
      i. Let thisValue be GetThisValue(ref).
   b. Else, the base of ref is an Environment Record
      i. Let thisValue be the result of calling the WithBaseObject concrete method of GetBase(ref).
6. Else Type(ref) is not Reference.
   a. Let thisValue be undefined.
7. Let thisCall be this CallExpression.
8. Let tailCall be IsInTailPosition(thisCall). (See 14.6.1)
9. Return EvaluateDirectCall(func, thisValue, Arguments, tailCall).

A CallExpression whose evaluation executes step 4.a.vii is a direct eval.

CallExpression : CallExpression Arguments

1. Let ref be the result of evaluating CallExpression.
2. Let thisCall be this CallExpression.
3. Let tailCall be IsInTailPosition(thisCall). (See 14.6.1)
4. Return EvaluateCall(ref, Arguments, tailCall).

12.3.4.2 Runtime Semantics: EvaluateCall( ref, arguments, tailPosition )

The abstract operation EvaluateCall takes as arguments a value ref, 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. If Type(ref) is Reference, then
   a. If IsPropertyReference(ref) is true, then
12.3.4.3 Runtime Semantics: EvaluateDirectCall(func, thisValue, arguments, tailPosition)

The abstract operation EvaluateDirectCall takes as arguments a value func, a value thisValue, a syntactic
grammer production arguments, and a Boolean argument tailPosition. It performs the following steps:

2. ReturnIfAbrupt(argList).
3. If Type(func) is not Object, throw a TypeError exception.
4. If IsCallable(func) is false, throw a TypeError exception.
5. If tailPosition is true, perform the PrepareForTailCall abstract operation.
6. Let result be Call(func, thisValue, argList).
7. Assert: If tailPosition is true, the above call will not return here, but instead evaluation will
continue as if the following return has already occurred.
8. Assert: If result is not an abrupt completion then Type(result) is an ECMAScript language type.
9. Return result.

12.3.5 The super Keyword

12.3.5.1 Runtime Semantics: Evaluation

SuperProperty: super [ Expression ]

1. Let propertyNameReference be the result of evaluating Expression.
2. Let propertyNameValue be GetValue(propertyNameReference).
3. Let propertyKey be ToPropertyKey(propertyNameValue).
4. ReturnIfAbrupt(propertyKey).
5. 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.
6. Return MakeSuperPropertyReference(propertyKey, strict).

SuperProperty: 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 MakeSuperPropertyReference(propertyKey, strict).

SuperCall: super Arguments

1. Let newTarget be GetNewTarget().
2. If newTarget is undefined, throw a ReferenceError exception.
3. Let func be GetSuperConstructor().
4. ReturnIfAbrupt(func).
5. Let argList be ArgumentListEvaluation of Arguments.
6. ReturnIfAbrupt(argList).
7. Let result be Construct(func, argList, newTarget).
8. ReturnIfAbrupt(result).
9. Let thisER be GetThisEnvironment( ).
10. Return the result of calling the BindThisValue concrete method of thisER with argument result.

12.3.5.2 Runtime Semantics: GetSuperConstructor ( )

The abstract operation GetSuperConstructor performs the following steps:

1. Let envRec be GetThisEnvironment( ).
2. Assert: envRec is a Function environment record.
3. Let activeFunction be envRec.[[FunctionObject]].
4. Let superConstructor be the result of calling activeFunction’s [[GetPrototypeOf]] internal method.
5. ReturnIfAbrupt(superConstructor).
6. If IsConstructor(superConstructor) is false, throw a TypeError exception.
7. Return superConstructor.

12.3.5.3 Runtime Semantics: MakeSuperPropertyReference(propertyKey, strict)

The abstract operation MakeSuperPropertyReference with arguments propertyKey and strict performs the following steps:

1. Let env be GetThisEnvironment( ).
2. If the result of calling the HasSuperBinding concrete method of env is false, throw a ReferenceError exception.
3. Let actualThis be the result of calling the GetThisBinding concrete method of env.
4. ReturnIfAbrupt(actualThis).
5. Let baseValue be the result of calling the GetSuperBase concrete method of env.
7. ReturnIfAbrupt(bv).
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.

12.3.6 Argument Lists

NOTE The evaluation of an argument list produces a List of values (see 6.2.1).

12.3.6.1 Runtime Semantics: ArgumentListEvaluation

See also: 12.2.8.2.1

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 spreadObj be GetValue(spreadRef).
4. Let iterator be GetIterator(spreadObj).
5. ReturnIfAbrupt(iterator).
6. Repeat
   a. Let next be IteratorStep(iterator).
   b. ReturnIfAbrupt(next).
   c. If next is false, return list.
   d. Let nextArg be IteratorValue(next).
   e. ReturnIfAbrupt(nextArg).
   f. Append nextArg as the last element of list.

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. Append arg to the end of precedingArgs.
7. Return precedingArgs.

ArgumentList : ArgumentList , . . . AssignmentExpression
1. Let precedingArgs be the result of evaluating ArgumentList.
2. Let spreadRef be the result of evaluating AssignmentExpression.
3. Let iterator be GetIterator(GetValue(spreadRef)).
4. ReturnIfAbrupt(iterator).
5. Repeat
   a. Let next be IteratorStep(iterator).
   b. ReturnIfAbrupt(next).
   c. If next is false, return precedingArgs.
   d. Let nextArg be IteratorValue(next).
   e. ReturnIfAbrupt(nextArg).
   f. Append nextArg as the last element of precedingArgs.

12.3.7 Tagged Templates

NOTE A tagged template is a function call where the arguments of the call are derived from a TemplateLiteral (12.2.8). The actual arguments include a template object (12.2.8.2.2) and the values produced by evaluating the expressions embedded within the TemplateLiteral.

12.3.7.1 Runtime Semantics: Evaluation

MemberExpression : MemberExpression TemplateLiteral
1. Let tagRef be the result of evaluating MemberExpression.
2. Let thisCall be this MemberExpression.
3. Let tailCall be IsInTailPosition(thisCall). (See 14.6.1)
4. Return EvaluateCall(tagRef, TemplateLiteral, tailCall).

CallExpression : CallExpression TemplateLiteral
1. Let tagRef be the result of evaluating CallExpression.
2. Let thisCall be this CallExpression.
3. Let tailCall be IsInTailPosition(thisCall). (See 14.6.1)
4. Return EvaluateCall(tagRef, TemplateLiteral, tailCall).

12.3.8 Meta Properties

12.3.8.1 Runtime Semantics: Evaluation

**NewTarget** : new . target

1. Return GetNewTarget().

12.4 Postfix Expressions

**Syntax**

PostfixExpression: 

- LeftHandSideExpression [? Yield]
  - LeftHandSideExpression [? Yield] ++
  - LeftHandSideExpression [? Yield] --

12.4.1 Static Semantics: Early Errors

PostfixExpression:

- LeftHandSideExpression ++
- LeftHandSideExpression --

- It is an early Reference Error if IsValidSimpleAssignmentTarget of LeftHandSideExpression is **false**.

12.4.2 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8

PostfixExpression:

- LeftHandSideExpression ++
- LeftHandSideExpression --

1. Return **false**.

12.4.3 Static Semantics: IsValidSimpleAssignmentTarget


PostfixExpression:

- LeftHandSideExpression ++
- LeftHandSideExpression --

1. Return **false**.
12.4.4 Postfix Increment Operator

12.4.4.1 Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression ++

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 12.7.5).
5. Let status be PutValue(lhs, newValue).
6. ReturnIfAbrupt(status).
7. Return oldValue.

12.4.5 Postfix Decrement Operator

12.4.5.1 Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression --

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 subtracting the value 1 from oldValue, using the same rules as for the - operator (12.7.5).
5. Let status be PutValue(lhs, newValue).
6. ReturnIfAbrupt(status).
7. Return oldValue.

12.5 Unary Operators

Syntax

UnaryExpression\[\gamma_{\text{expr}}\] :

  PostfixExpression\[\gamma_{\text{expr}}\]
  delete UnaryExpression\[\gamma_{\text{expr}}\]
  void UnaryExpression\[\gamma_{\text{expr}}\]
  typeof UnaryExpression\[\gamma_{\text{expr}}\]
  ++ UnaryExpression\[\gamma_{\text{expr}}\]
  -- UnaryExpression\[\gamma_{\text{expr}}\]
  + UnaryExpression\[\gamma_{\text{expr}}\]
  = UnaryExpression\[\gamma_{\text{expr}}\]
  ~ UnaryExpression\[\gamma_{\text{expr}}\]
  ! UnaryExpression\[\gamma_{\text{expr}}\]

12.5.1 Static Semantics: Early Errors

UnaryExpression :

  ++ UnaryExpression
  -- UnaryExpression

- It is an early Reference Error if IsValidSimpleAssignmentTarget of UnaryExpression is false.
12.5.2 Static Semantics: `IsFunctionDefinition`

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

```
UnaryExpression:
  delete UnaryExpression
  void UnaryExpression
  typeof UnaryExpression
  ++ UnaryExpression
  -- UnaryExpression
  + UnaryExpression
  - UnaryExpression
  ~ UnaryExpression
  ! UnaryExpression
```

1. Return `false`.

12.5.3 Static Semantics: `IsValidSimpleAssignmentTarget`


```
UnaryExpression:
  delete UnaryExpression
  void UnaryExpression
  typeof UnaryExpression
  ++ UnaryExpression
  -- UnaryExpression
  + UnaryExpression
  - UnaryExpression
  ~ UnaryExpression
  ! UnaryExpression
```

1. Return `false`.

12.5.4 The `delete` Operator

12.5.4.1 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 : IdentifierReference`.
- It is a Syntax Error if the derived `UnaryExpression` is `PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList` and `CoverParenthesizedExpressionAndArrowParameterList` ultimately derives a phrase that, if used in place of `UnaryExpression`, would produce a Syntax Error according to these rules. This rule is recursively applied.
NOTE The last rule means that expressions such as
  `delete (((foo)))`
produce early errors because of recursive application of the first rule.

12.5.4.2 Runtime Semantics: Evaluation

`UnaryExpression : delete UnaryExpression`

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. Assert: `IsStrictReference(ref)` is `false`.
   b. Return `true`.
5. If `IsPropertyReference(ref)` is `true`, then
   a. If `IsSuperReference(ref)`, 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`, 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.

12.5.5 The `void` Operator

12.5.5.1 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.

12.5.6 The `typeof` Operator

12.5.6.1 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".
3. Let `val` be `GetVal(val)`.
4. `ReturnIfAbrupt(val)`.
5. Return a String according to Table 36.

### Table 36 — typeof Operator Results

<table>
<thead>
<tr>
<th>Type of <code>val</code></th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>&quot;undefined&quot;</td>
</tr>
<tr>
<td>Null</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Boolean</td>
<td>&quot;boolean&quot;</td>
</tr>
<tr>
<td>Number</td>
<td>&quot;number&quot;</td>
</tr>
<tr>
<td>String</td>
<td>&quot;string&quot;</td>
</tr>
<tr>
<td>Symbol</td>
<td>&quot;symbol&quot;</td>
</tr>
<tr>
<td>Object (ordinary and does not implement <code>[[Call]]</code>)</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Object (standard exotic and does not implement <code>[[Call]]</code>)</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Object (implements <code>[[Call]]</code>)</td>
<td>&quot;function&quot;</td>
</tr>
<tr>
<td>Object (non-standard exotic, and does not implement <code>[[Call]]</code>)</td>
<td>Implementation-defined. Must not be &quot;undefined&quot;, &quot;boolean&quot;, &quot;function&quot;, &quot;number&quot;, &quot;symbol&quot;, or &quot;string&quot;.</td>
</tr>
</tbody>
</table>

NOTE Implementations are discouraged from defining new `typeof` result values for non-standard exotic objects. If possible "object" should be used for such objects.

12.5.7 Prefix Increment Operator

12.5.7.1 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 12.7.5).
5. Let `status` be `PutValue(expr, newValue)`.
6. `ReturnIfAbrupt(status)`.
7. Return `newValue`.

12.5.8 Prefix Decrement Operator

12.5.8.1 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 12.7.5).
5. Let status be PutValue(expr, newValue).
6. ReturnIfAbrupt(status).
7. Return newValue.

12.5.9 Unary + Operator

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

12.5.9.1 Runtime Semantics: Evaluation

UnaryExpression : + UnaryExpression

1. Let expr be the result of evaluating UnaryExpression.
2. Return ToNumber(GetValue(expr)).

12.5.10 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.

12.5.10.1 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.

12.5.11 Bitwise NOT Operator (~)

12.5.11.1 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.

12.5.12 Logical NOT Operator (!)

12.5.12.1 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.

12.6 Multiplicative Operators

Syntax

\[\text{MultiplicativeExpression}_{\text{yield}} : \]
\[\text{UnaryExpression}_{\text{yield}} \rightarrow \text{MultiplicativeOperator \ UnaryExpression}_{\text{yield}}\]

\[\text{MultiplicativeOperator} : \text{one of} \]
\(* \ / \ %\]

12.6.1 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.4.2, 12.5.2, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

\[\text{MultiplicativeExpression} : \text{MultiplicativeExpression} \ MultiplicativeOperator \ UnaryExpression\]

1. Return false.

12.6.2 Static Semantics: IsValidSimpleAssignmentTarget


\[\text{MultiplicativeExpression} : \text{MultiplicativeExpression} \ MultiplicativeOperator \ UnaryExpression\]

1. Return false.

12.6.3 Runtime Semantics: Evaluation

\[\text{MultiplicativeExpression} : \text{MultiplicativeExpression} \ MultiplicativeOperator \ UnaryExpression\]

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 MultiplicativeOperator (*, /, or %) to lnum and rnum as specified in 12.6.3.1, 12.6.3.2, or 12.6.3.3.

12.6.3.1 Applying the * Operator

The * MultiplicativeOperator 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 nor NaN is involved, the product is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode. If the magnitude is too large to represent, the result is then an infinity of appropriate sign. If the magnitude is too small to represent, the result is then a zero of appropriate sign. The ECMAScript language requires support of gradual underflow as defined by IEEE 754.

12.6.3.2 Applying the / Operator

The / MultiplicativeOperator 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.

12.6.3.3 Applying the % Operator

The % MultiplicativeOperator 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.

12.7 Additive Operators

Syntax

AdditiveExpression \[\text{=}\] AdditiveExpression + MultiplicativeExpression
AdditiveExpression \[\text{=}\] AdditiveExpression - MultiplicativeExpression

12.7.1 Static Semantics: IsValidFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

AdditiveExpression : AdditiveExpression + MultiplicativeExpression
AdditiveExpression - MultiplicativeExpression

1. Return false.

12.7.2 Static Semantics: IsValidSimpleAssignmentTarget

AdditiveExpression:
  AdditiveExpression + MultiplicativeExpression
  AdditiveExpression - MultiplicativeExpression

1. Return false.

12.7.3 The Addition operator (+)

NOTE The addition operator either performs string concatenation or numeric addition.

12.7.3.1 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. Let lstr be ToString(lprim).
   b. ReturnIfAbrupt(lstr).
   c. Let rstr be ToString(rprim).
   d. ReturnIfAbrupt(rstr).
   e. Return the String that is the result of concatenating lstr and rstr.
12. Let lnum be ToNumber(lprim).
13. ReturnIfAbrupt(lnum).
14. Let rnum be ToNumber(rprim).
15. ReturnIfAbrupt(rnum).
16. Return the result of applying the addition operation to lnum and rnum. See the Note below 12.7.5.

NOTE 1 No hint is provided in the calls to ToPrimitive in steps 7 and 9. All standard 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.

NOTE 2 Step 11 differs from step 5 of the Abstract Relational Comparison algorithm (7.2.9), by using the logical-or operation instead of the logical-and operation.

12.7.4 The Subtraction Operator (-)

12.7.4.1 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 12.7.5.

12.7.5 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.

NOTE 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).

12.8 Bitwise Shift Operators

Syntax

\[
\text{ShiftExpression} = \text{AdditiveExpression} \quad \text{ShiftExpression} = \text{AdditiveExpression} \quad \text{ShiftExpression} = \text{AdditiveExpression} \quad \text{ShiftExpression} = \text{AdditiveExpression} \\
\]

12.8.1 Static Semantics: IsFunctionDefinition
ShiftExpression:
  ShiftExpression <<= AdditiveExpression
  ShiftExpression >>= AdditiveExpression
  ShiftExpression >>> AdditiveExpression

1. Return false.

### 12.8.2 Static Semantics: IsValidSimpleAssignmentTarget


ShiftExpression:
  ShiftExpression <<= AdditiveExpression
  ShiftExpression >>= AdditiveExpression
  ShiftExpression >>> AdditiveExpression

1. Return false.

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

**NOTE**

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

#### 12.8.3.1 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 ToUint32(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 left shifting lnum by shiftCount bits. The result is a signed 32-bit integer.

### 12.8.4 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.

#### 12.8.4.1 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 ToUint32(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.

12.8.5 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.

12.8.5.1 Runtime Semantics: Evaluation

\textbf{ShiftExpression} : \textbf{ShiftExpression} >>> \textbf{AdditiveExpression}

1. Let lref be the result of evaluating \textbf{ShiftExpression}.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating \textbf{AdditiveExpression}.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let lnum be ToUint32(lval).
8. ReturnIfAbrupt(lnum).
9. Let rnum be ToUint32(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.

12.9 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.

\textbf{Syntax}

\textbf{RelationalExpression}\textsubscript{In Yield} : \\
\hspace{1em} \textbf{ShiftExpression}\textsubscript{Yield} >\textbf{ShiftExpression}\textsubscript{Yield} \\
\hspace{1em} \textbf{ShiftExpression}\textsubscript{Yield} <\textbf{ShiftExpression}\textsubscript{Yield} \\
\hspace{1em} \textbf{ShiftExpression}\textsubscript{Yield} >=\textbf{ShiftExpression}\textsubscript{Yield} \\
\hspace{1em} \textbf{ShiftExpression}\textsubscript{Yield} <=\textbf{ShiftExpression}\textsubscript{Yield} \\
\hspace{1em} \textbf{instanceof} \textbf{ShiftExpression}\textsubscript{Yield} \\
\hspace{1em} \textbf{string} \textbf{RelationalExpression}\textsubscript{Yield} \textbf{in} \textbf{ShiftExpression}\textsubscript{Yield}

NOTE The \textsubscript{In} grammar parameter is needed to avoid confusing the \textbf{in} operator in a relational expression with the \textbf{in} operator in a \textbf{for} statement.
12.9.1 Static Semantics: `IsFunctionDefinition`

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

RelationalExpression:
- `RelationalExpression < ShiftExpression`
- `RelationalExpression > ShiftExpression`
- `RelationalExpression <= ShiftExpression`
- `RelationalExpression >= ShiftExpression`
- `RelationalExpression instanceof ShiftExpression`
- `RelationalExpression in ShiftExpression`

1. Return `false`.

12.9.2 Static Semantics: `IsValidSimpleAssignmentTarget`


RelationalExpression:
- `RelationalExpression < ShiftExpression`
- `RelationalExpression > ShiftExpression`
- `RelationalExpression <= ShiftExpression`
- `RelationalExpression >= ShiftExpression`
- `RelationalExpression instanceof ShiftExpression`
- `RelationalExpression in ShiftExpression`

1. Return `false`.

12.9.3 Runtime Semantics: Evaluation

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` (see 7.2.9)
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 `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`.

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`.

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 `InstanceofOperator(lval, rval)`.

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`.
5. Let \( rval \) be `GetValue(rref)`.  
6. ReturnIfAbrupt(rval).
7. If `Type(rval)` is not `Object`, throw a `TypeError` exception.  
8. Return `HasProperty(rval, ToPropertyKey(lval))`.

12.9.4 Runtime Semantics: InstanceofOperator(O, C)

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 `GetMethod(C, @@hasInstance)`.  

3. ReturnIfAbrupt(instOfHandler).
4. If instOfHandler is not undefined, then
   a. Return ToBoolean(Call(instOfHandler, C, «O»)).
5. If IsCallable(C) is false, throw a TypeError exception.
6. Return 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.

12.10 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[?, ?In, ?Yield]:
   RelationalExpression[?, ?In, ?Yield]

12.10.1 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

EqualityExpression:
   EqualityExpression == RelationalExpression
   EqualityExpression != RelationalExpression
   EqualityExpression === RelationalExpression
   EqualityExpression !== RelationalExpression
   Return false.

12.10.2 Static Semantics: IsValidSimpleAssignmentTarget


EqualityExpression:
   EqualityExpression == RelationalExpression
   EqualityExpression != RelationalExpression
   EqualityExpression === RelationalExpression
   EqualityExpression !== RelationalExpression
   Return false.
12.10.3 Runtime Semantics: Evaluation

EqualityExpression : EqualityExpression == RelationalExpression
1. Let lref be the result of evaluating EqualityExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating RelationalExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Return the result of performing Abstract Equality Comparison rval == lval.

EqualityExpression : EqualityExpression != RelationalExpression
1. Let lref be the result of evaluating EqualityExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating RelationalExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let r be the result of performing Abstract Equality Comparison 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 GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating RelationalExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Return the result of performing Strict Equality Comparison rval === lval.

EqualityExpression : EqualityExpression !== RelationalExpression
1. Let lref be the result of evaluating EqualityExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating RelationalExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let r be the result of performing Strict Equality Comparison rval === lval.
8. If r is true, return false. Otherwise, return true.

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 == 1b.

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 normalized form.

12.11 Binary Bitwise Operators

Syntax

BitwiseANDExpression

EqualityExpression 

BitwiseANDExpression & EqualityExpression

BitwiseXORExpression

BitwiseXORExpression ^ BitwiseANDExpression

BitwiseORExpression

BitwiseORExpression | BitwiseXORExpression

12.11.1 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

BitwiseANDExpression : BitwiseANDExpression & EqualityExpression

BitwiseXORExpression : BitwiseXORExpression ^ BitwiseANDExpression

BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

1. Return false.

12.11.2 Static Semantics: IsValidSimpleAssignmentTarget


BitwiseANDExpression : BitwiseANDExpression & EqualityExpression

BitwiseXORExpression : BitwiseXORExpression ^ BitwiseANDExpression

BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

1. Return false.

12.11.3 Runtime Semantics: Evaluation

The production A : A @ B, where @ is one of the bitwise operators in the productions above, is evaluated as follows:
1. Let \( lref \) be the result of evaluating \( A \).
2. Let \( lval \) be \( \text{GetValue}(lref) \).
3. \text{ReturnIfAbrupt}(lval).
4. Let \( rref \) be the result of evaluating \( B \).
5. Let \( rval \) be \( \text{GetValue}(rref) \).
6. \text{ReturnIfAbrupt}(rval).
7. Let \( lnum \) be \( \text{ToInt32}(lval) \).
8. \text{ReturnIfAbrupt}(lnum).
9. Let \( rnum \) be \( \text{ToInt32}(rval) \).
10. \text{ReturnIfAbrupt}(rnum).
11. Return the result of applying the bitwise operator @ to \( lnum \) and \( rnum \). The result is a signed 32 bit integer.

12.12 Binary Logical Operators

Syntax

\[
\text{LogicalANDExpression} := \text{LogicalANDExpression} \&\& \text{BitwiseORExpression} \\
\text{LogicalORExpression} := \text{LogicalANDExpression} \text{|| LogicalANDExpression}
\]

NOTE The value produced by a \&\& or \text{||} operator is not necessarily of type Boolean. The value produced will always be the value of one of the two operand expressions.

12.12.1 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

\[
\text{LogicalANDExpression} : \text{LogicalANDExpression} \&\& \text{BitwiseORExpression} \\
\text{LogicalORExpression} : \text{LogicalANDExpression} \text{|| LogicalANDExpression}
\]

1. Return \text{false}.

12.12.2 Static Semantics: IsValidSimpleAssignmentTarget


\[
\text{LogicalANDExpression} : \text{LogicalANDExpression} \&\& \text{BitwiseORExpression} \\
\text{LogicalORExpression} : \text{LogicalORExpression} \text{|| LogicalANDExpression}
\]

1. Return \text{false}.

12.12.3 Runtime Semantics: Evaluation

\[
\text{LogicalANDExpression} : \text{LogicalANDExpression} \&\& \text{BitwiseORExpression}
\]

1. Let \( lref \) be the result of evaluating \( \text{LogicalANDExpression} \).
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).

12.13 Conditional Operator ( ? : )

Syntax

ConditionalExpression[ln, γval] :
   LogicalORExpression[ln, γval] || LogicalANDExpression

NOTE The grammar for a ConditionalExpression in ECMAScript is slightly 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.

12.13.1 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

ConditionalExpression :: LogicalORExpression ? AssignmentExpression : AssignmentExpression

1. Return false.

12.13.2 Static Semantics: IsValidSimpleAssignmentTarget


ConditionalExpression :: LogicalORExpression ? AssignmentExpression : AssignmentExpression

1. Return false.

12.13.3 Runtime Semantics: Evaluation

ConditionalExpression :: LogicalORExpression ? AssignmentExpression : AssignmentExpression

1. Let lref be the result of evaluating LogicalORExpression.
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(\( falseRef \)).

### 12.14 Assignment Operators

**Syntax**

\[
AssignmentExpression[?[], ??] : \\
  ConditionalExpression[?[], ??] \\
  [+Yield] YieldExpression[??] \\
  ArrowFunction[?[], ??] \\
  LeftHandSideExpression[??] = AssignmentExpression[?[], ??] \\
  LeftHandSideExpression[??] AssignmentOperator AssignmentExpression
\]

**AssignmentOperator** : one of

\[
*= /= %= += -= <<= >>= >>>= &= ^= |=
\]

### 12.14.1 Static Semantics: Early Errors

**AssignmentExpression** : LeftHandSideExpression = AssignmentExpression

- It is a Syntax Error if \( LeftHandSideExpression \) is either an \( ObjectLiteral \) or an \( ArrayLiteral \) and the lexical token sequence matched by \( LeftHandSideExpression \) cannot be parsed with no tokens left over using AssignmentPattern as the goal symbol.
- 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 an early Reference Error if IsValidSimpleAssignmentTarget of \( LeftHandSideExpression \) is **false**.

### 12.14.2 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.15.1, 14.1.12, 14.4.8, 14.5.8.

**AssignmentExpression** : ArrowFunction

1. Return **true**.

**AssignmentExpression** :

\[
  YieldExpression
  LeftHandSideExpression = AssignmentExpression \\
  LeftHandSideExpression AssignmentOperator AssignmentExpression
\]

1. Return **false**.
12.14.3 Static Semantics: IsValidSimpleAssignmentTarget

See also: 12.1.3, 12.2.0.3, 12.2.9.3, 12.3.1.3, 12.4.3, 12.5.3, 12.6.2, 12.7.2, 12.8.2, 12.9.2, 12.10.2, 12.11.2, 12.12.2, 12.13.2, 12.15.2.

AssignmentExpression:

YieldExpression
ArrowFunction
LeftHandSideExpression = AssignmentExpression
LeftHandSideExpression AssignmentOperator AssignmentExpression

1. Return false.

12.14.4 Runtime Semantics: Evaluation

AssignmentExpression\[? Yield\] : LeftHandSideExpression\[? Yield\] = AssignmentExpression\[? Yield\]

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. If IsAnonymousFunctionDefinition(AssignmentExpression) and IsIdentifierRef of LeftHandSideExpression are both true, then
      i. Let hasNameProperty be HasOwnProperty(rval, "name").
      ii. ReturnIfAbrupt(hasNameProperty).
      iii. If hasNameProperty is false, perform SetFunctionName(rval, GetReferencedName(lref)).
   f. Let status be PutValue(lref, rval).
   g. ReturnIfAbrupt(status).
   h. Return rval.
2. Let assignmentPattern be the parse of the source code corresponding to LeftHandSideExpression using AssignmentPattern\[? Yield\] as the goal symbol.
3. Let rref be the result of evaluating AssignmentExpression.
4. Let rval be GetValue(rref).
5. ReturnIfAbrupt(rval).
6. Let status be the result of performing DestructuringAssignmentEvaluation of assignmentPattern using rval as the argument.
7. ReturnIf Abrupt(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 op be the \( \oplus \) where AssignmentOperator is \( \oplus \)
8. Let \( r \) be the result of applying \( \oplus \) to \( lval \) and \( rval \) as if evaluating the expression \( lval \oplus rval \).
9. Let status be PutValue(lref, r).
10. ReturnIfAbrupt(status).
11. Return r.
NOTE When an assignment occurs within strict mode code, it is a runtime error if `lref` in step 1.1 of the first algorithm or step 9 of the second algorithm it 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 `false`, to an accessor property with the attribute value `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.

12.14.5 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`.

```
AssignmentPattern[Yield]:
  ObjectAssignmentPattern[Yield]
  ArrayAssignmentPattern[Yield]

ObjectAssignmentPattern[Yield]:
  {  }
  { AssignmentPropertyList[Yield] } { AssignmentPropertyList[Yield] }

ArrayAssignmentPattern[Yield]:
  [ Elisionopt AssignmentRestElement[Yieldopt] ]
  [ AssignmentElementList[Yield] ]
  [ AssignmentElementList[Yield], Elisionopt AssignmentRestElement[Yieldopt] ]

AssignmentPropertyList[Yield]:
  AssignmentProperty[Yield]
  AssignmentPropertyList[Yield], AssignmentProperty[Yield]

AssignmentElementList[Yield]:
  AssignmentElisionElement[Yield]
  AssignmentElementList[Yield], AssignmentElisionElement[Yield]

AssignmentElisionElement[Yield]:
  Elisionopt AssignmentElement[Yield]

AssignmentProperty[Yield]:
  IdentifierReference[Yield], InitializerIn[Yieldopt]
  PropertyName : AssignmentElement[Yield]

AssignmentElement[Yield]:
  DestructuringAssignmentTarget[Yield] InitializerIn[Yieldopt]

AssignmentRestElement[Yield]:
  . . . DestructuringAssignmentTarget[Yield]

DestructuringAssignmentTarget[Yield]:
  LeftHandSideExpression[Yield]
```
12.14.5.1 Static Semantics: Early Errors

AssignmentProperty : IdentifierReference Initializer

- It is a Syntax Error if IsValidSimpleAssignment of IdentifierReference is false.

DestructuringAssignmentTarget : LeftHandSideExpression

- 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.
- It is a Syntax Error if LeftHandSideExpression is neither an ObjectLiteral nor an ArrayLiteral and IsValidSimpleAssignmentTarget(LeftHandSideExpression) is false.

12.14.5.2 Runtime Semantics: DestructuringAssignmentEvaluation

with parameter value

ObjectAssignmentPattern : { }

1. Let valid be RequireObjectCoercible(value).
2. ReturnIfAbrupt(valid).
3. Return NormalCompletion(empty).

ArrayAssignmentPattern : [ ]

1. Let iterator be GetIterator(value).
2. ReturnIfAbrupt(iterator).
3. Return IteratorClose(iterator, NormalCompletion(empty)).

ArrayAssignmentPattern : [ Elision ]

1. Let iterator be GetIterator(value).
2. ReturnIfAbrupt(iterator).
3. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
4. Return IteratorClose(iterator, result).

ArrayAssignmentPattern : [ Elision, AssignmentRestElement ]

1. Let iterator be GetIterator(value).
2. ReturnIfAbrupt(iterator).
3. If Elision is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
   b. If status is an abrupt completion, return IteratorClose(iterator, status).
4. Let result be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentRestElement with iterator as the argument.
5. Return IteratorClose(iterator, result).

ArrayAssignmentPattern : [ AssignmentElementList ]

1. Let iterator be GetIterator(value).
2. ReturnIfAbrupt(iterator).
3. Let result be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElementList using iterator as the argument.
4. Return IteratorClose(iterator, result).

ArrayAssignmentPattern : [ AssignmentElementList , Elisionopt AssignmentRestElementopt ]

1. Let iterator be GetIterator(value).
2. ReturnIfAbrupt(iterator).
3. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElementList using iterator as the argument.
4. If status is an abrupt completion, return IteratorClose(iterator, status).
5. If Elision is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
5. If AssignmentRestElement is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentRestElement with iterator as the argument.
6. If AssignmentRestElement is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentRestElement with iterator as the argument.
7. Return IteratorClose(iterator, status).

AssignmentPropertyList : AssignmentPropertyList , AssignmentProperty

1. Let status be the result of performing DestructuringAssignmentEvaluation for AssignmentPropertyList using value as the argument.
2. ReturnIfAbrupt(status).
3. Return the result of performing DestructuringAssignmentEvaluation for AssignmentProperty using value as the argument.

AssignmentProperty : IdentifierReference Initializeropt

1. Let P be StringValue of IdentifierReference.
2. Let lref be ResolveBinding(P).
3. ReturnIfAbrupt(P).
4. Let v be GetValue(value, P).
5. ReturnIfAbrupt(v).
6. If Initializeropt is present and v is undefined, then
   a. Let defaultValue be the result of evaluating Initializer.
6. If v is an abrupt completion, return IteratorClose(iterator, status).
6. If AssignmentRestElement is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentRestElement with iterator as the argument.
7. Return IteratorClose(iterator, status).

AssignmentProperty : PropertyName : AssignmentElement

1. Let name be the result of evaluating PropertyName.
2. ReturnIfAbrupt(name).
3. Return the result of performing KeyedDestructuringAssignmentEvaluation of AssignmentElement with value and name as the arguments.

12.14.5.3 Runtime Semantics: IteratorDestructuringAssignmentEvaluation

with parameters iterator
AssignmentElementList : AssignmentElisionElement
1. Return the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElisionElement using iterator as the argument.

AssignmentElementList : AssignmentElementList , AssignmentElisionElement
1. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElementList using iterator as the argument.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElisionElement using iterator as the argument.

AssignmentElisionElement : AssignmentElement
1. Return the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElement with iterator as the argument.

AssignmentElisionElement : Elision AssignmentElement
1. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of AssignmentElement with iterator as the argument.

Elision : ,
1. Return IteratorStep(iterator).

Elision : Elision ,
1. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
2. ReturnIfAbrupt(status).
3. Return IteratorStep(iterator).

AssignmentElementTarget : DestructuringAssignmentTarget Initializeropt
1. If DestructuringAssignmentTarget is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Letoref be the result of evaluating DestructuringAssignmentTarget.
   b. ReturnIfAbrupt(oref).
2. Let next be IteratorStep(iterator).
3. ReturnIfAbrupt(next).
4. If next is false, let value be undefined
5. Else
   a. Let value be IteratorValue(next).
   b. ReturnIfAbrupt(value).
6. If Initializer is present and value is undefined, then
   a. Let defaultvalue be the result of evaluating Initializer.
   b. Let v be GetValue(defaultValue)
   c. ReturnIfAbrupt(v).
7. Else, let v be value.
8. If DestructuringAssignmentTarget is an ObjectLiteral or an ArrayLiteral, then
a. Let nestedAssignmentPattern be the parse of the source code corresponding to
   DestructuringAssignmentTarget using either AssignmentPattern or AssignmentPattern[Yield] as
   the goal symbol depending upon whether this AssignmentElement has the Yield parameter.
b. Return the result of performing DestructuringAssignmentEvaluation of
   nestedAssignmentPattern with \( v \) as the argument.

c. If Initializer is present and value is undefined and IsAnonymousFunctionDefinition(Initializer) and
   IsIdentifierRef of DestructuringAssignmentTarget are both true, then
   a. Let hasNameProperty be HasOwnProperty(\( v \), "name").
   b. ReturnIfAbrupt(hasNameProperty).
   c. If hasNameProperty is false, perform SetFunctionName(\( v \), GetReferencedName(lref)).
d. Let accumulationFinished be false.
   e. Repeat until accumulationFinished is true.
      a. Let next be IteratorStep(iterator).
      b. ReturnIfAbrupt(next).
      c. If next is false, then
         i. Let accumulationFinished be true.
      d. else,
         i. Let nextValue be IteratorValue(next).
         ii. ReturnIfAbrupt(nextValue).
         iii. Let status be CreateDataProperty(\( A \), ToString(ToUint32(n)) nextValue).
         iv. Assert: status is true.
         v. Increment n by 1.
   e. If DestructuringAssignmentTarget is neither an ObjectLiteral nor an ArrayLiteral, then
      a. Return PutValue(lref, \( A \)).
    7. Let nestedAssignmentPattern be the parse of the source code corresponding to
       DestructuringAssignmentTarget using either AssignmentPattern or AssignmentPattern[Yield] as
       the goal symbol depending upon whether this AssignmentElement has the Yield parameter.
    8. Return the result of performing DestructuringAssignmentEvaluation of
       nestedAssignmentPattern with \( A \) as the argument.

**NOTE**
Left to right evaluation order is maintained by evaluating a DestructuringAssignmentTarget that is not a
destructuring pattern prior to accessing the iterator or evaluating the Initializer.

**AssignmentRestElement\( [\text{Yield}] \): . . . DestructuringAssignmentTarget**

1. If DestructuringAssignmentTarget is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Let lref be the result of evaluating DestructuringAssignmentTarget.
   b. ReturnIfAbrupt(lref).
2. Let A be ArrayCreate(0).
3. Let n=0;
4. Let accumulationFinished be false.
5. Repeat until accumulationFinished is true.
   a. Let next be IteratorStep(iterator).
   b. ReturnIfAbrupt(next).
   c. If next is false, then
      i. Let accumulationFinished be true.
   d. else,
      i. Let nextValue be IteratorValue(next).
      ii. ReturnIfAbrupt(nextValue).
      iii. Let status be CreateDataProperty(\( A \), ToString(ToUint32(n)) nextValue).
      iv. Assert: status is true.
   v. Increment n by 1.
6. If DestructuringAssignmentTarget is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Return PutValue(lref, \( A \)).
7. Let nestedAssignmentPattern be the parse of the source code corresponding to
   DestructuringAssignmentTarget using either AssignmentPattern or AssignmentPattern[Yield] as
   the goal symbol depending upon whether this AssignmentElement has the Yield parameter.
8. Return the result of performing DestructuringAssignmentEvaluation of
   nestedAssignmentPattern with \( A \) as the argument.

**12.14.5.4 Runtime Semantics: KeyedDestructuringAssignmentEvaluation**

with parameters value and propertyName

AssignmentElement\( [\text{Yield}] \): DestructuringAssignmentTarget Initializeropt

1. If DestructuringAssignmentTarget is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Let lref be the result of evaluating DestructuringAssignmentTarget.
   b. ReturnIfAbrupt(lref).
2. Let v be GetValue(value, propertyName).
3. ReturnIfAbrupt(v).
4. If `Initializer` is present and `v` is `undefined`, then
   a. Let `defaultValue` be the result of evaluating `Initializer`.
   b. Let `rhsValue` be `GetValuesOf(defaultValue)`
   c. Return `Abrupt(rhsValue)`.
5. Else, let `rhsValue` be `v`.
6. If `DestructuringAssignmentTarget` is an `ObjectLiteral` or an `ArrayLiteral`, then
   a. Let `AssignmentPattern` be the parse of the source code corresponding to
      `DestructuringAssignmentTarget` using either `AssignmentPattern` or `AssignmentPattern`[`yield`]
      as the goal symbol depending upon whether this `AssignmentElement` has the `yield` parameter.
   b. Return the result of performing `DestructuringAssignmentEvaluation` of `AssignmentPattern` with
      `rhsValue` as the argument.
7. If `Initializer` is present and `v` is `undefined` and `IsAnonymousFunctionDefinition(Initializer)` and
   `IsIdentifierRef of DestructuringAssignmentTarget` are both `true`, then
   a. Let `hasOwnProperty` be `OwnProperty(rhsValue, "name")`.
   b. Return `Abrupt(hasNameProperty)`.
   c. If `hasOwnProperty` is `false`, perform `SetFunctionName(rhsValue, GetReferencedName(lref))`.
8. Return `PutValue(lref, rhsValue)`.

12.15 Comma Operator ( , )

Syntax

```
Expression[?In, ?Yield] :
  AssignmentExpression[?In, ?Yield]
  Expression[?In, ?Yield] , AssignmentExpression[?In, ?Yield]
```

12.15.1 Static Semantics: `IsFunctionDefinition`

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1,

Expression : Expression , AssignmentExpression

1. Return `false`.

12.15.2 Static Semantics: `IsValidSimpleAssignmentTarget`

See also: 12.1.3, 12.2.0.3, 12.2.9.3, 12.3.1.3, 12.4.3, 12.5.3, 12.6.2, 12.7.2, 12.8.2, 12.9.2, 12.10.2,

Expression : Expression , AssignmentExpression

1. Return `false`.

12.15.3 Runtime Semantics: Evaluation

Expression : Expression , AssignmentExpression

1. Let `lref` be the result of evaluating `Expression`.
2. Return `Abrupt(GetValue(lref))`
3. Let `rref` be the result of evaluating `AssignmentExpression`.
4. Return `GetValue(rref)`.

NOTE GetValue must be called even though its value is not used because it may have observable side-effects.
13  ECMAScript Language: Statements and Declarations

Syntax

Statement[Yield, Return] :
  BlockStatement[Yield, Return]
  VariableStatement[Yield]
  EmptyStatement
  ExpressionStatement[Yield]
  IfStatement[Yield, Return]
  BreakableStatement[Yield, Return]
  ContinueStatement[Yield]
  BreakStatement[Yield]
  ++Return ReturnStatement[Yield]
  WithStatement[Yield, Return]
  LabelledStatement[Yield, Return]
  ThrowStatement[Yield]
  TryStatement[Yield, Return]
  DebuggerStatement

Declaration[Yield] :
  HoistableDeclaration[Yield]
  ClassDeclaration[Yield]
  LexicalDeclaration[In, Yield]

HoistableDeclaration[Yield, Default] :
  FunctionDeclaration[Yield, Default]
  GeneratorDeclaration[Yield, Default]

BreakableStatement[Yield, Return] :
  IterationStatement[Yield, Return]
  SwitchStatement[Yield, Return]

13.0  Statement Semantics

13.0.1  Static Semantics: ContainsDuplicateLabels

With argument labelSet.


Statement :
  VariableStatement
  EmptyStatement
  ExpressionStatement
  ContinueStatement
  BreakStatement
  ReturnStatement
  ThrowStatement
  DebuggerStatement

1.  Return false.
13.0.2 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


Statement :
  VariableStatement
  EmptyStatement
  ExpressionStatement
  ContinueStatement
  ReturnStatement
  ThrowStatement
  DebuggerStatement
1. Return false.

13.0.3 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.


Statement :
  VariableStatement
  EmptyStatement
  ExpressionStatement
  BreakStatement
  ReturnStatement
  ThrowStatement
  DebuggerStatement
1. Return false.

BreakableStatement : IterationStatement
1. Let newIterationSet be a copy of iterationSet with all the elements of labelSet appended.
2. Return ContainsUndefinedContinueTarget of IterationStatementList with arguments newIterationSet and « ».

13.0.4 Static Semantics: DeclarationPart

HoistableDeclaration : FunctionDeclaration
1. Return FunctionDeclaration.

HoistableDeclaration : GeneratorDeclaration
1. Return GeneratorDeclaration.

Declaration : ClassDeclaration
1. Return ClassDeclaration.
Declaration: LexicalDeclaration

1. Return LexicalDeclaration.

13.0.5 Static Semantics: VarDeclaredNames

See also: 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

Statement:
EmptyStatement
ExpressionStatement
ContinueStatement
BreakStatement
ReturnStatement
ThrowStatement
DebuggerStatement

1. Return a new empty List.

13.0.6 Static Semantics: VarScopedDeclarations

See also: 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

Statement:
EmptyStatement
ExpressionStatement
ContinueStatement
BreakStatement
ReturnStatement
ThrowStatement
DebuggerStatement

1. Return a new empty List.

13.0.7 Runtime Semantics: LabelledEvaluation

With argument labelSet.

See also: 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.11, 13.12.14.

BreakableStatement: IterationStatement

1. Let stmtResult be the result of performing LabelledEvaluation of IterationStatement with argument labelSet.
2. If stmtResult.[[type]] is break and stmtResult.[[target]] is empty, then
   a. If stmtResult.[[value]] is empty, let stmtResult be NormalCompletion(undefined).
   b. Else, let stmtResult be NormalCompletion(stmtResult.[[value]])
3. Return stmtResult.

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, 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.

13.0.8 Runtime Semantics: Evaluation

HoistableDeclaration :
  FunctionDeclaration
  GeneratorDeclaration
1. Return NormalCompletion(empty).

BreakableStatement :
  IterationStatement
  SwitchStatement
1. Let newLabelSet be a new empty List.
2. Return the result of performing LabelledEvaluation of this BreakableStatement with argument newLabelSet.

13.1 Block

Syntax

BlockStatement[Yield, Return] :
  Block[Yield, Return]
Block[Yield, Return] :
  { StatementList[Yield, Return] }
StatementList[Yield, Return] :
  StatementListItem[Yield, Return]
StatementListItem[Yield, Return] :
  Statement[Yield, Return]
Declaration[Yield, Return]

13.1.1 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.

13.1.2 Static Semantics: ContainsDuplicateLabels

With argument labelSet.

Block : { }
1. Return false.

StatementList : StatementList StatementListItem
1. Let hasDuplicates be ContainsDuplicateLabels of StatementList with argument labelSet.
2. If hasDuplicates is true, return true.
3. Return ContainsDuplicateLabels of StatementListItem with argument labelSet.

StatementListItem : Declaration
1. Return false.

13.1.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


Block : { }
1. Return false.

StatementList : StatementList StatementListItem
1. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of StatementList with argument labelSet.
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedBreakTarget of StatementListItem with argument labelSet.

StatementListItem : Declaration
1. Return false.

13.1.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.


Block : { }
1. Return false.

StatementList : StatementList StatementListItem
1. Let hasUndefinedLabels be ContainsUndefinedContinueTarget of StatementList with arguments iterationSet and « ».
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedContinueTarget of StatementListItem with arguments iterationSet and « ».
StatementListItem : Declaration
  1. Return false.

13.1.5 Static Semantics: LexicallyDeclaredNames

See also: 13.11.2, 13.12.6, 14.1.15, 14.2.10, 15.1.3, 15.2.1.11.

Block : { }
  1. Return a new empty List.

StatementList : StatementList StatementListItem
  1. Let names be LexicallyDeclaredNames of StatementList.
  2. Append to names the elements of the LexicallyDeclaredNames of StatementListItem.
  3. Return names.

StatementListItem : Statement
  1. If Statement is Statement : LabelledStatement, return LexicallyDeclaredNames of Statement.
  2. Return a new empty List.

StatementListItem : Declaration
  1. Return the BoundNames of Declaration.

13.1.6 Static Semantics: LexicallyScopedDeclarations

See also: 13.11.5, 13.12.6, 14.1.16, 14.2.11, 15.1.4, 15.2.1.12, 15.2.3.8.

StatementList : StatementList StatementListItem
  1. Let declarations be LexicallyScopedDeclarations of StatementList.
  2. Append to declarations the elements of the LexicallyScopedDeclarations of StatementListItem.
  3. Return declarations.

StatementListItem : Statement
  1. If Statement is Statement : LabelledStatement, return LexicallyScopedDeclarations of Statement.
  2. Return a new empty List.

StatementListItem : Declaration
  1. Return a new List containing DeclarationPart of Declaration.

13.1.7 Static Semantics: TopLevelLexicallyDeclaredNames

See also: 13.12.8.

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, return a new empty List.
   2. If Declaration is Declaration : GeneratorDeclaration, return a new empty List.
   3. 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.

13.1.8 Static Semantics: TopLevelLexicallyScopedDeclarations

See also: 13.12.9.

Block : { }
   1. Return a new empty List.

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, return a new empty List.
   2. If Declaration is Declaration : GeneratorDeclaration, return a new empty List.
   3. Return a new List containing Declaration.

13.1.9 Static Semantics: TopLevelVarDeclaredNames

See also: 13.12.10.

Block : { }
   1. Return a new empty List.

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, return the BoundNames of Declaration.
   2. If Declaration is Declaration : GeneratorDeclaration, return the BoundNames of Declaration.
   3. Return a new empty List.
StatementListItem : Statement

1. If Statement is Statement : LabelledStatement, return TopLevelVarDeclaredNames of Statement.
2. Return VarDeclaredNames of Statement.

NOTE At the top level of a function or script, inner function declarations are treated like var declarations.

13.1.10 Static Semantics: TopLevelVarScopedDeclarations

See also: 13.12.11.

Block : { }
  1. Return a new empty List.

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 : LabelledStatement, return TopLevelVarScopedDeclarations of Statement.
2. Return VarScopedDeclarations of Statement.

StatementListItem : Declaration

1. If Declaration is Declaration : FunctionDeclaration, return a new List containing FunctionDeclaration.
2. If Declaration is Declaration : GeneratorDeclaration, return a new List containing GeneratorDeclaration.
3. Return a new empty List.

13.1.11 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

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

1. Return a new empty List.
13.1.12 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

Block : {  }
  1. Return a new empty List.

StatementList : StatementList StatementListItem
  1. Let declarations be VarScopedDeclarations of StatementList.
  2. Append to declarations the elements of the VarScopedDeclarations of StatementListItem.
  3. Return declarations.

StatementListItem : Declaration
  1. Return a new empty List.

13.1.13 Runtime Semantics: Evaluation

Block : {  }
  1. Return NormalCompletion[ undefined ].

Block : { StatementList }
  1. Let oldEnv be the running execution context’s LexicalEnvironment.
  2. Let blockEnv be NewDeclarativeEnvironment(oldEnv).
  3. Perform BlockDeclarationInstantiation(StatementList, 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 5 and 6 of the above algorithm ensure that the value of a StatementList is the value of the last value producing item 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;")
```
13.1.14 Runtime Semantics: BlockDeclarationInstantiation( code, env )

NOTE When a Block or CaseBlock production is evaluated a new Declarative Environment Record is created and bindings for each block scoped variable, constant, function, generator function, or class declared in the block are instantiated in the environment record.

BlockDeclarationInstantiation 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 LexicallyScopedDeclarations of code.
2. 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 and true as the arguments.
      ii. Else,
         1. Let status be the result of calling env’s CreateMutableBinding concrete method passing dn and false as the arguments.
         2. Assert: status is never an abrupt completion.
   b. If d is a GeneratorDeclaration production or a FunctionDeclaration 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 InitializeBinding concrete method passing fn, and fo as the arguments.

13.2 Declarations and the Variable Statement

13.2.1 Let and Const Declarations

NOTE 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 Initializer is assigned the value of its Initializer’s AssignmentExpression when the LexicalBinding is evaluated, not when the variable is created. If a LexicalBinding in a let declaration does not have an Initializer the variable is assigned the value undefined when the LexicalBinding is evaluated.

Syntax

```
LexicalDeclaration[Yield]:
  LetOrConst BindingList[Yield, Yield] ;
LetOrConst:
  let
  const

BindingList[Yield, Yield] :
  LexicalBinding[Yield, Yield]
  BindingList[Yield, Yield], LexicalBinding[Yield, Yield]

LexicalBindings[Yield, Yield] :
  BindingIdentifier[Yield] Initializer[Yield, Yield] ?
  BindingPattern[Yield, Yield] Initializer[Yield, Yield] ?
```
13.2.1.1 Static Semantics: Early Errors

LexicalDeclaration : LetOrConst BindingList ;

- It is a Syntax Error if the BoundNames of BindingList contains "let".
- It is a Syntax Error if the BoundNames of BindingList contains any duplicate entries.

LexicalBinding : BindingIdentifier Initializeropt

- It is a Syntax Error if Initializer is not present and IsConstantDeclaration of the LexicalDeclaration containing this production is true.

13.2.1.2 Static Semantics: BoundNames

See also: 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

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 Initializeropt

1. Return the BoundNames of BindingIdentifier.

LexicalBinding : BindingPattern Initializer

1. Return the BoundNames of BindingPattern.

13.2.1.3 Static Semantics: IsConstantDeclaration

See also: 14.1.11, 14.4.8, 14.5.7, 15.2.3.7.

LexicalDeclaration : LetOrConst BindingList ;

1. Return IsConstantDeclaration of LetOrConst.

LetOrConst : let

1. Return false.

LetOrConst : const

1. Return true.

13.2.1.4 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 lhs be ResolveBinding(StringValue of BindingIdentifier).
2. Return InitializeReferencedBinding(lhs, undefined).

NOTE A static semantics rule ensures that this form of LexicalBinding never occurs in a \const{} declaration.

LexicalBinding : BindingIdentifier Initializer
1. Let bindingId be StringValue of BindingIdentifier.
2. Let lhs be ResolveBinding(bindingId).
3. Let rhs be the result of evaluating Initializer.
4. Let value be GetValue(rhs).
5. ReturnIfAbrupt(value).
6. If IsAnonymousFunctionDefinition(Initializer) is true, then
   a. Let hasNameProperty be HasOwnProperty(value, "name").
   b. ReturnIfAbrupt(hasNameProperty).
   c. If hasNameProperty is false, perform SetFunctionName(value, bindingId).
7. Return InitializeReferencedBinding(lhs, value).

LexicalBinding : BindingPattern Initializer
1. Let rhs be the result of evaluating Initializer.
2. Let value be GetValue(rhs).
3. ReturnIfAbrupt(value).
4. Let env be the running execution context’s LexicalEnvironment.
5. Return the result of performing BindingInitialization for BindingPattern using value and env as the arguments.

13.2.2 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 initialized to \undefined{} when created. Within the scope of any VariableEnvironment a common BindingIdentifier may appear in more than one VariableDeclaration but those declarations collective define only one variable. A variable defined by a VariableDeclaration with an Initializer is assigned the value of its Initializer’s AssignmentExpression when the VariableDeclaration is executed, not when the variable is created.

Syntax

VariableStatement\#Yield :
  var VariableDeclarationList\[?, \#yield\] ;

VariableDeclarationList\[?, \#yield\] :
  VariableDeclaration\[?, \#yield\] ;
  VariableDeclarationList\[?, \#yield\] + VariableDeclaration\[?, \#yield\] ;
VariableDeclaration:  
  BindingIdentifier? Yield Initializer? Yieldopt  
  BindingPattern? Yield Initializer? Yieldopt

13.2.2.1 Static Semantics:  BoundNames

See also: 13.2.1.2, 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

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 Initializeropt  
  1. Return the BoundNames of BindingIdentifier.

VariableDeclaration : BindingPattern Initializer
  1. Return the BoundNames of BindingPattern.

13.2.2.2 Static Semantics:  VarDeclaredNames


VariableStatement : var VariableDeclarationList  
  1. Return BoundNames of VariableDeclarationList.

13.2.2.3 Static Semantics:  VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

VariableDeclarationList : VariableDeclaration  
  1. Return a new List containing VariableDeclaration.

VariableDeclarationList : VariableDeclarationList , VariableDeclaration  
  1. Let declarations be VarScopedDeclarations of VariableDeclarationList.  
  2. Append VariableDeclaration to declarations.  
  3. Return declarations.

13.2.2.4 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 Initializer

1. Let bindingId be StringValue of BindingIdentifier.
2. Let lhs be ResolveBinding(bindingId)
3. ReturnIfAbrupt(lhs).
4. Let rhs be the result of evaluating Initializer.
5. Let value be GetValue(rhs).
6. ReturnIfAbrupt(value).
7. If IsAnonymousFunctionDefinition(Initializer) is true, then
   a. Let hasNameProperty be HasOwnProperty(value, "name").
   b. ReturnIfAbrupt(hasNameProperty).
   c. If hasNameProperty is false, perform SetFunctionName(value, bindingId).
8. Return PutValue(lhs, value).

NOTE If a VariableDeclaration is nested within a with statement and the BindingIdentifier in the VariableDeclaration is the same as a property name of the binding object of the with statement’s object environment record, then step 7 will assign value to the property instead of assigning to the VariableEnvironment binding of the Identifier.

VariableDeclaration : BindingPattern Initializer

1. Let rhs be the result of evaluating Initializer.
2. Let rval be GetValue(rhs).
3. ReturnIfAbrupt(rval).
4. Return the result of performing BindingInitialization for BindingPattern passing rval and undefined as arguments.

13.2.3 Destructuring Binding Patterns

Syntax

BindingPattern[Yield, GeneratorParameter]:
  ObjectBindingPattern[Yield, ?GeneratorParameter]
  ArrayBindingPattern[Yield, ?GeneratorParameter]

ObjectBindingPattern[Yield, GeneratorParameter]:
  { }
  { BindingPropertyList[Yield, ?GeneratorParameter] }
  { BindingPropertyList[Yield, ?GeneratorParameter], }

ArrayBindingPattern[Yield, GeneratorParameter]:
  [ Elision? BindingRestElement[Yield, ?GeneratorParameter], ]
  [ BindingElementList[Yield, ?GeneratorParameter] ]
  [ BindingElementList[Yield, ?GeneratorParameter], Elision? BindingRestElement[Yield, ?GeneratorParameter], ]
**13.2.3.1 Static Semantics: BoundNames**

See also: 13.2.1.2, 13.2.2.1, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

ObjectBindingPattern : { }

1. Return an empty List.

ArrayBindingPattern : [ Elisionopt ]

1. Return an empty List.

ArrayBindingPattern : [ Elisionopt BindingRestElement ]

1. Return the BoundNames of BindingRestElement.

ArrayBindingPattern : [ BindingElementList, Elisionopt ]

1. Return the BoundNames of BindingElementList.

ArrayBindingPattern : [ BindingElementList, Elisionopt 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 : BindingElementList , BindingElisionElement
1. Let names be BoundNames of BindingElementList.
2. Append to names the elements of BoundNames of BindingElisionElement.
3. Return names.

BindingElisionElement : Elision opt BindingElement
1. Return BoundNames of BindingElement.

BindingProperty : PropertyName : BindingElement
1. Return the BoundNames of BindingElement.

SingleNameBinding : BindingIdentifier Initialize opt
1. Return the BoundNames of BindingIdentifier.

BindingElement : BindingPattern Initialize opt
1. Return the BoundNames of BindingPattern.

13.2.3.2 Static Semantics: ContainsExpression

See also: 14.1.5, 14.2.4.

ObjectBindingPattern : { }
1. Return false.

ArrayBindingPattern : [ Elision opt ]
1. Return false.

ArrayBindingPattern : [ Elision opt , BindingRestElement ]
1. Return false.

ArrayBindingPattern : [ BindingElementList , Elision opt ]
1. Return ContainsExpression of BindingElementList.

ArrayBindingPattern : [ BindingElementList , Elision opt , BindingRestElement ]
1. Return ContainsExpression of BindingElementList.

BindingPropertyList : BindingPropertyList , BindingProperty
1. Let has be ContainsExpression of BindingPropertyList.
2. If has is true, return true.
3. Return ContainsExpression of BindingProperty.
**BindingElementList**: BindingElementList, BindingElisionElement

1. Let `has` be ContainsExpression of `BindingElementList`.
2. If `has` is `true`, return `true`.
3. Return ContainsExpression of `BindingElisionElement`.

**BindingElisionElement**: Elisionopt BindingElement

1. Return ContainsExpression of `BindingElement`.

**BindingProperty**: PropertyName : BindingElement

1. Let `has` be IsComputedPropertyKey of `PropertyName`.
2. If `has` is `true`, return `true`.
3. Return the ContainsExpression of `BindingElement`.

**BindingElement**: BindingPattern Initializer

1. Return `true`.

**SingleNameBinding**: BindingIdentifier

1. Return `false`.

**SingleNameBinding**: BindingIdentifier Initializer

1. Return `true`.

13.2.3.3 **Static Semantics: HasInitializer**

See also: 13.2.3.3, 14.1.7, 14.2.7.

**BindingElement**: BindingPattern

1. Return `false`.

**BindingElement**: BindingPattern Initializer

1. Return `true`.

**SingleNameBinding**: BindingIdentifier

1. Return `false`.

**SingleNameBinding**: BindingIdentifier Initializer

1. Return `true`.

13.2.3.4 **Static Semantics: IsSimpleParameterList**

See also: 14.1.12, 14.2.8.

**BindingElement**: BindingPattern

1. Return `false`.
BindingElement : BindingPattern Initializer
   1. Return false.

SingleNameBinding : BindingIdentifier
   1. Return true.

SingleNameBinding : BindingIdentifier Initializer
   1. Return false.

13.2.3.5 Runtime Semantics: BindingInitialization

With parameters value and environment.

See also: 12.1.5, 13.6.4.8.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialization value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialized in order to deal with the possibility of multiple parameters with the same name.

BindingPattern : ObjectBindingPattern
   1. Let valid be RequireObjectCoercible(value).
      2. ReturnIfAbrupt(valid).
      3. Return the result of performing BindingInitialization for ObjectBindingPattern using value and environment as arguments.

BindingPattern : ArrayBindingPattern
   1. Let iterator be GetIterator(value).
      2. ReturnIfAbrupt(iterator).
      3. Let result be the result of performing IteratorBindingInitialization for ArrayBindingPattern using iterator, and environment as arguments.
      4. Return IteratorClose(iterator, result).

ObjectBindingPattern : {}
   1. Return NormalCompletion(empty).

BindingPropertyList : BindingPropertyList , BindingProperty
   1. Let status be the result of performing BindingInitialization for BindingPropertyList using value and environment as arguments.
   2. ReturnIfAbrupt(status).
   3. Return the result of performing BindingInitialization 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 KeyedBindingInitialization for SingleNameBinding using value, environment, and name as the arguments.
**BindingProperty : PropertyName : BindingElement**

1. Let P be the result of evaluating PropertyName
2. ReturnIfAbrupt(P)
3. Return the result of performing KeyedBindingInitialization for BindingElement using value, environment, and P as arguments.

### 13.2.3.6 Runtime Semantics: IteratorBindingInitialization

With parameters iterator, and environment.

See also: 14.1.21, 14.2.15.

**NOTE** When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialization value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialized in order to deal with the possibility of multiple parameters with the same name.

**ArrayBindingPattern : [ ]**

1. Return NormalCompletion(empty).

**ArrayBindingPattern : [ Elision ]**

1. Return the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.

**ArrayBindingPattern : [ Elisionopt BindingRestElement ]**

1. If Elision is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
   b. ReturnIfAbrupt(status).
2. Return the result of performing IteratorBindingInitialization for BindingRestElement using iterator and environment as arguments.

**ArrayBindingPattern : [ BindingElementList ]**

1. Return the result of performing IteratorBindingInitialization for BindingElementList using iterator and environment as arguments.

**ArrayBindingPattern : [ BindingElementList , ]**

1. Return the result of performing IteratorBindingInitialization for BindingElementList using iterator and environment as arguments.

**ArrayBindingPattern : [ BindingElementList , Elision ]**

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList using iterator and environment as arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
ArrayBindingPattern : [ BindingElementList , Elisionopt BindingRestElement ]

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList using iterator and environment as arguments.
2. ReturnIfAbrupt(status).
3. If Elision is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
   b. ReturnIfAbrupt(status).
4. Return the result of performing IteratorBindingInitialization for BindingRestElement using iterator and environment as arguments.

BindingElementList : BindingEllisionElement

1. Return the result of performing IteratorBindingInitialization for BindingEllisionElement using iterator and environment as arguments.

BindingElementList : BindingElementList , BindingEllisionElement

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList using iterator and environment as arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorBindingInitialization for BindingEllisionElement using iterator and environment as arguments.

BindingEllisionElement : BindingElement

1. Return the result of performing IteratorBindingInitialization of BindingElement with iterator and environment as the arguments.

BindingEllisionElement : Elision BindingElement

1. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iterator as the argument.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorBindingInitialization of BindingElement with iterator and environment as the arguments.

BindingElement : SingleNameBinding

1. Return the result of performing IteratorBindingInitialization for SingleNameBinding using iterator and environment as the arguments.

SingleNameBinding : BindingIdentifier Initializeropt

1. Let bindingId be StringValue of BindingIdentifier.
2. Let lhs be ResolveBinding(bindingId).
3. ReturnIfAbrupt(lhs).
4. Let next be IteratorStep(iterator).
5. ReturnIfAbrupt(next).
6. If next is false, let v be undefined
7. Else
   a. Let v be IteratorValue(next).
   b. ReturnIfAbrupt(v).
8. If Initializer is present and v is undefined, then
a. Let `defaultValue` be the result of evaluating `Initializer`.
b. Let `v` be `GetValue(defaultValue)`.
c. `ReturnIfAbrupt(v)`.
d. If `IsAnonymousFunctionDefinition(Initializer)` is `true`, then
   i. Let `hasOwnProperty` be `HasOwnProperty(v, "name")`.
   ii. `ReturnIfAbrupt(hasOwnProperty)`.
   iii. If `hasOwnProperty` is `false`, `perform SetFunctionName(v, bindingId)`.
9. If `environment` is `undefined`, return `PutValue(lhs, v)`.
10. Return `InitializeReferencedBinding(lhs, v)`.

**BindingElement : BindingPattern Initializeropt**

1. Let `next` be `IteratorStep(iterator)`.
2. `ReturnIfAbrupt(next)`.
3. If `next` is `false`, let `v` be `undefined`
4. Else
   a. Let `v` be `IteratorValue(next)`.
   b. `ReturnIfAbrupt(v)`.
5. If `Initializer` is present and `v` is `undefined`, then
   a. Let `defaultValue` be the result of evaluating `Initializer`.
   b. Let `v` be `GetValue(defaultValue)`.
   c. `ReturnIfAbrupt(v)`.
6. Return the result of performing `BindingInitialization` of `BindingPattern` with `v` and `environment` as the arguments.

**BindingRestElement : ... BindingIdentifier**

1. Let `lhs` be `ResolveBinding(StringValue of BindingIdentifier)`.
2. `ReturnIfAbrupt(lhs)`.
3. Let `A` be `ArrayCreate(0)`.
4. Let `n=0`.
5. Repeat,
   a. Let `next` be `IteratorStep(iterator)`.
   b. `ReturnIfAbrupt(next)`.
   c. If `next` is `false` then
      i. If `environment` is `undefined`, then `PutValue(lhs, A)`.
     ii. `Return InitializeReferencedBinding(lhs, A)`.
   d. Let `nextValue` be `IteratorValue(next)`.
   e. `ReturnIfAbrupt(nextValue)`.
   f. Let `status` be `CreateDataProperty(A, ToString(ToUint32(n)), nextValue)`.
   g. Assert: `status` is `true`.
   h. Increment `n` by 1.

**13.2.3.7 Runtime Semantics: KeyedBindingInitialization**

With parameters `value`, `environment`, and `propertyName`.

NOTE When `undefined` is passed for `environment` it indicates that a `PutValue` operation should be used to assign the initialization value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialized in order to deal with the possibility of multiple parameters with the same name.

**BindingElement : BindingPattern Initializeropt**

1. Let `v` be `GetValue(value, propertyName)`.
2. ReturnIfAbrupt(v).
3. If `Initializer` is present and v is `undefined`, then
   a. Let `defaultValue` be the result of evaluating `Initializer`.
   b. Let v be GetValue(`defaultValue`).
   c. ReturnIfAbrupt(v).
4. Return the result of performing BindingInitialization for `BindingPattern` passing v and `environment` as arguments.

**SingleNameBinding : BindingIdentifier**

1. Let `bindingId` be StringValue of `BindingIdentifier`.
2. Let `lhs` be ResolveBinding(`bindingId`).
3. ReturnIfAbrupt(`lhs`).
4. Let v be GetValue(`value`, `propertyName`).
5. ReturnIfAbrupt(v).
6. If `Initializer` is present and v is `undefined`, then
   a. Let `defaultValue` be the result of evaluating `Initializer`.
   b. Let v be GetValue(`defaultValue`).
   c. ReturnIfAbrupt(v).
   d. If IsAnonymousFunctionDefinition(`Initializer`) is true, then
      i. Let `hasNameProperty` be HasOwnProperty(v, "name").
      ii. ReturnIfAbrupt(`hasNameProperty`).
      iii. If `hasNameProperty` is false, perform `SetFunctionName(v, bindingId)`.
7. If `environment` is `undefined`, return PutValue(`lhs`, v).

13.3 Empty Statement

**Syntax**

```
EmptyStatement : ;
```

**Runtime Semantics: Evaluation**

```
EmptyStatement : ;
```

1. Return NormalCompletion(`empty`).

13.4 Expression Statement

**Syntax**

```
ExpressionStatement : [lookahead $] { [ , function, class, let [ [ ] ]] Expression; , ?Expression }
```

**NOTE** An `ExpressionStatement` cannot start with a LEFT CURLY BRACKET 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`. An `ExpressionStatement` cannot start with the two token sequence `let {` because that would make it ambiguous with a `let LexicalDeclaration whose first LexicalBinding was an ArrayBindingPattern`. 

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13.4.1 Runtime Semantics: Evaluation

ExpressionStatement : Expression ;

1. Let exprRef be the result of evaluating Expression.
2. Return GetValue(exprRef).

13.5 The if Statement

Syntax

IfStatement[HasReturn] :
  if ( Expression[In,Yield] ) Statement[HasReturn] else Statement[HasReturn]
  if ( Expression[In,Yield] ) Statement[HasReturn]

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.

13.5.1 Static Semantics: Early Errors

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

- It is a Syntax Error if IsLabelledFunction(Statement) is true for any occurrence of Statement in these rules.

NOTE It is only necessary to apply this rule if the extension specified in B.3.2 is implemented.

13.5.2 Static Semantics: ContainsDuplicateLabels

With argument labelSet.


IfStatement : if ( Expression ) Statement else Statement

1. Let hasUndefinedLabels be ContainsDuplicateLabels of the first statement with argument labelSet.
2. If hasUndefinedLabels is true, return true.
3. Return ContainsDuplicateLabels of the second statement with argument labelSet.

IfStatement : if ( Expression ) Statement

1. Return ContainsDuplicateLabels of statement with argument labelSet.

13.5.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.

IfStatement: if (Expression) Statement else Statement

1. Let hasUndefinedLabels be `ContainsUndefinedBreakTarget` of the first Statement with argument `labelSet`.
2. If hasUndefinedLabels is true, return true.
3. Return `ContainsUndefinedBreakTarget` of the second Statement with argument `labelSet`.

IfStatement: if (Expression) Statement

1. Return `ContainsUndefinedBreakTarget` of Statement with argument `labelSet`.

13.5.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.


IfStatement: if (Expression) Statement else Statement

1. Let hasUndefinedLabels be `ContainsUndefinedContinueTarget` of the first Statement with arguments `iterationSet` and « ».
2. If hasUndefinedLabels is true, return true.
3. Return `ContainsUndefinedContinueTarget` of the second Statement with arguments `iterationSet` and « ».

IfStatement: if (Expression) Statement

1. Return `ContainsUndefinedContinueTarget` of Statement with arguments `iterationSet` and « ».

13.5.5 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

IfStatement: if (Expression) Statement else Statement

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.

13.5.6 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

IfStatement: if (Expression) Statement else Statement

1. Let declarations be `VarScopedDeclarations` of the first Statement.
2. Append to declarations the elements of the `VarScopedDeclarations` of the second Statement.
3. Return declarations.
IfStatement : if ( Expression ) Statement
1. Return the VarDeclaredNames of Statement.

13.5.7 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.[] 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.[] is normal and stmtValue.[value] is empty, then
   a. Return NormalCompletion(undefined).
7. Return stmtValue.

13.6 Iteration Statements

Syntax

IterationStatement[Yield, Return] :
  do Statement[Yield, Return] while ( Expression[Yield, Return] ) ; opt
  while ( Expression[Yield, Return] ) Statement[Yield, Return]
   Statement[Yield, Return]
   Statement[Yield, Return]
  for ( ; Expression[Yield, Return]opt ) Statement[Yield, Return]
  for ( ForBinding[Yield, Return] in Expression[Yield, Return] ) Statement[Yield, Return]
  for ( ForDeclaration[Yield, Return] of AssignmentExpression[Yield, Return] ) Statement[Yield, Return]

Comment [AWB1318]: Breaking change from ESS: completion reform
Comment [AWB619]: Breaking change from ESS: completion reform
Comment [AWB1320]: Breaking change from ESS: completion reform
Comment [AWB621]: This is breaking change from ESS which allowed a VariableDeclarationNoIn to appear here. See discussion thread "lexical for-in/for-of loose end"
ForDeclaration[Yield]:
LetOrConst ForBinding[Yield]

ForBinding[Yield]:
BindingIdentifier[Yield]
BindingPattern[Yield]

NOTE 1  A semicolon is not required after a do-while statement.

13.6.0 Semantics

13.6.0.1 Static Semantics: Early Errors

IterationStatement:
  do Statement while (Expression); opt
  while (Expression) Statement
  for ([lookahead = let | ] Expressionopt; Expressionopt; Expressionopt) Statement
  for (var VariableDeclarationList; Expressionopt; Expressionopt) Statement
  for (LexicalDeclaration Expressionopt; Expressionopt) Statement
  for ([lookahead = let | ] LeftHandSideExpression in Expression) Statement
  for (var ForBinding in Expression) Statement
  for (ForDeclaration in Expression) Statement
  for (var ForBinding of AssignmentExpression) Statement
  for (ForDeclaration of AssignmentExpressionopt, Yield) Statement

- It is a Syntax Error if IsLabelledFunction(Statement) is true for any occurrence of Statement in these rules.

NOTE  It is only necessary to apply this rule if the extension specified in B.3.2 is implemented.

13.6.0.2 Runtime Semantics: LoopContinues(completion, labelSet)

The abstract operation LoopContinues with arguments completion and labelSet is defined by the following step:

1. If completion.[[type]] is normal, return true.
2. If completion.[[type]] is not continue, return false.
3. If completion.[[target]] is empty, return true.
4. If completion.[[target]] is an element of labelSet, return true.
5. Return false.

NOTE  Within the Statement part of an IterationStatement a ContinueStatement may be used to begin a new iteration.

13.6.1 The do-while Statement

13.6.1.1 Static Semantics: ContainsDuplicateLabels

With argument labelSet.


Comment [AWB622]: Note that this is technically a breaking change from ES5, however it is made to match web reality.

Comment [AWB623]: This is breaking change from ES5 which allowed a VariableDeclarationNoIn to appear here. See es-discuss thread "lexical for-in/for-of loose end"
IterationStatement: do Statement while (Expression) :opt

1. Return ContainsDuplicateLabels of Statement with argument labelSet.

13.6.1.2 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


IterationStatement: do Statement while (Expression) :opt

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

13.6.1.3 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.


IterationStatement: do Statement while (Expression) :opt

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.6.1.4 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

IterationStatement: do Statement while (Expression) :opt

1. Return the VarDeclaredNames of Statement.

13.6.1.5 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

IterationStatement: do Statement while (Expression) :opt

1. Return the VarScopedDeclarations of Statement.

13.6.1.6 Runtime Semantics: LabelledEvaluation

With argument labelSet.

See also: 13.0.6, 13.6.2.5, 13.6.3.6, 13.6.4.11, 13.12.12.

IterationStatement: do Statement while (Expression) :opt

1. Let \( V = \text{undefined} \).
2. Repeat
   a. Let stmt be the result of evaluating Statement.
b. If LoopContinues (stmt, labelSet) is false, return stmt.

c. If stmt.[[value]] is not empty, let V = stmt.[[value]].

d. Let exprRef be the result of evaluating Expression.

e. Let exprValue be GetValue(exprRef).

f. If exprValue.[[type]] is normal, then
   i. If ToBoolean(exprValue) is false, return NormalCompletion(V).

g. Else
   i. Assert: exprValue is an abrupt completion.
      ii. If LoopContinues (exprValue, labelSet) is false, return exprValue.

13.6.2 The while Statement

13.6.2.1 Static Semantics: ContainsDuplicateLabels

With argument labelSet.


IterationStatement : while ( Expression ) Statement

1. Return ContainsDuplicateLabels of Statement with argument labelSet.

13.6.2.2 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


IterationStatement : while ( Expression ) Statement

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

13.6.2.3 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.


IterationStatement : while ( Expression ) Statement

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.6.2.4 Static Semantics: VarDeclaredNames


IterationStatement : while ( Expression ) Statement

1. Return the VarDeclaredNames of Statement.
13.6.2.5 Static Semantics: Var Scoped Declarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

IterationStatement: `while ( Expression ) Statement`

1. Return the Var Scoped Declarations of Statement.

13.6.2.6 Runtime Semantics: Labelled Evaluation

With argument `labelSet`.

See also: 13.0.6, 13.6.1.5, 13.6.3.6, 13.6.4.11, 13.12.12.

IterationStatement: `while ( Expression ) Statement`

1. Let `V = undefined`.
2. Repeat
   a. Let `exprRef` be the result of evaluating `Expression`.
   b. Let `exprValue` be `GetValue(exprRef)`.
   c. If `exprValue.[[type]]` is `normal`, then
      i. If `ToBoolean(exprValue)` is `false`, return `NormalCompletion(V)`.
   d. Else,
      i. Assert: `exprValue` is an abrupt completion.
      ii. If `LoopContinues(exprValue, labelSet)` is `false`, return `exprValue`.
   e. Let `stmt` be the result of evaluating `Statement`.
   f. If `LoopContinues(stmt, labelSet)` is `false`, return `stmt`.
   g. If `stmt.[[value]]` is not empty, let `V = stmt.[[value]].`

13.6.3 The `for` Statement

13.6.3.1 Static Semantics: Early Errors

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

- It is a Syntax Error if any element of the `BoundNames` of `LexicalDeclaration` also occurs in the `VarDeclaredNames` of `Statement`.

13.6.3.2 Static Semantics: Contains Duplicate Labels

With argument `labelSet`.


IterationStatement:

- `for ( [lookahead e] let | var | [lookahead e ] ) Expressionopt ; Expressionopt ; Expressionopt ) Statement`
- `for ( LexicalDeclaration Expressionopt ; Expressionopt ) Statement`
- `for ( var VariableDeclarationList ; Expressionopt ) Statement`
- `for ( LexicalDeclaration Expressionopt ; Expressionopt ) Statement`

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

Comment [AWB625]: ES5 breaking change: completion reform
13.6.3.3 Static Semantics: `ContainsUndefinedBreakTarget`

With argument `labelSet`.


**IterationStatement**:

```
for ([lookahead ∈ {let | ]} Expressionopt ; Expressionopt ; Expressionopt) Statement
for (var VariableDeclarationList; Expressionopt ; Expressionopt) Statement
for (LexicalDeclaration Expressionopt ; Expressionopt) Statement
```

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

13.6.3.4 Static Semantics: `ContainsUndefinedContinueTarget`

With arguments `iterationSet` and `labelSet`.


**IterationStatement**:

```
for ([lookahead ∈ {let | ]} Expressionopt ; Expressionopt ; Expressionopt) Statement
for (var VariableDeclarationList; Expressionopt ; Expressionopt) Statement
for (LexicalDeclaration Expressionopt ; Expressionopt) Statement
```

1. Return `ContainsUndefinedContinueTarget` of `Statement` with arguments `iterationSet` and « ».

13.6.3.5 Static Semantics: `VarDeclaredNames`

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

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

1. Return the `VarDeclaredNames` of `Statement`.

**IterationStatement**: `for ( var VariableDeclarationList ; Expressionopt ; Expressionopt) Statement`

1. Let `names` be `BoundNames` of `VariableDeclarationList`.
2. Append to `names` the elements of the `VarDeclaredNames` of `Statement`.
3. Return `names`.

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

1. Return the `VarDeclaredNames` of `Statement`.

13.6.3.6 Static Semantics: `VarScopedDeclarations`

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.
IterationStatement: for ( Expressionopt; Expressionopt; Expressionopt) Statement
1. Return the VarScopedDeclarations of Statement.

IterationStatement: for ( var VariableDeclarationList; Expressionopt; Expressionopt) Statement
1. Let declarations be VarScopedDeclarations of VariableDeclarationList.
2. Append to declarations the elements of the VarScopedDeclarations of Statement.
3. Return declarations.

IterationStatement: for ( LexicalDeclaration Expressionopt; Expressionopt) Statement
1. Return the VarScopedDeclarations of Statement.

13.6.3.7 Runtime Semantics: LabelledEvaluation

With argument labelSet.

See also: 13.0.6, 13.6.1.5, 13.6.2.5, 13.6.4.11, 13.12.12.

IterationStatement: for ( Expressionopt; Expressionopt; Expressionopt) Statement
1. If the first Expression is present, then
   a. Let exprRef be the result of evaluating the first Expression.
   b. Let exprValue be GetValue(exprRef).
   c. If LoopContinues(exprValue, labelSet) is false, return exprValue.
2. Return the result of performing ForBodyEvaluation with the second Expression as the testExpr argument, the third Expression as the incrementExpr argument, Statement as the stmt argument, « » as the perIterationBindings, and with labelSet.

IterationStatement: for ( var VariableDeclarationList; Expressionopt; Expressionopt) Statement
1. Let varDcl be the result of evaluating VariableDeclarationList.
2. If LoopContinues(varDcl, labelSet) is false, return varDcl.
3. Return the result of performing ForBodyEvaluation with the first Expression as the testExpr argument, the second Expression as the incrementExpr argument, Statement as the stmt argument, « » as the perIterationBindings, and with labelSet.

IterationStatement: for ( LexicalDeclaration Expressionopt; Expressionopt) Statement
1. Let oldEnv be the running execution context’s LexicalEnvironment.
2. Let loopEnv be NewDeclarativeEnvironment(oldEnv).
3. Let isConst be the result of performing IsConstantDeclaration of LexicalDeclaration.
4. Let boundNames be the BoundNames of LexicalDeclaration.
5. For each element dn of boundNames do
   a. If isConst is true, then
      i. Call loopEnv’s CreateImmutableBinding concrete method passing dn and true as the arguments.
   b. Else,
      i. Call loopEnv’s CreateMutableBinding concrete method passing dn and false as the arguments.
      ii. Assert: The above call to CreateMutableBinding will never return an abrupt completion.
6. Set the running execution context’s LexicalEnvironment to loopEnv.
7. Let forDcl be the result of evaluating LexicalDeclaration.
8. If LoopContinues(forDcl, labelSet) is false, then
a. Set the running execution context’s LexicalEnvironment to oldEnv.
b. Return forDcl.

9. If isConst is false, let perIterationLets be boundNames otherwise let perIterationLets be « ».
10. Let bodyResult be the result of performing ForBodyEvaluation with the first Expression as the testExpr argument, the second Expression as the incrementExpr argument, Statement as the stmt argument, perIterationLets as the perIterationBindings, and with labelSet.
11. Set the running execution context’s LexicalEnvironment to oldEnv.
12. Return bodyResult.

13.6.3.8 Runtime Semantics: ForBodyEvaluation

The abstract operation ForBodyEvaluation with arguments testExpr, incrementExpr, stmt, perIterationBindings, and labelSet is performed as follows:

1. Let V = undefined.
2. Let status be CreatePerIterationEnvironment(perIterationBindings).
3. ReturnIfAbrupt(status).
4. Repeat
   a. If testExpr is not [empty], then
      i. Let testExprRef be the result of evaluating testExpr.
      ii. Let testExprValue be GetValue(testExprRef).
      iii. If testExprValue.[[type]] is normal, then
           1. If ToBoolean(testExprValue) is false, return NormalCompletion(V).
           2. Else, if LoopContinues(testExprValue, labelSet) is false, return testExprValue.
   b. Let result be the result of evaluating stmt.
   c. If LoopContinues(result, labelSet) is false, return result.
   d. If result.[[value]] is not empty, let V = result.[[value]].
   e. Let status be CreatePerIterationEnvironment(perIterationBindings).
   f. ReturnIfAbrupt(status).
   g. 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.

13.6.3.9 Runtime Semantics: CreatePerIterationEnvironment

The abstract operation CreatePerIterationEnvironment with argument perIterationBindings is performed as follows:

1. If perIterationBindings has any elements, then
   a. Let lastIterationEnv be the running execution context’s LexicalEnvironment.
   b. Let outer be lastIterationEnv’s outer environment reference.
   c. Assert: outer is not null.
   d. Let thisIterationEnv be NewDeclarativeEnvironment(outer).
   e. For each element bn of perIterationBindings do,
      i. Let status be the result of calling thisIterationEnv’s CreateMutableBinding concrete method passing bn and false as the arguments.
      ii. Assert: status is never an abrupt completion.
      iii. Let lastValue be the result of calling lastIterationEnv’s GetBindingValue concrete method passing bn and true as the arguments.
      iv. ReturnIfAbrupt(lastValue).
v. Call the InitializeBinding concrete method of thisIterationEnv passing bn and lastValue as the arguments.

f. Set the running execution context’s LexicalEnvironment to thisIterationEnv.

2. Return undefined

13.6.4 The for-in and for-of Statements

13.6.4.1 Static Semantics: Early Errors

IterationStatement :
   for ( LeftHandSideExpression in Expression ) Statement
   for ( LeftHandSideExpression of AssignmentExpression ) Statement

   • 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 IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

   • It is a Syntax Error if the LeftHandSideExpression is CoverParenthesizedExpressionAndArrowParameterList : ( Expression ) and Expression derives a production that would produce a Syntax Error according to these rules if that production is substituted for LeftHandSideExpression. This rule is recursively applied.

NOTE The last rule means that the other rules are applied even if parentheses surround Expression.

IterationStatement :
   for ( ForDeclaration in Expression ) Statement
   for ( ForDeclaration of AssignmentExpression ) Statement

   • It is a Syntax Error if the BoundNames of ForDeclaration contains "let".

   • It is a Syntax Error if any element of the BoundNames of ForDeclaration also occurs in the VarDeclaredNames of Statement.

   • It is a Syntax Error if the BoundNames of ForDeclaration contains any duplicate entries.

13.6.4.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

ForDeclaration : LetOrConst ForBinding

   1. Return the BoundNames of ForBinding.

13.6.4.3 Static Semantics: ContainsDuplicateLabels

   With argument labelSet.

**IterationStatement**:
- `for (lookahead ≠ let) LeftHandSideExpression in Expression)` Statement
- `for (var ForBinding in Expression)` Statement
- `for (ForDeclaration in Expression)` Statement
- `for (lookahead ≠ let) LeftHandSideExpression of AssignmentExpression)` Statement
- `for (var ForBinding of AssignmentExpression)` Statement
- `for (ForDeclaration of AssignmentExpression[0, γεδί])` Statement

1. Return ContainsDuplicateLabels of Statement with argument `labelSet`.

### 13.6.4.4 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.


**IterationStatement**:
- `for (lookahead ≠ let) LeftHandSideExpression in Expression)` Statement
- `for (var ForBinding in Expression)` Statement
- `for (ForDeclaration in Expression)` Statement
- `for (lookahead ≠ let) LeftHandSideExpression of AssignmentExpression)` Statement
- `for (var ForBinding of AssignmentExpression)` Statement
- `for (ForDeclaration of AssignmentExpression[0, γεδί])` Statement

1. Return ContainsUndefinedBreakTarget of Statement with argument `labelSet`.

### 13.6.4.5 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.


**IterationStatement**:
- `for (lookahead ≠ let) LeftHandSideExpression in Expression)` Statement
- `for (var ForBinding in Expression)` Statement
- `for (ForDeclaration in Expression)` Statement
- `for (lookahead ≠ let) LeftHandSideExpression of AssignmentExpression)` Statement
- `for (var ForBinding of AssignmentExpression)` Statement
- `for (ForDeclaration of AssignmentExpression[0, γεδί])` Statement

1. Return ContainsUndefinedContinueTarget of Statement with arguments `iterationSet` and « ».

### 13.6.4.6 Static Semantics: IsDestructuring

See also: 12.3.1.3.

**ForDeclaration** : LetOrConst ForBinding

1. Return IsDestructuring of `ForBinding`.
ForBinding : BindingIdentifier
1. Return false.

ForBinding : BindingPattern
1. Return true.

13.6.4.7 Static Semantics: VarDeclaredNames
See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

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.

13.6.4.8 Static Semantics: VarScopedDeclarations
See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

IterationStatement : for ( LeftHandSideExpression in Expression ) Statement
1. Return the VarScopedDeclarations of Statement.

IterationStatement : for ( var ForBinding in Expression ) Statement
1. Let declarations be a List containing ForBinding.
2. Append to declarations the elements of the VarScopedDeclarations of Statement.
3. Return declarations.
IterationStatement: `for ( ForDeclaration in Expression )` Statement

1. Return the VarScopedDeclarations of Statement.

IterationStatement: `for ( LeftHandSideExpression of AssignmentExpression )` Statement

1. Return the VarScopedDeclarations of Statement.

IterationStatement: `for ( var ForBinding of AssignmentExpression )` Statement

1. Let declarations be a List containing ForBinding.
2. Append to declarations the elements of the VarScopedDeclarations of Statement.
3. Return declarations.

IterationStatement: `for ( ForDeclaration of AssignmentExpression )` Statement

1. Return the VarScopedDeclarations of Statement.

### 13.6.4.9 Runtime Semantics: BindingInitialization

With arguments value and environment.

See also: 12.1.5, 13.2.3.5.

NOTE `undefined` is passed for environment to indicate that a PutValue operation should be used to assign the initialization value. This is the case for `var` statements and the formal parameter lists of some non-strict functions (see 9.2.13). In those cases a lexical binding is hoisted and preinitialized prior to evaluation of its initializer.

ForDeclaration: `LetOrConst ForBinding`

1. Return the result of performing BindingInitialization for ForBinding passing value and environment as the arguments.

### 13.6.4.10 Runtime Semantics: BindingInstantiation

With argument environment.

ForDeclaration: `LetOrConst ForBinding`

1. For each element name of the BoundNames of ForBinding do
   a. If IsConstantDeclaration of LetOrConst is true, then
      i. Call environment’s CreateImmutableBinding concrete method with arguments name and true.
   b. Else,
      i. Call environment’s CreateMutableBinding concrete method with argument name.
      ii. Assert: The above call to CreateMutableBinding will never return an abrupt completion.

### 13.6.4.11 Runtime Semantics: LabelledEvaluation

With argument labelSet.

See also: 13.0.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.12.14.
IterationStatement: `for ( LeftHandSideExpression in Expression )` Statement

1. Let `keyResult` be `ForIn/OfExpressionEvaluation(« », Expression, enumerate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(LeftHandSideExpression, Statement, keyResult, assignment, labelSet)`.  

IterationStatement: `for ( var ForBinding in Expression )` Statement

1. Let `keyResult` be `ForIn/OfExpressionEvaluation(« », Expression, enumerate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(ForBinding, Statement, keyResult, varBinding, labelSet)`.  

IterationStatement: `for ( ForDeclaration in Expression )` Statement

1. Let `keyResult` be the result of performing `ForIn/OfExpressionEvaluation(BoundNames of ForDeclaration, Expression, enumerate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(ForDeclaration, Statement, keyResult, lexicalBinding, labelSet)`.  

IterationStatement: `for ( LeftHandSideExpression of AssignmentExpression )` Statement

1. Let `keyResult` be the result of performing `ForIn/OfExpressionEvaluation( AssignmentExpression, iterate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(LeftHandSideExpression, Statement, keyResult, assignment, labelSet)`.  

IterationStatement: `for ( var ForBinding of AssignmentExpression )` Statement

1. Let `keyResult` be the result of performing `ForIn/OfExpressionEvaluation( AssignmentExpression, iterate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(ForBinding, Statement, keyResult, varBinding, labelSet)`.  

IterationStatement: `for ( ForDeclaration of AssignmentExpression )` Statement

1. Let `keyResult` be the result of performing `ForIn/OfExpressionEvaluation( BoundNames of ForDeclaration, AssignmentExpression, iterate, labelSet)`.  
2. ReturnIfAbrupt(`keyResult`).  
3. Return `ForIn/OfBodyEvaluation(ForDeclaration, Statement, keyResult, lexicalBinding, labelSet)`.  

13.6.4.12 Runtime Semantics: ForIn/OfExpressionEvaluation Abstract Operation

The abstract operation `ForIn/OfExpressionEvaluation` is called with arguments `TDZnames`, `expr`, `iterationKind`, and `labelSet`. The value of `iterationKind` is either `enumerate` or `iterate`.  

1. Let `oldEnv` be the running execution context’s `LexicalEnvironment`.  
2. If `TDZnames` is not an empty List, then  
   a. Assert: `TDZnames` has no duplicate entries.  
   b. Let `TDZ` be `NewDeclarativeEnvironment(oldEnv)`.  
   c. For each string `name` in `TDZnames`, do  
      i. Let `status` be the result of calling `TDZ`’s `CreateMutableBinding` concrete method passing `name` and `false` as the arguments.  
      ii. Assert: `status` is never an abrupt completion.
d. Set the running execution context’s LexicalEnvironment to TDZ.
3. Let exprRef be the result of evaluating the production that is expr.
4. Set the running execution context’s LexicalEnvironment to oldEnv.
5. Let exprValue be GetValue(exprRef).
6. If exprValue is an abrupt completion,
   a. If LoopContinues(exprValue, labelSet) is false, return exprValue.
   b. Else, return Completion([type]: break, [[value]]=[empty], [[target]]=[empty]).
7. If iterationKind is enumerate, then
   a. If exprValue.[[value]] is null or undefined, then
      i. Return Completion([type]: break, [[value]]=[empty], [[target]]=[empty]).
   b. Let obj be ToObject(exprValue).
   c. Let keys be the result of calling the [[Enumerate]] internal method of obj with no arguments.
8. Else,
   a. Assert: iterationKind is iterate.
   b. Let keys be GetIterator(exprValue).
9. If keys is an abrupt completion, then
   a. If LoopContinues(keys, labelSet) is false, return keys.
   b. Assert: keys.[[type]] is continue.
   c. Return Completion([type]: break, [[value]]=[empty], [[target]]=[empty]).
10. Return keys.

13.6.4.13 Runtime Semantics: ForIn/OfBodyEvaluation

The abstract operation ForIn/OfBodyEvaluation is called with arguments lhs, stmt, iterator, 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 V = undefined.
3. Let destructuring be IsDestructuring of lhs.
4. If destructuring is true and if lhsKind is assignment, then
   a. Assert: lhs is a LeftHandSideExpression.
   b. Let assignmentPattern be the parse of the source code corresponding to lhs using AssignmentPattern as the goal symbol.
5. Repeat
   a. If lhsKind is either assignment or varBinding, then
      i. If destructuring is false, then
         1. Let lhsRef be the result of evaluating lhs (it may be evaluated repeatedly).
         2. ReturnIfAbrupt(lhsRef).
      Else
         i. Assert: lhsKind is lexicalBinding.
         ii. Assert: lhs is a ForDeclaration.
         iii. Let iterationEnv be NewDeclarativeEnvironment(oldEnv).
         iv. Set the running execution context’s LexicalEnvironment to iterationEnv.
         v. Perform BindingInstantiation for lhs passing iterationEnv as the argument.
         vi. If destructuring is false, then
            1. Assert: lhs binds a single name.
            2. Let lhsName be the sole element of BoundNames of lhs.
            3. Let lhsRef be ResolveBinding(lhsName, iterationEnv).
            4. Assert: lhsRef is not an abrupt completion.
   Else
      i. Set the running execution context’s LexicalEnvironment to oldEnv.
      ii. Return nextResult.
   d. If nextResult is an abrupt completion, then
      i. Set the running execution context’s LexicalEnvironment to oldEnv.
      ii. Return nextResult.
If `nextResult` is `false`, then
i. Set the running execution context’s LexicalEnvironment to `oldEnv`.
ii. Return NormalCompletion(`V`).

Let `nextValue` be `IteratorValue(nextResult)`.
If `nextValue` is an abrupt completion, then
i. Set the running execution context’s LexicalEnvironment to `oldEnv`.
ii. Return `nextValue`.

If `destructuring` is `false`, then
i. If `lhsKind` is `lexicalBinding`, then
   1. Let `status` be `InitializeReferencedBinding(lhsRef, nextValue)`.
   2. Else,
      1. Let `status` be `PutValue(lhsRef, nextValue)`.
   iii. Else,
      1. If `lhsKind` is `assignment`, then
         1. Let `status` be the result of performing `DestructuringAssignmentEvaluation` of
            `assignmentPattern` using `nextValue` as the argument.
      2. Else if `lhsKind` is `varBinding`, then
         1. Assert: `lhs` is a `ForBinding`.
         2. Let `status` be the result of performing `BindingInitialization` for `lhs` passing `nextValue`
            and `undefined` as the arguments.
      iii. Else,
      1. Assert: `lhs` is `lexicalBinding`.
      2. Assert: `lhs` is a `ForDeclaration`.
      3. Let `status` be the result of performing `BindingInitialization` for `lhs` passing `nextValue`
         and `iterationEnv` as arguments.

j. If `status` is an abrupt completion, then
i. Set the running execution context’s LexicalEnvironment to `oldEnv`.
ii. Return `IteratorClose(iterator, status)`.

k. Let `status` be the result of evaluating `stmt`.
l. If `status`.[[type]] is `normal` and `status`.[[value]] is not empty, then
i. Let `V = status`.[[value]].
m. Set the running execution context’s LexicalEnvironment to `oldEnv`.

n. If `LoopContinues(status, labelSet)` is `false`, then
i. Return `IteratorClose(iterator, status)`.

13.6.4.14 Runtime Semantics: Evaluation

ForBinding : BindingIdentifier

1. Let `bindingId` be `StringValue` of `BindingIdentifier`.
2. Return `ResolveBinding(bindingId)`

13.7 The `continue` Statement

Syntax

```
ContinueStatement[ Yield ] : continue ;
```
13.7.1 Static Semantics: Early Errors

*ContinueStatement:* `continue ;
ContinueStatement: `continue` LabelIdentifier ;`

- It is a Syntax Error if this production is not nested, directly or indirectly (but not crossing function boundaries), within an `IterationStatement`.

13.7.2 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.

See also: 13.0.3, 13.1.4, 13.5.4, 13.6.2.3, 13.6.3.4, 13.6.4.5, 13.10.4, 13.11.4, 13.12.4, 13.14.4, 15.2.1.4.

*ContinueStatement:* `continue ;`

1. Return `false`.

*ContinueStatement:* `continue` `LabelIdentifier ;`

1. If the `StringValue` of `LabelIdentifier` is not an element of `iterationSet`, return `true`.
2. Return `false`.

13.7.3 Runtime Semantics: Evaluation

*ContinueStatement:* `continue ;`

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

*ContinueStatement:* `continue` `LabelIdentifier ;`

1. Let `label` be the `StringValue` of `LabelIdentifier`.
2. Return `Completion{[type]: continue, [value]: empty, [target]: label}`.

13.8 The `break` Statement

Syntax

*BreakStatement*[Yield]:

```
break ;
break [no LineTerminator here] `LabelIdentifier` ?
```

13.8.1 Static Semantics: Early Errors

*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`.

13.8.2 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`. 

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BreakStatement : break ;
   1. Return false.

BreakStatement : break LabelIdentifier ;
   1. If the StringValue of LabelIdentifier is not an element of labelSet, return true.
   2. Return false.

13.8.3 Runtime Semantics: Evaluation

BreakStatement : break ;
   1. Return Completion{[[type]]: break, [[value]]: empty, [[target]]: empty}.

BreakStatement : break LabelIdentifier ;
   1. Let label be the StringValue of LabelIdentifier.
   2. Return Completion{[[type]]: break, [[value]]: empty, [[target]]: label}.

13.9 The return Statement

Syntax

ReturnStatement[;yield] :
   return ;
   return [noLineTerminator 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.

13.9.1 Runtime Semantics: Evaluation

ReturnStatement : return ;
   1. Return Completion{[[type]]: return, [[value]]: undefined, [[target]]: empty}.

ReturnStatement : return 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}.

13.10 The with Statement

Syntax

WithStatement[;yield, ;return] :
   with { Expression[?, ?] } Statement[;yield, ;return]
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.

13.10.1 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.
- It is a Syntax Error if IsLabelledFunction(*Statement*) is `true`.

NOTE It is only necessary to apply the second rule if the extension specified in B.3.2 is implemented.

13.10.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.


*WithStatement* : `with (Expression) Statement`

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

13.10.3 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.


*WithStatement* : `with (Expression) Statement`

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

13.10.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.


*WithStatement* : `with (Expression) Statement`

1. Return `ContainsUndefinedContinueTarget` of `Statement` with arguments `iterationSet` and `« »`.

13.10.5 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

*WithStatement* : `with (Expression) Statement`

1. Return the `VarDeclaredNames` of `Statement`. 
13.10.6 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

WithStatement : with ( Expression ) Statement
  1. Return the VarScopedDeclarations of Statement.

13.10.7 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 NewObjectEnvironment(obj, oldEnv).
  6. Set the withEnvironment flag of newEnv’s environment record 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.

13.11 The switch Statement

Syntax


CaseBlock[?Yield, Return] :
  { CaseClauses[?Yield, ?Return]opt }

CaseClause[?Yield, Return] :
  CaseClause[?Yield, ?Return]

DefaultClause[?Yield, Return] :

13.11.1 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.

13.11.2 Static Semantics: ContainsDuplicateLabels

With argument labelSet.


SwitchStatement : switch ( Expression ) CaseBlock
1. Return ContainsDuplicateLabels of CaseBlock with argument labelSet.

CaseBlock : { }
1. Return false.

CaseBlock : { CaseClausesopt DefaultClause CaseClausesopt }
1. If the first CaseClauses is present, then
   a. Let hasDuplicates be ContainsDuplicateLabels of the first CaseClauses with argument labelSet.
   b. If hasDuplicates is true, return true.
2. Let hasDuplicates be ContainsDuplicateLabels of DefaultClause with argument labelSet.
3. If hasDuplicates is true, return true.
4. If the second CaseClauses is not present, return false.
5. Return ContainsDuplicateLabels of the second CaseClauses with argument labelSet.

CaseClauses : CaseClauses CaseClause
1. Let hasDuplicates be ContainsDuplicateLabels of CaseClauses with argument labelSet.
2. If hasDuplicates is true, return true.
3. Return ContainsDuplicateLabels of CaseClause with argument labelSet.

CaseClause : case Expression : StatementListopt
1. If the StatementList is present, return ContainsDuplicateLabels of StatementList.
2. Else return false.

DefaultClause : default : StatementListopt
1. If the StatementList is present, return ContainsDuplicateLabels of StatementList with argument labelSet.
2. Else return false.

13.11.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


SwitchStatement : switch ( Expression ) CaseBlock
1. Return ContainsUndefinedBreakTarget of CaseBlock with argument labelSet.
CaseBlock : { }
  1. Return false.

CaseBlock : { CaseClausesopt DefaultClause CaseClausesopt }
  1. If the first CaseClauses is present, then
     a. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of the first CaseClauses with argument labelSet.
     b. If hasUndefinedLabels is true, return true.
  2. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of DefaultClause with argument labelSet.
  3. If hasUndefinedLabels is true, return true.
  4. If the second CaseClauses is not present, return false.
  5. Return ContainsUndefinedBreakTarget of the second CaseClauses with argument labelSet.

CaseClauses : CaseClauses CaseClause
  1. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of CaseClauses with argument labelSet.
  2. If hasUndefinedLabels is true, return true.
  3. Return ContainsUndefinedBreakTarget of CaseClause with argument labelSet.

CaseClause : case Expression : StatementListopt
  1. If the StatementList is present, return ContainsUndefinedBreakTarget of StatementList with argument labelSet.
  2. Else return false.

DefaultClause : default : StatementListopt
  1. If the StatementList is present, return ContainsUndefinedBreakTarget of StatementList with argument labelSet.
  2. Else return false.

13.11.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

2. Let `hasUndefinedLabels` be `ContainsUndefinedContinueTarget of DefaultClause` with arguments `iterationSet` and « ».
3. If `hasUndefinedLabels` is `true`, return `true`.
4. If the second `CaseClauses` is not present, return `false`.
5. Return `ContainsUndefinedContinueTarget of the second CaseClauses` with arguments `iterationSet` and « ».

**CaseClauses : CaseClauses CaseClause**

1. Let `hasUndefinedLabels` be `ContainsUndefinedContinueTarget of CaseClauses` with arguments `iterationSet` and « ».
2. If `hasUndefinedLabels` is `true`, return `true`.
3. Return `ContainsUndefinedContinueTarget of CaseClause` with arguments `iterationSet` and « ».

**CaseClause : case Expression : StatementListopt**

1. If the `StatementList` is present, return `ContainsUndefinedContinueTarget of StatementList` with arguments `iterationSet` and « ».
2. Else return `false`.

**DefaultClause : default : StatementListopt**

1. If the `StatementList` is present, return `ContainsUndefinedContinueTarget of StatementList` with arguments `iterationSet` and « ».
2. Else return `false`.

### 13.11.5 Static Semantics: LexicallyDeclaredNames

See also: 13.1.2, 13.12.6, 14.1.15, 14.2.10, 15.1.3, 15.2.1.11.

**CaseBlock : { }**

1. Return a new empty List.

**CaseBlock : { CaseClausesopt DefaultClause CaseClausesopt }**

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`.

**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 : StatementListopt**

1. If the `StatementList` is present, return the `LexicallyDeclaredNames` of `StatementList`.
2. Else return a new empty List.
DefaultClause: \textbf{default} \textcolon \text{StatementList}_{\text{opt}}

1. If the \text{StatementList} is present, return the LexicallyDeclaredNames of \text{StatementList}.
2. Else return a new empty List.

13.11.6 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.12.7, 14.1.16, 14.2.11, 15.1.4, 15.2.1.12, 15.2.3.8.

CaseBlock: \{ \}

1. Return a new empty List.

CaseBlock: \{ \text{CaseClauses}_{\text{opt}} \text{DefaultClause} \text{CaseClauses}_{\text{opt}} \}

1. If the first \text{CaseClauses} is present, let \text{declarations} be the LexicallyScopedDeclarations of the first \text{CaseClauses}.
2. Else let \text{declarations} be a new empty List.
3. Append to \text{declarations} the elements of the LexicallyScopedDeclarations of the \text{DefaultClause}.
4. If the second \text{CaseClauses} is not present, return \text{declarations}.
5. Else return the result of appending to \text{declarations} the elements of the LexicallyScopedDeclarations of the second \text{CaseClauses}.

CaseClauses: \text{CaseClauses} \text{CaseClause}

1. Let \text{declarations} be LexicallyScopedDeclarations of \text{CaseClauses}.
2. Append to \text{declarations} the elements of the LexicallyScopedDeclarations of \text{CaseClause}.
3. Return \text{declarations}.

CaseClause: \textbf{case} \text{Expression} \textcolon \text{StatementList}_{\text{opt}}

1. If the \text{StatementList} is present, return the LexicallyScopedDeclarations of \text{StatementList}.
2. Else return a new empty List.

DefaultClause: \textbf{default} \textcolon \text{StatementList}_{\text{opt}}

1. If the \text{StatementList} is present, return the LexicallyScopedDeclarations of \text{StatementList}.
2. Else return a new empty List.

13.11.7 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

SwitchStatement: \textbf{switch} ( \text{Expression} ) \text{CaseBlock}

1. Return the VarDeclaredNames of \text{CaseBlock}.

CaseBlock: \{ \}

1. Return a new empty List.

CaseBlock: \{ \text{CaseClauses}_{\text{opt}} \text{DefaultClause} \text{CaseClauses}_{\text{opt}} \}

1. If the first \text{CaseClauses} is present, let \text{names} be the VarDeclaredNames of the first \text{CaseClauses}.
2. Else let \text{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`.

```plaintext
CaseClauses : CaseClauses CaseClause
1. Let `names` be VarDeclaredNames of `CaseClauses`.
2. Append to `names` the elements of the VarDeclaredNames of `CaseClause`.
3. Return `names`.
```

```plaintext
CaseClause : case Expression : StatementListopt
1. If the `StatementList` is present, return the VarDeclaredNames of `StatementList`.
2. Else return a new empty List.
```

```plaintext
DefaultClause : default : StatementListopt
1. If the `StatementList` is present, return the VarDeclaredNames of `StatementList`.
2. Else return a new empty List.
```

### 13.11.8 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

```plaintext
SwitchStatement : switch ( Expression ) CaseBlock
1. Return the VarScopedDeclarations of `CaseBlock`.
```

```plaintext
CaseBlock : { }
1. Return a new empty List.
```

```plaintext
CaseBlock : { CaseClausesopt DefaultClause CaseClausesopt }
1. If the first `CaseClauses` is present, let `declarations` be the VarScopedDeclarations of the first `CaseClauses`.
2. Else let `declarations` be a new empty List.
3. Append to `declarations` the elements of the VarScopedDeclarations 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 VarScopedDeclarations of the second `CaseClauses`.
```

```plaintext
CaseClauses : CaseClauses CaseClause
1. Let `declarations` be VarScopedDeclarations of `CaseClauses`.
2. Append to `declarations` the elements of the VarScopedDeclarations of `CaseClause`.
3. Return `declarations`.
```

```plaintext
CaseClause : case Expression : StatementListopt
1. If the `StatementList` is present, return the VarScopedDeclarations of `StatementList`.
2. Else return a new empty List.
```
DefaultClause : \texttt{default} : StatementList\textsubscript{opt}

1. If the \texttt{StatementList} is present, return the VarScopedDeclarations of \texttt{StatementList}.
2. Else return a new empty List.

13.11.9 Runtime Semantics: CaseBlockEvaluation

With argument \textit{input}.

\texttt{CaseBlock} : \{ \}

1. Return NormalCompletion(\texttt{undefined}).

\texttt{CaseBlock} : \{ \texttt{CaseClauses} \}

1. Let \texttt{V} = \texttt{undefined}.
2. Let \texttt{A} be the List of \texttt{CaseClause} items in \texttt{CaseClauses}, in source text order.
3. Let \texttt{searching} be \texttt{true}.
4. Repeat, for each \texttt{CaseClause}, \texttt{C}, in \texttt{A}
   a. If \texttt{searching} is \texttt{true}, then
      i. Let \texttt{clauseSelector} be the result of CaseSelectorEvaluation of \texttt{C}.
      ii. ReturnIfAbrupt(\texttt{clauseSelector}).
      iii. Let \texttt{matched} be the result of performing \texttt{Strict Equality Comparison} \textit{input} \texttt{===} \texttt{clauseSelector}.
      iv. If \texttt{matched} is \texttt{true}, then
         1. Set \texttt{searching} to \texttt{false}.
         2. If \texttt{C} has a \texttt{StatementList}, then
            a. Let \texttt{V} be the result of evaluating \texttt{C}'s \texttt{StatementList}.
            b. ReturnIfAbrupt(\texttt{V}).
   b. Else \texttt{searching} is \texttt{false}.
      i. If \texttt{C} has a \texttt{StatementList}, then
         1. Let \texttt{R} be the result of evaluating \texttt{C}'s \texttt{StatementList}.
         2. If \texttt{R}.\.[[value]] is not \texttt{empty}, let \texttt{V} = \texttt{R}.\.[[value]].
         3. If \texttt{R} is an abrupt completion, return Completion([[\texttt{type}]]: \texttt{R}.[[\texttt{type}]], [[\texttt{value}]]: \texttt{V}, [[\texttt{target}]]: \texttt{R}.[[\texttt{target}]]).
5. Return NormalCompletion(\texttt{V}).

\texttt{CaseBlock} : \{ \texttt{CaseClauses}\textsubscript{opt} DefaultClause \texttt{CaseClauses}\textsubscript{opt} \}

1. Let \texttt{V} = \texttt{undefined}.
2. Let \texttt{A} be the list of \texttt{CaseClause} items in the first \texttt{CaseClauses}, in source text order. If the first \texttt{CaseClauses} is not present \texttt{A} is « ». 
3. Let \texttt{found} be \texttt{false}.
4. Repeat letting \texttt{C} be in order each \texttt{CaseClause} in \texttt{A}
   a. If \texttt{found} is \texttt{false}, then
      i. Let \texttt{clauseSelector} be the result of CaseSelectorEvaluation of \texttt{C}.
      ii. If \texttt{clauseSelector} is an abrupt completion, then
         1. If \texttt{clauseSelector}.\.[[value]] is \texttt{empty}, return Completion([[\texttt{type}]]: \texttt{clauseSelector}.[[\texttt{type}]], [[\texttt{value}]]: \texttt{undefined}, [[\texttt{target}]]: \texttt{clauseSelector}.[[\texttt{target}]]).
         2. Else, return \texttt{clauseSelector}.
      iii. Let \texttt{found} be the result of performing \texttt{Strict Equality Comparison} \textit{input} \texttt{===} \texttt{clauseSelector}.
   b. If \texttt{found} is \texttt{true}, then
      i. Let \texttt{R} be the result of evaluating \texttt{CaseClause} \texttt{C}.
      ii. If \texttt{R}.\.[[value]] is not \texttt{empty}, let \texttt{V} = \texttt{R}.[[\texttt{value}]].
13.11.10 Runtime Semantics: CaseSelectorEvaluation

CaseClause : case Expression : StatementListopt

1. Let exprRef be the result of evaluating Expression.
2. Return GetValue(exprRef).

NOTE CaseSelectorEvaluation 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.

13.11.11 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 NewDeclarativeEnvironment(oldEnv).
6. Perform BlockDeclarationInstantiation(CaseBlock, blockEnv).
7. Let $R$ be the result of performing CaseBlockEvaluation of $CaseBlock$ with argument $switchValue$.
8. Set the running execution context’s LexicalEnvironment to $oldEnv$.

**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 $StatementList$.

### 13.12 Labelled Statements

**Syntax**

$LabelledStatement[Yield, Return] :$

- $LabelIdentifier[Yield] : LabelledItem[Yield, Return]$

$LabelledItem[Yield, Return] :$

- $Statement[Yield, Return]$
- $FunctionDeclaration[Yield]$

**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 other than the introduction of a label to a $label$ set.

### 13.12.1 Static Semantics: Early Errors

$LabelledItem : FunctionDeclaration$

- It is a Syntax Error if any source code matches this rule.

**NOTE** An alternative definition for this rule is provided in B.3.2.

### 13.12.2 Static Semantics: ContainsDuplicateLabels

With argument $labelSet$.

LabelledStatement : LabelIdentifier : LabelledItem

1. Let label be the StringValue of LabelIdentifier.
2. If label is an element of labelSet, return true.
3. Let newLabelSet be a copy of labelSet with label appended.
4. Return ContainsDuplicateLabels of LabelledItem with argument newLabelSet.

LabelledItem : FunctionDeclaration

1. Return false.

13.12.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


LabelledStatement : LabelIdentifier : LabelledItem

1. Let label be the StringValue of LabelIdentifier.
2. Let newLabelSet be a copy of labelSet with label appended.
3. Return ContainsUndefinedBreakTarget of LabelledItem with argument newLabelSet.

LabelledItem : FunctionDeclaration

1. Return false.

13.12.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

See also: 13.0.3, 13.1.4, 13.5.4, 13.6.1.3, 13.6.2.3, 13.6.3.4, 13.6.4.5, 13.7.2, 13.10.4, 13.11.4, 13.14.4, 15.2.1.4.

LabelledStatement : LabelIdentifier : LabelledItem

1. Let label be the StringValue of LabelIdentifier.
2. Let newLabelSet be a copy of labelSet with label appended.
3. Return ContainsUndefinedContinueTarget of LabelledItem with arguments iterationSet and newLabelSet.

LabelledItem : FunctionDeclaration

1. Return false.

13.12.5 Static Semantics: IsLabelledFunction ( stmt )

The abstract operation IsLabelledFunction with argument stmt performs the following steps:

1. If stmt is not a LabelledStatement, return false.
2. Let item be the LabelledItem component of stmt.
3. If item is LabelledItem : FunctionDeclaration, return true.
4. Let subStmt be the Statement component of item.
5. Return IsLabelledFunction(subStmt).
13.12.6 Static Semantics: LexicallyDeclaredNames

See also: 13.1.2, 13.11.2, 14.1.15, 14.2.10, 15.1.3, 15.2.1.11.

LabelledStatement : LabelIdentifier : LabelledItem
   1. Return the LexicallyDeclaredNames of LabelledItem.

LabelledItem : Statement
   1. Return a new empty List.

LabelledItem : FunctionDeclaration
   1. Return BoundNames of FunctionDeclaration.

13.12.7 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.11.6, 14.1.16, 14.2.11, 15.1.4, 15.2.1.12, 15.2.3.8.

LabelledStatement : LabelIdentifier : LabelledItem
   1. Return the LexicallyScopedDeclarations of LabelledItem.

LabelledItem : Statement
   1. Return a new empty List.

LabelledItem : FunctionDeclaration
   1. Return a new List containing FunctionDeclaration.

13.12.8 Static Semantics: TopLevelLexicallyDeclaredNames

See also: 13.1.7.

LabelledStatement : LabelIdentifier : LabelledItem
   1. Return a new empty List.

13.12.9 Static Semantics: TopLevelLexicallyScopedDeclarations

See also: 13.1.8.

LabelledStatement : LabelIdentifier : LabelledItem
   1. Return a new empty List.

13.12.10 Static Semantics: TopLevelVarDeclaredNames

See also: 13.1.9.

LabelledStatement : LabelIdentifier : LabelledItem
   1. Return the TopLevelVarDeclaredNames of LabelledItem.
LabelledItem : Statement
  1. If Statement is Statement : LabelledStatement, return TopLevelVarDeclaredNames of Statement.
  2. Return VarDeclaredNames of Statement.

LabelledItem : FunctionDeclaration
  1. Return BoundNames of FunctionDeclaration.

13.12.11 Static Semantics: TopLevelVarScopedDeclarations

See also: 13.1.10.

LabelledStatement : LabelIdentifier : LabelledItem
  1. Return the TopLevelVarScopedDeclarations of LabelledItem.

LabelledItem : Statement
  1. If Statement is Statement : LabelledStatement, return TopLevelVarScopedDeclarations of Statement.
  2. Return VarScopedDeclarations of Statement.

LabelledItem : FunctionDeclaration
  1. Return a new List containing FunctionDeclaration.

13.12.12 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.14.5, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

LabelledStatement : LabelIdentifier : LabelledItem
  1. Return the VarDeclaredNames of LabelledItem.

LabelledItem : FunctionDeclaration
  1. Return a new empty List.

13.12.13 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.14.6, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

LabelledStatement : LabelIdentifier : LabelledItem
  1. Return the VarScopedDeclarations of LabelledItem.

LabelledItem : FunctionDeclaration
  1. Return a new empty List.


With argument labelSet.
See also: 13.0.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.11.

**LabelledStatement** : LabelIdentifier : LabelledItem

1. Let label be the StringValue of LabelIdentifier.
2. Append label as an element of labelSet.
3. Let stmtResult be the result of performing LabelledEvaluation of LabelledItem with argument labelSet.
4. If stmtResult.
   •[[type]] is break and SameValue(stmtResult.
   •[[target]], label), then
     a. Return NormalCompletion(stmtResult.
   •[[value]]).
5. Return stmtResult.

**LabelledItem** : Statement

1. If Statement is either a LabelledStatement or a BreakableStatement, then
   a. Return the result of performing LabelledEvaluation of Statement with argument labelSet.
2. Else,
   a. Return the result of evaluating Statement.

**LabelledItem** : FunctionDeclaration

1. Return the result of evaluating FunctionDeclaration.

### 13.12.15 Runtime Semantics: Evaluation

**LabelledStatement** : LabelIdentifier : LabelledItem

1. Let newLabelSet be a new empty List.
2. Return the result of performing LabelledEvaluation of LabelledItem with argument newLabelSet.

### 13.13 The throw Statement

**Syntax**

```
ThrowStatement : throw Expression
```

#### 13.13.1 Runtime Semantics: Evaluation

1. Let exprRef be the result of evaluating Expression.
2. Let exprValue be GetValue(exprRef).
3. ReturnIfAbrupt(exprValue).
4. Return Completion({[[type]]: throw, [[value]]: exprValue, [[target]]: empty}).

### 13.14 The try Statement

**Syntax**

```
TryStatement[catch, finally] :
  try Block[catch, finally][yield, ?return]
  try Block[catch, finally][yield, ?return]
  try Block[catch, finally][yield, ?return]
```

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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.

13.14.1 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.

NOTE An alternative static semantics for this production is given in B.3.5.

13.14.2 Static Semantics: ContainsDuplicateLabels

With argument labelSet.

See also: 13.0.1, 13.1.2, 13.5.2, 13.6.1.1, 13.6.2.1, 13.6.3.2, 13.6.4.3, 13.10.2, 13.11.2, 15.2.1.2.

TryStatement : try Block Catch
1. Let hasDuplicates be ContainsDuplicateLabels of Block with argument labelSet.
2. If hasDuplicates is true, return true.
3. Return ContainsDuplicateLabels of Catch with argument labelSet.

TryStatement : try Block Finally
1. Let hasDuplicates be ContainsDuplicateLabels of Block with argument labelSet.
2. If hasDuplicates is true, return true.
3. Return ContainsDuplicateLabels of Finally with argument labelSet.

TryStatement : try Block Catch Finally
1. Let hasDuplicates be ContainsDuplicateLabels of Block with argument labelSet.
2. If hasDuplicates is true, return true.
3. Let hasDuplicates be ContainsDuplicateLabels of Catch with argument labelSet.
4. If hasDuplicates is true, return true.
5. Return ContainsDuplicateLabels of Finally with argument labelSet.

Catch : catch ( CatchParameter ) Block
1. Return ContainsDuplicateLabels of Block with argument labelSet.
13.14.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.


TryStatement : try Block Catch

1. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of Block with argument labelSet.
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedBreakTarget of Catch with argument labelSet.

TryStatement : try Block Finally

1. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of Block with argument labelSet.
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedBreakTarget of Finally with argument labelSet.

TryStatement : try Block Catch Finally

1. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of Block with argument labelSet.
2. If hasUndefinedLabels is true, return true.
3. Let hasUndefinedLabels be ContainsUndefinedBreakTarget of Catch with argument labelSet.
4. If hasUndefinedLabels is true, return true.
5. Return ContainsUndefinedBreakTarget of Finally with argument labelSet.

Catch : catch ( CatchParameter ) Block

1. Return ContainsUndefinedBreakTarget of Block with argument labelSet.

13.14.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

See also: 13.0.3, 13.1.4, 13.5.4, 13.6.1.3, 13.6.2.3, 13.6.3.4, 13.6.4.5, 13.7.2, 13.10.4, 13.11.4, 13.12.4, 15.2.1.4.

TryStatement : try Block Catch

1. Let hasUndefinedLabels be ContainsUndefinedContinueTarget of Block with arguments iterationSet and « ».
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedContinueTarget of Catch with arguments iterationSet and « ».

TryStatement : try Block Finally

1. Let hasUndefinedLabels be ContainsUndefinedContinueTarget of Block with arguments iterationSet and « ».
2. If hasUndefinedLabels is true, return true.
3. Return ContainsUndefinedContinueTarget of Finally with arguments iterationSet and « ».
TryStatement: `try` Block Catch Finally

1. Let `hasUndefinedLabels` be `ContainsUndefinedContinueTarget` of `Block` with arguments `iterationSet` and « ».
2. If `hasUndefinedLabels` is true, return true.
3. Let `hasUndefinedLabels` be `ContainsUndefinedContinueTarget` of `Catch` with arguments `iterationSet` and « ».
4. If `hasUndefinedLabels` is true, return true.
5. Return `ContainsUndefinedContinueTarget` of `Finally` with arguments `iterationSet` and « ».

Catch: `catch` ( `CatchParameter` ) Block

1. Return `ContainsUndefinedContinueTarget` of `Block` with arguments `iterationSet` and « ».

13.14.5 Static Semantics: `VarDeclaredNames`

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 14.1.18, 14.2.13, 15.1.5, 15.2.1.13.

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`.

13.14.6 Static Semantics: `VarScopedDeclarations`

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 14.1.19, 14.2.14, 15.1.6, 15.2.1.14.

TryStatement: `try` Block Catch

1. Let `declarations` be `VarScopedDeclarations` of `Block`.
2. Append to `declarations` the elements of the `VarScopedDeclarations` of `Catch`.
3. Return `declarations`.

TryStatement: `try` Block Finally

1. Let `declarations` be `VarScopedDeclarations` of `Block`.
2. Append to declarations the elements of the VarScopedDeclarations of Finally.
3. Return declarations.

TryStatement : try Block Catch Finally
1. Let declarations be VarScopedDeclarations of Block.
2. Append to declarations the elements of the VarScopedDeclarations of Catch.
3. Append to declarations the elements of the VarScopedDeclarations of Finally.
4. Return declarations.

Catch : catch ( CatchParameter ) Block
1. Return the VarScopedDeclarations of Block.

13.14.7 Runtime Semantics: CatchClauseEvaluation

with parameter thrownValue

Catch : catch ( CatchParameter ) Block
1. Let oldEnv be the running execution context’s LexicalEnvironment.
2. Let catchEnv be NewDeclarativeEnvironment(oldEnv).
3. For each element argName of the BoundNames of CatchParameter, do
   a. Call the CreateMutableBinding concrete method of catchEnv passing argName as the argument.
   b. Assert: The above call to CreateMutableBinding will never return an abrupt completion.
4. Set the running execution context’s LexicalEnvironment to catchEnv.
5. Let status be the result of performing BindingInitialization for CatchParameter passing thrownValue and catchEnv as arguments.
6. If status is an abrupt completion, then
   a. Set the running execution context’s LexicalEnvironment to oldEnv.
   b. Return status.
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.

13.14.8 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 CatchClauseEvaluation 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.
2. If \( B.\{\text{type}\} \) is \texttt{throw}, then
   a. Let \( C \) be the result of performing \texttt{CatchClauseEvaluation} of \texttt{Catch} with parameter \( B.\{\text{value}\} \).
3. Else \( B.\{\text{type}\} \) is not \texttt{throw},
   a. Let \( C \) be \( B \).
4. Let \( F \) be the result of evaluating \texttt{Finally}.
5. If \( F.\{\text{type}\} \) is normal, return \( C \).
6. Return \( F \).

13.15 The \texttt{debugger} statement

Syntax
\[
\text{DebuggerStatement} : \quad \texttt{debugger ;}
\]

13.15.1 Runtime Semantics: Evaluation

NOTE Evaluating the \texttt{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.

\[
\text{DebuggerStatement} : \texttt{debugger ;}
\]

1. If an implementation defined debugging facility is available and enabled, then
   a. Perform an implementation defined debugging action.
   b. Let \( \text{result} \) be an implementation defined \texttt{Completion} value.
2. Else
   a. Let \( \text{result} \) be \texttt{NormalCompletion}().
3. Return \( \text{result} \).

14 ECMAScript Language: Functions and Classes

NOTE Various ECMAScript language elements cause the creation of ECMAScript function objects (9.1.14). Evaluation of such functions starts with the execution of their \([\text{Call}]\) internal method (9.2.2).

14.1 Function Definitions

Syntax
\[
\text{FunctionDeclaration}_{\lll\text{Yield, Default}} : \quad \texttt{function BindingIdentifier}_{?\text{Yield}}(\text{FormalParameters})\{\text{FunctionBody}\}
\]
\[
\text{FunctionExpression} : \quad \texttt{function BindingIdentifier_{\text{opt}}(\text{FormalParameters})\{\text{FunctionBody}\}}
\]
\[
\text{StrictFormalParameters}_{\lll\text{Yield, GeneratorParameter}} : \quad \text{FormalParameters}_{?\text{Yield}, ?\text{GeneratorParameter}}
\]
\[
\text{FormalParameters}_{?\text{Yield, GeneratorParameter}} : \quad \{\text{empty}\}
\]
\[
\text{FormalParameterList}_{?\text{Yield, ?\text{GeneratorParameter}}} : \quad \text{FormalParameter}_{?\text{Yield}, ?\text{GeneratorParameter}}
\]

A Directive Prologue is the longest sequence of `ExpressionStatement` productions occurring as the initial `StatementList` productions of a `FunctionBody` or a `ScriptBody` 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 code unit 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 and which does not have a meaning defined by the implementation.

14.1.2 Static Semantics: Early Errors

`FunctionDeclaration` : `function BindingIdentifier ( FormalParameters ) { FunctionBody }`
and
`FunctionExpression` : `function BindingIdentifieropt ( FormalParameters ) { FunctionBody }`

- If the source code matching this production is strict code, the Early Error rules for `StrictFormalParameters` : `FormalParameters` are applied.
- If the source code matching this production is strict code, it is a Syntax Error if `BindingIdentifier` is the `IdentifierName eval` or the `IdentifierName arguments`.

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• It is a Syntax Error if any element of the BoundNames of `FormalParameters` also occurs in the LexicallyDeclaredNames of `FunctionBody`.
• It is a Syntax Error if `FormalParameters` Contains SuperCall is `true`.
• It is a Syntax Error if `FunctionBody` Contains SuperCall is `true`.

NOTE The LexicallyDeclaredNames of a `FunctionBody` does not include identifiers bound using var or function declarations.

**StrictFormalParameters : FormalParameters**

• It is a Syntax Error if BoundNames of `FormalParameters` contains any duplicate elements.

**FormalParameters : FormalParameterList**

• It is a Syntax Error if IsSimpleParameterList of `FormalParameterList` is `false` and BoundNames of `FormalParameterList` contains any duplicate elements.

NOTE Multiple occurrences of the same `BindingIdentifier` in a `FormalParameterList` is only allowed for non-strict functions and generator functions that have simple parameter lists.

**FunctionBody : FunctionStatementList**

• It is a Syntax Error if the LexicallyDeclaredNames of `FunctionStatementList` contains any duplicate entries.
• It is a Syntax Error if any element of the LexicallyDeclaredNames of `FunctionStatementList` also occurs in the VarDeclaredNames of `FunctionStatementList`.
• It is a Syntax Error if ContainsDuplicateLabels of `FunctionStatementList` with argument « » is `true`.
• It is a Syntax Error if ContainsUndefinedBreakTarget of `FunctionStatementList` with argument « » is `true`.
• It is a Syntax Error if ContainsUndefinedContinueTarget of `FunctionStatementList` with arguments « » and « » is `true`.

14.1.3 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

**FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }**

1. Return the BoundNames of `BindingIdentifier`.

**FunctionDeclaration : function ( FormalParameters ) { FunctionBody }**

1. Return « "*default*" ».

NOTE « "*default*" » is used within this specification as a synthetic name for hoistable anonymous functions that are defined using export declarations.

**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`.

 Deleted:
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.

14.1.4 Static Semantics: Contains

With parameter symbol.

See also: 5.3, 12.2.5.2, 12.3.1.1, 14.2.3, 14.4.4, 14.5.4

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.

14.1.5 Static Semantics: ContainsExpression

See also: 13.2.3.2, 14.2.4.

FormalParameters : [empty]
1. Return false.

FormalParameterList : FunctionRestParameter
1. Return false.

FormalParameterList : FormalsList , FunctionRestParameter
1. Return ContainsExpression of FormalsList.

FormalsList : FormalsList , FormalParameter
1. If ContainsExpression of FormalsList is true, return true.
2. Return ContainsExpression of FormalParameter.

14.1.6 Static Semantics: ExpectedArgumentCount

See also: 14.2.6, 14.3.2.

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 Initializer. A FormalParameter without an initializer is allowed after the first parameter with an initializer but such parameters are considered to be optional with `undefined` as their default value.

FormalsList : FormalParameter

1. If HasInitializer of FormalParameter is `true` return 0
2. Return 1.

FormalsList : FormalsList , FormalParameter

1. Let count be the ExpectedArgumentCount of FormalsList.
2. If HasInitializer of FormalsList is `true` or HasInitializer of FormalParameter is `true`, return count.

14.1.7 Static Semantics: FormalParameters

FunctionDeclaration : `function` BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return FormalParameters.

14.1.8 Static Semantics: HasInitializer

See also: 13.2.3.3, 14.2.7.

FormalParameters : [empty]

1. Return `false`.

FormalParameterList : FunctionRestParameter

1. Return `false`.

FormalParameterList : FormalsList , FunctionRestParameter

1. If HasInitializer of FormalsList is `true`, return `true`.
2. Return `false`.

FormalsList : FormalsList , FormalParameter

1. If HasInitializer of FormalsList is `true`, return `true`.
2. Return HasInitializer of FormalParameter.

14.1.9 Static Semantics: HasName

See also: 14.2.8, 14.4.6, 14.5.6.

FunctionExpression : `function` ( FormalParameters ) { FunctionBody }

1. Return `false`. 
FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return true.

14.1.10 Static Semantics: IsAnonymousFunctionDefinition ( production) Abstract Operation

The abstract operation IsAnonymousFunctionDefinition determines if its argument is a function definition that does not bind a name. The argument production is the result of parsing an AssignmentExpression or Initializer. The following steps are taken:

1. If IsFunctionDefinition of production is false, return false.
2. Let hasName be the result of HasName of production.
3. If hasName is true, return false.
4. Return true.

14.1.11 Static Semantics: IsConstantDeclaration

See also: 13.2.1.3, 14.4.8, 14.5.7, 15.2.3.7.

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }
FunctionDeclaration : function ( FormalParameters ) { FunctionBody }

1. Return false.

14.1.12 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.4.8, 14.5.8.

FunctionExpression : function ( FormalParameters ) { FunctionBody }

1. Return true.

FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return true.

14.1.13 Static Semantics: IsSimpleParameterList

See also: 13.2.3.4, 14.2.8

FormalParameters : [empty]

1. Return true.

FormalParameterList : FormalRestParameter

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 \texttt{FormalParameter}.

\textit{FormalParameter} : \texttt{BindingElement}

1. Return IsSimpleParameterList of \texttt{BindingElement}.

\subsection*{14.1.14 Static Semantics: IsStrict}

\textbf{See also:} 15.1.2, 15.2.1.7.

\textit{FunctionStatementList} : \textit{StatementList}opt

1. If this \textit{FunctionStatementList} is contained in strict code or if \textit{StatementList} is strict code, return \texttt{true}. Otherwise, return \texttt{false}.

\subsection*{14.1.15 Static Semantics: LexicallyDeclaredNames}

\textbf{See also:} 13.1.2, 13.11.2, 13.12.6, 14.2.10, 15.1.3, 15.2.1.11.

\textit{FunctionStatementList} : [\texttt{empty}]

1. Return an empty List.

\textit{FunctionStatementList} : \textit{StatementList}

1. Return TopLevelLexicallyDeclaredNames of \textit{StatementList}.

\subsection*{14.1.16 Static Semantics: LexicallyScopedDeclarations}

\textbf{See also:} 13.1.6, 13.11.6, 13.12.7, 14.2.11, 15.1.4, 15.2.1.12, 15.2.3.8.

\textit{FunctionStatementList} : [\texttt{empty}]

1. Return an empty List.

\textit{FunctionStatementList} : \textit{StatementList}

1. Return the TopLevelLexicallyScopedDeclarations of \textit{StatementList}.

\subsection*{14.1.17 Static Semantics: NeedsSuperBinding}

\textbf{See also:} 14.2.12, 14.3.7, 14.4.11.

\textit{FunctionDeclaration} : \texttt{function} \texttt{BindingIdentifier} \ ( \textit{FormalParameters} \) \ \{ \textit{FunctionBody} \}

\textit{FunctionDeclaration} : \texttt{func} \texttt{tion} \ ( \textit{FormalParameters} \) \ \{ \textit{FunctionBody} \}

1. If \textit{FormalParameters} Contains \texttt{SuperProperty} is \texttt{true}, return \texttt{true}.
2. Return \textit{FunctionBody} Contains \texttt{SuperProperty}.

\textit{FunctionExpression} : \texttt{function} \texttt{BindingIdentifier}opt \ ( \textit{FormalParameters} \) \ \{ \textit{FunctionBody} \}

1. If \textit{FormalParameters} Contains \texttt{SuperProperty} is \texttt{true}, return \texttt{true}.
2. Return \textit{FunctionBody} Contains \texttt{SuperProperty}.

\textit{FormalParameters} : [\texttt{empty}]

1. Return \texttt{false}.
FormalParameters : FormalParameterList
  1. Return FormalParameterList Contains SuperProperty.

FunctionBody : FunctionStatementList
  1. Return FunctionStatementList Contains SuperProperty.

14.1.18 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.2.13, 15.1.5, 15.2.1.13.

FunctionStatementList : [empty]
  1. Return an empty List.

FunctionStatementList : StatementList
  1. Return the TopLevelVarDeclaredNames of StatementList.

14.1.19 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.2.14, 15.1.6, 15.2.1.14.

FunctionStatementList : [empty]
  1. Return an empty List.

FunctionStatementList : StatementList
  1. Return the TopLevelVarScopedDeclarations of StatementList.

14.1.20 Runtime Semantics: EvaluateBody

  With parameter functionObject.

See also: 14.2.16, 14.4.12.

FunctionBody : FunctionStatementList
  1. The code of this FunctionBody is strict mode code if it is contained in strict mode code or if the Directive Prologue (14.1.1) of its FunctionStatementList contains a Use Strict Directive or if any of the conditions in 10.2.1 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. Return the result of evaluating FunctionStatementList.

14.1.21 Runtime Semantics: IteratorBindingInitialization

  With parameters iterator and environment.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialization value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialized in order to deal with the possibility of multiple parameters with the same name.
FormalParameters : [empty]

1. Return NormalCompletion(empty).

FormalParameterList : FormalsList , FunctionRestParameter

1. Let restIndex be the result of performing IteratorBindingInitialization for FormalsList using iterator and environment as the arguments.
2. ReturnIfAbrupt(restIndex).
3. Return the result of performing IteratorBindingInitialization for FunctionRestParameter using iterator and environment as the arguments.

FormalsList : FormalsList , FormalParameter

1. Let status be the result of performing IteratorBindingInitialization for FormalsList using iterator and environment as the arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorBindingInitialization for FormalParameter using iterator and environment as the arguments.

14.1.22 Runtime Semantics: InstantiateFunctionObject

With parameter scope.

See also: 14.4.13.

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. If the FunctionDeclaration is contained in strict code or if its FunctionBody is strict code, let strict be true. Otherwise let strict be false.
2. Let name be StringValue of BindingIdentifier.
4. If NeedsSuperBinding of FunctionDeclaration is true, then
   a. Perform MakeMethod(F, undefined).
5. Perform MakeConstructor(F).
6. Perform SetFunctionName(F, name).
7. Return F.

FunctionDeclaration : function ( FormalParameters ) { FunctionBody }

1. If the FunctionDeclaration is contained in strict code or if its FunctionBody is strict code, let strict be true. Otherwise let strict be false.
2. Let F be FunctionCreate(Normal, FormalParameters, FunctionBody, scope, strict).
3. If NeedsSuperBinding of FunctionDeclaration is true, then
   a. Perform MakeMethod(F, undefined).
4. Perform MakeConstructor(F).
5. Perform SetFunctionName(F, "default").
6. Return F.

NOTE An anonymous FunctionDeclaration can only occur as part of an export default declaration.
14.1.23 Runtime Semantics: Evaluation

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

FunctionDeclaration : function ( 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, let strict be true. Otherwise let strict be false.
2. Let scope be the LexicalEnvironment of the running execution context.
4. If NeedsSuperBinding of FunctionExpression is true, then
   a. Perform MakeMethod(closure, undefined).
5. Perform MakeConstructor(closure).

FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. If the FunctionExpression is contained in strict code or if its FunctionBody is strict code, let strict be true. Otherwise let strict be false.
2. Let runningContext be the running execution context’s Lexical Environment.
3. Let funcEnv be NewDeclarativeEnvironment(runningContext).
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 FunctionCreate(Normal, FormalParameters, FunctionBody, funcEnv, strict).
8. If NeedsSuperBinding of FunctionExpression is true, then
   a. Perform MakeMethod(closure, undefined).
9. Perform MakeConstructor(closure).
10. Perform SetFunctionName(closure, name).
11. Call the InitializeBinding concrete method of envRec passing name and closure as the arguments.
12. 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.

FunctionStatementList : [empty]

1. Return NormalCompletion(undefined).

14.2 Arrow Function Definitions

Syntax

ArrowFunctionIn, Yield : ArrowParameters[?Yield] [no LineTerminator here] => ConciseBody[?Yield]

ConciseBody[Yield] :
[lookahead ≠ {} AssignmentExpression[Yield]
{ FunctionBody }]

Supplemental Syntax

When the production

ArrowParameters[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

is recognized the following grammar is used to refine the interpretation of

CoverParenthesizedExpressionAndArrowParameterList:

ArrowFormalParameters[Yield, GeneratorParameter] :
( StrictFormalParameters[Yield, ?GeneratorParameter] )

14.2.1 Static Semantics: Early Errors

ArrowFunction : ArrowParameters => ConciseBody

• It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the LexicallyDeclaredNames of ConciseBody.

ArrowParameters[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

• If the Yield grammar parameter is present on ArrowParameters, it is a Syntax Error if the lexical token sequence matched by CoverParenthesizedExpressionAndArrowParameterList[Yield] cannot be parsed with no tokens left over using ArrowFormalParameters[Yield, GeneratorParameter] as the goal symbol.
• If the Yield grammar parameter is not present on ArrowParameters, it is a Syntax Error if the lexical token sequence matched by CoverParenthesizedExpressionAndArrowParameterList[Yield] cannot be parsed with no tokens left over using ArrowFormalParameters as the goal symbol.
• All early errors rules for ArrowFormalParameters and its derived productions also apply to CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[Yield].

NOTE: The yield operator cannot be used within expressions that are part of an ArrowFormalParameters.

14.2.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.1.3, 14.4.2, 14.5.2, 15.2.2.2, 15.2.3.1.

ArrowParameters[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[Yield];
2. Return the BoundNames of formals.

14.2.3 Static Semantics: Contains

With parameter symbol.

See also: 5.3, 12.2.5.2, 12.3.1.1, 14.1.4, 14.4.4, 14.5.4
ArrowFunction : ArrowParameters => ConciseBody

1. If symbol is not one of SuperProperty, SuperCall, super or this, return false.
2. If ArrowParameters Contains symbol is true, return true;
3. Return ConciseBody Contains symbol.

NOTE Normally, Contains does not look inside most function forms. However, Contains is used to detect this and super usage within an ArrowFunction.

ArrowParameters[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[Yield];
2. Return formals Contains symbol.

14.2.4 Static Semantics: ContainsExpression

See also: 13.2.3.2, 14.1.5.

ArrowParameters : BindingIdentifier

1. Return false.

ArrowParameters[Yield] : CoverParenthesizedExpressionAndArrowParameterList[Yield]

1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[Yield];
2. Return the ContainsExpression of formals.

14.2.5 Static Semantics: CoveredFormalsList

ArrowParameters : BindingIdentifier

1. Return BindingIdentifier.

CoverParenthesizedExpressionAndArrowParameterList[Yield]

( Expression )
( )
( ... BindingIdentifier )
( Expression , ... BindingIdentifier )

1. If the [Yield] grammar parameter is present for CoverParenthesizedExpressionAndArrowParameterList[Yield], return the result of parsing the lexical token stream matched by CoverParenthesizedExpressionAndArrowParameterList[Yield] using ArrowFormalParameters[Yield, GeneratorParameter] as the goal symbol.
2. If the [Yield] grammar parameter is not present for CoverParenthesizedExpressionAndArrowParameterList[Yield], return the result of parsing the lexical token stream matched by CoverParenthesizedExpressionAndArrowParameterList using ArrowFormalParameters as the goal symbol.

14.2.6 Static Semantics: ExpectedArgumentCount

See also: 14.1.5, 14.3.2.
ArrowParameters : BindingIdentifier
  1. Return 1.

ArrowParameters[?Yield] : CoverParenthesizedExpressionAndArrowParameterList[?Yield]
  1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[?Yield].
  2. Return the ExpectedArgumentCount of formals.

14.2.7 Static Semantics: HasInitializer

See also: 13.2.3.3, 14.1.7.

ArrowParameters : BindingIdentifier
  1. Return false.

ArrowParameters : CoverParenthesizedExpressionAndArrowParameterList
  1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList.
  2. Return the HasInitializer of formals.

14.2.8 Static Semantics: HasName

See also: 14.1.9, 14.4.6, 14.5.6.

ArrowFunction : ArrowParameters => ConciseBody
  1. Return false.

14.2.9 Static Semantics: IsSimpleParameterList

See also: 13.2.3.4, 14.1.12.

ArrowParameters : BindingIdentifier
  1. Return true.

ArrowParameters[?Yield] : CoverParenthesizedExpressionAndArrowParameterList[?Yield]
  1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList[?Yield].
  2. Return the IsSimpleParameterList of formals.

14.2.10 Static Semantics: LexicallyDeclaredNames

See also: 13.1.2, 13.1.3, 13.2.6, 14.1.15, 15.1.3, 15.2.1.11.

ConciseBody : AssignmentExpression
  1. Return an empty List.

14.2.11 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.1.16, 13.1.18, 14.1.16, 15.1.4, 15.2.1.12, 15.2.3.8.
ConciseBody : AssignmentExpression
  1. Return an empty List.

14.2.12 Static Semantics: NeedsSuperBinding

See also: 14.1.17, 14.3.7, 14.4.11.

ArrowFunction : ArrowParameters => ConciseBody
  1. Return false.

NOTE NeedsSuperBinding is used to determine whether a function requires its own super bindings. This is never the case for Arrow Functions.

14.2.13 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 15.1.5, 15.2.1.13.

ConciseBody : AssignmentExpression
  1. Return an empty List.

14.2.14 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 15.1.6, 15.2.1.14.

ConciseBody : AssignmentExpression
  1. Return an empty List.

14.2.15 Runtime Semantics: IteratorBindingInitialization

  With parameters iterator and environment.

See also: 13.2.3.6, 14.1.21.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialization value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialized in order to deal with the possibility of multiple parameters with the same name.

ArrowParameters : BindingIdentifier
  1. Let next be IteratorStep(iterator).
  2. ReturnIfAbrupt(next).
  3. If next is false, let v be undefined
  4. Else
     a. Let v be IteratorValue(next).
     b. ReturnIfAbrupt(v).
  5. Return the result of performing BindingInitialization for BindingIdentifier using v and environment as the arguments.
ArrowParameters, Yield : CoverParenthesizedExpressionAndArrowParameterList, Yield

1. Let formals be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList, Yield.
2. Return the result of performing IteratorBindingInitialization of formals with arguments iterator and environment.

14.2.16 Runtime Semantics: EvaluateBody

With parameter functionObject.

See also: 14.1.20, 14.4.12.

ConciseBody : 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 10.2.1 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. ReturnIfAbrupt(exprValue).
5. Return Completion({[[type]]: return, [[value]]: exprValue, [[target]]: empty}).

14.2.17 Runtime Semantics: Evaluation

ArrowFunction, Yield : ArrowParameters, Yield => ConciseBody

1. If the code of this ArrowFunction is contained in strict mode code or if any of the conditions in 10.2.1 apply, let strict be true. Otherwise let strict be false.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let parameters be CoveredFormalsList of ArrowParameters, Yield.
4. Let closure be FunctionCreate(Arrow, parameters, ConciseBody, scope, strict).
5. Return closure.

NOTE An ArrowFunction does not define local bindings for arguments, super, or this. Any reference to arguments, super, or this within an ArrowFunction must resolve to a binding in a lexically enclosing environment. Typically, this will be the Function Environment of an immediately enclosing function. Even though an ArrowFunction may contain references to super, the function object created in step 4 is not made into a method by performing MakeMethod. 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.

14.3 Method Definitions

Syntax

MethodDefinition, Yield : 
 (PropertyName, Yield) ( StrictFormalParameters ) { FunctionBody } 
GeneratorMethod, Yield 
  get PropertyName, Yield ( ) { FunctionBody } 
  set PropertyName, Yield ( PropertySetParameterList ) { FunctionBody }
PropertySetParameterList:
  FormalParameter

14.3.1 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 LexicallyDeclaredNames of FunctionBody.

MethodDefinition: set PropertyName ( PropertySetParameterList ) { FunctionBody }
- 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.

14.3.2 Static Semantics: ComputedPropertyContains

With parameter symbol.

See also: 12.2.5.2, 14.4.3, 14.5.5.

MethodDefinition:
  PropertyName ( StrictFormalParameters ) { FunctionBody }
  get PropertyName ( ) { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }

  1. Return the result of ComputedPropertyContains for PropertyName with argument symbol.

14.3.3 Static Semantics: ExpectedArgumentCount

See also: 14.1.5, 14.2.6.

PropertySetParameterList: FormalParameter

  1. If HasInitializer of FormalParameter is true return 0
  2. Return 1.

14.3.4 Static Semantics: HasComputedPropertyKey

See also: 12.2.5.4, 14.4.5

MethodDefinition:
  PropertyName ( StrictFormalParameters ) { FunctionBody }
  get PropertyName ( ) { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }

  1. Return HasComputedPropertyKey of PropertyName.

14.3.5 Static Semantics: HasDirectSuper

See also: 14.4.6.
MethodDefinition: PropertyName (StrictFormalParameters) { FunctionBody }
1. If StrictFormalParameters Contains SuperCall is true, return true.
2. Return FunctionBody Contains SuperCall.

MethodDefinition: get PropertyName () { FunctionBody }
1. Return FunctionBody Contains SuperCall.

MethodDefinition: set PropertyName (PropertySetParameterList) { FunctionBody }
1. If PropertySetParameterList Contains SuperCall is true, return true.
2. Return FunctionBody Contains SuperCall.

14.3.6 Static Semantics: PropName

See also: 12.2.5.6, 14.4.10, 14.5.12

MethodDefinition:
  PropertyName (StrictFormalParameters) { FunctionBody }
  get PropertyName () { FunctionBody }
  set PropertyName (PropertySetParameterList) { FunctionBody }
1. Return PropName of PropertyName.

14.3.7 Static Semantics: NeedsSuperBinding

See also: 14.1.17, 14.2.12, 14.4.11.

MethodDefinition: PropertyName (StrictFormalParameters) { FunctionBody }
1. If StrictFormalParameters Contains SuperProperty is true, return true.
2. Return FunctionBody Contains SuperProperty.

MethodDefinition: get PropertyName () { FunctionBody }
1. Return FunctionBody Contains SuperProperty.

MethodDefinition: set PropertyName (PropertySetParameterList) { FunctionBody }
1. If PropertySetParameterList Contains SuperProperty is true, return true.
2. Return FunctionBody Contains SuperProperty.

14.3.8 Static Semantics: SpecialMethod

MethodDefinition: PropertyName (StrictFormalParameters) { FunctionBody }
1. Return false.

MethodDefinition:
  GeneratorMethod
  get PropertyName () { FunctionBody }
  set PropertyName (PropertySetParameterList) { FunctionBody }
1. Return true.
14.3.9 Runtime Semantics: DefineMethod

With parameters `object` and optional parameter `functionPrototype`.

```javascript
MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }
```

1. Let `propKey` be the result of evaluating `PropertyName`.
2. ReturnIfAbrupt(`propKey`).
3. Let `strict` be IsStrict of `FunctionBody`.
4. Let `scope` be the running execution context’s LexicalEnvironment.
5. Let `closure` be FunctionCreate(`Method`, `StrictFormalParameters`, `FunctionBody`, `scope`, `strict`). If `functionPrototype` was passed as a parameter then pass its value as the `functionPrototype` optional argument of FunctionCreate.
6. If NeedsSuperBinding of `MethodDefinition` is `true`, then
   a. Perform MakeMethod(`closure`, `object`).
7. Return the Record(`[[key]]`: `propKey`, `[[closure]]`: `closure`).

14.3.10 Runtime Semantics: PropertyDefinitionEvaluation

With parameters `object` and `enumerable`.

See also: 12.2.5.9, 14.4.14, B.3.1

```javascript
MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }
```

1. Let `methodDef` be DefineMethod of `MethodDefinition` with argument `object`.
2. ReturnIfAbrupt(`methodDef`).
3. Perform SetFunctionName(`methodDef`[`[[closure]]`, `methodDef`[`[[key]]`]).
5. Return DefinePropertyOrThrow(`object`, `methodDef`[`[[key]]`, `desc`]).

MethodDefinition : GeneratorMethod

See 14.4.

```javascript
MethodDefinition : get PropertyName ( ) { FunctionBody }
```

1. Let `propKey` be the result of evaluating `PropertyName`.
2. ReturnIfAbrupt(`propKey`).
3. Let `strict` be IsStrict of `FunctionBody`.
4. Let `scope` be the running execution context’s LexicalEnvironment.
5. Let `formalParameterList` be the production `FormalParameters` : `empty`.
7. If NeedsSuperBinding of `MethodDefinition` is `true`, then
   a. Perform MakeMethod(`closure`, `object`).
8. Perform SetFunctionName(`closure`, `propKey`, "get").
10. Return DefinePropertyOrThrow(`object`, `propKey`, `desc`).

MethodDefinition : set PropertyName ( PropertySetParameterList ) { FunctionBody }

1. Let `propKey` be the result of evaluating `PropertyName`.  

Deleted:

```
Assert: SetFunctionName will not return an abrupt completion.
CreateData
methodDef`[`[[closure]]
```

Deleted:

```
Assert: SetFunctionName will not return an abrupt completion.
```

Deleted: true
2. ReturnIfAbrupt(propKey).
3. Let strict be IsStrict of FunctionBody.
4. Let scope be the running execution context’s LexicalEnvironment.
5. Let closure be FunctionCreate(Method, PropertySetParameterList, FunctionBody, scope, strict).
6. If NeedsSuperBinding of MethodDefinition is true, then
   a. Perform MakeMethod(closure, object).
7. Perform SetFunctionName(closure, propKey, "set").
8. Let desc be the PropertyDescriptor{[[Set]]: closure, [[Enumerable]]: enumerable, [[Configurable]]: true}.
9. Return DefinePropertyOrThrow(object, propKey, desc).

14.4 Generator Function Definitions

Syntax

GeneratorMethod* : * PropertyName? (StrictFormalParameters* [Yield, GeneratorParameter] ) { GeneratorBody[Yield] }

GeneratorDeclaration* : function * BindingIdentifier? (FormalParameters[Yield, GeneratorParameter] ) { GeneratorBody[Yield] }
   [+Default] function * (FormalParameters[Yield, GeneratorParameter] ) { GeneratorBody[Yield] }

GeneratorExpression : function * BindingIdentifierOpt (FormalParameters[Yield, GeneratorParameter] ) { GeneratorBody[Yield] }

GeneratorBody[Yield] : FunctionBody[?Yield]

YieldExpressionOpt :
    yield
    yield [no LineTerminator here] Lexical goal InputElementRegExpAssignmentExpression[no, Yield]
    yield [no LineTerminator here] * Lexical goal InputElementRegExpAssignmentExpression[?Yield, Yield]

NOTE 1 YieldExpression cannot be used within the FormalParameters of a generator function because any expressions that are part of FormalParameters are evaluated before the resulting generator object is in a resumable state.

NOTE 2 Abstract operations relating to generator objects are defined in 25.3.3.

14.4.1 Static Semantics: Early Errors

GeneratorMethod : * PropertyName (StrictFormalParameters ) { GeneratorBody }
   • It is a Syntax Error if HasDirectSuper(GeneratorMethod) is true.
   • It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the LexicallyDeclaredNames of GeneratorBody.

GeneratorDeclaration : function * BindingIdentifier (FormalParameters ) { GeneratorBody }
   • It is a Syntax Error if HasDirectSuper(GeneratorDeclaration) is true.

GeneratorExpression : function * BindingIdentifierOpt (FormalParameters ) { GeneratorBody }
   • It is a Syntax Error if HasDirectSuper(GeneratorExpression) is true.
GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody } 
and 
GeneratorExpression : function * BindingIdentifier_opt ( FormalParameters ) { GeneratorBody } 

- If the source code matching this production is strict code, the Early Error rules for StrictFormalParameters : FormalParameters are applied.
- If the source code matching this production is strict code, it is a Syntax Error if BindingIdentifier is the IdentifierName eval or the IdentifierName arguments.
- It is a Syntax Error if any element of the BoundNames of FormalParameters also occurs in the LexicallyDeclaredNames of GeneratorBody.

14.4.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.5.2, 15.2.2.2, 15.2.3.1.

GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody } 
1. Return the BoundNames of BindingIdentifier.

GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody } 
1. Return "*default*".

NOTE "*default*" is used within this specification as a synthetic name for hoistable anonymous functions that are defined using export declarations.

14.4.3 Static Semantics: ComputedPropertyContains

With parameter symbol.

See also: 12.2.5.2, 14.3.2, 14.5.5.

GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody } 
1. Return the result of ComputedPropertyContains for PropertyName with argument symbol.

14.4.4 Static Semantics: Contains

With parameter symbol.

See also: 5.3, 12.2.5.2, 12.3.1.1, 14.1.4, 14.2.3, 14.5.4

GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody } 
GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody } 
1. Return false.

GeneratorExpression : function * BindingIdentifier_opt ( FormalParameters ) { GeneratorBody } 
1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.
14.4.5 Static Semantics: HasComputedPropertyKey

See also: 12.2.5.4, 14.3.4.

GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
  1. Return IsComputedPropertyKey of PropertyName.

14.4.6 Static Semantics: HasDirectSuper

See also: 14.3.5.

GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
  1. If StrictFormalParameters Contains SuperCall is true, return true.
  2. Return GeneratorBody Contains SuperCall.

14.4.7 Static Semantics: HasName

See also: 14.1.9, 14.2.8, 14.5.6.

GeneratorExpression : function * ( FormalParameters ) { GeneratorBody }
  1. Return false.

GeneratorExpression : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
  1. Return true.

14.4.8 Static Semantics: IsConstantDeclaration

See also: 13.2.1.3, 14.1.11, 14.5.7, 15.2.3.7.

GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody }
  1. Return false.

14.4.9 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.5.8.

GeneratorExpression : function * ( FormalParameters ) { GeneratorBody }
  1. Return true.

GeneratorExpression : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
  1. Return true.

14.4.10 Static Semantics: PropName

See also: 12.2.5.6, 14.3.5, 14.5.12
GeneratorMethod :: PropertyName ( StrictFormalParameters ) { GeneratorBody }

1. Return PropName of PropertyName.

14.4.11 Static Semantics: NeedsSuperBinding

See also: 14.1.17, 14.2.12, 14.3.7.

GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody }

1. If FormalParameters Contains SuperProperty is true, return true.
2. Return GeneratorBody Contains SuperProperty.

GeneratorExpression : function * BindingIdentifier_opt ( FormalParameters ) { GeneratorBody }

1. If FormalParameters Contains SuperProperty is true, return true.
2. Return GeneratorBody Contains SuperProperty.

GeneratorMethod :: PropertyName ( StrictFormalParameters ) { GeneratorBody }

1. If StrictFormalParameters Contains SuperProperty is true, return true.
2. Return GeneratorBody Contains SuperProperty.

14.4.12 Runtime Semantics: EvaluateBody

With parameter functionObject.

See also: 14.1.20, 14.2.16.

GeneratorBody : FunctionBody

1. Let G be be OrdinaryCreateFromConstructor (functionObject, "%GeneratorPrototype%", «[GeneratorState], [[GeneratorContext]]»).
2. ReturnIfAbrupt (G).
3. Let result be GeneratorStart (G, FunctionBody).
4. ReturnIfAbrupt (result).
5. Return Completion { [type]: return, [value]: result, [target]: empty }.

NOTE If the generator was invoked using [[Call]], the this binding will have already been initialized in the normal manner. If the generator was invoked using [[Construct]], the this bind is not initialized and any references to this within the FunctionBody with produce a ReferenceError exception.

14.4.13 Runtime Semantics: InstantiateFunctionObject

With parameter scope.

See also: 14.1.22.

GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }

1. If the GeneratorDeclaration is contained in strict code or if its GeneratorBody is strict code, let strict be true. Otherwise let strict be false.
2. Let name be StringValue of BindingIdentifier.
3. Let F be GeneratorFunctionCreate (Normal, FormalParameters, GeneratorBody, scope, strict).
4. If NeedsSuperBinding of GeneratorDeclaration is true, then
   a. Perform MakeMethod(F, undefined).
5. Let prototype be ObjectCreate(%GeneratorPrototype%).
6. Perform MakeConstructor(F, true, prototype).
7. Perform SetFunctionName(F, name).
8. Return F.

GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody }
1. If the GeneratorDeclaration is contained in strict code or if its GeneratorBody is strict code, let
   strict be true. Otherwise let strict be false.
2. Let F be GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, scope, strict).
3. If NeedsSuperBinding of GeneratorDeclaration is true, then
   a. Perform MakeMethod(F, undefined).
4. Let prototype be ObjectCreate(%GeneratorPrototype%).
5. Perform MakeConstructor(F, true, prototype).
6. Perform SetFunctionName(F, "default").
7. Return F.

NOTE An anonymous GeneratorDeclaration can only occur as part of an export default declaration.

14.4.14 Runtime Semantics: PropertyDefinitionEvaluation

   With parameter object and enumerable.

See also: 12.2.5.9, 14.3.10, B.3.1

GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
1. Let propKey be the result of evaluating PropertyName.
2. ReturnIfAbrupt(propKey).
3. Let strict be IsStrict of GeneratorBody.
4. Let scope be the running execution context’s LexicalEnvironment.
5. Let closure be GeneratorFunctionCreate(Method, StrictFormalParameters, GeneratorBody, scope, strict).
6. If NeedsSuperBinding of GeneratorMethod is true, then
   a. Perform MakeMethod(closure, object).
7. Let prototype be ObjectCreate(%GeneratorPrototype%).
8. Perform MakeConstructor(closure, true, prototype).
9. Perform SetFunctionName(closure, propKey).
10. Let desc be the Property Descriptor{[[Value]]: closure, [[Writable]]: true, [[Enumerable]]: enumerable, [[Configurable]]: true}.
11. Return DefinePropertyOrThrow(object, propKey, desc).

14.4.15 Runtime Semantics: Evaluation

GeneratorExpression : function * ( FormalParameters ) { GeneratorBody }
1. Let strict be IsStrict of GeneratorBody.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let closure be GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, scope, strict).
4. If NeedsSuperBinding of GeneratorExpression is true, then
a. Perform MakeMethod(closure, undefined).
5. Let prototype be ObjectCreate(%GeneratorPrototype%).
6. Perform MakeConstructor(closure, true, prototype).
7. Return closure.

**GeneratorExpression**: `function * BindingIdentifier ( FormalParameters ) { GeneratorBody }

1. Let strict be IsStrict of GeneratorBody.
2. Let runningContext be the running execution context’s Lexical Environment.
3. Let funcEnv be NewDeclarativeEnvironment(runningContext).
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 GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, funcEnv, strict).
8. If NeedsSuperBinding of GeneratorExpression is true, then
   a. Perform MakeMethod(closure, undefined).
9. Let prototype be ObjectCreate(%GeneratorPrototype%).
10. Perform MakeConstructor(closure, true, prototype).
11. Perform SetFunctionName(closure, name).
12. Call the InitializeBinding concrete method of envRec passing name and closure as the arguments.

**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`  
1. Return GeneratorYield(CreateIterResultObject(undefined, false)).

**YieldExpression**: `yield AssignmentExpression`  
1. Let exprRef be the result of evaluating AssignmentExpression.
2. Let value be GetValue(exprRef).
3. ReturnIfAbrupt(value).
4. Return GeneratorYield(CreateIterResultObject(value, false)).

**YieldExpression**: `* AssignmentExpression`  
1. Let exprRef be the result of evaluating AssignmentExpression.
2. Let value be GetValue(exprRef).
3. Let iterator be GetIterator(value).
4. ReturnIfAbrupt(iterator).
5. Let received be NormalCompletion(undefined).
6. Repeat
   a. If received.[[type]] is normal, then
      i. Let innerResult be IteratorNext(iterator, received.[[value]]).
      ii. ReturnIfAbrupt(innerResult).
      iii. Let done be IteratorComplete(innerResult).
      iv. ReturnIfAbrupt(done).
   v. If done is true, then
      i. Return IteratorValue (innerResult).
vi. Let received be GeneratorYield(innerResult).

b. Else if received.[[type]] is throw, then
   i. Let throw be GetMethod(iterator, "throw").
   ii. ReturnAbrupt(throw).
   iii. If throw is not undefined, then
       1. Let innerResult be Call(throw, iterator, received.[[value]]).
       2. ReturnAbrupt(innerResult).
       3. NOTE: Exceptions from the inner iterator throw method are propagated. Normal completions from an inner throw method are processed similarly to an inner next.
       4. If Type(innerResult) is not Object, throw a TypeError exception.
       5. Let done be IteratorComplete(innerResult).
       6. ReturnAbrupt(done).
       7. If done is true, then
          a. Return Completion([[type]: return, [[value]]: IteratorValue(innerResult), [[target]]: empty]).
       8. Let received be GeneratorYield(innerResult).
   iv. Else,
       1. NOTE: If iterator does not have a throw method, this throw is going to terminate the yield* loop. But first we need to give iterator a chance to clean up.
       2. Let closeResult = IteratorClose(iterator, received).
       3. ReturnAbrupt(closeResult).
       4. Throw a TypeError exception.

c. Else,
   i. Assert: received.[[type]] is return.
   ii. Let return be GetMethod(iterator, "return").
   iii. ReturnAbrupt(return).
   iv. If return is undefined, return received.
   v. Let innerResult be Call(return, iterator, received.[[value]]).
   vi. ReturnAbrupt(innerResult).
   vii. If Type(innerResult) is not Object, throw a TypeError exception.
   viii. Let done be IteratorComplete(innerResult).
   ix. ReturnAbrupt(done).
   x. If done is true, then
      1. Return Completion([[type]: return, [[value]]: IteratorValue(innerResult), [[target]]: empty]).
   xi. Let received be GeneratorYield(innerResult).

14.5 Class Definitions

Syntax

ClassDeclaration(yield, Default):

```javascript
class BindingIdentifier[?Yield] | ClassTail[?Yield]
{+Default} class ClassTail[?Yield]
```

ClassExpression(?Yield,?GeneratorParameter):

```javascript
class BindingIdentifier[?Yield,opt] | ClassTail[?Yield,?GeneratorParameter]
```

ClassTail[?Yield,?GeneratorParameter]:

```javascript
[+GeneratorParameter] ClassHeritage[?Yield,?opt] { ClassBody[?Yield,?opt] }
[+GeneratorParameter] ClassHeritage[?opt] { ClassBody[?opt] }
```
ClassHeritage[Yield] :
  extends LeftHandSideExpression[Yield]

ClassBody[Yield] :
  ClassElementList[Yield]

ClassElementList[Yield] :
  ClassElement[Yield]
  ClassElementList[Yield] ClassElement[Yield]

ClassElement[Yield] :
  MethodDefinition[Yield]
    static MethodDefinition[Yield]

NOTE A ClassBody is always strict code.

14.5.1 Static Semantics: Early Errors

ClassBody : ClassElementList
  • It is a Syntax Error if PrototypePropertyNameList of ClassElementList contains more than one occurrence of "constructor".

ClassElement : MethodDefinition
  • It is a Syntax Error if PropName of MethodDefinition is not "constructor" and HasDirectSuper(MethodDefinition) is true.
  • 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 HasDirectSuper(MethodDefinition) is true.
  • It is a Syntax Error if PropName of MethodDefinition is "prototype".

14.5.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 15.2.2.2, 15.2.3.1.

ClassDeclaration : class BindingIdentifier ClassTail
  1. Return the BoundNames of BindingIdentifier.

ClassDeclaration : class ClassTail
  1. Return "**default**".

14.5.3 Static Semantics: ConstructorMethod

ClassElementList : ClassElement
  1. If ClassElement is the production ClassElement : return empty.
  2. If IsStatic of ClassElement is true, return empty.
3. If PropName of ClassElement is not "constructor", return empty.
4. Return ClassElement.

ClassElementList : ClassElementList ClassElement

1. Let head be ConstructorMethod of ClassElementList.
2. If head is not empty, return head.
3. If ClassElement is the production ClassElement : ;, return empty.
4. If IsStatic of ClassElement is true, return empty.
5. If PropName of ClassElement is not "constructor", return empty.
6. Return ClassElement.

NOTE Early Error rules ensure that there is only one method definition named "constructor" and that it is not an accessor property or generator definition.

14.5.4 Static Semantics: Contains

With parameter symbol.

See also: 5.3, 12.2.5.2, 12.3.1.1, 14.1.4, 14.2.3, 14.4.4

ClassTail : ClassHeritageopt { ClassBody }

1. If symbol is ClassBody, return true.
2. If symbol is ClassHeritage, then
   a. If ClassHeritage is present, return true otherwise return false.
3. Let inHeritage be ClassHeritage Contains symbol.
4. If inHeritage is true, return true.
5. Return the result of ComputedPropertyContains for ClassBody with argument symbol.

NOTE Static semantic rules that depend upon substructure generally do not look into class bodies except for PropertyName productions.

14.5.5 Static Semantics: ComputedPropertyContains

With parameter symbol.

See also: 12.2.5.2, 14.3.2, 14.4.3.

ClassElementList : ClassElementList ClassElement

1. Let inList be the result of ComputedPropertyContains for ClassElementList with argument symbol.
2. If inList is true, return true.
3. Return the result of ComputedPropertyContains for ClassElement with argument symbol.

ClassElement : MethodDefinition

1. Return the result of ComputedPropertyContains for MethodDefinition with argument symbol.

ClassElement : static MethodDefinition

1. Return the result of ComputedPropertyContains for MethodDefinition with argument symbol.

ClassElement : ;

1. Return false.
14.5.6 Static Semantics: HasName

See also: 14.1.9, 14.2.8, 14.4.6.

ClassExpression : class ClassTail
  1. Return false.

ClassExpression : class BindingIdentifier ClassTail
  1. Return true.

14.5.7 Static Semantics: IsConstantDeclaration

See also: 13.2.1.3, 14.1.11, 14.4.8, 15.2.3.7.

ClassDeclaration : class BindingIdentifier ClassTail
ClassDeclaration : class ClassTail
  1. Return false.

14.5.8 Static Semantics: IsFunctionDefinition

See also: 12.2.0.2, 12.2.9.2, 12.3.1.2, 12.4.2, 12.5.2, 12.6.1, 12.7.1, 12.8.1, 12.9.1, 12.10.1, 12.11.1, 12.12.1, 12.13.1, 12.14.2, 12.15.1, 14.1.12, 14.4.8.

ClassExpression : class ClassTail
  1. Return true.

ClassExpression : class BindingIdentifier ClassTail
  1. Return true.

14.5.9 Static Semantics: IsStatic

ClassElement : MethodDefinition
  1. Return false.

ClassElement : static MethodDefinition
  1. Return true.

ClassElement : :
  1. Return false.

14.5.10 Static Semantics: NonConstructorMethodDefinitions

ClassElementList : ClassElement
  1. If ClassElement is the production ClassElement : ; return a new empty List.
  2. If IsStatic of ClassElement is false and PropName of ClassElement is "constructor", return a new empty List.
  3. Return a List containing ClassElement.
ClassElementList : ClassElementList ClassElement
  1. Let list be NonConstructorMethodDefinitions of ClassElementList.
  2. If ClassElement is the production ClassElement : list, return list.
  3. If IsStatic of ClassElement is false and PropName of ClassElement is "constructor", return list.
  4. Append ClassElement to the end of list.
  5. Return list.

14.5.11 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.

14.5.12 Static Semantics: PropName

See also: 12.2.5.6, 14.3.5, 14.4.10

ClassElement : ;
  1. Return empty.

14.5.13 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.

14.5.14 Runtime Semantics: ClassDefinitionEvaluation

With parameter className.

ClassTail : ClassHeritageopt { ClassBodyopt }
  1. Let lex be the LexicalEnvironment of the running execution context.
2. Let classScope be NewDeclarativeEnvironment(lex).
3. Let classScopeEnvRec be classScope’s environment record.
4. If className is not undefined, then
   a. Call the CreateImmutableBinding concrete method of classScopeEnvRec passing className and true as the arguments.
5. If ClassHeritage_opt is not present, then
   a. Let protoParent be the intrinsic object %ObjectPrototype%.
   b. Let constructorParent be the intrinsic object %FunctionPrototype%.
6. Else
   a. Set the running execution context’s LexicalEnvironment to classScope.
   b. Let superclass be the result of evaluating ClassHeritage.
   c. Set the running execution context’s LexicalEnvironment to lex.
   d. ReturnIfAbrupt(superclass).
   e. If superclass is null, then
      i. Let protoParent be null.
      ii. Let constructorParent be the intrinsic object %FunctionPrototype%.
   f. Else if IsConstructor(superclass) is false, throw a TypeError exception.
   g. Else
      i. If superclass has a [[FunctionKind]] internal slot whose value is 'generator', throw a TypeError exception.
      ii. Let protoParent be Get(superclass, "prototype").
      iii. ReturnIfAbrupt(protoParent).
      iv. If Type(protoParent) is neither Object nor Null, throw a TypeError exception.
      v. Let constructorParent be superclass.
7. Let proto be ObjectCreate(protoParent).
8. If ClassBody_opt is present, let constructor be ConstructorMethod of ClassBody.
9. Else
   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.
10. Set the running execution context’s LexicalEnvironment to classScope.
11. Let constructorInfo be the result of performing DefineMethod for constructor with arguments proto and constructorParent as the optional functionPrototype argument.
12. Let F be constructorInfo.[[closure]].
13. If ClassHeritage_opt is present, set F’s [[ConstructorKind]] internal slot to "derived".
14. Perform MakeConstructor(F, false, proto).
15. Perform MakeClassConstructor(F).
16. Let desc be the PropertyDescriptor [[Value]]: F, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true.
17. Call the [[DefineOwnProperty]] internal method of proto with arguments "constructor" and desc.
18. If ClassBody_opt is not present, let methods be a new empty List.
20. For each ClassElement m in order from methods
   a. If IsStatic of m is false, then
      i. Let status be the result of performing PropertyDefinitionEvaluation for m with arguments proto and false.
   b. Else,
14.5.15 Runtime Semantics: BindingClassDeclarationEvaluation

1. Let status be the result of performing PropertyDefinitionEvaluation for m with argument F and false.
2. If status is an abrupt completion, then
   i. Set the running execution context’s LexicalEnvironment to lex.
   ii. Return status.
3. Set the running execution context’s LexicalEnvironment to lex.
4. If className is not undefined, then
   a. Call the InitializeBinding concrete method of classScopeEnvRec passing className and F as the arguments.
5. Return F.

ClassDeclaration : class BindingIdentifier ClassTail
1. Let className be StringValue of BindingIdentifier.
2. Let value be the result of ClassDefinitionEvaluation of classTail with argument className.
3. ReturnIfAbrupt(value).
4. Let hasNameProperty be HasOwnProperty(value, "name").
5. ReturnIfAbrupt(hasNameProperty).
6. If hasNameProperty is false, then perform SetFunctionName(value, className).
7. Let env be the running execution context’s LexicalEnvironment.
8. Let status be the result of InitializeBoundName(className, value, env).
9. ReturnIfAbrupt(status).
10. Return value.

NOTE ClassDeclaration : class ClassTail only occurs as part of an ExportDeclaration and the setting of a name property and establishing its binding are handled as part of the evaluation action for that production. See 15.2.3.10.

14.5.16 Runtime Semantics: Evaluation

ClassDeclaration : class BindingIdentifier ClassTail
1. Let status be the result of BindingClassDeclarationEvaluation of this ClassDeclaration.
2. ReturnIfAbrupt(status).
3. Return NormalCompletion(empty).

NOTE ClassDeclaration : class ClassTail only occurs as part of an ExportDeclaration and is never directly evaluated.
6. Return NormalCompletion(value).

NOTE   If the class definition included a "name" static method then that method is not over-written with a "name" data property for the class name.

14.6 Tail Position Calls

14.6.1 Static Semantics: IsInTailPosition(nonterminal) Abstract Operation

The abstract operation IsInTailPosition with argument nonterminal performs the following steps:

1. Assert: nonterminal is a parsed grammar production.
2. If the source code matching nonterminal is not strict code, return false.
3. If nonterminal is not contained within a FunctionBody or ConciseBody, return false.
4. Let body be the FunctionBody or ConciseBody that most closely contains nonterminal.
5. If body is the FunctionBody of a GeneratorMethod, GeneratorDeclaration, or a GeneratorExpression, return false.
6. Return the result of HasProductionInTailPosition of body with argument nonterminal.

NOTE   Tail Position calls are only defined in strict mode code because of a common non-standard language extension (see 9.2.8) that enables observation of the chain of caller contexts.

14.6.2 Static Semantics: HasProductionInTailPosition

With parameter nonterminal.

NOTE   nonterminal is a parsed grammar production that represent a specific range of source code. When the following algorithms compare nonterminal to other grammar symbols they are testing whether the same source code was matched by both symbols.

14.6.2.1 Statement Rules

ConciseBody : AssignmentExpression

1. Return HasProductionInTailPosition of AssignmentExpression with argument nonterminal.

StatementList : StatementList StatementListItem

1. Let has be HasProductionInTailPosition of StatementList with argument nonterminal.
2. If has is true, return true.
3. Return HasProductionInTailPosition of StatementListItem with argument nonterminal.

FunctionStatementList : [empty]
StatementList : Declaration
Statement : VariableStatement
EmptyStatement
ExpressionStatement
ContinueStatement
BreakStatement
ThrowStatement
DebuggerStatement
Block : {}  
ReturnStatement : return ;  
LabelledItem : FunctionDeclaration  
IterationStatement :  
  for ( LeftHandSideExpression in Expression ) Statement  
  for ( var ForBinding in Expression ) Statement  
  for ( ForDeclaration in Expression ) Statement  
  for ( LeftHandSideExpression of AssignmentExpression ) Statement  
  for ( var ForBinding of AssignmentExpression ) Statement  
  for ( ForDeclaration of AssignmentExpression ) Statement  
CaseBlock : {}  
  1. Return false.

IfStatement : if ( Expression ) Statement else Statement  
  1. Let has be HasProductionInTheTailPosition of the first Statement with argument nonterminal.  
  2. If has is true, return true.  
  3. Return HasProductionInTheTailPosition of the second Statement with argument nonterminal.

IfStatement : if ( Expression ) Statement  
IterationStatement :  
  do Statement while ( Expression ) ;  
  while ( Expression ) Statement  
  for ( Expressionopt ; Expressionopt ; Expressionopt ) Statement  
  for ( var VariableDeclarationList ; Expressionopt ; Expressionopt ) Statement  
  for ( LexicalDeclaration ; Expressionopt ; Expressionopt ) Statement  
WithStatement : with ( Expression ) Statement  
  1. Return HasProductionInTheTailPosition of Statement with argument nonterminal.

LabelledStatement :  
  LabelIdentifier : LabelledItem  
  1. Return HasProductionInTheTailPosition of LabelledItem with argument nonterminal.

ReturnStatement : return Expression ;  
  1. Return HasProductionInTheTailPosition of Expression with argument nonterminal.

SwitchStatement : switch ( Expression ) CaseBlock  
  1. Return HasProductionInTheTailPosition of CaseBlock with argument nonterminal.

CaseBlock : { CaseClausesopt DefaultClause CaseClausesopt }  
  1. Let has be false.  
  2. If the first CaseClauses is present, let has be HasProductionInTheTailPosition of the first CaseClauses with argument nonterminal.  
  3. If has is true, return true.  
  4. Let has be HasProductionInTheTailPosition of the DefaultClause with argument nonterminal.  
  5. If has is true, return true.  
  6. If the second CaseClauses is present, let has be HasProductionInTheTailPosition of the second CaseClauses with argument nonterminal.  
  7. Return has.
CaseClauses : CaseClauses CaseClause
1. Let has be HasProductionInTailPosition of CaseClauses with argument nonterminal.
2. If has is true, return true.
3. Return HasProductionInTailPosition of CaseClause with argument nonterminal.

CaseClause : case Expression : StatementListopt
DefaultClause : default : StatementListopt
1. If StatementList is present, return HasProductionInTailPosition of StatementList with argument nonterminal.
2. Return false.

TryStatement : try Block Catch
1. Return HasProductionInTailPosition of Catch with argument nonterminal.

TryStatement : try Block Finally
TryStatement : try Block Catch Finally
1. Return HasProductionInTailPosition of Finally with argument nonterminal.

Catch : catch ( CatchParameter ) Block
1. Return HasProductionInTailPosition of Block with argument nonterminal.

14.6.2.2 Expression Rules

NOTE A potential tail position call that is immediately followed by return GetValue of the call result is also a possible tail position call. Function calls cannot return reference values, so such a GetValue operation will always returns the same value as the actual function call result.

AssignmentExpression :
YieldExpression
ArrowFunction
LeftHandSideExpression = AssignmentExpression
LeftHandSideExpression AssignmentOperator AssignmentExpression

BitwiseANDExpression : BitwiseANDExpression & EqualityExpression
BitwiseXORExpression : BitwiseXORExpression ^ BitwiseANDExpression
BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

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

RelationalExpression :
RelationalExpression < ShiftExpression
RelationalExpression > ShiftExpression
RelationalExpression <= ShiftExpression
RelationalExpression >= ShiftExpression
RelationalExpression instanceof ShiftExpression
RelationalExpression in ShiftExpression
ShiftExpression:
  ShiftExpression << AdditiveExpression
  ShiftExpression >> AdditiveExpression
  ShiftExpression >>> AdditiveExpression

AdditiveExpression:
  AdditiveExpression + MultiplicativeExpression
  AdditiveExpression - MultiplicativeExpression

MultiplicativeExpression:
  MultiplicativeExpression MultiplicativeOperator UnaryExpression

UnaryExpression:
  delete UnaryExpression
  void UnaryExpression
  typeof UnaryExpression
  ++ UnaryExpression
  -- UnaryExpression
  + UnaryExpression
  ~ UnaryExpression
  ! UnaryExpression

PostfixExpression:
  LeftHandSideExpression ++
  LeftHandSideExpression --

CallExpression:
  CallExpression [ Expression ]
  CallExpression . IdentifierName

MemberExpression:
  MemberExpression [ Expression ]
  MemberExpression . IdentifierName
  SuperProperty

PrimaryExpression:
  this
  IdentifierReference
  Literal
  ArrayLiteral
  ObjectLiteral
  FunctionExpression
  ClassExpression
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral

1. Return false.

Expression:
  AssignmentExpression
  Expression , AssignmentExpression

1. Return HasProductionInTailPosition of AssignmentExpression with argument nonterminal.
ConditionalExpression : LogicalORExpression ? AssignmentExpression : AssignmentExpression

1. Let has be HasProductionInTailPosition of the first AssignmentExpression with argument nonterminal.
2. If has is true, return true.
3. Return HasProductionInTailPosition of the second AssignmentExpression with argument nonterminal.

LogicalANDExpression : LogicalANDExpression && BitwiseORExpression

1. Return HasProductionInTailPosition of BitwiseORExpression with argument nonterminal.

LogicalORExpression : LogicalORExpression || LogicalANDExpression

1. Return HasProductionInTailPosition of LogicalANDExpression with argument nonterminal.

CallExpression :
  MemberExpression Arguments
  SuperCall
  CallExpression Arguments
  CallExpression TemplateLiteral

1. If this CallExpression is nonterminal, return true.
2. Return false.

MemberExpression :
  MemberExpression TemplateLiteral
  new MemberExpression Arguments

1. If this MemberExpression is nonterminal, return true.
2. Return false.

NewExpression : new NewExpression

1. If this NewExpression is nonterminal, return true.
2. Return false.

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoveredParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return HasProductionInTailPosition of expr with argument nonterminal.

ParenthesizedExpression :
  ( Expression )

1. Return HasProductionInTailPosition of Expression with argument nonterminal.

14.6.3 Runtime Semantics: PrepareForTailCall ( )

The abstract operation PrepareForTailCall performs the following steps:

1. Let leafContext be the running execution context.
2. Suspend leafContext.
3. Pop leafContext from the execution context context stack. The execution context now on the top of the stack becomes the running execution context.
4. Assert: leafContext has no further use. It will never be activated as the running execution context.
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 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.

15 ECMAScript Language: Scripts and Modules

15.1 Scripts

Syntax

Script
  ScriptBody

ScriptBody
  StatementList

15.1.1 Static Semantics: Early Errors

ScriptBody : 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.
- It is a Syntax Error if StatementList contains super unless the source code containing super is eval code that is being processed by a direct eval that is contained in function code.
- It is a Syntax Error if StatementList contains NewTarget unless the source code containing NewTarget is eval code that is being processed by a direct eval that is contained in function code.
- It is a Syntax Error if ContainsDuplicateLabels of StatementList with argument « » is true.
- It is a Syntax Error if ContainsUndefinedBreakTarget of StatementList with argument « » is true.
- It is a Syntax Error if ContainsUndefinedContinueTarget of StatementList with arguments « » and « » is true.

15.1.2 Static Semantics: IsStrict

See also: 14.1.14, 15.2.1.9.

ScriptBody : StatementList

1. If this ScriptBody is contained in strict code or if StatementList is strict code, return true. Otherwise, return false.

15.1.3 Static Semantics: LexicallyDeclaredNames

See also: 13.1.2, 13.11.2, 13.12.6, 14.1.15, 14.2.10, 15.2.1.11.

ScriptBody : StatementList

1. Return TopLevelLexicallyDeclaredNames of StatementList.
NOTE At the top level of a Script, function declarations are treated like var declarations rather than like lexical declarations.

15.1.4 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.11.6, 13.12.7, 14.1.16, 14.2.11, 15.2.1.12, 15.2.3.8.

ScriptBody : StatementList
1. Return TopLevelLexicallyScopedDeclarations of StatementList.

15.1.5 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.2.1.13.

ScriptBody : StatementList
1. Return TopLevelVarDeclaredNames of StatementList.

15.1.6 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.2.1.14.

ScriptBody : StatementList
1. Return TopLevelVarScopedDeclarations of StatementList.

15.1.7 Runtime Semantics: ScriptEvaluation

With argument realm.

Script : ScriptBodyopt
1. The code of this Script is strict mode code if the Directive Prologue (14.1.1) of its ScriptBody contains a Use Strict Directive or if any of the conditions of 10.2.1 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 scriptCtx be a new ECMAScript code execution context.
5. Set the Function of scriptCtx to null.
6. Set the Realm of scriptCtx to realm.
7. Set the VariableEnvironment of scriptCtx to globalEnv.
8. Set the LexicalEnvironment of scriptCtx to globalEnv.
9. Suspend the currently running execution context.
10. Push scriptCtx on to the execution context stack; scriptCtx is now the running execution context.
11. Let result be GlobalDeclarationInstantiation(ScriptBody, globalEnv).
12. If result.[[type]] is normal, then
   a. let result be the result of evaluating ScriptBody.
13. If result.[[type]] is normal and result.[[value]] is empty, then
   a. let result be NormalCompletion(undefined).
14. Suspend scriptCtx and remove it from the execution context stack.
15. Assert: the execution context stack is not empty.
16. Resume the context that is now on the top of the execution context stack as the running execution context.
17. Return result.

15.1.8 Runtime Semantics: GlobalDeclarationInstantiation (script, env)

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.

GlobalDeclarationInstantiation is performed as follows using arguments script and env. script is the ScriptBody for which the execution context is being established. env is the global lexical environment in which bindings are to be created.

1. Let envRec be env’s environment record.
2. Assert: envRec is a GlobalEnvironmentRecord.
3. Let lexNames be the LexicallyDeclaredNames of script.
4. Let varNames be the VarDeclaredNames of script.
5. For each name in lexNames, do
   a. If the result of calling envRec’s HasVarDeclaration concrete method passing name as the argument is true, throw a SyntaxError exception.
   b. If the result of calling envRec’s HasLexicalDeclaration concrete method passing name as the argument is true, throw a SyntaxError exception.
   c. If the result of calling envRec’s HasRestrictedGlobalProperty concrete method passing name as the argument is true, throw a SyntaxError exception.
6. For each name in varNames, do
   a. If the result of calling envRec’s HasLexicalDeclaration concrete method passing name as the argument is true, throw a SyntaxError exception.
7. Let varDeclarations be the VarScopedDeclarations of script.
8. Let functionsToInitialize be an empty List.
9. Let declaredFunctionNames be an empty List.
10. For each d in varDeclarations, in reverse list order do
    a. If d is neither a VariableDeclaration nor a ForBinding, then
       i. Assert: d is either a FunctionDeclaration or a GeneratorDeclaration.
       ii. NOTE: If there are multiple FunctionDeclarations for the same name, the last declaration is used.
    iii. Let fn be the sole element of the BoundNames of d.
    iv. If fn is not an element of declaredFunctionNames, then
       1. Let fnDefinable be the result of calling envRec’s CanDeclareGlobalFunction concrete method passing fn as the argument.
       2. If fnDefinable is false, throw TypeError exception.
       3. Append fn to declaredFunctionNames.
       4. Insert d as the first element of functionsToInitialize.
11. Let declaredVarNames be an empty List.
12. For each d in varDeclarations, do
    a. If d is a VariableDeclaration or a ForBinding, 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 envRec’s CanDeclareGlobalVar concrete method passing vn as the argument.
             b. If vnDefinable is false, throw TypeError exception.
            c. If vn is not an element of declaredVarNames, then
               i. Append vn to declaredVarNames.
13. NOTE: No abnormal terminations occur after this algorithm step if the global object is an ordinary object. However, if the global object is a Proxy exotic object it may exhibit behaviours that cause abnormal terminations in some of the following steps.

14. Let lexDeclarations be the LexicallyScopedDeclarations of script.

15. 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. Let status be the result of calling envRec’s CreateImmutableBinding concrete method passing dn and true as the arguments.
      ii. Else
         1. Let status be the result of calling envRec’s CreateMutableBinding concrete method passing dn and false as the arguments.
      iii. ReturnIfAbrupt(status).

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. Let status be the result of calling envRec’s CreateGlobalFunctionBinding concrete method passing fn, fo, and false as the arguments.
   d. ReturnIfAbrupt(status).

17. For each String vn in declaredVarNames, in list order do
   a. Let status be the result of calling envRec’s CreateGlobalVarBinding concrete method passing vn and false as the argument.
   b. ReturnIfAbrupt(status).

18. Return NormalCompletion(empty)

NOTE Early errors specified in 15.1.1 prevent name conflicts between function/var declarations and let/const/class declarations as well as redeclaration of let/const/class 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 GlobalDeclarationInstantiation. If any such errors are detected, no bindings are instantiated for the script. However, if the global object is defined using Proxy exotic objects then the runtime tests for conflicting declarations may be unreliable resulting in an abrupt completion and some global declarations not being instantiated. If this occurs, the code for the Script is not evaluated.

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 declarations.

15.1.9 Runtime Semantics: ScriptEvaluationJob (sourceCodeId)

The job ScriptEvaluationJob with parameter sourceCodeId parses, validates, and evaluates the Script whose source code is host accessible using sourceCodeId.

1. Assert: sourceCodeId is a host provided script source code identifier.
2. Let source be HostGetSource(sourceCodeId).
3. If source is an abrupt completion, let script be source.
4. Else,
   a. Assert: source is a SourceCharacter sequence (see 10).
   b. Parse source using Script as the goal symbol and analyze the parse result for any Early Error conditions. If the parse was successful and no early errors were found, let script be the resulting parse tree. Otherwise, let script be an indication of one or more parsing errors and/or early errors. Parsing and early error detection may be interwoven in an implementation dependent manner. If more than one parse or early error is present, the number and ordering of reported errors is implementation dependent but at least one error must be reported.
5. If script is an error indication, then
   a. Report or log the error(s) in an implementation dependent manner.
   b. Let status be NormalCompletion(\texttt{undefined}).
6. Else,
   a. Let realm be the running execution context’s Realm.
   b. Let status be the result of ScriptEvaluation of script with argument realm.
7. NextJob status.

NOTE
An implementation may parse a Script and analyze it for Early Error conditions prior to the execution of the ScriptEvaluationJob for that Script. However, the reporting of any errors must be deferred until the ScriptEvaluationJob is actually executed.

15.2 Modules

Syntax
Module : ModuleBody*opt
ModuleBody : ModuleItemList
ModuleItemList : ModuleItem
ModuleItemList ModuleItemList ModuleItem
ModuleItem : ImportDeclaration
ExportDeclaration
StatementList_item

15.2.1 Module Semantics

15.2.1.1 Static Semantics: Early Errors

ModuleBody : ModuleItemList
- It is a Syntax Error if the LexicallyDeclaredNames of ModuleItemList contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of ModuleItemList also occurs in the VarDeclaredNames of ModuleItemList.
- It is a Syntax Error if the ExportedNames of ModuleItemList contains any duplicate entries.
- It is a Syntax Error if any element of the ExportedBindings of ModuleItemList do not also occur in either the VarDeclaredNames of ModuleItemList, or the LexicallyDeclaredNames of ModuleItemList.
- It is a Syntax Error if ModuleItemList Contains \texttt{super}.
- It is a Syntax Error if ModuleItemList Contains \texttt{NewTarget}.
- It is a Syntax Error if ContainsDuplicateLabels of ModuleItemList with argument \texttt{« »} is \texttt{true}.
- It is a Syntax Error if ContainsUndefinedBreakTarget of ModuleItemList with argument \texttt{« »} is \texttt{true}.
- It is a Syntax Error if ContainsUndefinedContinueTarget of ModuleItemList with arguments \texttt{« »} and \texttt{« »} is \texttt{true}.
NOTE The duplicate ExportedNames rule implies that multiple `export default` ExportDeclaration items within a ModuleBody is a Syntax Error. Additional error conditions relating to conflicting or duplicate declarations are checked during module linking prior to evaluation of a Module. If any such errors are detected the Module is not evaluated.

15.2.1.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.


ModuleItemList : ModuleItemList ModuleItem
1. Let `hasDuplicates` be ContainsDuplicateLabels of `ModuleItemList` with argument `labelSet`.
2. If `hasDuplicates` is `true`, return `true`.
3. Return ContainsDuplicateLabels of `ModuleItem` with argument `labelSet`.

ModuleItem :
  ImportDeclaration
  ExportDeclaration
1. Return `false`.

15.2.1.3 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.


ModuleItemList : ModuleItemList ModuleItem
1. Let `hasUndefinedLabels` be ContainsUndefinedBreakTarget of `ModuleItemList` with argument `labelSet`.
2. If `hasUndefinedLabels` is `true`, return `true`.
3. Return ContainsUndefinedBreakTarget of `ModuleItem` with argument `labelSet`.

ModuleItem :
  ImportDeclaration
  ExportDeclaration
1. Return `false`.

15.2.1.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.


ModuleItemList : ModuleItemList ModuleItem
1. Let `hasUndefinedLabels` be ContainsUndefinedContinueTarget of `ModuleItemList` with arguments `iterationSet` and « ».
2. If `hasUndefinedLabels` is `true`, return `true`.
3. Return ContainsUndefinedContinueTarget of `ModuleItem` with arguments `iterationSet` and « ».
ModuleItem :
  ImportDeclaration
  ExportDeclaration
  1. Return false.

15.2.1.5 Static Semantics: ExportedBindings

See also: 15.2.3.3.

NOTE ExportedBindings are the locally bound names that are explicitly associated with a Module’s ExportedNames.

ModuleItemList : ModuleItemList ModuleItem
  1. Let names be ExportedBindings of ModuleItemList.
  2. Append to names the elements of the ExportedBindings of ModuleItem.
  3. Return names.

ModuleItem :
  ImportDeclaration
  StatementListItem
  1. Return a new empty List.

15.2.1.6 Static Semantics: ExportedNames

See also: 15.2.3.4.

NOTE ExportedNames are the externally visible names that a Module explicitly maps to one of its local name bindings.

ModuleItemList : ModuleItemList ModuleItem
  1. Let names be ExportedNames of ModuleItemList.
  2. Append to names the elements of the ExportedNames of ModuleItem.
  3. Return names.

ModuleItem : ExportDeclaration
  1. Return the ExportedNames of ExportDeclaration.

ModuleItem :
  ImportDeclaration
  StatementListItem
  1. Return a new empty List.

15.2.1.7 Static Semantics: ExportEntries

See also: 15.2.3.5.

Module : [empty]
  1. Return a new empty List.
ModuleItemList : ModuleItemList ModuleItem
1. Let entries be ExportEntries of ModuleItemList.
2. Append to entries the elements of the ExportEntries of ModuleItem.
3. Return entries.

ModuleItem :
  ImportDeclaration
  StatementList
1. Return a new empty List.

15.2.1.8 Static Semantics: ImportEntries

See also:15.2.2.3.

Module : [empty]
1. Return a new empty List.

ModuleItemList : ModuleItemList ModuleItem
1. Let entries be ImportEntries of ModuleItemList.
2. Append to entries the elements of the ImportEntries of ModuleItem.
3. Return entries.

ModuleItem :
  ExportDeclaration
  StatementList
1. Return a new empty List.

15.2.1.9 Static Semantics: IsStrict

See also: 14.1.14, 15.1.2.

Module : [empty]
ModuleBody : ModuleItemList
1. Return true.

15.2.1.10 Static Semantics: ModuleRequests

See also: 15.2.2.5, 15.2.3.7.

Module : [empty]
1. Return a new empty List.

ModuleItemList : ModuleItem
1. Return ModuleRequests of ModuleItem.

ModuleItemList : ModuleItemList ModuleItem
1. Let moduleNames be ModuleRequests of ModuleItemList.
2. Let additionalNames be ModuleRequests of ModuleItem.
3. Append to moduleNames each element of additionalNames that is not already an element of moduleNames.
4. Return moduleNames.

ModuleItem : StatementListItem
1. Return a new empty List.

15.2.1.11 Static Semantics: LexicallyDeclaredNames

See also: 13.1.2, 13.11.2, 13.12.6, 14.1.15, 14.2.10, 15.1.3.

NOTE The LexicallyDeclaredNames of a Module includes the names of all of its imported bindings.

ModuleItemList : ModuleItemList ModuleItem
1. Let names be LexicallyDeclaredNames of ModuleItemList.
2. Append to names the elements of the LexicallyDeclaredNames of ModuleItem.
3. Return names.

ModuleItem : ImportDeclaration
1. Return the BoundNames of ImportDeclaration.

ModuleItem : ExportDeclaration
1. If ExportDeclaration is export VariableStatement, return a new empty List.
2. Return the BoundNames of ExportDeclaration.

ModuleItem : StatementListItem
1. Return LexicallyDeclaredNames of StatementListItem.

NOTE At the top level of a Module, function declarations are treated like lexical declarations rather than like var declarations.

15.2.1.12 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.11.6, 13.12.7, 14.1.16, 14.2.11, 15.1.4, 15.2.3.8.

Module : [empty]
1. Return a new empty List.

ModuleItemList : ModuleItemList ModuleItem
1. Let declarations be LexicallyScopedDeclarations of ModuleItemList.
2. Append to declarations the elements of the LexicallyScopedDeclarations of ModuleItem.
3. Return declarations.

ModuleItem : ImportDeclaration
1. Return a new empty List.
15.2.1.13 Static Semantics: VarDeclaredNames

See also: 13.0.5, 13.1.11, 13.2.2.2, 13.5.5, 13.6.1.4, 13.6.2.4, 13.6.3.5, 13.6.4.7, 13.10.5, 13.11.7, 13.12.12, 13.14.5, 14.1.18, 14.2.13, 15.1.5.

**Module**: ModuleItemList ModuleItem

1. Let names be VarDeclaredNames of ModuleItemList.
2. Append to names the elements of the VarDeclaredNames of ModuleItem.
3. Return names.

**ModuleItem**: ImportDeclaration

1. Return an empty List.

**ModuleItem**: ExportDeclaration

1. If ExportDeclaration is export VariableStatement, return BoundNames of ExportDeclaration.
2. Return a new empty List.

15.2.1.14 Static Semantics: VarScopedDeclarations

See also: 13.0.6, 13.1.12, 13.2.2.3, 13.5.6, 13.6.1.5, 13.6.2.5, 13.6.3.6, 13.6.4.8, 13.10.6, 13.11.8, 13.12.13, 13.14.6, 14.1.19, 14.2.14, 15.1.6.

**Module**: [empty]

1. Return a new empty List.

**ModuleItemList**: ModuleItemList ModuleItem

1. Let declarations be VarScopedDeclarations of ModuleItemList.
2. Append to declarations the elements of the VarScopedDeclarations of ModuleItem.
3. Return declarations.

**ModuleItem**: ImportDeclaration

1. Return a new empty List.

**ModuleItem**: ExportDeclaration

1. If ExportDeclaration is export VariableStatement, return VarScopedDeclarations of VariableStatement.
2. Return a new empty List.

15.2.1.15 Static and Runtime Semantics: Module Records

A Module Record encapsulates static declarative information about the imports and exports of a single module. Additionally it includes three fields that are only used at runtime: [[Environment]], [[Namespace]], and [[Evaluated]].

Each Module Record has the fields defined in Table 37:
### Table 37 — Module Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[SourceCodeId]]</code></td>
<td>String</td>
<td>A host supplied sourceCodeId that uniquely identifies the source code of this module.</td>
</tr>
<tr>
<td><code>[[ImportedModules]]</code></td>
<td>List of Module Records</td>
<td>A List of all the modules that are directly imported by the module represented by this record. The List is ordered based upon the first explicit import of each module in the list.</td>
</tr>
<tr>
<td><code>[[ECMAScriptCode]]</code></td>
<td>a parse result</td>
<td>The result of parsing the source code of this module using Module as the goal symbol.</td>
</tr>
<tr>
<td><code>[[ImportEntries]]</code></td>
<td>List of ImportEntry Records</td>
<td>A List of ImportEntry records derived from the code of this module. Module names within the ImportEntry records have been host normalized.</td>
</tr>
<tr>
<td><code>[[LocalExportEntries]]</code></td>
<td>List of ExportEntry Records</td>
<td>A List of ExportEntry records derived from the code of this module that correspond to declarations that occur within the module. Module names within the ImportEntry records have been host normalized.</td>
</tr>
<tr>
<td><code>[[IndirectExportEntries]]</code></td>
<td>List of ExportEntry Records</td>
<td>A List of ExportEntry records derived from the code of this module that correspond to reexported imports that occur within the module. Module names within the ImportEntry records have been host normalized.</td>
</tr>
<tr>
<td><code>[[StarExportEntries]]</code></td>
<td>List of ExportEntry Records</td>
<td>A List of ExportEntry records derived from the code of this module that correspond to export * declarations that occur within the module. Module names within the ImportEntry records have been host normalized.</td>
</tr>
<tr>
<td><code>[[Environment]]</code></td>
<td>Lexical Environment</td>
<td>The Lexical Environment containing the top level bindings for this module. This field is set when the modules is linked.</td>
</tr>
<tr>
<td><code>[[Namespace]]</code></td>
<td>Object</td>
<td>undefined</td>
</tr>
<tr>
<td><code>[[Evaluated]]</code></td>
<td>Boolean</td>
<td>Initially false, true if evaluation of this module has started. Remains true when evaluation completes, even if it is an abrupt completion.</td>
</tr>
</tbody>
</table>

An ImportEntry Record is a Record that digests information about a single declarative import. Each ImportEntry Record has the fields defined in Table 38:

**Deleted:** the host supplied module identifiers, host normalized names of

**Deleted:** lexical
Table 38 — ImportEntry Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[ModuleRequest]]</td>
<td>String</td>
<td>The module name that was stated in the FromClause of the ImportDeclaration.</td>
</tr>
<tr>
<td>[[ImportModule]]</td>
<td>Module Record</td>
<td>The Module Record that the FromClause resolved to.</td>
</tr>
<tr>
<td>[[ImportName]]</td>
<td>String</td>
<td>The name under which the desired binding is exported by [[ImportModule]]. The value &quot;*&quot; indicates that the import request is for the target module’s namespace object.</td>
</tr>
<tr>
<td>[[LocalName]]</td>
<td>String</td>
<td>The name that is used to locally access the imported value from within the importing module.</td>
</tr>
</tbody>
</table>

NOTE: The following table gives examples of ImportEntry records fields used to represent the syntactic import forms:

<table>
<thead>
<tr>
<th>Import Statement Form</th>
<th>[[ModuleRequest]]</th>
<th>[[ImportName]]</th>
<th>[[LocalName]]</th>
</tr>
</thead>
<tbody>
<tr>
<td>import v from &quot;mod&quot;;</td>
<td>&quot;mod&quot;</td>
<td>&quot;default&quot;</td>
<td>&quot;v&quot;</td>
</tr>
<tr>
<td>import * as ns from &quot;mod&quot;;</td>
<td>&quot;mod&quot;</td>
<td>&quot;*&quot;</td>
<td>&quot;ns&quot;</td>
</tr>
<tr>
<td>import (x) from &quot;mod&quot;;</td>
<td>&quot;mod&quot;</td>
<td>&quot;x&quot;</td>
<td></td>
</tr>
<tr>
<td>import (x as v) from &quot;mod&quot;;</td>
<td>&quot;mod&quot;</td>
<td>&quot;x&quot;</td>
<td>&quot;v&quot;</td>
</tr>
<tr>
<td>import from &quot;mod&quot;;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An ImportEntry Record is not created.

Table 39 — ExportEntry Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[ExportName]]</td>
<td>String</td>
<td>The name under which the desired binding is exported by this module.</td>
</tr>
<tr>
<td>[[ModuleRequest]]</td>
<td>String</td>
<td>null</td>
</tr>
<tr>
<td>[[ImportModule]]</td>
<td>Module Record</td>
<td>The Module Record that the FromClause resolved to.</td>
</tr>
<tr>
<td>[[ImportName]]</td>
<td>String</td>
<td>null</td>
</tr>
<tr>
<td>[[LocalName]]</td>
<td>String</td>
<td>null</td>
</tr>
</tbody>
</table>

NOTE: The following table gives examples of the ExportEntry record fields used to represent the syntactic export forms:
<table>
<thead>
<tr>
<th>Export Statement Form</th>
<th>[[ExportName]]</th>
<th>[[ModuleRequest]]</th>
<th>[[ModuleName]]</th>
<th>[[LocalName]]</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>export var v;</code></td>
<td>&quot;v&quot;</td>
<td>null</td>
<td>&quot;v&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export default function f{};</code></td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>&quot;f&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export default function(){};</code></td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>&quot;<em>default</em>&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export default 42;</code></td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>&quot;<em>default</em>&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export {x}</code></td>
<td>&quot;x&quot;</td>
<td>null</td>
<td>&quot;x&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export {v as x}</code></td>
<td>&quot;x&quot;</td>
<td>null</td>
<td>&quot;x&quot;</td>
<td></td>
</tr>
<tr>
<td><code>export v from &quot;mod&quot;;</code></td>
<td>&quot;mod&quot;</td>
<td>null</td>
<td>&quot;x&quot;</td>
<td>null</td>
</tr>
<tr>
<td><code>export * from &quot;mod&quot;;</code></td>
<td>null</td>
<td>null</td>
<td>&quot;*&quot;</td>
<td>null</td>
</tr>
</tbody>
</table>

15.2.1.15.1 CreateModule(sourceCodeId) Abstract Operation

The abstract operation CreateModule creates and returns a new Module Record. The argument sourceCodeId is a host supplied module identifier.

The following steps are taken:
1. Let mod be a new Module Record.
2. Set mod.[[Evaluated]] to false.
3. Set mod.[[SourceCodeId]] to sourceCodeId.
4. Set all other fields of mod to undefined.
5. Return mod.

15.2.1.15.2 ModuleAt(list, sourceCodeId)

The abstract operation ModuleAt retrieves a Module Record from a List of Module Records. The following steps are taken:
1. Assert: list is a List whose elements are Module Records.
2. Assert: sourceCodeId is a String that is a host supplied sourceCodeId identifier.
3. For each element m of list, do
   a. If SameValue(m.[[SourceCodeId]], sourceCodeId) is true, return m.
4. Return undefined.

15.2.1.16 Static Semantics: ParseModuleAndImports (realm, moduleSrcId, visited)

The abstract operation ParseModuleAndImports with arguments realm, moduleSrcId, and visited creates the Module Record for the module source code identified by its moduleSrcId argument. It also creates module records (if they do not already exist) for modules that are directly or indirectly imported by the named module. ParseModuleAndImports performs the following steps:
1. Assert: Type(moduleSrcId) is String.
2. Assert: moduleSrcId is a host supplied sourceCodeId.
3. Let vm be ModuleAt(visited, moduleSrcId).
4. If vm is not undefined, return vm.
5. Let mods be realm.[[modules]].
6. Let rm be ModuleAt(mods, moduleSrcId).
7. If rm is not undefined, return rm.
8. Let m be CreateModule(moduleSrcId).
9. Append m to visited.
10. Let src be HostGetSource(moduleSrcId).
11. If src is an abrupt completion or any other implementation defined error indication, then
a. Let `errors` be `src`.

12. Else,
   a. Let `source` be `src`.[[value]].
   b. Assert: `source` is a `SourceCharacter` sequence (see clause 10).
   c. Parse `source` using `Module` as the goal symbol and analyze the parse result for any Early Error conditions. If the parse was successful and no early errors were found, let `body` be the resulting parse tree. Otherwise, let `errors` be an indication of one or more parsing errors and/or early errors. Parsing and early error detection may be interweaved in an implementation dependent manner. If more than one parse or early error is present, the number and ordering of reported errors is implementation dependent but at least one error must be reported.

13. If `errors` is an abrupt completion or error indication, then
   a. Throw a `SyntaxError` exception. Additional implementation dependent errors information may be attached to the exception object.

14. Set `m.[[ECMAScriptCode]]` to `body`.
15. Let `requestedModules` be the `ModuleRequests` of `body`.
16. Let `importedModules` be a new empty List.
17. For each String `requestedName` in `requestedModules`, do
   a. Let `requestedSrcID` be `NormalizeModuleName(requestedName, moduleSrcId)`.
   b. ReturnIfAbrupt(`requestedSrcID`).
   c. Let `importedModule` be `ParseModuleAndImports(realm, requestedSrcID, visited)`.
   d. ReturnIfAbrupt(`importedModule`).
   e. If `importedModule` is not an element of `importedModules`, append `importedModule` to `importedModules`.

18. Set `m.[[ImportedModules]]` to `importedModules`.
19. Let `importEntries` be `ImportEntries` of `body`.
20. For each record `ie` in `importEntries`, do
   a. Let `requestedSrcID` be `NormalizeModuleName(ie.[[ModuleRequest]], moduleSrcId)`.
   b. ReturnIfAbrupt(`requestedSrcID`).
   c. Assert: `importedModules` includes a Module Record whose `[[SourceCodeId]]` is `requestedSrcID`.
   d. Set `ie.[[ImportModule]]` to `ModuleAt(importedModules, requestedSrcID)`.

21. Set `m.[[LocalExportEntries]]` to `localExportEntries`.
22. Let `indirectExportEntries` be a new empty List.
23. Let `starExportEntries` be a new empty List.
24. Let `exportEntries` be `ExportEntries` of `body`.
25. For each record `ee` in `exportEntries`, do
   a. If `ee.[[ModuleRequest]]` is `null`, then
      i. Append `ee` to `localExportEntries`.
   b. Else,
      i. Let `requestedSrcID` be `NormalizeModuleName(ee.[[ModuleRequest]], moduleSrcId)`.
      ii. ReturnIfAbrupt(`requestedSrcID`).
      iii. Assert: `importedModules` includes a Module Record whose `[[SourceCodeId]]` is `requestedSrcID`.
      iv. Set `ee.[[ImportModule]]` to `ModuleAt(importedModules, requestedSrcID)`.
      v. If `ee.[[ModuleName]]` is "**", then
         i. Append `ee` to `starExportEntries`.
      vi. Else,
         i. Append `ee` to `indirectExportEntries`.

27. Set `m.[[LocalExportEntries]]` to `localExportEntries`.
28. Set `m.[[IndirectExportEntries]]` to `indirectExportEntries`.
29. Set `m.[[StarExportEntries]]` to `starExportEntries`.
30. Return `m`. 

Deleted:

Deleted:
NOTE An implementation may parse the source code identified by a host supplied module identifier as a Module and analyze it for Early Error conditions prior to the evaluation of a ParseModuleAndImports for that module identifier. However, the reporting of any errors must be deferred until such a ParseModuleAndImports is actually evaluated.

15.2.16.1 NormalizeModuleName(unnormalizedName, referSrcId)

1. Let moduleSrcId be HostNormalizeModuleName(unnormalizedName, referSrcId).
2. If moduleSrcId is undefined, throw a SyntaxError exception.
3. Return moduleSrcId.

15.2.17 Static Semantics: GetExportedNames(module, circularitySet)

The abstract operation GetExportedNames with arguments module and circularitySet returns a list of all names that are either directly or indirectly exported from a module. It performs the following steps:

1. Assert: module is a Module Record.
2. If circularitySet contains module, then
   a. Assert: We’ve reached the starting point of an import * circularity.
   b. Return a new empty List.
3. Append module to circularitySet.
4. Let exportedNames be a new empty List.
5. For each ExportEntry Record e in module. [[LocalExportEntries]], do
   a. Assert: module provides the leaf binding for this export.
   b. Append e. [[ExportName]] to exportedNames.
6. For each ExportEntry Record e in module. [[IndirectExportEntries]], do
   a. Assert: module imports a specific binding for this export.
   b. Append e. [[ExportName]] to exportedNames.
7. For each ExportEntry Record e in module. [[StarExportEntries]], do
   a. Let circularitySetCopy be a copy of the circularitySet List.
   b. Let starNames be GetExportedNames(e. [[ImportModule]], circularitySetCopy).
   c. For each element n of starNames, do
      i. If n is not an element of exportedNames, then
         a. If SameValue(n, "default") is false, then
            a. Append n to exportedNames.
8. Return exportedNames.

NOTE GetExportedNames does not filter out or throw an exception for names that have ambiguous bindings.

15.2.18 Static Semantics: ResolveExport( module, exportName, circularitySet)

The abstract operation ResolveExport with arguments module, exportName, and circularitySet performs the following steps:

1. Assert: module is a Module Record.
2. For each Record r of [[module]]. [[exportName]] in circularitySet, do:
   a. If module and r are the same Module Record and SameValue(exportName, r. [[exportName]]) is true, then
      i. Assert: this is a circular import request.
      ii. Throw a SyntaxError exception.
3. Append the Record of [[module]]. [[exportName]]. [[exportName]] to circularitySet.
4. For each ExportEntry Record e in module. [[LocalExportEntries]], do
   a. If SameValue(exportName, e. [[ExportName]]) is true, then
      i. Assert: module provides the leaf binding for this export.
ii. Return Record([[module]]: module, [[bindingName]]: module.[[LocalName]]).

5. For each ExportEntry Record e in module.[[IndirectExportEntries]], do
   a. If SameValue(exportName, e.[[ExportName]]) is true, then
      i. Assert: module imports a specific binding for this export.
      ii. Return ResolveExport(e.[[ImportModule]], e.[[ImportName]], circularitySet).

6. If SameValue(exportName, "default") is true, then
   a. Assert: A default export was not explicitly defined by this module.
   b. Throw a SyntaxError exception.
   c. NOTE A default export cannot be provided by an export *.

7. Let starResolution be null.

8. For each ExportEntry Record e in module.[[StarExportEntries]], do
   a. Let circularitySetCopy be a copy of the circularitySet List.
   b. Let resolution be ResolveExport(e.[[ImportModule]], exportName, circularitySetCopy).
   c. ReturnIfAbrupt(resolution).
   d. If resolution is not null, then
      i. If starResolution is not null, then
         1. Assert: there is more than one * import that includes the requested name.
         2. Throw a SyntaxError exception.
      ii. Let starResolution be resolution.

9. Return starResolution.

NOTE ResolveExport attempts to resolve an imported binding to the actual defining module and local binding name. The defining module may be the module passed as the module parameter or some other module that is imported by that module. The parameter circularitySet is used to detect unresolved circular import/export paths. If a pair consisting of specific module record and exportName is reached that is already in circularitySet, an import circularity has been encountered. Before recursively calling ResolveExport, a pair consisting of module and exportName is added to circularitySet.

If a defining module is found a Record([[module]], [[bindingName]]) is returned. This record identifies the resolved binding of the originally requested export. If no definition was found, null is returned. If the request is found to be circular or ambiguous a SyntaxError exception is thrown.

15.2.1.19 Runtime Semantics: ModuleEvaluationJob ( sourceCodeId )

A ModuleEvaluationJob with parameter sourceCodeId is a job that fetches, parses, validates, and evaluates the Module whose source code is host accessible using sourceCodeId.

1. Assert: Type(sourceCodeId) is String.
2. Assert: sourceCodeId is a host provided module source code identifier.
3. Let realm be the running execution context’s Realm.
4. Let mods be realm.[[modules]].
5. Let m be ModuleAt(mods, sourceCodeId).
6. If m is undefined, then
   a. Let newModules be an empty List.
   b. Let m be ParseModuleAndImports(realm, sourceCodeId, newModules).
   c. If m is an abrupt completion or any other implementation defined error indication, then
      i. Report or log the error(s) in an implementation dependent manner.
      ii. NextJob NormalCompletion(undefined).
   d. Let linkStatus be LinkModules(realm, newModules).
   e. If linkStatus is an abrupt completion, then
      i. Report or log a module linking error in an implementation dependent manner.
      ii. NextJob NormalCompletion(undefined).
7. Let status be the result of ModuleEvaluation(m, realm).
8. NextJob status.

15.2.1.20 Runtime Semantics: LinkModules( realm, newModuleSet)

The abstract operation LinkModules with arguments realm and newModuleSet performs the following steps:

1. Let modules be a copy of the List realm.[[modules]].
2. Append to modules the elements of newModuleSet.
3. For each Module Record m that is an element of newModuleSet, do
   a. Let status be ModuleDeclarationInstantiation( m, realm, modules).
   b. ReturnIfAbrupt( status).
4. Assert: all elements of newModuleSet have been instantiated and are ready to be evaluated.
5. Append to realm.[[modules]] the elements of newModuleSet.
6. Return NormalCompletion( empty).

15.2.1.21 Runtime Semantics: ModuleDeclarationInstantiation( module, realm, moduleSet )

ModuleDeclarationInstantiation is performed as follows using arguments module, realm, and moduleSet.
module is the Module Record for which a ModuleEnvironment is being established. realm is the Realm Record with which the module is associated, and moduleSet is a List of Module Records from which this module may import bindings.

1. Let code be module.[[ECMAScriptCode]].
2. For each ExportEntry Record e in module.[[DirectExportEntries]], do
   a. Let resolution be ResolveExport( module, e.[[ExportName]], « »).
   b. ReturnIfAbrupt( resolution).
   c. If resolution is null, throw a SyntaxError exception.
3. Assert: all named exports from module are resolvable.
4. Let env be NewModuleEnvironment( realm.[[globalEnv]]).
5. Let envRec be env’s environment record.
6. Set module.[[Environment]] to env.
7. For each ImportEntry Record in in module.[[ImportEntries]], do
   a. If in.[[ImportName]] is « ** », then
      i. Let importedModule be in.[[ImportModule]].
      ii. Assert: importedModule is not undefined.
      iii. Let namespace be importedModule.[[Namespace]].
      iv. If namespace is undefined, then
         1. Let exportedNames be GetExportedNames( importedModule, « »).
         2. Let namespace be ModuleNamespaceCreate( importedModule, exportedNames).
         v. Let status be the result of calling envRec’s CreateImmutableBinding concrete method passing in.[[LocalName]] and true as the arguments.
         vi. Assert: status is not an abrupt completion.
         vii. Call envRec’s InitializeBinding concrete method passing in.[[LocalName]], and namespace as the arguments.
   b. else,
      i. Let resolution be ResolveExport( in.[[ImportModule]], in.[[ImportName]], « »).
      ii. ReturnIfAbrupt( resolution).
      iii. If resolution is null, throw a SyntaxError exception.
      iv. Call envRec’s CreateImportBinding concrete method passing in.[[LocalName]], resolution.[[module]], resolution.[[bindingName]] as the argument.
8. Let varDeclarations be the VarScopedDeclarations of code.
9. For each element d in varDeclarations do
   a. For each element dn of the BoundNames of d do
i. Let status be the result of calling envRec’s CreateMutableBinding concrete method passing dn and false as the arguments.
ii. Assert: status is not an abrupt completion.
iii. Call envRec’s InitializeBinding concrete method passing dn, and undefined as the arguments.

10. Let lexDeclarations be the LexicallyScopedDeclarations of code.
11. For each element d in lexDeclarations do
   a. For each element dn of the BoundNames of d do
      i. If IsConstantDeclaration of d is true, then
         1. Let status be the result of calling envRec’s CreateImmutableBinding concrete method passing dn and true as the arguments.
      ii. Else,  
         1. Let status be the result of calling envRec’s CreateMutableBinding concrete method passing dn and false as the arguments.
      iii. Assert: status is not an abrupt completion.
      iv. If d is a GeneratorDeclaration production or a FunctionDeclaration production, then
         1. Let fo be the result of performing InstantiateFunctionObject for d with argument env.
         2. Call envRec’s InitializeBinding concrete method passing dn, and fo as the arguments.
   
12. Return NormalCompletion(empty).

15.2.1.22 Runtime Semantics: ModuleEvaluation(module, realm)

   1. If module.[[Evaluated]] is true, return undefined.
   2. Set module.[[Evaluated]] to true.
   3. For each Module Record required that is an element of module.[[ImportedModules]], do
      a. Assert: realm.[[modules]] includes required.
      b. Let status be ModuleEvaluation(required, realm).
      c. ReturnIfAbrupt(status).
   4. Let moduleCtx be a new ECMAScript code execution context.
   5. Set the Function of moduleCtx to null.
   6. Set the Realm of moduleCtx to realm.
   7. Assert: module has been linked and declarations in its module environment have been instantiated.
   8. Set the VariableEnvironment of moduleCtx to module.[[Environment]].
   9. Set the LexicalEnvironment of moduleCtx to module.[[Environment]].
   10. Suspend the currently running execution context.
   11. Push moduleCtx on to the execution context stack; moduleCtx is now the running execution context.
   12. Let result be the result of evaluating module.[[ECMAScriptCode]].
   13. Suspend moduleCtx and remove it from the execution context stack.
   14. Resume the context that is now on the top of the execution context stack as the running execution context.
   15. Return result.

15.2.1.23 Runtime Semantics: Evaluation

Module : [empty]

ModuleItemList : ModuleItemList ModuleItem

   1. Let sl be the result of evaluating ModuleItemList.
   2. ReturnIfAbrupt(sl).
   3. Let s be the result of evaluating ModuleItem.
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 5 and 6 of the above algorithm ensure that the value of a `ModuleItemList` is the value of the last value producing item in the `ModuleItemList`.

ModuleItem : ImportDeclaration
1. Return NormalCompletion(empty).

15.2.2 Imports

Syntax

ImportDeclaration : import ImportClause FromClause ;
import ModuleSpecifier ;

ImportClause :
ImportedDefaultBinding
NamespaceImport
NamedImports
ImportedDefaultBinding, NamespaceImport
ImportedDefaultBinding, NamedImports

ImportedDefaultBinding :
ImportedBinding

NamespaceImport :
* as ImportedBinding

NamedImports :
{ }
{ ImportsList }
{ ImportsList , }

FromClause :
from ModuleSpecifier

ImportsList :
ImportSpecifier
ImportsList, ImportSpecifier

ImportSpecifier :
ImportedBinding
IdentifierName as ImportedBinding

ModuleSpecifier :
StringLiteral

ImportedBinding :
BindingIdentifier
15.2.2.1 Static Semantics: Early Errors

ModuleItem : ImportDeclaration

- It is a Syntax Error if the BoundNames of ImportDeclaration contains any duplicate entries.

15.2.2.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.3.1.

ImportDeclaration : import ImportClause FromClause;
1. Return the BoundNames of ImportClause.

ImportDeclaration : import ModuleSpecifier;
1. Return a new empty List.

ImportClause : ImportedDefaultBinding, NameSpaceImport
1. Let names be the BoundNames of ImportedDefaultBinding.
2. Append to names the elements of the BoundNames of NameSpaceImport.
3. Return names.

ImportClause : ImportedDefaultBinding, NamedImports
1. Let names be the BoundNames of ImportedDefaultBinding.
2. Append to names the elements of the BoundNames of NamedImports.
3. Return names.

NamedImports : { }
1. Return a new empty List.

ImportsList : ImportsList, ImportSpecifier
1. Let names be the BoundNames of ImportsList.
2. Append to names the elements of the BoundNames of ImportSpecifier.
3. Return names.

ImportSpecifier : IdentifierName as ImportedBinding
1. Return the BoundNames of ImportedBinding.

15.2.2.3 Static Semantics: ImportEntries

See also: 15.2.1.7.

ImportDeclaration : import ImportClause FromClause;
1. Let module be the sole element of ModuleRequests of FromClause.
2. Return ImportEntriesForModule of ImportClause with argument module.

ImportDeclaration : import ModuleSpecifier;
1. Return a new empty List.
15.2.2.4 Static Semantics: ImportEntriesForModule

With parameter module.

ImportClause : ImportedDefaultBinding, NameSpaceImport

1. Let entries be ImportEntriesForModule of ImportedDefaultBinding with argument module.
2. Append to entries the elements of the ImportEntriesForModule of NameSpaceImport with argument module.
3. Return entries.

ImportClause : ImportedDefaultBinding, NamedImports

1. Let entries be ImportEntriesForModule of ImportedDefaultBinding with argument module.
2. Append to entries the elements of the ImportEntriesForModule of NamedImports with argument module.
3. Return entries.

ImportedDefaultBinding: ImportedBinding

1. Let localName be the sole element of BoundNames of ImportedBinding.
2. Let defaultEntry be the Record { [[ModuleRequest]]: module, [[ImportName]]: "default", [[LocalName]]: localName }.
3. Return a new List containing defaultEntry.

NameSpaceImport : * as ImportedBinding

1. Let localName be the StringValue of ImportedBinding.
2. Let entry be the Record { [[ModuleRequest]]: module, [[ImportName]]: "*", [[LocalName]]: localName }.
3. Return a new List containing entry.

NamedImports : { }

1. Return a new empty List.

ImportsList : ImportsList, ImportSpecifier

1. Let specs be the ImportEntriesForModule of ImportsList with argument module.
2. Append to specs the elements of the ImportEntriesForModule of ImportSpecifier with argument module.
3. Return specs.

ImportSpecifier : ImportedBinding

1. Let localName be the sole element of BoundNames of ImportedBinding.
2. Let entry be the Record { [[ModuleRequest]]: module, [[ImportName]]: localName, [[LocalName]]: localName }.
3. Return a new List containing entry.

ImportSpecifier : IdentifierName as ImportedBinding

1. Let importName be the StringValue of IdentifierName.
2. Let localName be the StringValue of ImportedBinding.
3. Let entry be the Record { [[ModuleRequest]]: module, [[ImportName]]: importName, [[LocalName]]: localName }.
4. Return a new List containing entry.

15.2.2.5 Static Semantics: ModuleRequests

See also: 15.2.1.10, 15.2.3.7.

ImportDeclaration : import ImportClause FromClause;

1. Return ModuleRequests of FromClause.

ModuleSpecifier : StringLiteral

1. Return a List containing the StringValue of StringLiteral.

15.2.2.6 Runtime Semantics: Evaluation

See 15.2.1.23.

15.2.3 Exports

Syntax

ExportDeclaration :
export * FromClause;
export ExportClause FromClause;
export ExportClause;
export VariableStatement
export Declaration
export default HoistableDeclaration[Default]
export default ClassDeclaration[Default]
export default [lookahead { function, class }] AssignmentExpression[In];

ExportClause :
{ }
{ ExportsList }
{ ExportsList , }

ExportsList :
ExportSpecifier
ExportsList , ExportSpecifier

ExportSpecifier :
IdentifierName
IdentifierName as IdentifierName

15.2.3.1 Static Semantics: Early Errors

ExportDeclaration : export ExportClause ;

- For each IdentifierName n in ReferencedBindings of ExportClause: It is a Syntax Error if StringValue of n is a ReservedWord or if the StringValue of n is one of: "implements", "interface", "let", "package", "private", "protected", "public", "static", or "yield".
NOTE The above rule means that each Referenced Bindings of ExportClause is treated as an IdentifierReference.

15.2.3.2 Static Semantics: BoundNames

See also: 13.2.1.2, 13.2.2.1, 12.1.2, 13.6.4.2, 14.1.3, 14.2.2, 14.4.2, 14.5.2, 15.2.2.2.

ExportDeclaration :

1. Return a new empty List.

ExportDeclaration : export VariableStatement

1. Return the BoundNames of VariableStatement.

ExportDeclaration : export Declaration

1. Return the BoundNames of Declaration.

ExportDeclaration : export default HoistableDeclaration

1. Let declarationNames be the BoundNames of HoistableDeclaration.
2. If declarationNames does not include the element "*default*", append "*default*" to declarationNames.
3. Return declarationNames.

ExportDeclaration : export default ClassDeclaration

1. Let declarationNames be the BoundNames of ClassDeclaration.
2. If declarationNames does not include the element "*default*", append "*default*" to declarationNames.
3. Return declarationNames.

ExportDeclaration : export default AssignmentExpression ;

1. Return "*default*".

15.2.3.3 Static Semantics: ExportedBindings

See also: 15.2.1.2.

ExportDeclaration :

export ExportClause FromClause ;

export * FromClause ;

1. Return a new empty List.

ExportDeclaration : export ExportClause ;

1. Return the Exported Bindings of ExportClause.
ExportDeclaration : `export VariableStatement`
   1. Return the BoundNames of `VariableStatement`.

ExportDeclaration : `export Declaration`
   1. Return the BoundNames of `Declaration`.

ExportDeclaration : `export default HoistableDeclaration`
ExportDeclaration : `export default ClassDeclaration`
ExportDeclaration : `export default AssignmentExpression` ;
   1. Return the BoundNames of this `ExportDeclaration`.

ExportClause : `{ }`
   1. Return a new empty List.

ExportsList : `ExportsList , ExportSpecifier`
   1. Let `names` be the ExportedBindings of `ExportsList`.
   2. Append to `names` the elements of the ExportedBindings of `ExportSpecifier`.
   3. Return `names`.

ExportSpecifier : `IdentifierName`
   1. Return a List containing the StringValue of `IdentifierName`.

ExportSpecifier : `IdentifierName as IdentifierName`
   1. Return a List containing the StringValue of the first `IdentifierName`.

15.2.3.4 Static Semantics: `ExportedNames`

See also: 15.2.1.6.

ExportDeclaration : `export * FromClause` ;
   1. Return a new empty List.

ExportDeclaration :
   `export ExportClause FromClause` ;
   `export ExportClause` ;
   1. Return the ExportedNames of `ExportClause`.

ExportDeclaration : `export VariableStatement`
   1. Return the BoundNames of `VariableStatement`.

ExportDeclaration : `export Declaration`
   1. Return the BoundNames of `Declaration`.
ExportDeclaration: `export default` HoistableDeclaration
ExportDeclaration: `export default` ClassDeclaration
ExportDeclaration: `export default` AssignmentExpression ;
  1. Return `"default"`.

ExportClause: `{ }`
  1. Return a new empty List.

ExportsList: `ExportsList`, ExportSpecifier
  1. Let `names` be the ExportedNames of `ExportsList`.
  2. Append to `names` the elements of the ExportedNames of `ExportSpecifier`.
  3. Return `names`.

ExportSpecifier: `IdentifierName`
  1. Return a List containing the StringValue of `IdentifierName`.

ExportSpecifier: `IdentifierName as IdentifierName`
  1. Return a List containing the StringValue of the second `IdentifierName`.

15.2.3.5 Static Semantics: ExportEntries

See also: 15.2.1.7.

ExportDeclaration: `export * FromClause` ;
  1. Let `module` be the sole element of `ModuleRequests` of `FromClause`.
  2. Let `entry` be the Record `[[ModuleRequest]]: module, [[ImportName]]: "*", [[LocalName]]: null, [[ExportName]]: null`.
  3. Return a new List containing `entry`.

ExportDeclaration: `export ExportClause FromClause` ;
  1. Let `module` be the sole element of `ModuleRequests` of `FromClause`.
  2. Return `ExportEntriesForModule` of `ExportClause` with argument `module`.

ExportDeclaration: `export ExportClause` ;
  1. Return `ExportEntriesForModule` of `ExportClause` with argument `null`.

ExportDeclaration: `export VariableStatement`
  1. Let `entries` be a new empty List.
  2. Let `names` be the BoundNames of `VariableStatement`.
  3. Repeat for each `name` in `names`.
     a. Append to `entries` the Record `[[ModuleRequest]]: null, [[ImportName]]: null, [[LocalName]]: name, [[ExportName]]: name`.
  4. Return `entries`.

ExportDeclaration: `export Declaration`
  1. Let `entries` be a new empty List.
2. Let names be the BoundNames of Declaration.
3. Repeat for each name in names,
   a. Append to entries the Record {[[ModuleRequest]]: null, [[ImportName]]: null, [[LocalName]]: name, [[ExportName]]: name }.
4. Return entries.

ExportDeclaration: `export default HoistableDeclaration`
1. Let names be BoundNames of HoistableDeclaration.
2. Let localName be the sole element of names.
3. Return a new List containing the Record {[[ModuleRequest]]: null, [[ImportName]]: null, [[LocalName]]: localName, [[ExportName]]: "default" }.

ExportDeclaration: `export default ClassDeclaration`
1. Let names be BoundNames of ClassDeclaration.
2. Let localName be the sole element of names.
3. Return a new List containing the Record {[[ModuleRequest]]: null, [[ImportName]]: null, [[LocalName]]: localName, [[ExportName]]: "default" }.

ExportDeclaration: `export default AssignmentExpression`
1. Let entry be the Record {[[ModuleRequest]]: null, [[ImportName]]: null, [[LocalName]]: "**default**", [[ExportName]]: "default" }.
2. Return a new List containing entry.

**NOTE**  **"**default**" is used within this specification as a synthetic name for anonymous default export values.

15.2.3.6 Static Semantics: ExportEntriesForModule

With parameter module.

ExportClause : { }
1. Return a new empty List.

ExportsList: ExportsList , ExportSpecifier
1. Let specs be the ExportEntriesForModule of ExportsList with argument module.
2. Append to specs the elements of the ExportEntriesForModule of ExportSpecifier with argument module.
3. Return specs.

ExportSpecifier : IdentifierName
1. Let sourceName be the StringValue of IdentifierName.
2. If module is null, then
   a. Let localName be sourceName.
   b. Let importName be null.
3. Else
   a. Let localName be null.
   b. Let importName be sourceName.
4. Return a new List containing the Record {[[ModuleRequest]]: module, [[ImportName]]: importName, [[LocalName]]: localName, [[ExportName]]: sourceName }.
ExportSpecifier : IdentifierName as IdentifierName

1. Let sourceName be the StringValue of the first IdentifierName.
2. Let exportName be the StringValue of the second IdentifierName.
3. If module is null, then
   a. Let localName be sourceName.
   b. Let importName be null.
4. Else
   a. Let localName be null.
   b. Let importName be sourceName.
5. Return a new List containing the Record {
   [[ModuleRequest]]: module, [[ImportName]]: importName, [[LocalName]]: localName, [[ExportName]]: exportName }.

15.2.3.7 Static Semantics: IsConstantDeclaration

See also: 13.2.1.3, 14.1.9, 14.4.5, 14.5.5.

ExportDeclaration :
   export * FromClause ;
   export ExportClause FromClause ;
   export ExportClause ;
   export default AssignmentExpression ;

1. Return false.

NOTE It is not necessary to treat export default AssignmentExpression as a constant declaration because there is no syntax that permits assignment to the internal bound name used to reference a module’s default object.

15.2.3.8 Static Semantics: LexicallyScopedDeclarations

See also: 13.1.6, 13.11.6, 13.12.7, 14.1.16, 14.2.11, 15.1.4, 15.2.1.12.

ExportDeclaration :
   export * FromClause ;
   export ExportClause FromClause ;
   export ExportClause ;
   export VariableStatement

1. Return a new empty List.

ExportDeclaration : export Declaration

1. Return a new List containing DeclarationPart of Declaration.

ExportDeclaration : export default HoistableDeclaration

1. Return a new List containing DeclarationPart of HoistableDeclaration.

ExportDeclaration : export default ClassDeclaration

1. Return a new List containing ClassDeclaration.

ExportDeclaration : export default AssignmentExpression ;
1. Return a new List containing this ExportDeclaration.

15.2.3.9 Static Semantics: ModuleRequests

See also: 15.2.1.10, 15.2.2.5.

ExportDeclaration : export * FromClause ; ExportDeclaration : export ExportClause FromClause ;

1. Return the ModuleRequests of FromClause.

ExportDeclaration :
    export ExportClause ; export VariableStatement export Declaration export default HoistableDeclaration export default ClassDeclaration export default AssignmentExpression ;

1. Return a new empty List.

15.2.3.10 Static Semantics: ReferencedBindings

ExportClause : { }

1. Return a new empty List.

ExportsList : ExportsList , ExportSpecifier

1. Let names be the ReferencedBindings of ExportsList.
2. Append to names the elements of the ReferencedBindings of ExportSpecifier.
3. Return names.

ExportSpecifier : IdentifierName

1. Return a List containing the IdentifierName.

ExportSpecifier : IdentifierName as IdentifierName

1. Return a List containing the first IdentifierName.

15.2.3.11 Runtime Semantics: Evaluation

ExportDeclaration :
    export * FromClause ; export ExportClause FromClause ; export ExportClause ;

1. Return NormalCompletion(empty).

ExportDeclaration : export VariableStatement
1. Return the result of evaluating VariableStatement.

ExportDeclaration: export Declaration

1. Return the result of evaluating Declaration.

ExportDeclaration: export default HoistableDeclaration

1. Return the result of evaluating HoistableDeclaration.

ExportDeclaration: export default ClassDeclaration

1. Let value be the result of BindingClassDeclarationEvaluation of ClassDeclaration.
2. ReturnIfAbrupt(value).
3. Let className be the sole element of BoundNames of ClassDeclaration.
4. If className is "*default*", then
   a. Let hasNameProperty be HasOwnProperty(value, "name").
   b. ReturnIfAbrupt(hasNameProperty).
   c. If hasNameProperty is false, perform SetFunctionName(value, "default").
   d. Let env be the running execution context's LexicalEnvironment.
   e. Let status be InitializeBoundName("*default*", value, env).
5. Return NormalCompletion(empty).

ExportDeclaration: export default AssignmentExpression

1. Let rhs be the result of evaluating AssignmentExpression.
2. Let value be GetValue(rhs).
3. ReturnIfAbrupt(value).
4. If IsAnonymousFunctionDefinition(AssignmentExpression) is true, then
   a. Let hasNameProperty be HasOwnProperty(value, "name").
   b. ReturnIfAbrupt(hasNameProperty).
   c. If hasNameProperty is false, perform SetFunctionName(value, "default").
5. Let env be the running execution context's LexicalEnvironment.
6. Let status be InitializeBoundName("*default*", value, env).
7. Return NormalCompletion(empty).

16  Error Handling and Language Extensions

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. The presence of an early error prevents the evaluation of the construct. An implementation must report early errors in a Script as part of the ScriptEvaluationJob for that Script. Early errors in a Module are reported at the point when the Module would be evaluated and the Module is never initialized. Early errors in eval code are reported at the time eval is called and prevent evaluation of the eval code. All errors that are not early errors are runtime errors.

An implementation must report as an early error any occurrence of a condition that is listed in a “Static Semantics: Early Errors” subclause of this specification.
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:

- Except as restricted in 16.1, an implementation may extend Script syntax, Module 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.
- Except as restricted in 16.1, 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.

16.1 Forbidden Extensions

An implementation must not extend this specification in the following ways:

- Other than as defined in this specification, ECMAScript Function objects defined using syntactic constructors in strict code must not be created with own properties named "caller" or "arguments" other than those that are created by applying the AddRestrictedFunctionProperties abstract operation (9.2.8) to the function. Such own properties also must not be created for function objects defined in non-strict code using an ArrowFunction, MethodDefinition, GeneratorDeclaration, GeneratorExpression, ClassDeclaration, or ClassExpression. Built-in functions, strict mode functions created using the Function constructor, generator functions created using the Generator constructor, and functions created using the bind method also must not be created with such own properties.
- If an implementation extends non-strict functions with an own property named "caller" the value of that property, as observed using [[Get]] or [[GetOwnProperty]], must not be a strict mode function object.
- The behaviour of the following methods must not be extended except as specified in ECMA-402: Object.prototype.toLocaleString, Array.prototype.toLocaleString, Number.prototype.toLocaleString, Date.prototype.toLocaleDateString, Date.prototype.toLocaleString, Date.prototype.toLocaleTimeString, String.prototype.localeCompare.
- The RegExp pattern grammars in 21.2.1 and B.1.4 must not be extended to recognize any of the source characters A-Z or a-z as IdentityEscape[U] when the U grammar parameter is present.
- The Syntactic Grammar must not be extended in any manner that allows the token : to immediate follow source code that matches the BindingIdentifier nonterminal symbol.
- When processing strict mode code, the syntax of NumericLiteral must not be extended to include LegacyOctalIntegerLiteral as defined in B.1.1.
• TemplateCharacter (11.8.6) must not be extended to include LegacyOctalEscapeSequence as defined in B.1.2.
• When processing strict mode code, the extensions defined in B.3.1, B.3.2, B.3.3, and B.3.4 must not be supported.
• When parsing for the Module goal symbol, the lexical grammar extensions defined in B.1.3 must not be supported.

17 ECMAScript Standard Built-in Objects

There are certain built-in objects available whenever an ECMAScript Script or Module 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 or indirectly as properties of accessible built-in objects.

Unless specified otherwise, a built-in object that is callable as a function is a Built-in Function object with the characteristics described in 9.3. Unless specified otherwise, the [[Extensible]] internal slot of a built-in object initially has the value true. Every built-in Function object has a [[Realm]] internal slot whose value is the code Realm for which the object was initially created.

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 built-in function or constructor 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. Such missing arguments are considered to be “not present” and may be identified in that manner by specification algorithms. In the description of a particular function, the terms “this value” and “NewTarget” have the meanings given in 9.3.

Unless otherwise specified in the description of a particular function, if a built-in function or constructor described 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.

Unless otherwise specified every built-in function and every built-in constructor has the Function prototype object, which is the initial value of the expression Function.prototype (19.2.3), as the value of its [[Prototype]] internal slot.

Unless otherwise specified every built-in prototype object has the Object prototype object, which is the initial value of the expression Object.prototype (19.1.3), as the value of its [[Prototype]] internal slot, except the Object prototype object itself.

Built-in function objects that are not identified as constructors do not implement the [[Construct]] internal method unless otherwise specified in the description of a particular function.
Unless otherwise specified, each built-in function defined in clauses 18 through 26 is created as if by calling the CreateBuiltInFunction abstract operation (9.3.3).

Every built-in Function object, including constructors, 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. However, rest parameters shown using the form “...name” are not included in the default argument count.

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.

Unless otherwise specified, the length property of a built-in Function object has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

Every built-in Function object, including constructors, that is not identified as an anonymous function has a name property whose value is a String. Unless otherwise specified, this value is the name that is given to the function in this specification. For functions that are specified as properties of objects, the name value is the property name string used to access the function. Functions that are specified as get or set accessor functions of built-in properties have “get ” or “set ” prepended to the property name string. The value of the name property is explicitly specified for each built-in functions whose property key is a symbol value.

Unless otherwise specified, the name property of a built-in Function object, if it exists, has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

Every other data property described in clauses 18 through 26 and in Annex B.2 has the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true } unless otherwise specified.

Every accessor property described in clauses 18 through 26 and in Annex B.2 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 described the get accessor is the default value, undefined.

18 The Global Object

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

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.

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

The value of the [[Prototype]] internal slot 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.
18.1 Value Properties of the Global Object

18.1.1 Infinity

The value of \texttt{Infinity} is \( +\infty \) (see 6.1.6). This property has the attributes \{ [Writable]: false, [Enumerable]: false, [Configurable]: false \}.

18.1.2 NaN

The value of \texttt{NaN} is \texttt{NaN} (see 6.1.6). This property has the attributes \{ [Writable]: false, [Enumerable]: false, [Configurable]: false \}.

18.1.3 undefined

The value of \texttt{undefined} is \texttt{undefined} (see 6.1.1). This property has the attributes \{ [Writable]: false, [Enumerable]: false, [Configurable]: false \}.

18.2 Function Properties of the Global Object

18.2.1 \texttt{eval (x)}

The \texttt{eval} function is the \%eval\% intrinsic object. When the \texttt{eval} function is called with one argument \( x \), the following steps are taken:

1. Let \texttt{evalRealm} be the value of the active function object’s [[Realm]] internal slot.
2. Let \texttt{strictCaller} be false.
3. Let \texttt{directEval} be false.
4. Return PerformEval(\( x \), \texttt{evalRealm}, \texttt{strictCaller}, \texttt{directEval}).

18.2.1.1 Runtime Semantics: PerformEval( \( x \), \texttt{evalRealm}, \texttt{strictCaller}, \texttt{direct} )

The abstract operation PerformEval takes with arguments \( x \), \texttt{evalRealm}, \texttt{strictCaller}, and \texttt{direct} performs the following steps:

1. Assert: If \texttt{direct} is false then \texttt{strictCaller} is also false.
2. If Type(\( x \)) is not String, return \( x \).
3. Let \texttt{script} be the ECMAScript code that is the result of parsing \( x \), interpreted as UTF-16 encoded Unicode text as described in 6.1.4, for the goal symbol Script. If the parse fails or any early errors are detected, throw a SyntaxError exception (but see also clause 16).
4. If \texttt{script} Contains ScriptBody is false, return undefined.
5. Let \texttt{body} be the ScriptBody of \texttt{script}.
6. If \texttt{strictCaller} is true, let \texttt{strictEval} be true.
7. Else, let \texttt{strictEval} be IsStrict of \texttt{script}.
8. Let \texttt{ctx} be the running execution context. If \texttt{direct} is true \texttt{ctx} will be the execution context that performed the direct \texttt{eval}. If \texttt{direct} is false \texttt{ctx} will be the execution context for the invocation of the eval function.
9. If \texttt{direct} is true, then
   a. Let \texttt{lexEnv} be NewDeclarativeEnvironment(\texttt{ctx}’s LexicalEnvironment).
   b. Let \texttt{varEnv} be \texttt{ctx}’s VariableEnvironment.
10. Else,
    a. Let \texttt{lexEnv} be NewDeclarativeEnvironment(\texttt{evalRealm}.[[globalEnv]]).
    b. Let \texttt{varEnv} be \texttt{evalRealm}.[[globalEnv]].
11. If `strictEval` is `true`, then
   a. Let `varEnv` be `lexEnv`.
12. If `ctx` is not already suspended, Suspend `ctx`.
13. Let `evalCtx` be a new ECMA Script code execution context.
14. Set the `evalCtx`’s Realm to `evalRealm`.
15. Set the `evalCtx`’s VariableEnvironment to `varEnv`.
16. Set the `evalCtx`’s LexicalEnvironment to `lexEnv`.
17. Push `evalCtx` on to the execution context stack; `evalCtx` is now the running execution context.
18. Let `result` be `EvalDeclarationInstantiation(body, varEnv, lexEnv, strictEval)`.
19. If `result.[[type]]` is `normal`, then
   a. Let `result` be the result of evaluating `body`.
20. If `result.[[type]]` is `normal` and `result.[[value]]` is `empty`, then
   a. Let `result` be `NormalCompletion(undefined)`.
21. Suspend `evalCtx` and remove it from the execution context stack.
22. Resume the context that is now on the top of the execution context stack as the running execution context.
23. 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. Bindings introduced by `let`, `const`, or `class` declarations are always instantiated in the LexicalEnvironment.

18.2.1.2 Runtime Semantics: `EvalDeclarationInstantiation(body, varEnv, lexEnv, strict)`

1. Let `lexNames` be the LexicallyDeclaredNames of `body`.
2. Let `varNames` be the VarDeclaredNames of `body`.
3. Let `varDeclarations` be the VarScopedDeclarations of `body`.
4. Let `lexEnvRec` be `lexEnv`’s environment record.
5. Let `varEnvRec` be `varEnv`’s environment record.
6. If `strict` is `false`, then
   a. If `varEnvRec` is a GlobalEnvironmentRecord, then
      i. For each `name` in `varNames`, do
         1. If the result of calling `varEnvRec`’s HasLexicalDeclaration concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
      2. NOTE: `eval` will not create a global var declaration that would be shadowed by a global lexical declaration.
   b. Else If `varEnvRec` is a Function Environment Record, then
      i. Let `topLexEnvRec` be `varEnvRec`’s environment record.
      ii. For each `name` in `varNames`, do
         1. Assert: `lexEnvRec` contains the top-level lexical declarations for the function.
      2. If the result of calling `topLexEnvRec`’s HasBinding concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
      3. NOTE: Within a function, a direct `eval` will not create a top-level var declaration that would be shadowed by a top-level lexical declaration.
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 neither a VariableDeclaration or a ForBinding, then
      i. Assert: `d` is either a FunctionDeclaration or a GeneratorDeclaration.
      ii. NOTE: If there are multiple FunctionDeclarations for the same name, the last declaration is used.
      iii. Let `fn` be the sole element of the BoundNames of `d`.

iv. If fn is not an element of declaredFunctionNames, then
1. If varEnvRec is a GlobalEnvironmentRecord, then
   a. Let fnDefinable be the result of calling varEnvRec's CanDeclareGlobalFunction
      concrete method passing fn as the argument.
   b. If fnDefinable is false, throw SyntaxError exception.
2. Append fn to declaredFunctionNames.
3. Insert d as the first element of functionsToInitialize.
10. Let declaredVarNames be an empty List.
11. For each d in varDeclarations, do
   a. If d is a VariableDeclaration or a ForBinding, then
      i. For each String vn in the BoundNames of d, do
         1. If vn is not an element of declaredFunctionNames, then
            a. If varEnvRec is a GlobalEnvironmentRecord, then
               i. Let vnDefinable be the result of calling varEnvRec's CanDeclareGlobalVar
                  concrete method passing vn as the argument.
               ii. If vnDefinable is false, throw SyntaxError exception.
            b. If vn is not an element of declaredVarNames, then
               i. Append vn to declaredVarNames.
   12. NOTE: No abnormal terminations occur after this algorithm step unless varEnvRec is a
       GlobalEnvironmentRecord and the global object is a Proxy exotic object.
13. Let lexDeclarations be the LexicallyScopedDeclarations of body.
14. 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. Let status be the result of calling lexEnvRec's CreateImmutableBinding concrete
            method passing dn and true as the arguments.
         ii. Else
            1. Let status be the result of calling lexEnvRec's CreateMutableBinding concrete
               method passing dn and false as the arguments.
      iii. ReturnIfAbrupt(status).
15. 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 lexEnv.
   c. If varEnvRec is a GlobalEnvironmentRecord, then
      i. Let status be the result of calling varEnvRec's CreateGlobalFunctionBinding concrete
         method passing fn, fo, and true as the arguments.
      ii. ReturnIfAbrupt(status).
   d. Else,
      i. Let status be the result of calling varEnvRec's CreateMutableBinding concrete method
         passing fn and true as the arguments.
      ii. ReturnIfAbrupt(status).
      iii. Call varEnvRec's InitializeBinding concrete method passing fn and fo as arguments.
16. For each String vn in declaredVarNames, in list order do
   a. If varEnvRec is a GlobalEnvironmentRecord, then
      i. Let status be the result of calling varEnvRec's CreateGlobalVarBinding concrete
         method passing vn and true as the argument.
   b. Else,
      i. Let status be the result of calling varEnvRec's CreateMutableBinding concrete method
         passing vn and true as the arguments.
      c. ReturnIfAbrupt(status).
      d. Call varEnvRec's InitializeBinding concrete method passing vn and undefined as arguments.
17. Return NormalCompletion(empty)
18.2.2 isFinite (number)

Returns **false** if the argument coerces to NaN, +∞, or −∞, and otherwise returns **true**.

1. Let `num` be ToNumber(number).
2. ReturnIfAbrupt(num).
3. If `num` is NaN, +∞, or −∞, return false.
4. Otherwise, return true.

18.2.3 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.

**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.

18.2.4 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:

5. Let `inputString` be ToString(string).
6. ReturnIfAbrupt(inputString).
7. Let `trimmedString` be a substring of `inputString` consisting of the leftmost code unit that is not a StrWhiteSpaceChar and all code units to the right of that code unit. (In other words, remove leading white space.) If `inputString` does not contain any such code units, let `trimmedString` be the empty string.
8. If neither `trimmedString` nor any prefix of `trimmedString` satisfies the syntax of a StrDecimalLiteral (see 7.1.3.1), return NaN.
9. Let `numberString` be the longest prefix of `trimmedString` which might be `trimmedString` itself, that satisfies the syntax of a StrDecimalLiteral.
10. Let `mathFloat` be MV of `numberString`.
11. If `mathFloat`=0, then
   a. If the first code unit of `trimmedString` is "-", return −0.
   b. Return +0.
12. Return the Number value for `mathFloat`.

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

18.2.5 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 code unit pairs °x or °X, in which...
case a radix of 16 is assumed. If \( \text{radix} \) is 16, the number may also optionally begin with the code unit pairs 0x or 0X.

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 code unit that is not a `StrWhiteSpaceChar` and all code unit following that code unit. (In other words, remove leading white space.) If `inputString` does not contain any such code unit, let \( S \) be the empty string.
4. Let \( \text{sign} \) be 1.
5. If \( S \) is not empty and the first code unit of \( S \) is \( \text{U+002D} \) (HYPHEN-MINUS), let \( \text{sign} \) be \( -1 \).
6. If \( S \) is not empty and the first code unit of \( S \) is \( \text{U+002B} \) (PLUS SIGN) or \( \text{U+002D} \) (HYPHEN-MINUS), remove the first code unit from \( S \).
7. Let \( R = \text{ToInt32(radix)} \).
8. ReturnIfAbrupt(`R`).
9. Let `stripPrefix` be `true`.
10. If \( R \neq 0 \), then
    a. If \( R < 2 \) or \( R > 36 \), 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 code units of \( S \) are either “0x” or “0X”, remove the first two code units from \( S \) and let \( R = 16 \).
13. If \( S \) contains any code units that is not a radix-\( R \) digit, let \( Z \) be the substring of \( S \) consisting of all code units before the first such code unit; 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. If `mathFloat` = 0, then
    a. If `sign` = -1, return -0.
    b. Return +0.
17. Let `number` be the Number value for `mathInt`.
18. Return \( \text{sign} \times \text{number} \).

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

18.2.6 URI Handling Functions

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 18.2.6.2, 18.2.6.3, 18.2.6.4 and 18.2.6.5.

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

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

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

where the italicized names represent components and ";", "/", ";" and "?" are reserved for use as separators. The encodeURI and decodeURI functions are intended to work with complete URIs; they assume that any reserved code units 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 code units represent text and so must be encoded so that they are not interpreted as reserved code units when the component is part of a complete URI.

The following lexical grammar specifies the form of encoded URIs.

**Syntax**

\[
\text{uri} :: \text{uriCharactersopt}
\]

\[
\text{uriCharacters} :: \text{uriCharacter uriCharactersopt}
\]

\[
\text{uriCharacter} :: \text{uriReserved} \text{uriUnescaped} \text{uriEscaped}
\]

\[
\text{uriReserved} :: \text{one of } ; / ? : @ & = + $ ,
\]

\[
\text{uriUnescaped} :: \text{uriAlpha} \text{DecimalDigit} \text{uriMark}
\]

\[
\text{uriEscaped} :: \% \text{HexDigit HexDigit}
\]

\[
\text{uriAlpha} :: \text{one of } a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
\]

\[
\text{uriMark} :: \text{one of } - _ . ! ~ * ' ( )
\]

**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 code unit to be included in a URI is not listed above or is not intended to have the special meaning sometimes given to the reserved code units, that code unit must be encoded. The code unit 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".

18.2.6.1.1 Runtime Semantics: Encode Abstract Operation

The encoding and escaping process is described by the abstract operation Encode taking two String arguments string and unescapedSet.

1. Let strLen be the number of code units 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 code unit at index k within string.
   c. If C is in unescapedSet, then
      i. Let S be a String containing only the code unit 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 unescapedSet,
      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.
         2. Let jChar be the code unit value of the code unit at index k within string.
         3. If jChar is less than 0xDC00 or greater than 0xDBFF, throw a URIError exception.
         4. Let V be (((the code unit value of C) – 0xD800) × 0x400 + (jChar – 0xDC00) + 0x10000).
      iii. Let Octets be the array of octets resulting by applying the UTF-8 transformation to V, and let L be the array size.
      iv. Let j be 0.
      v. Repeat, while j < L
         1. Let jOctet be the value at index j within Octets.
         2. Let S be a String containing three code units “%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.

18.2.6.1.2 Runtime Semantics: Decode Abstract Operation

The unescaping and decoding process is described by the abstract operation Decode taking two String arguments string and reservedSet.

1. Let strLen be the number of code units 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 code unit at index \( k \) within \( string \).
   c. If \( C \) is not ‘%’, then
      i. Let \( S \) be the String containing only the code unit \( C \).
   d. Else \( C \) is ‘%’,
      i. Let \( start \) be \( k \).
      ii. If \( k + 2 \) is greater than or equal to \( strLen \), throw a \texttt{URIError} exception.
      iii. If the code units at index \((k+1)\) and \((k+2)\) within \( string \) do not represent hexadecimal digits, throw a \texttt{URIError} exception.
   v. Increment \( k \) by 2.
   vi. If the most significant bit in \( B \) is 0, then
      1. Let \( C \) be the code unit with code unit value \( B \).
      2. If \( C \) is not in \texttt{reservedSet}, then
         a. Let \( S \) be the String containing only the code unit \( C \).
      3. Else \( C \) is in \texttt{reservedSet},
         a. Let \( S \) be the substring of \( string \) from index \( start \) to index \( k \) inclusive.
   vii. Else the most significant bit in \( B \) is 1,
      1. Let \( n \) be the smallest nonnegative integer such that \((B \ll n) \& 0x80 \) is equal to 0.
      2. If \( n \) equals 1 or \( n \) is greater than 4, throw a \texttt{URIError} exception.
      3. Let \( Octets \) be an array of 8-bit integers of size \( n \).
      4. Put \( B \) into \( Octets \) at index \( 0 \).
      5. If \( k + (3 \times (n – 1)) \) is greater than or equal to \( strLen \), throw a \texttt{URIError} exception.
      6. Let \( j \) be 1.
    7. Repeat, while \( j < n \)
      a. Increment \( k \) by 1.
      b. If the code unit at index \( k \) within \( string \) is not “%”, throw a \texttt{URIError} exception.
      c. If the code units at index \((k+1)\) and \((k+2)\) within \( string \) do not represent hexadecimal digits, throw a \texttt{URIError} exception.
      d. Let \( B \) be the 8-bit value represented by the two hexadecimal digits at index \((k+1)\) and \((k+2)\).
      e. If the two most significant bits in \( B \) are not 10, throw a \texttt{URIError} exception.
      f. Increment \( k \) by 2.
      g. Put \( B \) into \( Octets \) at index \( j \).
      h. Increment \( j \) by 1.
    8. 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 a \texttt{URIError} exception.
9. If \( V < 0x10000 \), then
   a. Let \( C \) be the code unit \( V \).
   b. If \( C \) is not in \texttt{reservedSet}, then
      i. Let \( S \) be the String containing only the code unit \( C \).
   c. Else \( C \) is in \texttt{reservedSet},
      i. Let \( S \) be the substring of \( string \) from index \( start \) to index \( k \) inclusive.
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 code units \( H \) 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 ECMA Script characters are specified in Table 40.

<table>
<thead>
<tr>
<th>Code Unit Value</th>
<th>Representation</th>
<th>1st Octet</th>
<th>2nd Octet</th>
<th>3rd Octet</th>
<th>4th Octet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0000 - 0x007F</td>
<td>00000000 0zzzzzz</td>
<td>0zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0080 - 0x077F</td>
<td>00000yyyy yyzzzzzz</td>
<td>110yyyy</td>
<td>10zzzzzz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0800 - 0x077F</td>
<td>x0x0yyyy yyzzzzzz</td>
<td>1110xxx</td>
<td>10yyyyyy</td>
<td>10zzzzzz</td>
<td></td>
</tr>
<tr>
<td>0x0880 - 0xDBFF</td>
<td>110110 vy vwwwxx</td>
<td>11110uuu</td>
<td>10wwwwww</td>
<td>10xxyyyy</td>
<td>10zzzzzz</td>
</tr>
<tr>
<td>0xDB80 - 0xDBFF</td>
<td>not followed by</td>
<td>causes URIError</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xDC00 - 0xDFFF</td>
<td>11011ly yyzzzzzz</td>
<td>11110uuu</td>
<td>10wwwwww</td>
<td>10xxyyyy</td>
<td>10zzzzzz</td>
</tr>
<tr>
<td>0xEO00 - 0x0FFF</td>
<td>causes URIError</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x10000 - 0x10FFFF</td>
<td>x0x0yyyy yyzzzzzz</td>
<td>1110xxx</td>
<td>10yyyyyy</td>
<td>10zzzzzz</td>
<td></td>
</tr>
</tbody>
</table>

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 0xD800-0xDBFF 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 code unit U+0000. Implementations of the Decode algorithm are required to throw a URIError when encountering such invalid sequences.

18.2.6.2 `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 UTF-16 encoding of the code points 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)`, that is, the result of calling `ToString` with `encodedURI` as its argument.
2. ReturnIfAbrupt(`uriString`).
3. Let `reservedURISet` be a String containing one instance of each code unit valid in `uriReserved plus “#”`.
4. Return `Decode(uriString, reservedURISet)`, that is, the result of calling `Decode` with `uriString` and `reservedURISet` as arguments.

Deleted: the result of calling

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

18.2.6.3  `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 UTF-16 encoding of the code points 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 `Decode(componentString, reservedURIComponentSet)`

18.2.6.4  `encodeURI` (uri)

The `encodeURI` function computes a new version of an UTF-16 encoded (6.1.4) URI in which each instance of certain code points is replaced by one, two, three, or four escape sequences representing the UTF-8 encoding of the code points.

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 `unescapedURISet` be a String containing one instance of each code unit valid in `uriReserved` and `uriUnescaped` plus "#".
4. Return `Encode(uriString, unescapedURISet)`

NOTE  The code point "#" is not encoded to an escape sequence even though it is not a reserved or unescaped URI code point.

18.2.6.5  `encodeURIComponent` (uriComponent)

The `encodeURIComponent` function computes a new version of an UTF-16 encoded (6.1.4) URI in which each instance of certain code points is replaced by one, two, three, or four escape sequences representing the UTF-8 encoding of the code point.

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 `unescapedURIComponentSet` be a String containing one instance of each code unit valid in `uriUnescaped`.
4. Return `Encode(componentString, unescapedURIComponentSet)`
18.3 Constructor Properties of the Global Object

18.3.1 Array (. . .)
See 22.1.1.

18.3.2 ArrayBuffer (. . .)
See 24.1.2.

18.3.3 Boolean (. . .)
See 19.3.1.

18.3.4 DataView (. . .)
See 24.2.2.

18.3.5 Date (. . .)
See 20.3.2.

18.3.6 Error (. . .)
See 19.5.1.

18.3.7 EvalError (. . .)
See 19.5.5.1.

18.3.8 Float32Array (. . .)
See 22.2.4.

18.3.9 Float64Array (. . .)
See 22.2.4.

18.3.10 Function (. . .)
See 19.2.1.

18.3.11 Int8Array (. . .)
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18.3.12 Int16Array (. . .)
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18.3.13 Int32Array ( . . . )
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18.3.14 Map ( . . . )
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18.3.16 Object ( . . . )
See 19.1.1.

18.3.17 Proxy ( . . . )
See 26.2.1.

18.3.18 Promise ( . . . )
See 25.4.3.

18.3.19 RangeError ( . . . )
See 19.5.5.2.

18.3.20 ReferenceError ( . . . )
See 19.5.5.3.

18.3.21 RegExp ( . . . )
See 21.2.3.

18.3.22 Set ( . . . )
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18.3.24 Symbol ( . . . )
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18.3.25 SyntaxError ( . . . )
See 19.5.5.4.
18.3.26 TypeError ( . . . )
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18.3.27 Uint8Array ( . . . )
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18.3.28 Uint8ClampedArray ( . . . )
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18.3.29 Uint16Array ( . . . )
See 22.2.4.

18.3.30 Uint32Array ( . . . )
See 22.2.4.

18.3.31 URIError ( . . . )
See 19.5.5.6.

18.3.32 WeakMap ( . . . )
See 23.3.1.

18.3.33 WeakSet ( . . . )
See 23.4.

18.4 Other Properties of the Global Object

18.4.1 JSON
See 24.3.

18.4.2 Math
See 20.2.

18.4.3 Reflect
See 26.1.
19 Fundamental Objects

19.1 Object Objects

19.1.1 The Object Constructor

The Object constructor is the %Object% intrinsic object and the initial value of the object property of the global object. When called as a constructor it creates new ordinary object. When Object is called as a function rather than as a constructor, it performs a type conversion.

The Object constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition.

19.1.1.1 Object ( [ value ] )

When Object function is called with optional argument value, the following steps are taken:

1. If NewTarget is either undefined nor the active function, then
   a. Return OrdinaryCreateFromConstructor(NewTarget, "%ObjectPrototype%").
2. If value is null, undefined or not supplied, return ObjectCreate(%ObjectPrototype%).
3. Return ToObject(value).

19.1.2 Properties of the Object Constructor

The value of the [[Prototype]] internal slot of the Object constructor is the intrinsic object %FunctionPrototype%.

Besides the length property (whose value is 1), the Object constructor has the following properties:

19.1.2.1 Object.assign ( target, ...sources )

The assign function is used to copy the values of all of the enumerable own properties from one or more source objects to a target object. When the assign function is called, the following steps are taken:

1. Let to be ToObject(target).
2. ReturnIfAbrupt(to).
3. If only one argument was passed, return to.
4. Let sources be the List of argument values starting with the second argument.
5. For each element nextSource of sources, in ascending index order,
   a. If nextSource is undefined or null, let keys be an empty List.
   b. Else,
      i. Let from be ToObject(nextSource).
      ii. ReturnIfAbrupt(from).
      iii. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of from.
      iv. ReturnIfAbrupt(keys).
   c. Repeat for each element nextKey of keys in List order,
      i. Let desc be the result of calling the [[GetProperty]] internal method of from with argument nextKey.
      ii. ReturnIfAbrupt(desc).
      iii. if desc is not undefined and desc.[[Enumerable]] is true, then
         1. Let propValue be Get(from, nextKey).
         2. ReturnIfAbrupt(propValue).
3. Let status be Put(to, nextKey, propValue, true);
4. ReturnIfAbrupt(status).
6. Return to.

The length property of the assign method is 2.

19.1.2.2 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 ObjectCreate(O).
3. If the argument Properties is present and not undefined, then
   a. Return the result of the abstract operation ObjectDefineProperties(obj, Properties).
4. Return obj.

19.1.2.3 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.

19.1.2.3.1 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 keys be the result of calling the [[OwnPropertyKeys]] internal method of props.
4. ReturnIfAbrupt(keys).
5. Let descriptors be an empty List.
6. Repeat for each element nextKey of keys in list order,
   a. Let propDesc be the result of calling the [[GetOwnProperty]] internal method of props with argument nextKey.
   b. ReturnIfAbrupt(propDesc).
   c. If propDesc is not undefined and propDesc.[[Enumerable]] is true, then
      i. Let descObj be the result of Get( props, nextKey).
      ii. ReturnIfAbrupt(descObj).
      iii. Let desc be ToPropertyDescriptor(descObj).
      iv. ReturnIfAbrupt(desc).
      v. Append the pair (a two element List) consisting of nextKey and desc to the end of descriptors.
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. ReturnIfAbrupt(status).
8. Return O.
19.1.2.4 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.
2. Let `key` be `ToPropertyKey(P)`.
3. ReturnIfAbrupt(`key`).
4. Let `desc` be `ToPropertyDescriptor(Attributes)`.
5. ReturnIfAbrupt(`desc`).
6. Let `success` be `DefinePropertyOrThrow(O, key, desc)`.
7. ReturnIfAbrupt(`success`).
8. Return `O`.

19.1.2.5 Object.freeze ( O )

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

1. If `Type(O)` is not Object, return `O`.
2. Let `status` be the result of `SetIntegrityLevel(O, "frozen")`.
3. ReturnIfAbrupt(`status`).
4. If `status` is `false`, throw a `TypeError` exception.
5. Return `O`.

19.1.2.6 Object.getOwnPropertyDescriptor ( O, P )

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

1. Let `obj` be `ToObject(O)`.
2. ReturnIfAbrupt(`obj`).
3. Let `key` be `ToPropertyKey(P)`.
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 `FromPropertyDescriptor(desc)`.

19.1.2.7 Object.getOwnPropertyNames ( O )

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

1. Return `GetOwnPropertyKeys(O, String)`.

19.1.2.8 Object.getOwnPropertySymbols ( O )

When the `getOwnPropertySymbols` function is called with argument `O`, the following steps are taken:

1. Return `GetOwnPropertyKeys(O, Symbol)`.

19.1.2.8.1 GetOwnPropertyKeys ( O, Type ) Abstract Operation

The abstract operation `GetOwnPropertyKeys` is called with arguments `O` and `Type` where `O` is an Object and `Type` is one of the ECMAScript specification types String or Symbol. The following steps are taken:

1. Let `obj` be `ToObject(O)`.
2. ReturnIfAbrupt(`obj`).
3. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of obj.
4. ReturnIfAbrupt(keys).
5. Let nameList be a new empty List.
6. Repeat for each element nextKey of keys in keys order,
   a. If Type(nextKey) is Type, then
      i. Append nextKey as the last element of nameList.
7. Return CreateArrayFromList(nameList).

19.1.2.9 Object.getPrototypeOf ( O )

When the getPrototypeOf function is called with argument O, the following steps are taken:
1. Let obj be ToObject(O).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the [[GetPrototypeOf]] internal method of obj.

19.1.2.10 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).

19.1.2.11 Object.isExtensible ( O )

When the isExtensible function is called with argument O, the following steps are taken:
1. If Type(O) is not Object, return false.
2. Return the result of IsExtensible(O).

19.1.2.12 Object.isFrozen ( O )

When the isFrozen function is called with argument O, the following steps are taken:
1. If Type(O) is not Object, return true.
2. Return TestIntegrityLevel(O, "frozen").

19.1.2.13 Object.isSealed ( O )

When the isSealed function is called with argument O, the following steps are taken:
1. If Type(O) is not Object, return true.
2. Return TestIntegrityLevel(O, "sealed").

19.1.2.14 Object.keys ( O )

When the keys function is called with argument O, the following steps are taken:
1. Let obj be ToObject(O).
2. ReturnIfAbrupt(obj).
3. Let nameList be EnumerableOwnNames(obj).
4. ReturnIfAbrupt(nameList).
5. Return CreateArrayFromList(nameList).

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 4.
19.1.2.15 Object.preventExtensions (O)

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

1. If `Type(O)` is not Object, return `O`.
2. Let `status` be the result of calling the `[[PreventExtensions]]` internal method of `O`.
3. ReturnIfAbrupt(`status`).
4. If `status` is `false`, throw a `TypeError` exception.
5. Return `O`.

19.1.2.16 Object.prototype

The initial value of `Object.prototype` is the intrinsic object `%ObjectPrototype%` (19.1.3).

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

19.1.2.17 Object.seal (O)

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

1. If `Type(O)` is not Object, return `O`.
2. Let `status` be the result of `Set Integrity Level (O, "sealed")`.
3. ReturnIfAbrupt(`status`).
4. If `status` is `false`, throw a `TypeError` exception.
5. Return `O`.

19.1.2.18 Object.setPrototypeOf (O, proto)

When the `setPrototypeOf` function is called with arguments `O` and `proto`, the following steps are taken:

1. Let `O` be `Require Object Coercible(O)`. ReturnIfAbrupt(`O`).
2. If `Type(proto)` is neither Object nor Null, throw a `TypeError` exception.
3. If `Type(O)` is not Object, return `O`.
4. Let `status` be the result of calling the `[[SetPrototypeOf]]` internal method of `O` with argument `proto`.
5. ReturnIfAbrupt(`status`).
6. If `status` is `false`, throw a `TypeError` exception.
7. Return `O`.

19.1.3 Properties of the Object Prototype Object

The Object prototype object is an ordinary object.

The value of the `[[Prototype]]` internal slot of the Object prototype object is `null` and the initial value of the `[[Extensible]]` internal slot is `true`.

19.1.3.1 Object.prototype.constructor

The initial value of `Object.prototype.constructor` is the intrinsic object `%Object%`.

19.1.3.2 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 HasOwnProperty(O, P).

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.

19.1.3.3 Object.prototype.isPrototypeOf ( V )

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

1. If Type(V) is not 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 [[GetPrototypeOf]] internal method of V with no arguments.
   b. If V is null, return false
   c. If SameValue(O, V) is true, return true.

NOTE  The ordering of steps 1 and 2 preserves 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.

19.1.3.4 Object.prototype.propertyIsEnumerable ( V )

When the propertyIsEnumerable 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. Let desc be the result of calling the [[GetOwnProperty]] internal method of O passing P as the argument.
6. ReturnIfAbrupt(desc).
7. If desc is undefined, return false.
8. 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 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.

19.1.3.5 Object.prototype.toLocaleString ( [ reserved1 [, reserved2 ] ] )

When the toLocaleString method is called, the following steps are taken:

1. Let O be the this value.
2. Return the result of Invoke(O, "toString").

The optional parameters to this function are not used but are intended to correspond to the parameter pattern used by ECMA-402 toLocaleString functions. Implementations that do not include ECMA-402 support must not use those parameter positions for other purposes.
NOTE 1  This function provides a generic toLocaleString implementation for objects that have no locale-specific toString behaviour. Array, Number, Date, and Typed Arrays provide their own locale-sensitive toLocaleString methods.

NOTE 2  ECMA-402 intentionally does not provide an alternative to this default implementation.

19.1.3.6 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. Let O be the result of calling ToObject passing the this value as the argument.
4. If IsArray(O) is true, let builtinTag be "Array".
5. Else, if O is an exotic String object, let builtinTag be "String".
6. Else, if O has an [[ParameterMap]] internal slot, let builtinTag be "Arguments".
7. Else, if O has a [[Call]] internal method, let builtinTag be "Function".
8. Else, if O has an [[ErrorData]] internal slot, let builtinTag be "Error".
9. Else, if O has a [[BooleanData]] internal slot, let builtinTag be "Boolean".
10. Else, if O has a [[NumberData]] internal slot, let builtinTag be "Number".
11. Else, if O has a [[DateValue]] internal slot, let builtinTag be "Date".
12. Else, if O has a [[RegExpMatcher]] internal slot, let builtinTag be "RegExp".
13. Else, let builtinTag be "Object".
14. Let tag be the result of Get(O, @@toStringTag).
15. ReturnIfAbrupt(tag).
16. If Type(tag) is not String, let tag be builtinTag.
17. Return the String that is the result of concatenating ", [object " tag, and "]".

NOTE  Historically, this function was occasionally used to access the string value of the [[Class]] internal slot 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 compatibility for legacy code that uses toString as a test for those specific kinds of built-in objects. It does not provide a reliable type testing mechanism for other kinds of built-in or program defined objects. In addition, programs can use @@toStringTag in ways that will invalidate the reliability of such legacy type tests.

19.1.3.7 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.

19.1.4 Properties of Object Instances

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

19.2 Function Objects

19.2.1 The Function Constructor

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 initializes a new Function object. Thus the function call `Function(...)` is equivalent to the object creation expression `new Function(...)` with the same arguments.

The `Function` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified `Function` behaviour must include a `super` call to the `Function` constructor to create and initialize a subclass instances with the internal slots necessary for built-in function behaviour. All ECMAScript 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.

19.2.1.1 Function ( p1, p2, ..., pn, body )

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

When the `Function` function is called with some arguments `p1`, `p2`, ..., `pn`, `body` (where `n` might be 0, that is, there are no "p" arguments, and where `body` might also not be provided), the following steps are taken:

1. Let `C` be the active function object.
2. Let `args` be the `argumentsList` that was passed to this function by `[[Call]]` or `[[Construct]]`.

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")

19.2.1.1.1 RuntimeSemantics: CreateDynamicFunction(constructor, newTarget, kind, args)

The abstract operation `CreateDynamicFunction` is called with arguments `constructor`, `newTarget`, `kind`, and `args`. `constructor` is the constructor function that is performing this action. `newTarget` is the constructor that `new` was initially applied to. `kind` is either "normal" or "generator", and `args` is a List containing the actual argument values that were passed to a `constructor`. The following steps are taken:

1. If `newTarget` is `undefined`, let `newTarget` be `constructor`.
2. If `kind` is "normal", then
   a. Let `goal` be the grammar symbol `FunctionBody`.
   b. Let `parameterGoal` be the grammar symbol `FormalParameters`.
   c. Let `fallbackProto` be "%FunctionPrototype%".
3. Else
   a. Let `goal` be the grammar symbol `GeneratorBodyGroup`.
   b. Let `parameterGoal` be the grammar symbol `FormalParameterSyntaxGeneratorParameterGroup`.
   c. Let `fallbackProto` be "%Generator%".
4. Let `argCount` be the number of elements in `args`.
5. Let `P` be the empty String.
6. If `argCount = 0`, let `bodyText` be the empty String.
7. Else if `argCount = 1`, let `bodyText` be `args[0]`.
8. Else `argCount > 1`,
   a. Let `firstArg` be `args[0]`.
   b. Let `P` be `ToString(firstArg)`.
c. ReturnIfAbrupt(P).
d. Let k be 1.
e. Repeat, while k < argCount - 1
   i. Let nextArg be args[k].
   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.
f. Increase k by 1.
9. Let bodyText be ToString(bodyText).
10. ReturnIfAbrupt(bodyText).

11. Let body be the result of parsing bodyText, interpreted as UTF-16 encoded Unicode text as described in 6.1.4, using goal as the goal symbol. Throw a SyntaxError exception if the parse fails or if any static semantics errors are detected.

12. If bodyText is strict mode code (see 10.2.1) then let strict be true, else let strict be false.

13. Let parameters be the result of parsing P, interpreted as UTF-16 encoded Unicode text as described in 6.1.4, using parameterGoal as the goal symbol. Throw a SyntaxError exception if the parse fails or if any static semantics errors are detected. If strict is true, the Early Error rules for StrictFormalParameters : FormalParameters are applied.

14. If any element of the BoundNames of parameters also occurs in the LexicallyDeclaredNames of body, throw a SyntaxError exception.

15. If parameters Contains SuperCall is true, throw a SyntaxError exception.

16. If parameters Contains SuperCall is true, throw a SyntaxError exception.

17. If strict is true, then
   a. If BoundNames of FormalParameters contains any duplicate elements

18. Let proto be the result of GetPrototypeFromConstructor(newTarget, fallbackProto).
19. ReturnIfAbrupt(proto).
20. Let F be FunctionAllocate(proto, strict, kind).
21. ReturnIfAbrupt(F).
22. Let realmF be the value of F’s [[Realm]] internal slot.
23. Let scope be realmF.{{[globalEnv]}},
24. Perform FunctionInitialize(F, Normal, strict, parameters, body, scope).
25. If NeedsSuperBinding of body is true or NeedsSuperBinding of parameters is true, then
   a. Perform MakeMethod(F, undefined).
26. If kind is "generator", then
   a. Let prototype be ObjectCreate(%GeneratorPrototype%).
   b. ReturnIfAbrupt(prototype).
   c. Perform MakeConstructor(F, true, prototype).
27. Else, perform MakeConstructor(F).
28. Perform SetFunctionName(F, "anonymous").
29. Return F.

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

19.2.2 Properties of the Function Constructor

The Function constructor is itself a built-in function object. The value of the [[Prototype]] internal slot of the Function constructor is %FunctionPrototype%, the intrinsic Function prototype object (19.2.3).

The value of the [[Extensible]] internal slot of the Function constructor is true.
The Function constructor has the following properties:

19.2.2.1 Function.length

This is a data property with a value of 1. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

19.2.2.2 Function.prototype

The value of Function.prototype is %FunctionPrototype%, the intrinsic Function prototype object (19.2.3).

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

19.2.3 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. It does not have a [[Construct]] internal method so it is not a constructor.

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 slot of the Function prototype object is the intrinsic object %ObjectPrototype% (19.1.3). The initial value of the [[Extensible]] internal slot of the Function prototype object is true.

The Function prototype object does not have a prototype property.

The value of the length property of the Function prototype object is 0.

The value of the name property of the Function prototype object is the empty String.

19.2.3.1 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, throw a TypeError exception.
2. If argArray is null or undefined, then
   a. Return Call(func, thisArg).
3. Let argList be the result of CreateListFromArrayLike(argArray).
4. ReturnIfAbrupt(argList).
5. Perform PrepareForTailCall().
6. Return Call(func, thisArg, argList).

The length property of the apply method is 2.

NOTE 1 The thisArg value is passed without modification as the this value. This is a change from Edition 3, where an 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. Even though the thisArg is passed without modification, non-strict mode functions still perform these transformations upon entry to the function.
NOTE 2  If `func` is an arrow function or a bound function then the `thisArg` will be ignored by the function `[[Call]]` in step 6.

19.2.3.2 Function.prototype.bind (thisArg, ...args)

When the `bind` method is called with argument `thisArg` and zero or more `args`, it performs the following steps:

1. Let `Target` be the this value.
2. If `Callable(Target)` is `false`, throw a `TypeError` exception.
3. Let `args` be a new (possibly empty) List consisting of all of the argument values provided after `thisArg` in order.
4. Let `F` be `BoundFunctionCreate(Target, thisArg, args)`.
5. Let `targetHasLength` be `HasOwnProperty(Target, "length")`.
6. ReturnIfAbrupt(`targetHasLength`).
7. If `targetHasLength` is `true`, then
   a. Let `targetLen` be `Get(Target, "length")`.
   b. ReturnIfAbrupt(`targetLen`).
   c. If `Type(targetLen)` is not Number, let `L` be 0.
   d. Else,
      i. Let `targetLen` be ToInteger(`targetLen`).
      ii. Let `L` be the larger of 0 and the result of `targetLen` minus the number of elements of `args`.
8. Else let `L` be 0.
9. Let `status` be `DefinePropertyOrThrow(F, "length", PropertyDescriptor {[[Value]]: L, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true}).
10. Assert: `status` is not an abrupt completion.
11. Let `targetName` be `Get(Target, "name")`.
12. ReturnIfAbrupt(`targetName`).
13. If `Type(targetName)` is not String, let `targetName` be the empty string.
14. Perform `SetFunctionName(F, targetName, "bound")`.
15. Return `F`.

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

NOTE 1  Function objects created using `Function.prototype.bind` are exotic objects. They also do not have a `prototype` property.

NOTE 2  If `Target` is an arrow function or a bound function then the `thisArg` passed to this method will not be used by subsequent calls to `F`.

19.2.3.3 Function.prototype.call (thisArg, ...args)

When the `call` method is called on an object `func` with argument `thisArg` and zero or more `args`, the following steps are taken:

1. If `Callable(func)` is `false`, 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 the second argument append each argument as the last element of `argList`.
4. Perform `PrepareForTailCall()`.
5. Return `Call(func, thisArg, argList)`.

The `length` property of the `call` method is 1.
NOTE 1  The thisArg value is passed without modification as the this value. This is a change from Edition 3, where an 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. Even though the thisArg is passed without modification, non-strict mode functions still perform these transformations upon entry to the function.

NOTE 2  If func is an arrow function or a bound function then the thisArg will be ignored by the function [[Call]] in step 5.

19.2.3.4 Function.prototype.constructor

The initial value of Function.prototype.constructor is the intrinsic object %Function%.

19.2.3.5 Function.prototype.toString() 

When the toString method is called on an object func the following steps are taken:

1. If func is a Bound Function exotic object, then
   a. Return an implementation-dependent String source code representation of func. The representation must conform to the rules below. It is implementation dependent whether the representation includes bound function information or information about the target function.
2. If Type(func) is Object and is either a Built-in function object or has an [[ECMAScriptCode]] internal slot, then
   a. Return an implementation-dependent String source code representation of func. The representation must conform to the rules below.
3. Throw a TypeError exception.

toString Representation Requirements:

- The string representation must have the syntax of a FunctionDeclaration FunctionExpression, GeneratorDeclaration, GeneratorExpression, ClassDeclaration, ClassExpression, ArrowFunction, MethodDefinition, or GeneratorMethod depending upon the actual characteristics of the object.
- The use and placement of white space, line terminators, and semicolons within the representation String is implementation-dependent.
- If the object was defined using ECMAScript code and the returned string representation is not in the form of a MethodDefinition or GeneratorMethod then the representation must be such that if the string is evaluated, using eval in a lexical context that is equivalent to the lexical context used to create the original object, it will result in a new functionally equivalent object. In that case the returned source code must not mention freely any variables that were not mentioned freely by the original function’s source code, even if these “extra” names were originally in scope.
- If the implementation cannot produce a source code string that meets these criteria then it must return a string for which eval will throw a SyntaxError exception.

19.2.3.6 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).

The value of the name property of this function is "[Symbol.hasInstance]".

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

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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

```javascript
v instanceof F
```

evaluates as

```javascript
F[@@hasInstance](v)
```

A constructor function can control which objects are recognized 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.

19.2.4 Function Instances

Every function instance is an ECMAScript function object and has the internal slots listed in Table 28. Function instances created using the `Function.prototype.bind` method (19.2.3.2) have the internal slots listed in Table 29.

The Function instances have the following properties:

19.2.4.1 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 `length` property depends on the function. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

19.2.4.2 name

The value of the `name` property is a `String` that is descriptive of the function. The name has no semantic significance but is typically a variable or property name that is used to refer to the function at its point of definition in ECMAScript code. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

Anonymous functions objects that do not have a contextual name associated with them by this specification do not have a `name` own property but inherit the `name` property of `%FunctionPrototype%`.

19.2.4.3 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 initialize the `[[Prototype]]` internal slot 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 are not a `GeneratorMethod`) or an `ArrowFunction` grammar production do not have a `prototype` property.
19.3 Boolean Objects

19.3.1 The Boolean Constructor

The Boolean constructor is the %Boolean% intrinsic object and the initial value of the Boolean property of the global object. When called as a constructor it creates and initializes a new Boolean object. When Boolean is called as a function rather than as a constructor, it performs a type conversion.

The Boolean constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified Boolean behaviour must include a super call to the Boolean constructor to create and initialize the subclass instance with a [[BooleanData]] internal slot.

19.3.1.1 Boolean ( value )

When Boolean is called with argument value, the following steps are taken:

1. Let b be ToBoolean(value).
2. If NewTarget is undefined, return b.
3. Let O be OrdinaryCreateFromConstructor(NewTarget, "%BooleanPrototype", «[[BooleanData]]»).
4. ReturnIfAbrupt(O).
5. Set the value of O’s [[BooleanData]] internal slot to b.
6. Return O.

19.3.2 Properties of the Boolean Constructor

The value of the [[Prototype]] internal slot of the Boolean constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the Boolean constructor has the following properties:

19.3.2.1 Boolean.prototype

The initial value of Boolean.prototype is the Boolean prototype object (19.3.3).

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

19.3.3 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 slot.

The value of the [[Prototype]] internal slot of the Boolean prototype object is the intrinsic object %ObjectPrototype% (19.1.3).

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 slot, then
   a. Assert: value’s [[BooleanData]] internal slot is a Boolean value.
   b. Return the value of value’s [[BooleanData]] internal slot.
3. Throw a **TypeError** exception.

19.3.3.1 **Boolean.prototype.constructor**

The initial value of **Boolean.prototype.constructor** is the intrinsic object `%Boolean%`.

19.3.3.2 **Boolean.prototype.toString ()**

The following steps are taken:

1. Let `b` be thisBooleanValue(\this\ value).
2. ReturnIfAbrupt(`b`).
3. If `b` is **true**, return "true"; else return "false".

19.3.3.3 **Boolean.prototype.valueOf ()**

The following steps are taken:

1. Return thisBooleanValue(\this\ value).

19.3.4 **Properties of Boolean Instances**

Boolean instances are ordinary objects that inherit properties from the Boolean prototype object. Boolean instances have a `[[BooleanData]]` internal slot. The `[[BooleanData]]` internal slot is the Boolean value represented by this Boolean object.

19.4 **Symbol Objects**

19.4.1 **The Symbol Constructor**

The Symbol constructor is the `%Symbol%` intrinsic object and the initial value of the **Symbol** property of the global object. When Symbol is called as a function, it returns a new Symbol value.

The Symbol constructor is not intended to be used with the **new** operator or to be subclassed. It may be used as the value of an extends clause of a class definition but a super call to the Symbol constructor will cause an exception.

19.4.1.1 **Symbol ([ description ])**

When Symbol is called with optional argument description, the following steps are taken:

1. If NewTarget is not **undefined**, throw a **TypeError** exception.
2. If description is **undefined**, let descString be **undefined**.
3. Else, let descString be ToString(description).
4. ReturnIfAbrupt(descString).
5. Return a new unique Symbol value whose [[Description]] value is descString.

19.4.2 **Properties of the Symbol Constructor**

The value of the `[[Prototype]]` internal slot of the Symbol constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the **length** property (whose value is 1), the Symbol constructor has the following properties:
19.4.2.1 Symbol.for (key)

When Symbol.for is called with argument key it performs the following steps:

1. Let stringKey be ToString(key).
2. ReturnIfAbrupt(stringKey).
3. For each element e of the GlobalSymbolRegistry List,
   a. If SameValue(e.[[key]], stringKey) is true, return e.[[symbol]].
4. Assert: GlobalSymbolRegistry does not currently contain an entry for stringKey.
5. Let newSymbol be a new unique Symbol value whose [[Description]] is stringKey.
6. Append the record { [[key]: stringKey, [[symbol]: newSymbol ] to the GlobalSymbolRegistry List.
7. Return newSymbol.

The GlobalSymbolRegistry is a List that is globally available. It is shared by all Code Realms. Prior to the evaluation of any ECMAScript code it is initialized as an empty List. Elements of the GlobalSymbolRegistry are Records with the structure defined in Table 41.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[key]]</td>
<td>A String</td>
<td>A string key used to globally identify a Symbol.</td>
</tr>
<tr>
<td>[[symbol]]</td>
<td>A Symbol</td>
<td>A symbol that can be retrieved from any Realm.</td>
</tr>
</tbody>
</table>

19.4.2.2 Symbol.hasInstance

The initial value of Symbol.hasInstance is the well known symbol @@hasInstance (Table 1). This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }

19.4.2.3 Symbol.isConcatSpreadable

The initial value of Symbol.isConcatSpreadable is the well known symbol @@isConcatSpreadable (Table 1). This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }

19.4.2.4 Symbol.iterator

The initial value of Symbol.iterator is the well known symbol @@iterator (Table 1). This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }

19.4.2.5 Symbol.keyFor (sym)

When Symbol.keyFor is called with argument sym it performs the following steps:

1. If Type(sym) is not Symbol, throw a TypeError exception.
2. For each element e of the GlobalSymbolRegistry List (see 19.4.2.1),
   a. If SameValue(e.[[symbol]], sym) is true, return e.[[key]].
3. Assert: GlobalSymbolRegistry does not currently contain an entry for sym.
4. Return undefined.
19.4.2.6 Symbol.match
The initial value of Symbol.match is the well known symbol @@match (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.7 Symbol.prototype
The initial value of Symbol.prototype is the Symbol prototype object (19.4.3).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.8 Symbol.replace
The initial value of Symbol.replace is the well known symbol @@replace (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.9 Symbol.search
The initial value of Symbol.search is the well known symbol @@search (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.10 Symbol.species
The initial value of Symbol.species is the well known symbol @@species (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.11 Symbol.split
The initial value of Symbol.split is the well known symbol @@split (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.12 Symbol.toPrimitive
The initial value of Symbol.toPrimitive is the well known symbol @@toPrimitive (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.13 Symbol.toStringTag
The initial value of Symbol.toStringTag is the well known symbol @@toStringTag (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 

19.4.2.14 Symbol.unscopables
The initial value of Symbol.unscopables is the well known symbol @@unscopables (Table 1).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

19.4.3 Properties of the Symbol Prototype Object

The Symbol prototype object is an ordinary object. It is not a Symbol instance and does not have a [[SymbolData]] internal slot.

The value of the [[Prototype]] internal slot of the Symbol prototype object is the intrinsic object %ObjectPrototype% (19.1.3).

19.4.3.1 Symbol.prototype.constructor

The initial value of Symbol.prototype.constructor is the intrinsic object %Symbol%.

19.4.3.2 Symbol.prototype.toString()

The following steps are taken:

1. Let s be the this value.
2. If Type(s) is Symbol, let sym be s.
3. Else.
   a. If Type(s) is not Object, throw a TypeError exception.
   b. If s does not have a [[SymbolData]] internal slot, throw a TypeError exception.
   c. Let sym be the value of s’s [[SymbolData]] internal slot.
4. Return SymbolDescriptiveString(sym).

19.4.3.2.1 SymbolDescriptiveString ( sym ) Abstract Operation

When the abstract operation SymbolDescriptiveString is called with argument sym, the following steps are taken:

1. Assert: Type(sym) is Symbol.
2. Let desc be the value of sym’s [[Description]] attribute.
3. If desc is undefined, let desc be the empty string.
4. Assert: Type(desc) is String.
5. Let result be the result of concatenating the strings "Symbol (", desc, and ") ".
6. Return result.

19.4.3.3 Symbol.prototype.valueOf()

The following steps are taken:

1. Let s be the this value.
2. If Type(s) is Symbol, return s.
3. If Type(s) is not Object, throw a TypeError exception.
4. If s does not have a [[SymbolData]] internal slot, throw a TypeError exception.
5. Return the value of s’s [[SymbolData]] internal slot.

19.4.3.4 Symbol.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".
When the @@toPrimitive method is called with argument hint, the following steps are taken:

1. Let s be the this value.
2. If Type(s) is Symbol, return s.
3. If Type(s) is not Object, throw a TypeError exception.
4. If s does not have a [[SymbolData]] internal slot, throw a TypeError exception.
5. Return the value of s’s [[SymbolData]] internal slot.

The value of the name property of this function is "[Symbol.toPrimitive]".

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

19.4.3.5 Symbol.prototype [@@toStringTag]

The initial value of the @@toStringTag property is the string value "Symbol".

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

19.4.4 Properties of Symbol Instances

Symbol instances are ordinary objects that inherit properties from the Symbol prototype object. Symbol instances have a [[SymbolData]] internal slot. The [[SymbolData]] internal slot is the Symbol value represented by this Symbol object.

19.5 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.

19.5.1 The Error Constructor

The Error constructor is the %Error% intrinsic object and the initial value of the Error property of the global object. When Error is called as a function rather than as a constructor, it creates and initializes a new Error object. Thus the function call Error(...) is equivalent to the object creation expression new Error(...) with the same arguments.

The Error constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified Error behaviour must include a super call to the Error constructor to create and initialize subclass instances with a [[ErrorData]] internal slot.

19.5.1.1 Error (message)

When the Error function is called with argument message the following steps are taken:

1. If NewTarget is undefined, let newTarget be the active function object, else let newTarget be NewTarget.
2. Let O be OrdinaryCreateFromConstructor(newTarget, "%ErrorPrototype", {[[ErrorData]]}).
3. ReturnIfAbrupt(O).
4. If message is not undefined, then
   a. Let msg be ToString(message).
   b. ReturnIfAbrupt(msg).
c. Let `msgDesc` be the PropertyDescriptor{ [[Value]]: `msg`, [[Writable]]: `true`, [[Enumerable]]: `false`, [[Configurable]]: `true` }.
d. Let `status` be the result of DefinePropertyOrThrow(`O`, "message", `msgDesc`).
e. Assert: `status` is not an abrupt completion.
5. Return `O`.

19.5.2 Properties of the Error Constructor

The value of the [[Prototype]] internal slot of the Error constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the length property (whose value is 1), the Error constructor has the following properties:

19.5.2.1 Error.prototype

The initial value of Error.prototype is the Error prototype object (19.5.3).

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

19.5.3 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 slot.

The value of the [[Prototype]] internal slot of the Error prototype object is the intrinsic object `%ObjectPrototype%` (19.1.3).

19.5.3.1 Error.prototype.constructor

The initial value of Error.prototype.constructor is the intrinsic object `%Error%`.

19.5.3.2 Error.prototype.message

The initial value of Error.prototype.message is the empty String.

19.5.3.3 Error.prototype.name

The initial value of Error.prototype.name is "Error".

19.5.3.4 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, let `name` be "Error"; otherwise let `name` be ToString(`name`).
6. ReturnIfAbrupt(`name`).
7. Let `msg` be the result of Get(`O`, "message").
8. ReturnIfAbrupt(`msg`).
9. If `msg` is undefined, let `msg` be the empty String; otherwise let `msg` be ToString(`msg`).
10. `ReturnIfAbrupt(msg)`.
11. If `name` is the empty String, return `msg`.
12. If `msg` is the empty String, return `name`.
13. Return the result of concatenating `name`, the code unit U+003A (COLON), the code unit U+0020 (SPACE), and `msg`.

19.5.4 Properties of Error Instances

Error instances are ordinary objects that inherit properties from the Error prototype object and have an `[[ErrorData]]` internal slot 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`.

19.5.5 Native Error Types Used in This Standard

A new instance of one of the `NativeError` objects below is thrown when a runtime error is detected. All of these objects share the same structure, as described in 19.5.6.

19.5.5.1 EvalError

This exception is not currently used within this specification. This object remains for compatibility with previous editions of this specification.

19.5.5.2 RangeError

Indicates a value that is not in the set or range of allowable values.

19.5.5.3 ReferenceError

Indicate that an invalid reference value has been detected.

19.5.5.4 SyntaxError

Indicates that a parsing error has occurred.

19.5.5.5 TypeError

Indicates the actual type of an operand is different than the expected type.

19.5.5.6 URIError

Indicates that one of the global URI handling functions was used in a way that is incompatible with its definition.

19.5.6 NativeError Object Structure

When an ECMAScript implementation detects a runtime error, it throws a new instance of one of the `NativeError` objects defined in 19.5.5. 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 19.5.5.

### 19.5.6.1 NativeError Constructors

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

Each `NativeError` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified `NativeError` behaviour must include a `super` call to the `NativeError` constructor to create and initialize subclass instances with a `[[ErrorData]]` internal slot.

#### 19.5.6.1.1 `NativeError(message)`

When a `NativeError` function is called with argument `message`, the following steps are taken:

1. If `NewTarget` is `undefined`, let `newTarget` be the active function object, else let `newTarget` be `NewTarget`.
2. Let `O` be `OrdinaryCreateFromConstructor(newTarget, "%NativeErrorPrototype", ```[[ErrorData]]``` )
3. ReturnIfAbrupt(`O`).
4. If `message` is not `undefined`, then
   a. Let `msg` be `ToString(message)`.
   b. Let `msgDesc` be the `PropertyDescriptor`{`[[Value]]`: `msg`, `[[Writable]]`: `true`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `true`}
   c. Let `status` be the result of `DefinePropertyOrThrow(O, "message", msgDesc)`.
   d. Assert: `status` is not an abrupt completion.
5. Return `O`.

The actual value of the string passed in step 2 is either "%EvalErrorPrototype", "%RangeErrorPrototype", "%ReferenceErrorPrototype", "%SyntaxErrorPrototype", "%TypeErrorPrototype", or "%URIErrorPrototype" corresponding to which `NativeError` constructor is being defined.

### 19.5.6.2 Properties of the NativeError Constructors

The value of the `[[Prototype]]` internal slot of a `NativeError` constructor is the intrinsic object `%Error%` (19.5.1).

Besides the `length` property (whose value is 1), each `NativeError` constructor has the following properties:

#### 19.5.6.2.1 `NativeError.prototype`

The initial value of `NativeError.prototype` is a `NativeError` prototype object (19.5.6.3). Each `NativeError` constructor has a separate prototype object.

This property has the attributes { `[[Writable]]`: `false`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `false` }.
19.5.6.3 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 slot.

The value of the [[Prototype]] internal slot of each NativeError prototype object is the intrinsic object `%ErrorPrototype%` (19.5.3).

19.5.6.3.1 NativeError.prototype.constructor

The initial value of the constructor property of the prototype for a given NativeError constructor is the corresponding intrinsic object `%NativeError%` (19.5.6.1).

19.5.6.3.2 NativeError.prototype.message

The initial value of the message property of the prototype for a given NativeError constructor is the empty String.

19.5.6.3.3 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).

19.5.6.4 Properties of NativeError Instances

NativeError instances are ordinary objects that inherit properties from their NativeError prototype object and have an [[ErrorData]] internal slot 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.

20 Numbers and Dates

20.1 Number Objects

20.1.1 The Number Constructor

The Number constructor is the `%Number%` intrinsic object and the initial value of the Number property of the global object. When called as a constructor, it creates and initializes a new Number object. When Number is called as a function rather than as a constructor, it performs a type conversion.

The Number constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified Number behaviour must include a super call to the Number constructor to create and initialize the subclass instance with a [[NumberData]] internal slot.

20.1.1.1 Number ([ value ])

When Number is called with argument number, the following steps are taken:

1. If no arguments were passed to this function invocation, let n be +0.
2. Else, let n be ToNumber(value).
3. ReturnIfAbrupt(n).
4. If NewTarget is undefined, return n.
5. Let O be OrdinaryCreateFromConstructor(NewTarget, "%NumberPrototype%", «[[NumberData]]»).
6. ReturnIfAbrupt(O).
7. Set the value of O’s [[NumberData]] internal slot to n.
8. Return O.

20.1.2 Properties of the Number Constructor

The value of the [[Prototype]] internal slot of the Number constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the Number constructor has the following properties:

20.1.2.1 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 }.

20.1.2.2 Number.isFinite (number)

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, +∞, or −∞, return false.
3. Otherwise, return true.

20.1.2.3 Number.isInteger (number)

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. If number is NaN, +∞, or −∞, return false.
3. Let integer be ToInteger(number).
4. If integer is not equal to number, return false.
5. Otherwise, return true.

20.1.2.4 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 (18.2.3) is that it does not convert its argument to a Number before determining whether it is NaN.
20.1.2.5 Number.isSafeInteger(number)

When the Number.isSafeInteger 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, +∞, or −∞, return false.
3. Let integer be ToInteger(number).
4. If integer is not equal to number, return false.
5. If abs(integer) ≤ 2^{53}−1, return true.
6. Otherwise, return false.

20.1.2.6 Number.MAX_SAFE_INTEGER

NOTE The value of Number.MAX_SAFE_INTEGER is the largest integer n such that n and n + 1 are both exactly representable as a Number value.

The value of Number.MAX_SAFE_INTEGER is 9007199254740991 (2^{53}−1).

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

20.1.2.7 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 }.

20.1.2.8 Number.MIN_SAFE_INTEGER

NOTE The value of Number.MIN_SAFE_INTEGER is the smallest integer n such that n and n − 1 are both exactly representable as a Number value.

The value of Number.MIN_SAFE_INTEGER is −9007199254740991 (−2^{53}−1).

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

20.1.2.9 Number.MIN_VALUE

The value of Number.MIN_VALUE is the smallest positive value of the Number type, which is approximately 5 \times 10^{-324}.

In the IEEE-754 double precision binary representation, the smallest possible value is a denormalized number. If an implementation does not support denormalized values, the value of Number.MIN_VALUE must be the smallest non-zero positive value that can actually be represented by the implementation.

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

20.1.2.10 Number.NaN

The value of Number.NaN is NaN.

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 
20.1.2.11 Number.NEGATIVE_INFINITY

The value of Number.NEGATIVE_INFINITY is \(-\infty\).

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

20.1.2.12 Number.parseFloat ( string )

The value of the Number.parseFloat data property is the same built-in function object that is the value of the parseFloat property of the global object defined in 18.2.4.

20.1.2.13 Number.parseInt ( string, radix )

The value of the Number.parseInt data property is the same built-in function object that is the value of the parseInt property of the global object defined in 18.2.5.

20.1.2.14 Number.POSITIVE_INFINITY

The value of Number.POSITIVE_INFINITY is \(+\infty\).

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

20.1.2.15 Number.prototype

The initial value of Number.prototype is the intrinsic object %NumberPrototype% (20.1.3).

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

20.1.3 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 slot.

The value of the [[Prototype]] internal slot of the Number prototype object is the intrinsic object %ObjectPrototype% (19.1.3).

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 slot 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 slot, then
   a. Assert: value’s [[NumberData]] internal slot is a Number value.
   b. Return the value of value’s [[NumberData]] internal slot.
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.
20.1.3.1 Number.prototype.constructor

The initial value of `Number.prototype.constructor` is the intrinsic object `%Number%`.

20.1.3.2 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 `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. Assert: `f` is 0, when `fractionDigits` is `undefined`.
5. ReturnIfAbrupt(`f`).
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` = `+∞`, then
   a. Return the concatenation of the Strings `s` and "Infinity".
10. If `f` < 0 or `f` > 20, throw a `RangeError` exception. However, an implementation is permitted to extend the behaviour of `toExponential` for values of `f` less than 0 or greater than 20. In this case `toExponential` would not necessarily throw `RangeError` for such values.
11. If `x` = 0, then
    a. Let `m` be the String consisting of `f+1` occurrences of the code unit 0x0030.
    b. Let `e` = 0.
12. Else `x` ≠ 0, then
    a. If `fractionDigits` is not `undefined`, then
       i. Let `e` and `a` be integers such that `10^e ≤ a < 10^{e+1}` and for which the exact mathematical value of `n × 10^e` = `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 × 10^e` is larger.
       b. Else `fractionDigits` is `undefined`, then
          i. Let `e`, `n`, and `f` be integers such that `f ≥ 0`, `10^e ≤ n < 10^{e+1}`, the Number value for `n × 10^{-f}` is `x`, and `f` is as small as possible. Note that the decimal representation of `n` has `f+1` digits, `n` is not divisible by 10, and the least significant digit of `n` is not necessarily uniquely determined by these criteria.
          c. Let `m` be the String consisting of the digits of the decimal representation of `n` (in order, with no leading zeroes).
13. If `f` ≠ 0, then
    a. Let `a` be the first element of `m`, and let `b` be the remaining `f` elements of `m`.
    b. Let `m` be the concatenation of the three Strings `a`, ".", and `b`.
14. If `e` = 0, then
    a. Let `c` = "+".
    b. Let `d` = "0".
15. Else
    a. If `e` > 0, let `c` = "+".
    b. Else `e` ≤ 0,
       i. Let `c` = "-".
ii. Let \( e = -e \).

16. Let \( m \) be the concatenation of the four Strings \( m, "e", c, \) and \( d \).

17. 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 17).

**NOTE** For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 12.b.i be used as a guideline:

- Let \( e, n, \) and \( f \) be integers such that \( f \geq 0, 10^f \leq n < 10^{f+1} \), the Number value for \( n \times 10^{-f} \) is \( x \), and \( f \) is as small as possible. If there are multiple possibilities for \( n \), choose the value of \( n \) for which \( n \times 10^{-f} \) is closest in value to \( x \). If there are two such possible values of \( n \), choose the one that is even.

**20.1.3.3 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. However, an implementation is permitted to extend the behaviour of `toFixed` for values of \( f \) less than 0 or greater than 20. In this case `toFixed` would not necessarily throw RangeError for such values.
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 \( x < 10^{11} \),
    a. Let \( n \) be an integer for which the exact mathematical value of \( n \times 10^f - x \) 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 17).

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).toFixed()` returns "1000000000000000100", while `(1000000000000000128).toFixed(0)` returns "1000000000000000128".

20.1.3.4 `Number.prototype.toLocaleString([reserved1[,reserved2]]])`

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the `Number.prototype.toLocaleString` method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the `toLocaleString` method is used.

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`.

The meanings of the optional parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not use those parameter positions for anything else.

The `length` property of the `toLocaleString` method is 0.

20.1.3.5 `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` (7.1.12) instead. Specifically, perform the following steps:

1. Let `x` be this `Number` value (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 code unit U+002D (HYPHEN-MINUS).
   b. Let `x = –x`.
9. If `x = +∞`, then
   a. Return the String that is the concatenation of `s` and "Infinity".
10. If `p < 1` or `p > 21`, throw a `RangeError` exception. However, an implementation is permitted to extend the behaviour of `toPrecision` for values of `p` less than 1 or greater than 21. In this case `toPrecision` would not necessarily throw `RangeError` for such values.
11. If `x = 0`, then
    a. Let `m` be the String consisting of `p` occurrences of the code unit U+0030 (DIGIT ZERO).
    b. Let `e = 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 \( n \times 10^{p+1} \times x \) is as close to zero as possible. If there are two such sets of \( e \) and \( n \), pick the \( e \) and \( n \) for which \( n \times 10^{p+1} \) 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. Assert: \( e \neq 0 \)
      ii. Let \( a \) be the first element of \( m \), and let \( b \) be the remaining \( p-1 \) elements of \( m \).
      iii. Let \( m \) be the concatenation of \( a \), code unit U+002E (FULL STOP), and \( b \).
      iv. If \( e > 0 \), then
         1. Let \( c \) be code unit U+002B (PLUS SIGN).
      v. Else \( e < 0 \),
         1. Let \( c \) be code unit U+002D (HYPHEN-MINUS).
         2. Let \( e = -e \).
      vi. Let \( d \) be the String consisting of the digits of the decimal representation of \( e \) (in order, with no leading zeroes).
      vii. Return the concatenation of \( s \), \( m \), code unit U+0065 (LATIN SMALL LETTER E), \( c \), and \( d \).
   13. If \( e = p-1 \), 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 U+002E (FULL STOP), and the remaining \( p-(e+1) \) elements of \( m \).
   15. Else \( e < 0 \),
      a. Let \( m \) be the String formed by the concatenation of code unit U+0030 (DIGIT ZERO), code unit U+002E (FULL STOP), \(-e\) occurrences of code unit U+0030 (DIGIT ZERO), and the String \( m \).
   16. Return the String that is the concatenation of \( s \) and \( m \).

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 17).

20.1.3.6 Number.prototype.toString ([radix])

**NOTE** The optional \( \text{radix} \) should be an integer value in the inclusive range 2 to 36. If \( \text{radix} \) not present or is undefined the Number 10 is used as the value of \( \text{radix} \).

The following steps are performed:

1. Let \( x \) be thisNumberValue(this value).
2. ReturnIfAbrupt(x).
3. If \( \text{radix} \) is not present, let \( \text{radixNumber} \) be 10.
4. Else if \( \text{radix} \) is undefined, let \( \text{radixNumber} \) be 10.
5. Else let \( \text{radixNumber} \) be ToInteger(radix).
6. ReturnIfAbrupt(radixNumber).
7. If \( \text{radixNumber} < 2 \) or \( \text{radixNumber} > 36 \), throw a RangeError exception.
8. If \( \text{radixNumber} = 10 \), return ToString(x).
9. Return the String representation of this Number value using the radix specified by \( \text{radixNumber} \).
   Letters a-z are used for digits with values 10 through 35. The precise algorithm is implementation-dependent, however the algorithm should be a generalization of that specified in 7.1.12.1.
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.

20.1.3.7 `Number.prototype.valueOf()`

1. Let `x` be `this.NumberValue(this value)`.
2. Return `x`.

20.1.4 Properties of Number Instances

Number instances are ordinary objects that inherit properties from the `Number` prototype object. Number instances also have a `[[NumberData]]` internal slot. The `[[NumberData]]` internal slot is the Number value represented by this Number object.

20.2 The Math Object

The Math object is a single ordinary object.

The value of the `[[Prototype]]` internal slot of the Math object is the intrinsic object `%ObjectPrototype%` (19.1.3).

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 6.1.6.

20.2.1 Value Properties of the Math Object

20.2.1.1 `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` }.

20.2.1.2 `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` }.

20.2.1.3 `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` }.

20.2.1.4 `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.

20.2.1.5 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.

20.2.1.6 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 }.

20.2.1.7 Math.SQRT1_2

The Number value for the square root of ½, 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.

20.2.1.8 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 }.

20.2.1.9 Math @@toStringTag

The initial value of the @@toStringTag property is the string value "Math".

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

20.2.2 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, the function performs a computation on the resulting Number value(s). The value returned by each function is a Number.

In the function descriptions below, the symbols NaN, -0, +0, -∞ and +∞ refer to the Number values described in 6.1.6.
NOTE     The behaviour of the functions `acos`, `acosh`, `asin`, `asinh`, `atan`, `atanh`, `atan2`, `cbrt`, `cos`, `cosh`, `exp`, `expm1`, `hypot`, `log`, `log1p`, `log2`, `log10`, `pow`, `random`, `sin`, `sinh`, `sqrt`, `tan`, and `tanh` 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).

20.2.2.1 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 -∞, the result is +∞.

20.2.2.2 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 +π.

- If `x` is NaN, the result is NaN.
- If `x` is greater than 1, the result is NaN.
- If `x` is less than -1, the result is NaN.
- If `x` is exactly 1, the result is +0.

20.2.2.3 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 +∞, the result is +∞.

20.2.2.4 Math.asin( x )

Returns an implementation-dependent approximation to the arc sine of `x`. The result is expressed in radians and ranges from -π/2 to +π/2.

- If `x` is NaN, the result is NaN.
- If `x` is greater than 1, the result is NaN.
- If `x` is less than -1, the result is NaN.
- If `x` is +0, the result is +0.
- If `x` is -0, the result is -0.

20.2.2.5 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 −\(\infty\).

20.2.2.6 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 −\(\pi/2\).

20.2.2.7 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 +0.
• If \(x\) is +0, the result is +0.
• If \(x\) is −0, the result is −0.

20.2.2.8 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 \(x = +0\), the result is an implementation-dependent approximation to +\(\pi/2\).
• If \(y > 0\) and \(x = −0\), the result is an implementation-dependent approximation to +\(\pi/2\).
• If \(y = +0\) and \(x > 0\), the result is +0.
• If \(y = +0\) and \(x = +0\), the result is +0.
• If \(y = +0\) and \(x = −0\), the result is an implementation-dependent approximation to +\(\pi\).
• If \(y = −0\) and \(x > 0\), the result is −0.
• If \(y = −0\) and \(x = +0\), the result is −0.
• If \(y = −0\) and \(x = −0\), the result is an implementation-dependent approximation to −\(\pi\).
• If \(y < 0\) and \(x = +0\), the result is an implementation-dependent approximation to −\(\pi\).
• If \(y < 0\) and \(x = −0\), the result is an implementation-dependent approximation to −\(\pi/2\).
• If \(y < 0\) and \(x = +0\), the result is an implementation-dependent approximation to −\(\pi/2\).
• If \(y > 0\) and \(y\) is finite and \(x = +\infty\), the result is +0.
• If \(y > 0\) and \(y\) is finite and \(x = −\infty\), the result is an implementation-dependent approximation to +\(\pi\).
• If \(y < 0\) and \(y\) is finite and \(x = +\infty\), the result is −0.
• If \( y < 0 \) and \( y \) is finite and \( x \) is \(-\infty\), the result is an implementation-dependent approximation to \(-\pi\).
• If \( y \) is \(+\infty\) and \( x \) is finite, the result is an implementation-dependent approximation to \(+\pi/2\).
• If \( y \) is \(-\infty\) and \( x \) is finite, the result is an implementation-dependent approximation to \(-\pi/2\).
• If \( y \) is \(+\infty\) and \( x \) is \(-\infty\), the result is an implementation-dependent approximation to \(+\pi/4\).
• If \( y \) is \(+\infty\) and \( x \) is \(+\infty\), the result is an implementation-dependent approximation to \(-\pi/4\).
• If \( y \) is \(-\infty\) and \( x \) is \(+\infty\), the result is an implementation-dependent approximation to \(+3\pi/4\).
• If \( y \) is \(-\infty\) and \( x \) is \(-\infty\), the result is an implementation-dependent approximation to \(+\pi/4\).

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 \(-\infty\).

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 \(-\infty\).

The value of Math.ceil (x) is the same as the value of \(-\text{Math.floor}(-x)\).

Math.clz32 (x)

When Math.clz32 is called with one argument \( x \), the following steps are taken:

1. Let \( n \) be ToUint32(x).
2. Let \( p \) be the number of leading zero bits in the 32-bit binary representation of \( n \).
3. 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.

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.
20.2.2.13 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 +∞, the result is +∞.
- If x is −∞, the result is +∞.

NOTE The value of \( \cosh(x) \) is the same as \( \exp(x) + \exp(-x)/2 \).

20.2.2.14 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 +∞, the result is +∞.
- If x is −∞, the result is +0.

20.2.2.15 Math.expm1 (x)

Returns an implementation-dependent approximation to subtracting 1 from the exponential function of x (e 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 to 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 +∞, the result is +∞.
- If x is −∞, the result is −1.

20.2.2.16 Math.floor (x)

Retruns the greatest (closest to +∞) 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 +∞, the result is +∞.
- If x is −∞, the result is −∞.
- 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).

20.2.2.17 Math.fround (x)

When Math.fround is called with argument x the following steps are taken:
1. If \( x \) is NaN, return NaN.
2. If \( x \) is one of +0, −0, +\( \infty \), −\( \infty \), return \( x \).
3. Let \( x_{32} \) be the result of converting \( x \) to a value in IEEE-754-2008 binary32 format using `roundTiesToEven`.
4. Let \( x_{64} \) be the result of converting \( x_{32} \) to a value in IEEE-754-2008 binary64 format.
5. Return the ECMAScript Number value corresponding to \( x_{64} \).

### 20.2.2.18 Math.hypot (value1, value2, ...values)

`Math.hypot` returns an implementation-dependent approximation of the square root of the sum of squares of its arguments.

- If no arguments are passed, 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.

The length property of the `hypot` function is 2.

**NOTE** Implementations should take care to avoid the loss of precision from overflows and underflows that are prone to occur in naive implementations when this function is called with two or more arguments.

### 20.2.2.19 Math.imul (x, y)

When the `Math.imul` is called with arguments \( x \) and \( y \) the following steps are taken:

1. Let \( a \) be `ToUint32(x)`.
2. Let \( b \) be `ToUint32(y)`.
3. Let `product` be \((a \times b)\) modulo 2\(^{32}\).
4. If `product` ≥ 2\(^{31}\), return `product` − 2\(^{32}\), otherwise return `product`.

### 20.2.2.20 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 +\( \infty \).

### 20.2.2.21 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 +\( \infty \).
20.2.2.22 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 +\(\infty\).

20.2.2.23 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 +\(\infty\).

20.2.2.24 Math.max ( value1, value2, …, values )

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 (7.2.9) except that +0 is considered to be larger than \(-0\).

The length property of the max method is 2.

20.2.2.25 Math.min ( value1, value2, …, values )

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 (7.2.9) except that +0 is considered to be larger than \(-0\).

The length property of the min method is 2.

20.2.2.26 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 +\( \infty \).
• 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 −\( \infty \).
• If \( y < 0 \) and \( x \) is finite and \( y \) is not an odd integer, the result is NaN.

20.2.2.27 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.

Each Math.random function created for distinct code Realms must produce a distinct sequence of values from successive calls.

20.2.2.28 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 not always the same as the value of Math.floor(\( x + 0.5 \)). When \( x \) is −0 or is less than 0 but greater than or equal to −0.5, Math.round(\( x \)) returns −0, but Math.floor(\( x + 0.5 \)) returns...
+0. Math.round(x) may also differ from the value of Math.floor(x+0.5) because of internal rounding when computing x+0.5.

20.2.2.29 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.

20.2.2.30 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 +∞ or –∞, the result is NaN.

20.2.2.31 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 +∞, the result is +∞.
- If x is –∞, the result is –∞.

NOTE The value of sinh(x) is the same as (exp(x) - exp(-x))/2.

20.2.2.32 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 +∞, the result is +∞.

20.2.2.33 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.

**20.2.2.34 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 \((\exp(x) - \exp(-x))/(\exp(x) + \exp(-x))\).

**20.2.2.35 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 \( -\infty \).
- If \( x \) is greater than 0 but less than 1, the result is +0.
- If \( x \) is less than 0 but greater than \( -1 \), the result is –0.

**20.3 Date Objects**

**20.3.1 Overview of Date Objects and Definitions of Abstract Operations**

The following functions are abstract operations that operate on time values (defined in 20.3.1.1). Note that, in every case, if any argument to one of these functions is NaN, the result will be NaN.

**20.3.1.1 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.
20.3.1.2 Day Number and Time within Day

A given time value \( t \) belongs to day number

\[
\text{Day}(t) = \text{floor}(t / \text{msPerDay})
\]

where the number of milliseconds per day is

\[
\text{msPerDay} = 86400000
\]

The remainder is called the time within the day:

\[
\text{TimeWithinDay}(t) = t \mod \text{msPerDay}
\]

20.3.1.3 Year Number

ECMAScript uses an extrapolated Gregorian system to map a day number to a year number and to determine the month and date within that year. In this system, leap years are precisely those which are (divisible by 4) and (not divisible by 100) or (divisible by 400)). The number of days in year number \( y \) is therefore defined by

\[
\text{DaysInYear}(y) = \begin{cases} 
365 & \text{if } (y \mod 4) \neq 0 \\
366 & \text{if } (y \mod 4) = 0 \text{ and } (y \mod 100) \neq 0 \\
365 & \text{if } (y \mod 100) = 0 \text{ and } (y \mod 400) \neq 0 \\
366 & \text{if } (y \mod 400) = 0
\end{cases}
\]

All non-leap years have 365 days with the usual number of days per month and leap years have an extra day in February. The day number of the first day of year \( y \) is given by:

\[
\text{DayFromYear}(y) = 365 \times (y-1970) + \text{floor}((y-1969)/4) - \text{floor}((y-1901)/100) + \text{floor}(y-1601)/400
\]

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:

\[
\text{InLeapYear}(t) = \begin{cases} 
0 & \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 365 \\
1 & \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 366
\end{cases}
\]

20.3.1.4 Month Number

Months are identified by an integer in the range 0 to 11, inclusive. The mapping \( \text{MonthFromTime}(t) \) from a time value \( t \) to a month number is defined by:

\[
\text{MonthFromTime}(t) = \begin{cases} 
0 & \text{if } 0 \leq \text{DayWithinYear}(t) < 31 \\
1 & \text{if } 31 \leq \text{DayWithinYear}(t) < 59 + \text{InLeapYear}(t) \\
2 & \text{if } 59 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 90 + \text{InLeapYear}(t) \\
3 & \text{if } 90 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 120 + \text{InLeapYear}(t) \\
4 & \text{if } 120 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 151 + \text{InLeapYear}(t) \\
5 & \text{if } 151 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 181 + \text{InLeapYear}(t) \\
6 & \text{if } 181 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 212 + \text{InLeapYear}(t)
\end{cases}
\]
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 MonthFromTime(0) = 0, corresponding to Thursday, 01 January, 1970.

20.3.1.5 Date Number

A date number is identified by an integer in the range 1 through 31, inclusive. The mapping DateFromTime(t) from a time value t to a date number is defined by:

\[
\begin{align*}
\text{DateFromTime}(t) &= \text{DayWithinYear}(t)+1 & \text{if MonthFromTime}(t)=0 \\
&= \text{DayWithinYear}(t) - 30 & \text{if MonthFromTime}(t)=1 \\
&= \text{DayWithinYear}(t) - 58 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=2 \\
&= \text{DayWithinYear}(t) - 89 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=3 \\
&= \text{DayWithinYear}(t) - 119 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=4 \\
&= \text{DayWithinYear}(t) - 150 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=5 \\
&= \text{DayWithinYear}(t) - 180 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=6 \\
&= \text{DayWithinYear}(t) - 211 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=7 \\
&= \text{DayWithinYear}(t) - 242 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=8 \\
&= \text{DayWithinYear}(t) - 272 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=9 \\
&= \text{DayWithinYear}(t) - 303 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=10 \\
&= \text{DayWithinYear}(t) - 333 - \text{InLeapYear}(t) & \text{if MonthFromTime}(t)=11
\end{align*}
\]

20.3.1.6 Week Day

The weekday for a particular time value t is defined as

\[
\text{WeekDay}(t) = (\text{Day}(t) + 4) \mod 7
\]

A weekday value of 0 specifies Sunday; 1 specifies Monday; 2 specifies Tuesday; 3 specifies Wednesday; 4 specifies Thursday; 5 specifies Friday; and 6 specifies Saturday. Note that WeekDay(0) = 4, corresponding to Thursday, 01 January, 1970.

20.3.1.7 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 http://www.iana.org/time-zones/.
20.3.1.8 Daylight Saving Time Adjustment

An implementation dependent algorithm using best available information on time zones to determine the local daylight saving time adjustment DaylightSavingTA(t), measured in milliseconds. An implementation of ECMAScript is expected to make its best effort to determine the local daylight saving time adjustment.

NOTE It is recommended that implementations use the time zone information of the IANA Time Zone Database http://www.iana.org/time-zones.

20.3.1.9 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 UTC(LocalTime(t)) is not necessarily always equal to t.

20.3.1.10 Hours, Minutes, Second, and Milliseconds

The following functions are useful in decomposing time values:

- \( \text{HourFromTime}(t) = \text{floor}(t / \text{msPerHour}) \mod \text{HoursPerDay} \)
- \( \text{MinFromTime}(t) = \text{floor}(t / \text{msPerMinute}) \mod \text{MinutesPerHour} \)
- \( \text{SecFromTime}(t) = \text{floor}(t / \text{msPerSecond}) \mod \text{SecondsPerMinute} \)
- \( \text{msFromTime}(t) = t \mod \text{msPerSecond} \)

where

- \( \text{HoursPerDay} = 24 \)
- \( \text{MinutesPerHour} = 60 \)
- \( \text{SecondsPerMinute} = 60 \)
- \( \text{msPerSecond} = 1000 \)
- \( \text{msPerMinute} = 60000 = \text{msPerSecond} \times \text{SecondsPerMinute} \)
- \( \text{msPerHour} = 3600000 = \text{msPerMinute} \times \text{MinutesPerHour} \)

20.3.1.11 MakeTime (hour, min, sec, ms)

The operator MakeTime calculates a number of milliseconds from its four arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If `hour` is not finite or `min` is not finite or `sec` is not finite or `ms` is not finite, return NaN.
2. Let \( h \) be `ToInteger(hour)`.
3. Let \( m \) be `ToInteger(min)`.
4. Let \( s \) be `ToInteger(sec)`.
5. Let \( milli \) be `ToInteger(ms)`.
6. Let \( t \) be \( h \times \text{msPerHour} + m \times \text{msPerMinute} + s \times \text{msPerSecond} + milli \), performing the arithmetic according to IEEE 754 rules (that is, as if using the ECMAScript operators \(*\) and \(+\)).
7. Return \( t \)
20.3.1.12 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 \( \text{YearFromTime}(t) \) is \( ym \) and \( \text{MonthFromTime}(t) \) is \( mn \) and \( \text{DateFromTime}(t) \) is 1; but if this is not possible (because some argument is out of range), return `NaN`.
8. Return \( \text{Day}(t) + dt - 1 \).

20.3.1.13 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 \( \text{day} \times \text{msPerDay} + \text{time} \).

20.3.1.14 TimeClip (time)

The operator TimeClip calculates a number of milliseconds from its argument, which must be an ECMAScript Number value. This operator functions as follows:

1. If `time` is not finite, return `NaN`.
2. If \( \text{abs}(\text{time}) > 8.64 \times 10^{15} \), return `NaN`.
3. Return \( \text{ToInteger}(\text{time}) + +0 \). (Adding a positive zero converts \(-0\) to \(+0\).)

NOTE The point of step 3 is that an implementation is permitted a choice of internal representations of time values, for example as a 64-bit signed integer or as a 64-bit floating-point value. Depending on the implementation, this internal representation may or may not distinguish \(-0\) and \(+0\).

20.3.1.15 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” 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.

20.3.1.15.1 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:

-283457-03-21T15:00:59.908Z 283458 B.C.
-000001-01-01T00:00:00Z 2 B.C.
+000000-01-01T00:00:00Z 1 B.C.
+000000-01-01T00:00:00Z 1 A.D.
20.3.2 The Date Constructor

The Date constructor is the %Date% intrinsic object and the initial value of the Date property of the global object. When called as a constructor it creates and initializes a new Date object. When Date is called as a function rather than as a constructor, it returns a String representing the current time (UTC).

The Date constructor is a single function whose behaviour is overloaded based upon the number and types of its arguments.

The Date constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified Date behaviour must include a super call to the Date constructor to create and initialize the subclass instance with a [[DateValue]] internal slot.

20.3.2.1 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 function call.
3. If NewTarget is not 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, let dt be ToNumber(date); else let dt be 1.
   f. ReturnIfAbrupt(dt).
   g. If hours is supplied, let h be ToNumber(hours); else let h be 0.
   h. ReturnIfAbrupt(h).
   i. If minutes is supplied, let min be ToNumber(minutes); else let min be 0.
   j. ReturnIfAbrupt(min).
   k. If seconds is supplied, let s be ToNumber(seconds); else let s be 0.
   l. ReturnIfAbrupt(s).
   m. If ms is supplied, let milli be ToNumber(ms); else let milli be 0.
   n. ReturnIfAbrupt(milli).
   o. If y is not NaN and 0 ≤ ToInteger(y) ≤ 99, let yr be 1900+ToInteger(y); otherwise, let yr be y.
   p. Let finalDate be MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli)).
   q. Let O be OrdinaryCreateFromConstructor(NewTarget, "%DatePrototype%", « [[DateValue]] »).
   r. ReturnIfAbrupt(O).
   s. Set the [[DateValue]] internal slot of O to TimeClip(UTC(finalDate)).
   t. Return O.
4. Else,
   a. Let now be the Number that is the time value (UTC) identifying the current time.
   b. Return ToDateString(now).
20.3.2.2 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 function call.
3. If `NewTarget` is not `undefined`, then
   a. If `Type(value)` is `Object` and `value` has a `[[DateValue]]` internal slot, then
      i. Let `tv` be `thisTimeValue(value)`.
   b. Else,
      i. Let `v` be `ToPrimitive(value)`.
         ii. If `Type(v)` is `String`, then
            1. Let `tv` be the result of parsing `v` as a date, in exactly the same manner as for the `parse` method (20.3.3.2). If the parse resulted in an abrupt completion, `tv` is the Completion Record.
            iii. Else,
               1. Let `tv` be `ToNumber(v)`.
      c. ReturnIfAbrupt(`tv`).
   d. Let `O` be `OrdinaryCreateFromConstructor(NewTarget, "%DatePrototype%", "[[DateValue]]")`.
   e. ReturnIfAbrupt(`O`).
   f. Set the `[[DateValue]]` internal slot of `O` to `TimeClip(tv)`.
   g. Return `O`.
4. Else,
   a. Let `now` be the Number that is the time value (UTC) identifying the current time.
   b. Return `ToDateString(now)`.

20.3.3 Properties of the Date Constructor

The value of the `[[Prototype]]` internal slot of the Date constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the `length` property (whose value is 7), the Date constructor has the following properties:
20.3.3.1 Date.now()

The \texttt{now} function returns a \texttt{Number} value that is the time value designating the UTC date and time of the occurrence of the call to \texttt{now}.

20.3.3.2 Date.parse ( string )

The \texttt{parse} function applies the \texttt{ToString} operator to its argument. If \texttt{ToString} results in an abrupt completion the Completion Record is immediately returned. Otherwise, \texttt{parse} interprets the resulting String as a date and time; it returns a \texttt{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 (including extended years) called out in Date Time String Format (20.3.1.15). If the String does not conform to that format the function may fall back to any implementation-specific heuristics or implementation-specific date formats. Unrecognizable Strings or dates containing illegal element values in the format String shall cause \texttt{Date.parse} to return \texttt{NaN}.

If \texttt{x} is any \texttt{Date} object whose milliseconds amount is zero within a particular implementation of ECMAScript, then all of the following expressions should produce the same numeric value in that implementation, if all the properties referenced have their initial values:

\begin{verbatim}
    x.valueOf()
    Date.parse(x.toString())
    Date.parse(x.toUTCString())
    Date.parse(x.toISOString())
\end{verbatim}

However, the expression

\begin{verbatim}
    Date.parse(x.toLocaleString())
\end{verbatim}

is not required to produce the same \texttt{Number} value as the preceding three expressions and, in general, the value produced by \texttt{Date.parse} is implementation-dependent when given any String value that does not conform to the Date Time String Format (20.3.1.15) and that could not be produced in that implementation by the \texttt{toString} or \texttt{toUTCString} method.

20.3.3.3 Date.prototype

The initial value of \texttt{Date.prototype} is the intrinsic object \texttt{%DatePrototype%} (20.3.4).

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

20.3.3.4 Date.UTC ( year , month [ , date [ , hours [ , minutes [ , seconds [ , ms ] ] ] ] ] )

When the \texttt{UTC} function is called with fewer than two arguments, the behaviour is implementation-dependent. When the \texttt{UTC} function is called with two to seven arguments, it computes the date from \texttt{year}, \texttt{month} and (optionally) \texttt{date}, \texttt{hours}, \texttt{minutes}, \texttt{seconds} and \texttt{ms}. The following steps are taken:

1. Let \texttt{y} be \texttt{ToNumber(year)}.
2. ReturnIfAbrupt(y).
3. Let \texttt{m} be \texttt{ToNumber(month)}.
4. ReturnIfAbrupt(m).
5. If \texttt{date} is supplied, let \texttt{dt} be \texttt{ToNumber(date)}; else let \texttt{dt} be \texttt{1}.
6. ReturnIfAbrupt(dt).
7. If \texttt{hours} is supplied, let \texttt{h} be \texttt{ToNumber(hours)}; else let \texttt{h} be \texttt{0}.
8. ReturnIfAbrupt(h).
9. If `minutes` is supplied, let `min` be `ToNumber(minutes)`; else let `min` be 0.
10. ReturnIfAbrupt(min).
11. If `seconds` is supplied, let `s` be `ToNumber(seconds)`; else let `s` be 0.
12. ReturnIfAbrupt(s).
13. If `ms` is supplied, let `milli` be `ToNumber(ms)`; else let `milli` be 0.
14. ReturnIfAbrupt(milli).
15. If `y` is not `NaN` and `0 ≤ ToInteger(y) ≤ 99`, let `yr` be `1900+ToInteger(y)`; otherwise, let `yr` be `y`.
16. Return TimeClip(MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli))).

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.

20.3.4 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 slot.

The value of the [[Prototype]] internal slot of the Date prototype object is the intrinsic object `%ObjectPrototype%` (20.3.4).

Unless explicitly defined 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 slot 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 slot, then
   a. Return the value of value's [[DateValue]] internal slot.
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. If the Type of the this value is not Object, a `TypeError` exception is thrown. 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.

20.3.4.1 Date.prototype.constructor

The initial value of `Date.prototype.constructor` is the intrinsic object `%Date%`.

20.3.4.2 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)).

20.3.4.3 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)).

20.3.4.4 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)).

20.3.4.5 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)).

20.3.4.6 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)).

20.3.4.7 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)).

20.3.4.8 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)).

20.3.4.9 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)).

20.3.4.10 Date.prototype.getTime ()

1. Return this time value.
20.3.4.11 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 \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( (t - \text{LocalTime}(t)) / \text{msPerMinute} \).

20.3.4.12 Date.prototype.getUTCDate ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{DateFromTime}(t) \).

20.3.4.13 Date.prototype.getUTCDay ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{WeekDay}(t) \).

20.3.4.14 Date.prototype.getUTCFullYear ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{YearFromTime}(t) \).

20.3.4.15 Date.prototype.getUTCHours ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{HourFromTime}(t) \).

20.3.4.16 Date.prototype.getUTCMilliseconds ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{msFromTime}(t) \).

20.3.4.17 Date.prototype.getUTCMilliseconds ( )

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
4. Return \( \text{msFromTime}(t) \).
20.3.4.18 Date.prototype.getUTCMonth ( )
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return MonthFromTime(\( t \)).

20.3.4.19 Date.prototype.getUTCSeconds ( )
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return SecFromTime(\( t \)).

20.3.4.20 Date.prototype.setDate ( date )
1. Let \( t \) be the result of LocalTime(this time value).
2. Let \( dt \) be ToNumber(\( date \)).
3. ReturnIfAbrupt(\( dt \)).
4. Let \( newDate \) be MakeDate(MakeDay(YearFromTime(\( t \)), MonthFromTime(\( t \)), \( dt \)), TimeWithinDay(\( t \))).
5. Let \( u \) be TimeClip(UTC(\( newDate \))).
6. Set the [[DateValue]] internal slot of this Date object to \( u \).
7. Return \( u \).

20.3.4.21 Date.prototype.setFullYear ( year [, month [, date ] ] )
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. ReturnIfAbrupt(\( y \)).
4. If \( month \) is not specified, let \( m \) be MonthFromTime(\( t \)); otherwise, let \( m \) be ToNumber(\( month \)).
5. ReturnIfAbrupt(\( m \)).
6. If \( date \) is not specified, let \( dt \) be DateFromTime(\( t \)); otherwise, let \( dt \) be ToNumber(\( date \)).
7. ReturnIfAbrupt(\( dt \)).
8. Let \( newDate \) be MakeDate(MakeDay(\( y \), \( m \), \( dt \)), TimeWithinDay(\( t \))).
9. Let \( u \) be TimeClip(UTC(\( newDate \))).
10. Set the [[DateValue]] internal slot of this Date object to \( u \).
11. Return \( u \).

The length property of the setFullYear method is 3.

NOTE If \( month \) is not specified, this method behaves as if \( month \) were specified with the value getMonth(). If \( date \) is not specified, it behaves as if \( date \) were specified with the value getDate().

20.3.4.22 Date.prototype.setHours ( hour [, min [, sec [, ms ] ] ] )
1. Let \( t \) be the result of LocalTime(this time value).
2. Let \( h \) be ToNumber(\( hour \)).
3. ReturnIfAbrupt(\( h \)).
4. If \( min \) is not specified, let \( m \) be MinFromTime(\( t \)); otherwise, let \( m \) be ToNumber(\( min \)).
5. ReturnIfAbrupt(\( m \)).
6. If \( sec \) is not specified, let \( s \) be SecFromTime(\( t \)); otherwise, let \( s \) be ToNumber(\( sec \)).
7. ReturnIfAbrupt(s).
8. If ms is not specified, let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
9. ReturnIfAbrupt(milli).
10. Let date be MakeDate(Day(t), MakeTime(h, m, s, milli)).
11. Let u be TimeClip(UTC(date)).
12. Set the [[DateValue]] internal slot of this Date object to u.
13. Return u.

The length property of the setHours method is 4.

NOTE If min is not specified, this method behaves as if min were specified with the value getMinutes(). If sec is not specified, it behaves as if sec were specified with the value getSeconds(). If ms is not specified, it behaves as if ms were specified with the value getMilliseconds().

20.3.4.23 Date.prototype.setMilliseconds (ms)
1. Let t be the result of LocalTime(this time value).
2. Let ms be ToNumber(ms).
3. ReturnIfAbrupt(ms).
4. Let time be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), ms).
5. Let u be TimeClip(UTC(MakeDate(Day(t), time))).
6. Set the [[DateValue]] internal slot of this Date object to u.
7. Return u.

20.3.4.24 Date.prototype.setMinutes (min [, sec [, ms ]] )
1. Let t be the result of LocalTime(this time value).
2. Let m be ToNumber(min).
3. ReturnIfAbrupt(m).
4. If sec is not specified, let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
5. ReturnIfAbrupt(s).
6. If ms is not specified, let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
7. ReturnIfAbrupt(milli).
8. Let date be MakeDate(Day(t), MakeTime(HourFromTime(t), m, s, milli)).
9. Let u be TimeClip(UTC(date)).
10. Set the [[DateValue]] internal slot of this Date object to u.
11. Return u.

The length property of the setMinutes method is 3.

NOTE If sec is not specified, this method 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().

20.3.4.25 Date.prototype.setMonth ( month [, date ] )
1. Let t be the result of LocalTime(this time value).
2. Let m be ToNumber(month).
3. ReturnIfAbrupt(m).
4. If date is not specified, let dt be DateFromTime(t); otherwise, let dt be ToNumber(date).
5. ReturnIfAbrupt(dt).
6. Let newDate be MakeDate(MakeDay(YearFromTime(t), m, dt), TimeWithinDay(t)).
7. Let u be TimeClip(UTC(newDate)).
8. Set the [[DateValue]] internal slot of this Date object to `u`.
9. Return `u`.

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

NOTE If `date` is not specified, this method behaves as if `date` were specified with the value `getDay()`.

20.3.4.26 `Date.prototype.setSeconds ( sec [, ms ] )`

1. Let `t` be the result of `LocalTime(this time value)`.
2. Let `s` be `ToNumber(sec)`.
3. ReturnIfAbrupt(`s`).
4. If `ms` is not specified, let `milli` be `msFromTime(t)`; otherwise, let `milli` be `ToNumber(ms)`.
5. ReturnIfAbrupt(`milli`).
6. Let `date` be `MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s, milli))`.
7. Let `u` be `TimeClip(UTC(date))`.
8. Set the `[[DateValue]]` internal slot of this Date object to `u`.
9. Return `u`.

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

NOTE If `ms` is not specified, this method behaves as if `ms` were specified with the value `getMilliseconds()`.

20.3.4.27 `Date.prototype.setTime ( time )`

1. Let `t` be `ToNumber(time)`.
2. ReturnIfAbrupt(`t`).
3. Let `v` be `TimeClip(t)`.
4. Set the `[[DateValue]]` internal slot of this Date object to `v`.
5. Return `v`.

20.3.4.28 `Date.prototype.setUTCDate ( date )`

1. Let `t` be this time value; but if this time value is `NaN`, let `t` be `+0`.
2. ReturnIfAbrupt(`t`).
3. Let `dt` be `ToNumber(date)`.
4. ReturnIfAbrupt(`dt`).
5. Let `newDate` be `MakeDate(MakeDay(YearFromTime(t), MonthFromTime(t), dt), TimeWithinDay(t))`.
6. Let `v` be `TimeClip(newDate)`.
7. Set the `[[DateValue]]` internal slot of this Date object to `v`.
8. Return `v`.

20.3.4.29 `Date.prototype.setUTCFullYear ( year [, month [, date ] ] )`

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. ReturnIfAbrupt(`y`).
5. If `month` is not specified, let `m` be `MonthFromTime(t)`; otherwise, let `m` be `ToNumber(month)`.
6. ReturnIfAbrupt(`m`).
7. If `date` is not specified, let `dt` be `DateFromTime(t)`; otherwise, let `dt` be `ToNumber(date)`.
8. ReturnIfAbrupt(dt).
9. Let newDate be MakeDate(MakeDay(y, m, dt), TimeWithinDay(t)).
10. Let v be TimeClip(newDate).
11. Set the [[DateValue]] internal slot of this Date object to v.
12. Return v.

The length property of the setUTCFullYear method is 3.

NOTE If month is not specified, this method behaves as if month were specified with the value getUTCMonth(). If date is not specified, it behaves as if date were specified with the value getUTCDate().

20.3.4.30 Date.prototype.setUTCHours ( hour [, min [, sec [, ms ]]] )

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let h be ToNumber(hour).
4. ReturnIfAbrupt(h).
5. If min is not specified, let m be MinFromTime(t); otherwise, let m be ToNumber(min).
6. ReturnIfAbrupt(m).
7. If sec is not specified, let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
8. ReturnIfAbrupt(s).
9. If ms is not specified, let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
10. ReturnIfAbrupt(milli).
11. Let newDate be MakeDate(Day(t), MakeTime(h, m, s, milli)).
12. Let v be TimeClip(newDate).
13. Set the [[DateValue]] internal slot of this Date object to v.

The length property of the setUTCHours method is 4.

NOTE If min is not specified, this method behaves as if min were specified with the value getUTCMinutes(). If sec is not specified, it behaves as if sec were specified with the value getUTCSeconds(). If ms is not specified, it behaves as if ms were specified with the value getUTCMilliseconds().

20.3.4.31 Date.prototype.setUTCMilliseconds ( ms )

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let milli be ToNumber(ms).
4. ReturnIfAbrupt(milli).
5. Let time be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), milli).
6. Let v be TimeClip(MakeDate(Day(t), time)).
7. Set the [[DateValue]] internal slot of this Date object to v.
8. Return v.

20.3.4.32 Date.prototype.setUTCMinutes ( min [, sec [, ms ] ] )

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let m be ToNumber(min).
4. If sec is not specified, let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
5. If ms is not specified, 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 slot of this Date object to `v`.

The `length` property of the `setUTCMilliseconds` method is `3`.

**NOTE** If `sec` is not specified, this method behaves as if `sec` were specified with the value `getUTCSeconds()`.
If `ms` is not specified, it function behaves as if `ms` were specified with the value returned by `getUTCMilliseconds()`.

20.3.4.33 `Date.prototype.setUTCMonth ( month [, date ] )`

1. Let `t` be this time value.
2. ReturnIfAbrupt(`t`).
3. Let `m` be `ToNumber(month)`.
4. If `date` is not specified, 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 slot of this Date object to `v`.
8. Return `v`.

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

**NOTE** If `date` is not specified, this method behaves as if `date` were specified with the value `getUTCDate()`.

20.3.4.34 `Date.prototype.setUTCSeconds ( sec [, ms ] )`

1. Let `t` be this time value.
2. ReturnIfAbrupt(`t`).
3. Let `s` be `ToNumber(sec)`.
4. If `ms` is not specified, 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 slot of this Date object to `v`.
8. Return `v`.

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

**NOTE** If `ms` is not specified, this method behaves as if `ms` were specified with the value `getUTCMilliseconds()`.

20.3.4.35 `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.

20.3.4.36 `Date.prototype.toISOString ()`

This function returns a String value representing the instance in time corresponding to this time value. The format of the String is the Date Time string format defined in 20.3.1.15. All fields are present in the String. The time zone is always UTC, denoted by the suffix Z. If this time value is not a finite Number or if
the year is not a value that can be represented in that format (if necessary using extended year format), a RangeError exception is thrown.

20.3.4.37 Date.prototype.toJSON (key)

This function provides a String representation of a Date object for use by JSON.stringify (24.3.2).

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 n be ToPrimitive(O, hint Number).
3. ReturnIfAbrupt(n).
4. If Type(n) is Number and n is not finite, return null.
5. Return Invoke(O, "toISOString").

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.

20.3.4.38 Date.prototype.toLocaleDateString ([reserved1, reserved2])

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the Date.prototype.toLocaleDateString method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the toLocaleDateString method is used.

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.

The meaning of the optional parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not use those parameter positions for anything else.

The length property of the toLocaleDateString method is 0.

20.3.4.39 Date.prototype.toLocaleString ([reserved1, reserved2])

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the Date.prototype.toLocaleString method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the toLocaleString method is used.

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.

The meaning of the optional parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not use those parameter positions for anything else.
The `length` property of the `toLocaleString` method is 0.

### 20.3.4.40 Date.prototype.toLocaleTimeString ( [ reserved1 ] , [ reserved2 ] )

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the `Date.prototype.toLocaleTimeString` method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the `toLocaleTimeString` method is used.

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.

The meaning of the optional parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not use those parameter positions for anything else.

The `length` property of the `toLocaleTimeString` method is 0.

### 20.3.4.41 Date.prototype.toString ()

The following steps are performed:

1. Let `O` be this Date object.
2. If `O` does not have a `[[DateValue]]` internal slot, then
   a. Let `tv` be NaN.
3. Else,
   a. Let `tv` be this time value.
4. Return `ToDateString(tv)`.

**NOTE** For any Date object `d` whose milliseconds amount is zero, the result of `Date.parse(d.toString())` is equal to `d.valueOf()`. See 20.3.3.2.

### 20.3.4.41.1 Runtime Semantics: `ToDateString(tv)` Abstract Operation

1. Assert: `Type(tv)` is Number.
2. If `tv` is NaN, return "Invalid Date".
3. Return an implementation-dependent String value that represents `tv` as a date and time in the current time zone using a convenient, human-readable form.

### 20.3.4.42 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.

### 20.3.4.43 Date.prototype.toUTCString ()

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent this time value 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 20.3.1.15. 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 20.3.1.15 but with a space rather than a "T" used to separate the date and time elements.

20.3.4.44 Date.prototype.valueOf( )

The valueOf function returns a Number, which is this time value.

20.3.4.45 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 object 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 the this value.
2. If Type(O) is not Object, 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).

The value of the name property of this function is "[Symbol.toPrimitive]".

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

20.3.5 Properties of Date Instances

Date instances are ordinary objects that inherit properties from the Date prototype object. Date instances also have a [[DateValue]] internal slot. The [[DateValue]] internal slot is the time value represented by this Date object.

21 Text Processing

21.1 String Objects

21.1.1 The String Constructor

The String constructor is the %String% intrinsic object and the initial value of the String property of the global object. When called as a constructor it creates and initializes a new String object. When String is called as a function rather than as a constructor, it performs a type conversion.

The String constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified String behaviour must include a super call to the String constructor to create and initialize the subclass instance with a [[StringData]] internal slot.

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21.1.1.1 String (value)

When String is called with argument value, the following steps are taken:

1. If no arguments were passed to this function invocation, let s be "".
2. Else,
   a. If NewTarget is undefined, and Type(value) is Symbol, return SymbolDescriptorString(value).
   b. Let s be ToString(value).
3. ReturnIfAbrupt(s).
4. If NewTarget is undefined, return s.
5. Return StringCreate(s, GetPrototypeFromConstructor(NewTarget, "StringPrototype")).

The length property of the String function is 1.

21.1.2 Properties of the String Constructor

The value of the [[Prototype]] internal slot of the String constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the String constructor has the following properties:

21.1.2.1 String.fromCharCode ( ...codeUnits )

The String.fromCharCode function may be called with any number of arguments which form the rest parameter codeUnits. The following steps are taken:

1. Let codeUnits be a List containing the arguments passed to this function.
2. Let length be the number of elements in codeUnits.
3. Let elements be a new List.
4. Let nextIndex be 0.
5. Repeat while nextIndex < length
   a. Let next be codeUnits[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.

21.1.2.2 String.fromCodePoint ( ...codePoints )

The String.fromCodePoint function may be called with any number of arguments which form the rest parameter codePoints. The following steps are taken:

1. Let codePoints be a List containing the arguments passed to this function.
2. Let length be number of elements in codePoints.
3. Let elements be a new List.
4. Let nextIndex be 0.
5. Repeat while nextIndex < length
   a. Let next be codePoints[nextIndex].
   b. Let nextCP be ToNumber(next).
c. ReturnIfAbrupt(nextCP).
d. If SameValue(nextCP, ToInteger(nextCP)) is false, throw a RangeError exception.
e. If nextCP ≤ 0 or nextCP > 0x10FFFF, throw a RangeError exception.
f. Append the elements of the UTF-16Encoding (10.1.1) 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 1.

21.1.2.3 String.prototype
The initial value of String.prototype is the intrinsic object %StringPrototype% (21.1.3).

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

21.1.2.4 String.raw (template, ...substitutions )
The String.raw function may be called with a variable number of arguments. The first argument is template and the remainder of the arguments form the List substitutions. The following steps are taken:
1. Let substitutions be a List consisting of all of the arguments passed to this function, starting with the second argument. If fewer than two arguments were passed, the List is empty.
2. Let numberOfSubstitutions be the number of elements in substitutions.
3. Let cooked be ToObject(template).
4. ReturnIfAbrupt(cooked).
5. Let rawValue be the result of Get(cooked, "raw").
6. Let raw be ToObject(rawValue).
7. ReturnIfAbrupt(raw).
8. Let literalSegments be the result of ToLength(Get(raw, "length")).
9. ReturnIfAbrupt(literalSegments).
10. If literalSegments ≤ 0, 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 code units are, in order, the elements in the List stringElements. If stringElements has no elements, the empty string is returned.
   g. If nextIndex < numberOfSubstitutions, let next be substitutions[nextIndex].
   h. Else, let next be the empty String.
   i. Let nextSub be ToString(next).
   j. ReturnIfAbrupt(nextSub).
   k. Append in order the code unit elements of nextSub to the end of stringElements.
   l. 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 (12.3.7). When called as such, the first argument will be a well formed template object and the rest parameter will contain the substitution values.

21.1.3 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 slot.

The value of the [[Prototype]] internal slot of the String prototype object is the intrinsic object %ObjectPrototype% (19.1.3).

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 slot 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 slot, then
   a. Assert: value’s [[StringData]] internal slot is a String value.
   b. Return the value of value’s [[StringData]] internal slot.
3. Throw a TypeError exception.

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.

21.1.3.1 String.prototype.charAt ( pos )

NOTE Returns a single element String containing the code unit at index pos in the String value resulting from converting this object to a String. If there is no element at that index, 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 RequireObjectCoercible(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 the empty String.
8. Return a String of length 1, containing one code unit from S, namely the code unit at index position.

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.
21.1.3.2 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 index pos in the String resulting from converting this object to a String. If there is no element at that index, the result is NaN.

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

1. Let O be RequireObjectCoercible(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 NaN.
8. Return a value of Number type, whose value is the code unit value of the element at index position in the String S.

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.

21.1.3.3 String.prototype.codePointAt (pos)

NOTE Returns a nonnegative integer Number less than 1114112 (0x110000) that is the code point value of the UTF-16 encoded code point (6.1.4) starting at the string element at index pos in the String resulting from converting this object to a String. If there is no element at that index, the result is undefined. If a valid UTF-16 surrogate pair does not begin at pos, the result is the code unit at pos.

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

1. Let O be RequireObjectCoercible(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, 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, return first.
12. Return ((first - 0xD800) × 1024) + (second - 0xDC00) + 0x10000.

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.

21.1.3.4 String.prototype.concat (...args)

NOTE When the concat method is called it returns a String consisting of the code units of the this object (converted to a String) followed by the code units of each of the arguments converted to a String. The result is a String value, not a String object.

When the concat method is called with zero or more arguments the following steps are taken:

1. Let O be RequireObjectCoercible(this value).
2. Let \( S \) be \( \text{toString}(O) \).
3. ReturnIfAbrupt(\( S \)).
4. Let \( \text{args} \) be a List whose elements are the arguments passed to this function.
5. Let \( R \) be \( S \).
6. Repeat, while \( \text{args} \) is not empty
   a. Remove the first element from \( \text{args} \) and let \( \text{next} \) be the value of that element.
   b. Let \( \text{nextString} \) be \( \text{toString}(\text{next}) \)
   c. ReturnIfAbrupt(\( \text{nextString} \)).
   d. Let \( R \) be the String value consisting of the code units of the previous value of \( R \) followed by the code units of \( \text{nextString} \).
7. Return \( R \).

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

\textbf{NOTE} The \texttt{concat} function is intentionally generic; it does not require that its \texttt{this} value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

\textbf{21.1.3.5} \texttt{String.prototype.constructor}  
The initial value of \( \text{String.prototype.constructor} \) is the intrinsic object \( \%\text{String}\% \).

\textbf{21.1.3.6} \texttt{String.prototype.endsWith ( searchString [, endPosition] )}  
The following steps are taken:
1. Let \( O \) be \( \text{RequireObjectCoercible(this value)} \).
2. Let \( S \) be \( \text{toString}(O) \).
3. ReturnIfAbrupt(\( S \)).
4. Let \( \text{isRegExp} \) be \( \text{IsRegExp(searchString)} \).
5. ReturnIfAbrupt(\( \text{isRegExp} \)).
6. If \( \text{isRegExp} \) is \texttt{true}, throw a \texttt{TypeError} exception.
7. Let \( \text{searchStr} \) be \( \text{toString(searchString)} \).
8. ReturnIfAbrupt(\( \text{searchStr} \)).
9. Let \( \text{len} \) be the number of elements in \( S \).
10. If \( \text{endPosition} \) is \texttt{undefined}, let \( \text{pos} \) be \( \text{len} \), else let \( \text{pos} \) be \( \text{toInteger(endPosition)} \).
11. ReturnIfAbrupt(\( \text{pos} \)).
12. Let \( \text{end} \) be \( \text{min(max(pos, 0), len)} \).
13. Let \( \text{searchLength} \) be the number of elements in \( \text{searchStr} \).
14. Let \( \text{start} \) be \( \text{end} - \text{searchLength} \).
15. If \( \text{start} \) is less than 0, return \texttt{false}.
16. If the \( \text{searchLength} \) sequence of elements of \( S \) starting at \( \text{start} \) is the same as the full element sequence of \( \text{searchStr} \), return \texttt{true}.
17. Otherwise, return \texttt{false}.

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

\textbf{NOTE 1} Returns \texttt{true} if the sequence of elements of \texttt{searchString} converted to a String is the same as the corresponding elements of this object (converted to a String) starting at \texttt{endPosition} – \texttt{length(this)}. Otherwise returns \texttt{false}.

\textbf{NOTE 2} Throwing an exception if the first argument is a RegExp is specified in order to allow future editions to define extends that allow such argument values.
NOTE 3  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.

21.1.3.7 String.prototype.includes ( searchString [, position ])

The `includes` method takes two arguments, `searchString` and `position`, and performs the following steps:

1. Let `O` be RequireObjectCoercible(this value).
2. Let `S` be ToString(`O`).
3. ReturnIfAbrupt(`S`).
4. Let `isRegExp` be `IsRegExp(searchString)`.  
5. ReturnIfAbrupt(`isRegExp`).
6. If `isRegExp` is true, throw a `TypeError` exception.  
7. Let `searchStr` be ToString(`searchString`).
8. ReturnIfAbrupt(`searchStr`).
9. Let `pos` be ToInteger(`position`). (If `position` is undefined, this step produces the value 0).
10. ReturnIfAbrupt(`pos`).
11. Let `len` be the number of elements in `S`.
12. Let `start` be min(max(`pos`, 0), `len`).
13. Let `searchLen` be the number of elements in `searchStr`.
14. 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 code unit at index `k+j` of `S` is the same as the code unit at index `j` of `searchStr`, return true; but if there is no such integer `k`, return false.

The `length` property of the `includes` 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 indices that are greater than or equal to `position`, return true; otherwise, returns false. If `position` is undefined, 0 is assumed, so as to search all of the String.

NOTE 2  Throwing an exception if the first argument is a RegExp is specified in order to allow future editions to define extensions that allow such argument values.

NOTE 3  The `includes` 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.

21.1.3.8 String.prototype.indexOf ( searchString [, position ])

NOTE  If `searchString` appears as a substring of the result of converting this object to a String, at one or more indices that are greater than or equal to `position`, then the smallest such index 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 RequireObjectCoercible(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 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 index k+j of S is the same as the code unit at index j of searchStr; but if there is no such integer k, 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.

21.1.3.9 String.prototype.lastIndexOf ( searchString [, position ] )

NOTE If searchString appears as a substring of the result of converting this object to a String at one or more indices that are smaller than or equal to position, then the greatest such index 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 RequireObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchStr be ToString(searchString).
5. ReturnIfAbrupt(searchStr).
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 index k+j of S is the same as the code unit at index j of searchStr; but if there is no such integer k, return the value -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 a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

21.1.3.10 String.prototype.localeCompare ( that [, reserved1 [, reserved2 ] ] )

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the localeCompare method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMAScript API the following specification of the localeCompare method is used.

When the localeCompare method is called with 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 a host 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 performing the comparisons, the following steps are performed to prepare the Strings:

1. Let \( O \) be \( \text{RequireObjectCoercible}(\text{this} \text{ value}) \).
2. Let \( S \) be \( \text{ToString}(O) \).
3. ReturnIfAbrupt(\( S \)).
4. Let \( \text{That} \) be \( \text{ToString}(\text{that}) \).
5. ReturnIfAbrupt(\( \text{That} \)).

The meaning of the optional second and third parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not assign any other interpretation to those parameter positions.

The `localeCompare` method, if considered as a function of two arguments `this` and `that`, is a consistent comparison function (as defined in 22.1.3.24) 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. This function must treat Strings that are canonically equivalent according to the Unicode standard as identical and must return 0 when comparing Strings that are considered canonically equivalent.

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

**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. However, regardless of the host provided comparison capabilities, this function must treat Strings that are canonically equivalent according to the Unicode standard as identical. It is recommended that this function not honour Unicode compatibility equivalences or decompositions. For a definition and discussion of canonical equivalence see the Unicode Standard, chapters 2 and 3, as well as Unicode Annex #15, Unicode Normalization Forms and Unicode Technical Note #5 Canonical Equivalence in Applications. Also see Unicode Technical Standard #10, Unicode Collation Algorithm.

**NOTE 3** The `localeCompare` function is intentionally generic; it does not require that its `this` value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

### 21.1.3.11 String.prototype.match ( regexp )

When the `match` method is called with argument `regexp`, the following steps are taken:

1. Let \( O \) be \( \text{RequireObjectCoercible}(\text{this} \text{ value}) \).
2. Let \( S \) be \( \text{ToString}(O) \).
3. ReturnIfAbrupt(\( S \)).
4. If `regexp` is not `undefined`, then
   a. Let `matcher` be `GetMethod(regexp, @@match).`
   b. ReturnIfAbrupt(`matcher`).
   c. If `matcher` is not `undefined`, then
      i. Return `Call(matcher, regexp, «S»)`.
5. Let \( rx \) be \( \text{RegExpCreate}(\text{regexp}, \text{undefined}) \) (see 21.2.3.3.3).
6. ReturnIfAbrupt(`rx`).
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.

21.1.3.12 `String.prototype.normalize ([form])`

When the `normalize` method is called with one argument `form`, the following steps are taken:

1. Let `O` be `RequireObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(S).
4. If `form` is not provided or `form` is `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", 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 Unicode Standard Annex #15, Unicode Normalization Forms.
9. Return `ns`.

The `length` property of the `normalize` method is 0.

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.

21.1.3.13 `String.prototype.repeat (count)`

The following steps are taken:

1. Let `O` be `RequireObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. ReturnIfAbrupt(S).
4. Let `n` be `ToInteger(count)`.
5. ReturnIfAbrupt(n).
6. If `n < 0`, throw a `RangeError` exception.
7. If `n` is `+∞`, 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`.

NOTE 1  This method creates a String consisting of the code units of the `this` object (converted to String) repeated `count` times.

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.

21.1.3.14 `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 `RequireObjectCoercible(this value)`.
2. Let `string` be `ToString(O)`.
3. ReturnIfAbrupt(string).
4. If `searchValue` is not `undefined`, then
   a. Let `replacer` be `GetMethod(searchValue, @@replace)`.
b. ReturnIfAbrupt(replacer).
c. If replacer is not undefined, then
d. Return Call(replacer, searchValue, «string, replaceValue»).
5. Let searchString be ToString(searchValue).
6. ReturnIfAbrupt(searchString).
7. Let functionalReplace be IsCallable(replaceValue).
8. If functionalReplace is false, then
a. Let replaceValue be ToString(replaceValue).
   b. ReturnIfAbrupt(replaceValue).
9. Search string for the first occurrence of searchString and let pos be the index 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.
10. If functionalReplace is true, then
a. Let replValue be Call(replaceValue, undefined, «matched, pos, and string»).
b. Let replStr be ToString(replValue).
c. ReturnIfAbrupt(replStr).
11. Else,
a. Let captures be an empty List.
b. Let replStr be GetReplaceSubstitution(matched, string, pos, captures, replaceValue).
12. Let tailPos be pos + the number of code units in matched.
13. Let newString be the String formed by concatenating the first pos code units of string, replStr, 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.

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.

21.1.3.14.1 Runtime Semantics: GetReplaceSubstitution Abstract Operation

The abstract operation GetReplaceSubstitution(matched, string, position, captures, replacement) 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 nonnegative integer.
7. Assert: captures is a possibly empty List of Strings.
8. Assert: Type(replacement) is String.
9. Let tailPos be position + matchLength.
10. Let m be the number of elements in captures.
11. Let result be a String value derived from replacement by copying code unit elements from replacement to result while performing replacements as specified in Table 42. These $ replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements.
12. Return result.
Table 42 — Replacement Text Symbol Substitutions

<table>
<thead>
<tr>
<th>Code units</th>
<th>Unicode Characters</th>
<th>Replacement text</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0024, 0x0024</td>
<td>$$</td>
<td>$$</td>
</tr>
<tr>
<td>0x0024, 0x0026</td>
<td>$</td>
<td>matched</td>
</tr>
<tr>
<td>0x0024, 0x0060</td>
<td>$$</td>
<td>If position is 0, the replacement is the empty String. Otherwise the replacement is the substring of string that starts at index 0 and whose last code point is at index position -1.</td>
</tr>
<tr>
<td>0x0024, 0x0027</td>
<td>$’</td>
<td>If tailPos ≥ stringLength, the replacement is the empty String. Otherwise the replacement is the substring of string that starts at index tailPos and continues to the end of string.</td>
</tr>
<tr>
<td>0x0024, N where 0x0031 ≤ N ≤ 0x0039</td>
<td>$$n</td>
<td>The n(^{th}) element of captures, where n is a single digit in the range 1 to 9. If n &gt; m and the n(^{th}) element of captures is undefined, use the empty string instead. If n≥m, the result is implementation-defined.</td>
</tr>
<tr>
<td>0x0024, N, N where 0x0030 ≤ N ≤ 0x0039</td>
<td>$$nn</td>
<td>The nn(^{th}) element of captures, where nn is a two-digit decimal number in the range 00 to 99. If nn &gt; m and the nn(^{th}) element of captures is undefined, use the empty String instead. If m &gt; 99, the result is implementation-defined.</td>
</tr>
</tbody>
</table>

21.1.3.15 `String.prototype.search (regexp)`

When the `search` method is called with argument `regexp`, the following steps are taken:

1. Let O be `RequireObjectCoercible(this value)`.  
2. Let `string` be `ToString(O)`.  
3. ReturnIfAbrupt(`string`).  
4. If `regexp` is not `undefined`, then
   a. Let `searcher` be `GetMethod(regexp, @@search)`.  
   b. ReturnIfAbrupt(`searcher`).  
   c. If `searcher` is not `undefined`, then
      i. Return `Call(searcher, regexp, «string»)`.
5. Let `rx` be `RegExpCreate(regexp, undefined)` (see 21.2.3.3).  
6. ReturnIfAbrupt(`rx`).  
7. Return `Invoke(rx, @@search, «string»)`.

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.

21.1.3.16 `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 index `start` and running to, but not including, index `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:

```
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```
1. Let \( O \) be RequireObjectCoercible(this value).
2. Let \( S \) be ToString(O).
3. ReturnIfAbrupt(S).
4. Let \( len \) be the number of elements in \( S \).
5. Let \( \text{start} \) be ToInteger\( (\text{start}) \).
6. ReturnIfAbrupt(\text{start}).
7. If end is undefined, let \( \text{end} \) be \( len \); else let \( \text{end} \) be ToInteger\( (\text{end}) \).
8. ReturnIfAbrupt(\text{end}).
9. If \( \text{start} \) < 0, let from be \( \text{max}(\text{len} + \text{start}, 0) \); otherwise let from be \( \text{min}(\text{start}, \text{len}) \).
10. Let \( \text{span} \) be \( \text{max}(\text{to} - \text{from}, 0) \).
11. Let \( \text{span} \) be \( \text{max}(\text{to} - \text{from}, 0) \).
12. Return a String value containing \( \text{span} \) consecutive elements from \( S \) beginning with the element at index from.

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.

21.1.3.17 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.

When the split method is called, the following steps are taken:

1. Let \( O \) be RequireObjectCoercible(this value).
2. ReturnIfAbrupt(\( O \)).
3. If separator is not undefined, then
   a. Let \( \text{splitter} \) be GetMethod(separator, @@split).
   b. ReturnIfAbrupt(\( \text{splitter} \)).
   c. If \( \text{splitter} \) is not undefined, then
      i. Return Call(\( \text{splitter} \), separator, «O, limit»).
4. Let \( S \) be ToString(\( O \)).
5. ReturnIfAbrupt(S).
6. Let A be ArrayCreate(0).
7. Let lengthA be 0.
8. If \( \text{limit} \) is undefined, let \( \text{lim} = 2^{31} - 1 \); else let \( \text{lim} = \text{ToLength(\text{limit})} \).
9. ReturnIfAbrupt(\( \text{lim} \)).
10. Let \( s \) be the number of elements in \( S \).
11. Let \( p = 0 \).
12. Let \( R \) be ToString(\( \text{separator} \)).
13. ReturnIfAbrupt(\( R \)).
14. If \( \text{lim} = 0 \), return A.
15. If separator is undefined, then
   a. Call CreateDataProperty(A, "0", S).
   b. Assert: The above call will never result in an abrupt completion.
   c. Return A.
16. If \( s = 0 \), then
   a. Let \( z \) be the result of SplitMatch(\( S \), 0, \( R \)).
b. If \( z \) is not false, return \( A \).
c. Call CreateDataProperty(\( A \), "0", \( S \)).
d. Assert: The above call will never result in an abrupt completion.
e. Return \( A \).

17. Let \( q = p \).

18. Repeat, while \( q \neq s \)
   a. Let \( e \) be the result of SplitMatch(\( S \), \( q \), \( R \)).
   b. If \( e \) is false, let \( q = q+1 \).
   c. Else \( e \) is an integer index into \( S \).
      i. If \( e = p \), let \( q = q+1 \).
      ii. Else \( e \neq p \),
          1. Let \( T \) be a String value equal to the substring of \( S \) consisting of the code units at indices \( p \) (inclusive) through \( q \) (exclusive).
          2. Call CreateDataProperty(\( A \), ToString(\( lengthA \)), \( T \)).
          3. Assert: The above call will never result in an abrupt completion.
          4. Increment \( lengthA \) by 1.
          5. Let \( p = e \).
          6. Let \( q = p \).
   7. If \( lengthA = \text{lim} \), return \( A \).

19. Let \( T \) be a String value equal to the substring of \( S \) consisting of the code units at indices \( p \) (inclusive) through \( s \) (exclusive).
20. Call CreateDataProperty(\( A \), ToString(\( lengthA \)), \( T \)).
21. Assert: The above call will never result in an abrupt completion.
22. Return \( A \).

The length property of the split method is 2.

NOTE 1 The value of \( \text{separator} \) may be an empty String, an empty regular expression, or a regular expression that can match an empty String. In this case, \( \text{separator} \) 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 \( \text{separator} \) 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 \( \text{separator} \) is a regular expression, only the first match at a given index of the this String is considered, even if backtracking could yield a non-empty-substring match at that index. (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 \( \text{separator} \) 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 \( \text{separator} \) is a regular expression that contains capturing parentheses, then each time \( \text{separator} \) 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(/<([^<>]+)>/) evaluates to the array ["A", undefined, "B", "bold", "/", "B", "and", undefined, "CODE", "coded", "/", "CODE", "]

If \( \text{separator} \) is undefined, then the result array contains just one String, which is the this value (converted to a String). If \( \text{limit} \) is not undefined, then the output array is truncated so that it contains no more than \( \text{limit} \) elements.

NOTE 2 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.
21.1.3.17.1 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:

1. Assert: $\text{Type}(R)$ is String.
2. Let $r$ be the number of code units in $R$.
3. Let $s$ be the number of code units in $S$.
4. If $q+r > s$, return false.
5. If there exists an integer $i$ between 0 (inclusive) and $r$ (exclusive) such that the code unit at index $q+i$ of $S$ is different from the code unit at index $i$ of $R$, return false.
6. Return $q+r$.

21.1.3.18 String.prototype.startsWith ( searchString [, position ] )

The following steps are taken:

1. Let $O$ be RequireObjectCoercible(this value).
2. Let $S$ be ToString($O$).
3. ReturnIfAbrupt($S$).
4. Let isRegExp be IsRegExp(searchString).
5. ReturnIfAbrupt(isRegExp).
6. If isRegExp is true, throw a TypeError exception.
7. Let searchString be ToString(searchString).
8. ReturnIfAbrupt(searchString).
9. Let pos be ToInteger(position). (If position is undefined, this step produces the value 0).
10. ReturnIfAbrupt(pos).
11. Let len be the number of elements in $S$.
12. Let start be min(max(pos, 0), len).
13. Let searchString be the number of elements in searchString.
14. If searchString + start is greater than len, return false.
15. If the searchString sequence of elements of $S$ starting at start is the same as the full element sequence of searchString, return true.
16. Otherwise, return false.

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 index position. Otherwise returns false.

NOTE 2  Throwing an exception if the first argument is a RegExp is specified in order to allow future editions to define extends that allow such argument values.

NOTE 3  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.

21.1.3.19 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 index start and running to, but not including, index end of the String (or through the end of the String is 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 `RequireObjectCoercible(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. ReturnIfAbrupt(intStart).
7. If `end` is `undefined`, let `intEnd` be `len`; else let `intEnd` be `ToInteger(end)`.
8. ReturnIfAbrupt(intEnd).
9. Let `finalStart` be `min(max(intStart, 0), len)`.
10. Let `finalEnd` be `min(max(intEnd, 0), len)`.
11. Let `from` be `min(finalStart, finalEnd)`.
12. Let `to` be `max(finalStart, finalEnd)`.
13. 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.

21.1.3.20 `String.prototype.toLocaleLowerCase ( [ reserved1 [, reserved2 ] ] )`

This function interprets a string value as a sequence of code points, as described in 6.1.4.

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.

The `length` property of the `toLocaleLowerCase` method is 0.

**NOTE 1** The meaning of the optional first and second parameters to this method is reserved for use by the ECMA-402 specification; it is recommended that implementations do not use those parameter positions 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.

21.1.3.21 `String.prototype.toLocaleUpperCase ( [ reserved1 [, reserved2 ] ] )`

This function interprets a string value as a sequence of code points, as described in 6.1.4.

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.
The `length` property of the `toLocaleUpperCase` method is `0`.

NOTE 1  The meaning of the optional first and second parameters to this method is reserved for use by the ECMA-402 specification; it is recommended that implementations do not use those parameter positions 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.

21.1.3.22 String.prototype.toLowercase()

This function interprets a string value as a sequence of code points, as described in 6.1.4. The following steps are taken:

1. Let O be `RequireObjectCoercible(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 6.1.4 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-16Encoding (10.1.1) 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 locale-insensitive case mappings in the Unicode Character Database (this explicitly includes not only the UnicodeData.txt file, but also all locale-insensitive mappings in 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.

21.1.3.23 String.prototype.toString()

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

1. Let s be `thisStringValue(this value).`
2. Return s.

NOTE  For a String object, the `toString` method happens to return the same thing as the `valueOf` method.

21.1.3.24 String.prototype.toUpperCase()

This function interprets a string value as a sequence of code points, as described in 6.1.4.

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.
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.

21.1.3.25 String.prototype.trim ()

This function interprets a string value as a sequence of code points, as described in 6.1.4.

The following steps are taken:

1. Let O be RequireObjectCoercible(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 code point is in Unicode general category “Zs”, code unit sequences are interpreted as UTF-16 encoded code point sequences as specified in 6.1.4.
5. Return T.

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.

21.1.3.26 String.prototype.valueOf ()

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

1. Let s be thisStringValue(this value).
2. Return s.

21.1.3.27 String.prototype[@@iterator]()

When the @@iterator method is called it returns an Iterator object (25.1.1.2) that iterates over the code points of a String value, returning each code point as a String value. The following steps are taken:

The following steps are taken:

1. Let O be RequireObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Return CreateStringIterator(S).

The value of the name property of this function is "[Symbol.iterator]".

21.1.4 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 slot.

String instances have a length property, and a set of enumerable properties with integer indexed names.
21.1.4.1 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 }.

21.1.5 String Iterator Objects

An String Iterator is an object, that represents a specific iteration over some specific String instance object. There is not a named constructor for String Iterator objects. Instead, String iterator objects are created by calling certain methods of String instance objects.

21.1.5.1 CreateStringIterator Abstract Operation

Several methods of String objects return Iterator objects. The abstract operation CreateStringIterator with argument string is used to create such iterator objects. It performs the following steps:

1. Assert: Type(string) is String.
2. Let iterator be the result of ObjectCreate(%StringIteratorPrototype%, «[[IteratedString]], [[StringIteratorNextIndex]] »).
3. Set iterator’s [[IteratedString]] internal slot to string.
4. Set iterator’s [[StringIteratorNextIndex]] internal slot to 0.
5. Return iterator.

21.1.5.2 The %StringIteratorPrototype% Object

All String Iterator Objects inherit properties from the %StringIteratorPrototype% intrinsic object. The %StringIteratorPrototype% object is an ordinary object and its [[Prototype]] internal slot is the %IteratorPrototype% intrinsic object (25.1.2). In addition, %StringIteratorPrototype% has the following properties:

21.1.5.2.1 %StringIteratorPrototype%.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 slots of an String Iterator Instance (21.1.5.3), throw a TypeError exception.
4. Let s be the value of the [[IteratedString]] internal slot of O.
5. If s is undefined, return CreateIterResultObject(undefined, true).
6. Let position be the value of the [[StringIteratorNextIndex]] internal slot of O.
7. Let len be the number of elements in s.
8. If position ≥ len, then
   a. Set the value of the [[IteratedString]] internal slot of O to undefined.
   b. Return CreateIterResultObject(undefined, true).
9. Let first be the code unit value at index position in s.
10. If first < 0xD800 or first > 0xDBFF or position+1 = len, let resultString be the string consisting of the single code unit first.
11. Else,
    a. Let second be the code unit value at index position+1 in the String S.
    b. If second < 0xDC00 or second > 0xDFFF, let resultString be the string consisting of the single code unit first.
c. Else, let resultString be the string consisting of the code unit first followed by the code unit second.

12. Let resultSize be the number of code units in resultString.
13. Set the value of the [[StringIteratorNextIndex]] internal slot of O to position + resultSize.
14. Return CreateIterResultObject(resultString, false).

21.1.5.2.2 %StringIteratorPrototype% [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value "String Iterator".

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

21.1.5.3 Properties of String Iterator Instances

String Iterator instances are ordinary objects that inherit properties from the %StringIteratorPrototype% intrinsic object. String Iterator instances are initially created with the internal slots listed in Table 45.

Table 43 — Internal Slots of String Iterator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[IteratedString]]</td>
<td>The String value whose elements are being iterated.</td>
</tr>
<tr>
<td>[[StringIteratorNextIndex]]</td>
<td>The integer index of the next string index to be examined by this iteration.</td>
</tr>
</tbody>
</table>

21.2 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.

21.2.1 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[n] :: Disjunction[\n]

Disjunction[n] :: Alternative[\n]

Alternative[\n] :: Disjunction[\n]

Alternative[\n] :: [empty]
```

```
Term[n]:: Alternative[\n]
```


Term ::
  Assertion
  Atom
  Atom Quantifier

Assertion ::
  ^
  $  \ b  B
  ( ? = Disjunction )
  ( ? ! Disjunction )

Quantifier ::
  QuantifierPrefix
  QuantifierPrefix ?

QuantifierPrefix ::
  
  *  
  +  
  ?  { DecimalDigits }
  { DecimalDigits , }
  { DecimalDigits , DecimalDigits }

Atom ::
  PatternCharacter
  .  \ AtomEscape  Character
  CharacterClass ( Disjunction )
  ( ? : Disjunction )

SyntaxCharacter :: one of
  ^ $ \ . * + ? ( ) [ ] { } |

PatternCharacter ::
  SourceCharacter but not SyntaxCharacter

AtomEscape ::
  DecimalEscape
  CharacterEscape
  CharacterClassEscape

CharacterEscape ::
  ControlEscape
  ControlLetter
  HexEscapeSequence
  RegExpUnicodeEscapeSequence
  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

RegExpUnicodeEscapeSequence[0] ::
  [+U] u LeadSurrogate \ u TrailSurrogate
  u Hex4Digits
  [+U] u { HexDigits }

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

LeadSurrogate ::
  Hex4Digits [match only if the SV of Hex4Digits is in the inclusive range 0xD800 to 0xDBFF]

TrailSurrogate ::
  Hex4Digits [match only if the SV of Hex4Digits is in the inclusive range 0xDC00 to 0xDFFF]

IdentityEscape[0] ::
  [+U] SyntaxCharacter but not UnicodeIDContinue

DecimalEscape ::
  DecimalIntegerLiteral [lookahead \ DecimalDigit]

CharacterClassEscape :: one of
  d D s S w W

CharacterClass[0] ::
  [ [lookahead \ {[*]} ClassRanges[0] ]
   [ ^ ClassRanges[0] ]

ClassRanges[0] ::
  [empty]
  NonemptyClassRanges[0]

NonemptyClassRange[0] ::
  ClassAtom[0]
  ClassAtom[0] NonemptyClassRangesNoDash[0]
  ClassAtom[0] = ClassAtom[0] ClassRanges[0]

NonemptyClassRangesNoDash[0] ::
  ClassAtomNoDash[0]
  ClassAtomNoDash[0] NonemptyClassRangesNoDash[0]
  ClassAtomNoDash[0] = ClassAtomNoDash[0] ClassRanges[0]

ClassAtom[0] ::
  ClassAtomNoDash[0]
21.2.2 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 slot.

A Pattern is either a BMP pattern or a Unicode pattern depending upon whether or not its associated flags contain an "u". A BMP pattern matches against a String interpreted as consisting of a sequence of 16-bit values that are Unicode code points in the range of the Basic Multilingual Plane. A Unicode pattern matches against a String interpreted as consisting of Unicode code points encoded using UTF-16. In the context of describing the behaviour of a BMP pattern “character” means a single 16-bit Unicode BMP code point. In the context of describing the behaviour of a Unicode pattern “character” means a UTF-16 encoded code point (6.1.4). In either context, “character value” means the numeric value of the code unit or code point.

The semantics of Pattern is defined as if a Pattern was a List of SourceCharacter values where each SourceCharacter corresponds to a Unicode code point. If a BMP pattern contains a non-BMP SourceCharacter the entire pattern is encoded using UTF-16 and the individual code units of that encoding are used as the elements of the List.

NOTE For example, consider a pattern expressed in source code as the single non-BMP character U+1D11E (MUSICAL SYMBOL G CLEF). Interpreted as a Unicode pattern, it would be a single element (character) List consisting of the single code point 0x1D11E. However, interpreted as a BMP pattern, it is first UTF-16 encoded to produce a two element List consisting of the code units 0xD834 and 0xDD1E.

Patterns are passed to the RegExp constructor as ECMAScript string values in which non-BMP characters are UTF-16 encoded. For example, the single character MUSICAL SYMBOL G CLEF pattern, expressed as a string value, is a String of length 2 whose elements were the code units 0xD834 and 0xDD1E. So no further translation of the string would be necessary to process it as a BMP pattern consisting of two pattern characters. However, to process it as a Unicode pattern the string value must be treated as if it was UTF-16 decoded into a List consisting of a single pattern character, the code point U+1D11E.

An implementation may not actually perform such translations to or from UTF-16, but the semantics of this specification requires that the result of pattern matching be as if such translations were performed.

21.2.2.1 Notation

The descriptions below use the following variables:

- Input is a List consisting of all of the characters, in order, of the String being matched by the regular expression pattern. Each character is either a code unit or a code point, depending
upon the kind of pattern involved. The notation input[n] means the n\textsuperscript{th} character of input, where n can range between 0 (inclusive) and InputLength (exclusive).

- **InputLength** is the number of characters in Input.
- **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 true if the RegExp object's [[OriginalFlags]] internal slot contains "i" and otherwise is false.
- **Multiline** is true if the RegExp object's [[OriginalFlags]] internal slot contains "m" and otherwise is false.
- **Unicode** is true if the RegExp object's [[OriginalFlags]] internal slot contains "u" and otherwise is false.

Furthermore, the descriptions below use the following internal data structures:

- A CharSet is a mathematical set of characters, either code units or code points depending up the state of the Unicode flag. "All characters" means either all code unit values or all code point values also depending upon the state if Unicode.
- A State is an ordered pair (endIndex, captures) where endIndex is an integer and captures is a List 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 n\textsuperscript{th} element of captures is either a List that represents the value obtained by the n\textsuperscript{th} set of capturing parentheses or undefined if the n\textsuperscript{th} 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 which are 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 Input, 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 Input, 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 Input and returns true if the condition matched or false if not.
An EscapeValue is either a character or an integer. An EscapeValue is used to denote the interpretation of a DecimalEscape escape sequence: a character \( ch \) means that the escape sequence is interpreted as the character \( ch \), while an integer \( n \) means that the escape sequence is interpreted as a backreference to the \( n \)th set of capturing parentheses.

21.2.2 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. If `Unicode` is `true`, let \( \text{Input} \) be a List consisting of the sequence of code points of \( str \) interpreted as a UTF-16 encoded (6.1.4) Unicode string. Otherwise, let \( \text{Input} \) be a List consisting of the sequence of code units that are the elements of \( str \). \( \text{Input} \) will be used throughout the algorithms in 21.2.2. Each element of \( \text{Input} \) is considered to be a character.
   2. Let `listIndex` be the index into \( \text{Input} \) of the character that was obtained from element `index` of \( str \).
   3. Let `InputLength` be the number of characters contained in \( \text{Input} \). This variable will be used throughout the algorithms in 21.2.2.
   4. Let \( c \) be a Continuation that always returns its State argument as a successful MatchResult.
   5. Let `cap` be a List of `NcapturingParens undefined` values, indexed 1 through `NcapturingParens`.
   6. Let \( x \) be the State \( (\text{listIndex}, \text{cap}) \).
   7. Call \( m(x, c) \) and return its result.

NOTE A Pattern evaluates ("compiles") to an internal procedure value. `RegExp.prototype.exec` and other methods 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 21.2.2 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).

21.2.2.3 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 steps when evaluated:
   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]
```

### 21.2.2.4 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 steps when evaluated:
   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 Input. 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`.

### 21.2.2.5 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 steps when evaluated:

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 as follows:

1. Return the Matcher that is the result of evaluating `Atom`.

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 `\infty`) `max`, and Boolean `greedy`.
3. If `max` is finite and less than `min`, 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 steps when evaluated:
   1. Call RepeatMatcher(m, min, max, greedy, x, c, parenIndex, parenCount) and return its result.

21.2.2.5.1 Runtime Semantics: RepeatMatcher Abstract Operation

The abstract operation RepeatMatcher takes eight parameters, a Matcher m, an integer min, an integer (or \( \infty \)) max, a Boolean greedy, a State x, a Continuation c, an integer parenIndex, and an integer parenCount, and performs the following steps:

1. If max is zero, return c(x).
2. Create an internal Continuation closure d that takes one State argument y and performs the following steps when evaluated:
   1. If min is zero and y's endIndex is equal to x's endIndex, return failure.
   2. If min is zero, let min2 be zero; otherwise let min2 be min – 1.
   3. If max is \( \infty \), let max2 be \( x \); 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 List.
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, return m(xr, d).
8. If greedy is false, then
   a. Call c(x) and let z be its result.
   b. If z is 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 character sequence 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 \( (n-1^{th}) \) 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 \( (n-1)^{th} \) repetition of Atom and so on.

Compare

```
/a[a-z]{2,4}/.exec("abcdefghi")
```
which returns "abode" with

```
/a[a-z]{2,4}?/.exec("abcdefghi")
```

which returns "abc".

Consider also

```
/(aa|aaba|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:

```
"aaaaaaaaaaaaaaaaaaaaa".replace(/^(a+)/(\d+),(\d+),(\d+)*/g,"$1")
```

which returns the gcd in unary notation "aaaaa".

NOTE 3  Step 5 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 character sequence 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\?/.exec("baaaac")
```

which returns the array

["b", ""]

21.2.2.6  Assertion

The production Assertion :: ^ evaluates by returning an internal AssertionTester closure that takes a State
argument x and performs the following steps when evaluated:

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.

NOTE  Even when the y flag is used with a pattern, ^ always matches only at the beginning of Input, or (if Multiline is true) at the beginning of a line.
The production `Assertion :: $` evaluates by returning an internal AssertionTester closure that takes a State argument `x` and performs the following steps when evaluated:

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`.

The production `Assertion :: \ b` evaluates by returning an internal AssertionTester closure that takes a State argument `x` and performs the following steps when evaluated:

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 steps when evaluated:

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` List.
   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.
21.2.2.6.1 Runtime Semantics: IsWordChar Abstract Operation

The abstract operation IsWordChar takes an integer parameter \( e \) and performs the following steps:

1. If \( e = -1 \) 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.

21.2.2.7 Quantifier

The production Quantifier :: QuantifierPrefix evaluates as follows:

1. Evaluate QuantifierPrefix to obtain the two results: an integer \( \text{min} \) and an integer (or \( \infty \)) \( \text{max} \).
2. Return the three results \( \text{min} \), \( \text{max} \), and true.

The production Quantifier :: QuantifierPrefix ? evaluates as follows:

1. Evaluate QuantifierPrefix to obtain the two results: an integer \( \text{min} \) and an integer (or \( \infty \)) \( \text{max} \).
2. Return the three results \( \text{min} \), \( \text{max} \), and false.

The production QuantifierPrefix :: * evaluates as follows:

1. Return the two results 0 and \( \infty \).

The production QuantifierPrefix :: + evaluates as follows:

1. Return the two results 1 and \( \infty \).

The production QuantifierPrefix :: ? evaluates as follows:

1. Return the two results 0 and 1.

The production QuantifierPrefix :: { DecimalDigits } evaluates as follows:

1. Let \( i \) be the MV of DecimalDigits (see 11.8.3).
2. Return the two results \( i \) and \( i \).

The production QuantifierPrefix :: { DecimalDigits , } evaluates as follows:

1. Let \( i \) be the MV of DecimalDigits.
2. Return the two results \( i \) and \( \infty \).

The production QuantifierPrefix :: { DecimalDigits , DecimalDigits } evaluates as follows:

1. Let \( i \) be the MV of the first DecimalDigits.
2. Let \( j \) be the MV of the second DecimalDigits.
3. Return the two results \( i \) and \( j \).

21.2.2.8 Atom

The production Atom :: PatternCharacter evaluates as follows:
Let $ch$ be the character matched by $PatternCharacter$.

Let $A$ be a one-element CharSet containing the character $ch$.

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 as follows:

1. Return the Matcher that is the result of evaluating $AtomEscape$.

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 $parentIndex$ 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 List.
      2. Let $xe$ be $x$'s endIndex.
      3. Let $ye$ be $y$'s endIndex.
      4. Let $s$ be a fresh List whose characters are the characters of $Input$ at indices $xe$ (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 as follows:

1. Return the Matcher that is the result of evaluating $Disjunction$.

21.2.2.8.1 Runtime Semantics: CharacterSetMatcher Abstract Operation

The abstract operation CharacterSetMatcher takes two arguments, a CharSet $A$ and a Boolean flag $invert$, and performs the following steps:

1. Return an internal Matcher closure that takes two arguments, a State $x$ and a Continuation $c$, and performs the following steps when evaluated:
   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 List.
8. Let \( y \) be the State (\( e+1, \cap \)).
9. Call \( c(y) \) and return its result.

21.2.2.8.2 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. If Unicode is true,
   a. If the file CaseFolding.txt of the Unicode Character Database provides a simple or common case folding mapping for \( ch \), return the result of applying that mapping to \( ch \).
   b. Else, return \( ch \).
3. Else,
   a. Assert: \( ch \) is a UTF-16 code unit.
   b. Let \( s \) be the ECMAScript String value consisting of the single code unit \( ch \).
   c. Let \( u \) be the same result produced as if by performing the algorithm for String.prototype.toUpperCase using \( s \) as the this value.
   d. ReturnIfAbrupt(\( u \)).
   e. Assert: \( u \) is a String value.
   f. If \( u \) does not consist of a single code unit, return \( ch \).
   g. Let \( cu \) be \( u \)’s single code unit element.
   h. If \( ch \)’s code unit value \( \geq 128 \) and \( cu \)’s code unit value < 128, return \( ch \).
   i. Return \( cu \).

NOTE 1 Parentheses of the form \( ( \text{Disjunction} ) \) 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 (\( \\backslash \) 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 \( (?:\text{Disjunction}) \) instead.

NOTE 2 The form \( (?!:\text{Disjunction}) \) 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 \( (?!:\text{Disjunction}) \) 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:
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("baaabaac")
```

looks for an `a` not immediately followed by some positive number `n` of `a`'s, a `b`, another `n` `a`'s (specified by the first `\2`) and a `c`. The second `\2` is outside the negative lookahead, so it matches against `undefined` and therefore always succeeds. The whole expression returns the array:

```
["aaaba", "a", undefined, "abaac"]
```

In case-insensitive matches when `Unicode` is `true`, all characters are implicitly case-folded using the simple mapping provided by the Unicode standard immediately before they are compared. The simple mapping always maps to a single code point, so it does not map, for example, U+00DF to “ß”. It may however map a code point outside the Basic Latin range to a character within, for example, “ſ” (U+017F) to “s”. Such characters are not mapped if `Unicode` is `false`. This prevents Unicode code points such as U+017F and U+212A from matching regular expressions such as `/[a-z]/i`, but they will match `/[a-z]/ui`.

### 21.2.2.9 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. Assert: `E` must be an integer.
4. Let `n` be that integer.
5. If `n=0` or `n>NcapturingParens` throw a **SyntaxError** exception.
6. Return an internal Matcher closure that takes two arguments, a State `x` and a Continuation `c`, and performs the following steps:
   1. Let `cap` be `x`'s `captures` List.
   2. Let `s` be `cap[n]`.
   3. If `s` is `undefined`, return `c(x)`.
   4. Let `e` be `s`'s `endIndex`.
   5. Let `len` be `s`'s length.
   6. Let `f` be `e+len`.
   7. If `f>InputLength`, return `failure`.
   8. If there exists an integer `i` between 0 (inclusive) and `len` (exclusive) such that `Canonicalize(s[i])` is not the same character value as `Canonicalize(Input[e+i])`, return `failure`.
   9. Let `y` be the State (`f`, `cap`).
   10. Call `c(y)` and return its result.

The production **AtomEscape :: CharacterEscape** evaluates as follows:

1. Evaluate **CharacterEscape** to obtain a character `ch`.
2. Let `A` be a one-element CharSet containing the character `ch`.
3. Call `CharacterSetMatcher(A, false)` and return its Matcher result.

Deleted: then
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 21.2.2.11). 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.

21.2.2.10 CharacterEscape

The production `CharacterEscape :: ControlEscape` evaluates by returning the character according to Table 44.

Table 44 — ControlEscape Character Values

<table>
<thead>
<tr>
<th>ControlEscape</th>
<th>Character Value</th>
<th>Code Point</th>
<th>Unicode Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>9</td>
<td>U+0009</td>
<td>CHARACTER TABULATION</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>n</td>
<td>10</td>
<td>U+000A</td>
<td>LINE FEED (LF)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>v</td>
<td>11</td>
<td>U+000B</td>
<td>LINE TABULATION</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>f</td>
<td>12</td>
<td>U+000C</td>
<td>FORM FEED (FF)</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>r</td>
<td>13</td>
<td>U+000D</td>
<td>CARRIAGE RETURN (CR)</td>
<td>&lt;CR&gt;</td>
</tr>
</tbody>
</table>

The production `CharacterEscape :: c ControlLetter` evaluates as follows:

1. Let `ch` be the character matched by `ControlLetter`.
2. Let `i` be `ch`'s character value.
3. Let `j` be the remainder of dividing `i` by 32.
4. Return the character whose character value is `j`.

The production `CharacterEscape :: HexEscapeSequence` evaluates as follows:

1. Return the character whose code is the SV of `HexEscapeSequence`.

The production `CharacterEscape :: RegExpUnicodeEscapeSequence` evaluates as follows:

1. Return the result of evaluating `RegExpUnicodeEscapeSequence`.

The production `CharacterEscape :: IdentityEscape` evaluates as follows:

1. Return the character matched by `IdentityEscape`.

The production `RegExpUnicodeEscapeSequence :: u LeadSurrogate \u TrailSurrogate` evaluates as follows:

1. Let `lead` be the result of evaluating `LeadSurrogate`.
2. Let `trail` be the result of evaluating `TrailSurrogate`.
3. Let `cp` be `UTF16Decode(lead, trail)`.
4. Return the character whose character value is `cp`.

The production `RegExpUnicodeEscapeSequence :: u Hex4Digits` evaluates as follows:

1. Return the character whose code is the SV of `Hex4Digits`. 
The production `RegExpUnicodeEscapeSequence :: u({HexDigits})` evaluates as follows:

1. Return the character whose code is the MV of `HexDigits`.

The production `LeadSurrogate :: Hex4Digits` evaluates as follows:

1. Return the character whose code is the SV of `Hex4Digits`.

The production `TrailSurrogate :: Hex4Digits` evaluates as follows:

1. Return the character whose code is the SV of `Hex4Digits`.

### 21.2.11 DecimalEscape

The production `DecimalEscape :: DecimalIntegerLiteral` evaluates as follows:

1. Let `i` be the MV of `DecimalIntegerLiteral`.
2. If `i` is zero, return the EscapeValue consisting of the character U+0000 (NULL).
3. Return the EscapeValue consisting of the integer `i`.

The definition of "the MV of `DecimalIntegerLiteral`" is in 11.8.3.

**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.

### 21.2.12 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` (11.2) or `LineTerminator` (11.3) 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`. 
21.2.2.13 CharacterClass

The production CharacterClass :: [ 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.

21.2.2.14 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.

21.2.2.15 NonemptyClassRanges

The production NonemptyClassRanges :: ClassAtom evaluates as follows:
1. Return the CharSet that is the result of evaluating ClassAtom.

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.

21.2.2.15.1 Runtime Semantics: CharacterRange Abstract Operation

The abstract operation CharacterRange takes two CharSet parameters A and B and performs the following steps:

1. If A does not contain exactly one character or B does not contain exactly one character, 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 character value of character a.
5. Let j be the character value of character b.
6. If i > j, throw a SyntaxError exception.
7. Return the set containing all characters numbered i through j, inclusive.
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 CharSet \( A \) 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 CharSet \( D \) and \( C \).

NOTE 1  ClassRanges can expand into single ClassAtom and/or ranges of two ClassAtom 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 \( \backslash w \)) or if the first ClassAtom's character value is greater than the second ClassAtom's character 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]/ matches all upper and lower-case letters in the Unicode Basic Latin block 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.

21.2.2.17 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.

21.2.2.18 ClassAtomNoDash

The production ClassAtomNoDash :: SourceCharacter but not one of \( \backslash \) or \} or - evaluates as follows:

1. Return the CharSet containing the character matched by SourceCharacter.

The production ClassAtomNoDash :: \ ClassEscape evaluates as follows:

1. Return the CharSet that is the result of evaluating ClassEscape.

21.2.2.19 ClassEscape

The production ClassEscape :: DecimalEscape evaluates as follows:

1. Evaluate DecimalEscape to obtain an EscapeValue \( E \).
2. If \( E \) is not a character, throw a SyntaxError exception.
3. Let \( ch \) be \( E \)'s character.
4. Return the one-element CharSet containing the character \( ch \).

Deleted: then
The production `ClassEscape ::= b` evaluates as follows:

1. Return the CharSet containing the single character `<BS>` U+0008 (BACKSPACE).

The production `ClassEscape ::= -` evaluates as follows:

1. Return the CharSet containing the single character '- ' U+002D (HYPEN-MINUS).

The production `ClassEscape ::= CharacterEscape` evaluates as follows:

1. Return the CharSet containing the single character that is the result of evaluating `CharacterEscape`.

The production `ClassEscape ::= CharacterClassEscape` evaluates as follows:

1. Return the CharSet that is the result of evaluating `CharacterClassEscape`.

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.

21.2.3 The RegExp Constructor

The RegExp constructor is the `%RegExp%` intrinsic object and the initial value of the `RegExp` property of the global object. When `RegExp` is called as a function rather than as a constructor, it creates and initializes a new RegExp object. Thus the function call `RegExp(…)` is equivalent to the object creation expression `new RegExp(…)` with the same arguments.

The RegExp constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified RegExp behaviour must include a `super` call to the RegExp constructor to create and initialize subclass instances with the necessary internal slots.

21.2.3.1 RegExp (pattern, flags)

The following steps are taken:

1. Let `patternIsRegExp` be `IsRegExp(pattern)`.  
2. ReturnIfAbrupt(`patternIsRegExp`).  
3. If NewTarget is not `undefined`, let `newTarget` be NewTarget.  
4. Else,  
   a. Let `newTarget` be the active function object.  
   b. If `patternIsRegExp` is `true` and `flags` is `undefined`, then  
      i. Let `patternConstructor` be `Get(pattern, "constructor")`.  
      ii. ReturnIfAbrupt(`patternConstructor`).  
      iii. If `SameValue(newTarget, patternConstructor)` is `true`, return `pattern`.  
5. If `Type(pattern)` is `Object` and `pattern` has a `[[RegExpMatcher]]` internal slot, then  
   a. Let `P` be the value of `pattern`'s `[[OriginalSource]]` internal slot.  
   b. If `flags` is `undefined`, let `F` be the value of `pattern`'s `[[OriginalFlags]]` internal slot.  
   c. Else, let `F` be `flags`.  
6. Else if `patternIsRegExp` is `true`, then  
   a. Let `P` be `Get(pattern, "source")`.  
   b. ReturnIfAbrupt(`P`).  
   c. If `flags` is `undefined`, then  
      i. Let `F` be `Get(pattern, "flags")`.  

ReturnIfAbrupt(F).

7. Else,
   a. Let P be pattern.
   b. Let F be flags.

8. Let O be RegExpAlloc(newTarget).
9. ReturnIfAbrupt(O).

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 recognized by RegExp, any REVERSE SOLIDUS (\) code points must be escaped within the StringLiteral to prevent them being removed when the contents of the StringLiteral are formed.

21.2.3.2 Abstract Operations for the RegExp Constructor

21.2.3.2.1 Runtime Semantics: RegExpAlloc Abstract Operation

When the abstract operation RegExpAlloc with argument newTarget is called, the following steps are taken:

1. Let obj be OrdinaryCreateFromConstructor(newTarget, "%RegExpPrototype%
   «[RegExpMatcher], [[OriginalSource]], [[OriginalFlags]]»).
2. ReturnIfAbrupt(obj).
3. Let status be the result of DefinePropertyOrThrow(obj, "lastIndex", PropertyDescriptor
   {[[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false}).
4. Assert: status is not an abrupt completion.
5. Return obj.

21.2.3.2.2 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, let P be the empty String.
2. Else, let P be ToString(pattern).
3. ReturnIfAbrupt(F).
4. If flags is undefined, let F be the empty String.
5. Else, let F be ToString(flags).
6. ReturnIfAbrupt(F).
7. If F contains any code unit other than "g", "i", "m", "u", or "y" or if it contains the same code unit more than once, throw a SyntaxError exception.
8. If F contains "u", let BMP be false; else let BMP be true.
9. If BMP is true, then
   a. Parse P using the grammars in 21.2.1 and interpreting each of its 16-bit elements as a Unicode BMP code point. UTF-16 decoding is not applied to the elements. The goal symbol for the parse is Pattern. Throw a SyntaxError exception if P did not conform to the grammar or if any elements of P were not matched by the parse.
   b. Let patternCharacters be a List whose elements are the code unit elements of P.
10. Else
    a. Parse P using the grammars in 21.2.1 and interpreting P as UTF-16 encoded Unicode code points (6.1.4). The goal symbol for the parse is Pattern. Throw a SyntaxError exception if P did not conform to the grammar or if any elements of P were not matched by the parse.
b. Let `patternCharacters` be a List whose elements are the code points resulting from applying UTF-16 decoding to `P`'s sequence of elements.

11. Set the value of `obj`'s `[[OriginalSource]]` internal slot to `P`.
12. Set the value of `obj`'s `[[OriginalFlags]]` internal slot to `F`.
13. Set `obj`'s `[[RegExpMatcher]]` internal slot to the internal procedure that evaluates the above parse of `P` by applying the semantics provided in 21.2.2 using `patternCharacters` as the pattern’s List of `SourceCharacter` values and `F` as the flag parameters.
14. Let `putStatus` be the result of `Put(obj, "lastIndex", 0, true)`.
15. ReturnIfAbrupt(`putStatus`).

21.2.3.2.3 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 `RegExpAlloc(%RegExp%)`.
2. ReturnIfAbrupt(`obj`).
3. Return `RegExpInitialize(obj, P, F)`.

21.2.3.2.4 Runtime Semantics: EscapeRegExpPattern Abstract Operation

When the abstract operation `EscapeRegExpPattern` with arguments `P` and `F` is called, the following occurs:

1. Let `S` be a String in the form of a `Pattern` (Pattern[U] if `F` contains "u") equivalent to `P` interpreted as UTF-16 encoded Unicode code points (6.1.4), in which certain code points are escaped as described below. `S` may or may not be identical to `P`; however, the internal procedure that would result from evaluating `S` as a `Pattern` (Pattern[U] if `F` contains "u") must behave identically to the internal procedure given by the constructed object's `[[RegExpMatcher]]` internal slot. Multiple calls to this abstract operation using the same values for `P` and `F` must produce identical results.
2. The code points `/` or any `LineTerminator` 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 "\002F", 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 "{}".
3. Return `S`.

21.2.4 Properties of the RegExp Constructor

The value of the `[[Prototype]]` internal slot of the RegExp constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the `length` property (whose value is 2), the RegExp constructor has the following properties:

21.2.4.1 RegExp.prototype

The initial value of `RegExp.prototype` is the RegExp prototype object (21.2.5).

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false ).
21.2.4.2 get RegExp @@species

RegExp@@species] is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is "get(Symbol.species)".

NOTE RegEx prototype methods normally use their this object’s constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

21.2.5 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 slot or any of the other internal slots of RegExp instance objects.

The value of the [[Prototype]] internal slot of the RegExp prototype object is the intrinsic object %ObjectPrototype% (19.1.3).

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

21.2.5.1 RegExp.prototype.constructor

The initial value of RegExp.prototype.constructor is the intrinsic object %RegExp%.

21.2.5.2 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, throw a TypeError exception.
3. If R does not have a [[RegExpMatcher]] internal slot, throw a TypeError exception.
4. Let S be ToString(string).
5. ReturnIfAbrupt(S).

21.2.5.2.1 Runtime Semantics: RegExpExec ( R, S ) Abstract Operation

The abstract operation RegExpExec with arguments R and S performs the following steps:

1. Assert: Type(R) is Object.
2. Assert: Type(S) is String.
3. Let exec be Get(R, "exec").
4. ReturnIfAbrupt(exec).
5. If IsCallable(exec) is true, then
   a. Let result be Call(exec, R, «S»).
   b. ReturnIfAbrupt(result).
   c. If Type(result) is neither Object or Null, throw a TypeError exception.
d. Return(result).
6. If R does not have a [[RegExpMatcher]] internal slot, throw a TypeError exception.

NOTE If a callable exec property is not found this algorithm falls back to attempting to use the built-in RegExp matching algorithm. This provides compatible behaviour for code written for prior editions where most built-in algorithms that use regular expressions did not perform a dynamic property lookup of exec.

21.2.5.2.2 Runtime Semantics: RegExpBuiltinExec ( R, S ) Abstract Operation

The abstract operation RegExpBuiltinExec with arguments R and S performs the following steps:

1. Assert: R is an initialized RegExp instance.
2. Assert: Type(S) is String.
3. Let length be the number of code units in S.
4. Let lastIndex be ToLength(Get(R, "lastIndex")),
5. ReturnIfAbrupt(lastIndex).
6. Let global be ToBoolean(Get(R, "global")),
7. ReturnIfAbrupt(global).
8. Let sticky be ToBoolean(Get(R, "sticky")),
9. ReturnIfAbrupt(sticky).
10. If global is false and sticky is false, let i = 0.
11. Let matcher be the value of R's [[RegExpMatcher]] internal slot.
12. Let flags be the value of R's [[OriginalFlags]] internal slot.
13. If flags contains "u", let fullUnicode be true, else let fullUnicode be false.
14. Let matchSucceeded be false.
15. Repeat, while matchSucceeded is false
   a. If lastIndex > length, then
      i. Let putStatus be Put(R, "lastIndex", 0, true).
      ii. ReturnIfAbrupt(putStatus).
      iii. Return null.
   b. Let r be the result of calling matcher with arguments S and lastIndex.
   c. If r is failure, then
      i. If sticky is true, then
         1. Let putStatus be Put(R, "lastIndex", 0, true).
         2. ReturnIfAbrupt(putStatus).
         3. Return null.
      ii. Let lastIndex = lastIndex + 1.
   d. else
      i. Assert: r is a State.
      ii. Set matchSucceeded to true.
16. Let e be r's endIndex value.
17. If fullUnicode is true, then
   a. e is an index into the Input character list, derived from S, matched by matcher. Let eUTF be the smallest index into S that corresponds to the character at element e of Input. If e is greater than the length of Input, then eUTF is 1 + the number of code units in S.
   b. Let e be eUTF.
18. If global is true or sticky is true,
   a. Let putStatus be the result of Put(R, "lastIndex", e, true).
   b. ReturnIfAbrupt(putStatus).
19. Let n be the length of r's captures List. (This is the same value as 21.2.2.1's NcapturingParen.)
20. Let A be the result of the abstract operation ArrayCreate(n + 1).
21. Assert: The value of A’s "length" property is \( n + 1 \).
22. Let matchIndex be lastIndex.
23. Assert: The following CreateDataProperty calls will not result in an abrupt completion.
24. Perform CreateDataProperty(A, "index", matchIndex).
26. Let matchedSubstr be the matched substring (i.e. the portion of S between offset \( \text{lastIndex} \) inclusive and offset \( e \) exclusive).
27. Perform CreateDataProperty(A, "0", matchedSubstr).
28. For each integer \( i \) such that \( i > 0 \) and \( i \leq n \)
   a. Let captureI be \( i \)th element of r’s captures List.
   b. If captureI is undefined, let capturedValue be undefined.
   c. Else if fullUnicode is true
      i. Assert: captureI is a List of code points.
      ii. Let capturedValue be a string whose code units are the UTF-16 Encoding (10.1.1) of the code points of capture.
   d. Else, fullUnicode is false
      i. Assert: captureI is a List of code units.
      ii. Let capturedValue be a string consisting of the code units of capture.
   e. Perform CreateDataProperty(A, ToString(i), capturedValue).
29. Return A.

21.2.5.3 get RegExp.prototype.flags

RegExp.prototype.flags 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, throw a TypeError exception.
3. Let result be the empty String.
4. Let global be ToBoolean(Get(R, "global")).
5. ReturnIfAbrupt(global).
6. If global is true, append "g" as the last code unit of result.
7. Let ignoreCase be ToBoolean(Get(R, "ignoreCase")).
8. ReturnIfAbrupt(ignoreCase).
9. If ignoreCase is true, append "i" as the last code unit of result.
10. Let multiline be ToBoolean(Get(R, "multiline")).
11. ReturnIfAbrupt(multiline).
12. If multiline is true, append "m" as the last code unit of result.
13. Let unicode be ToBoolean(Get(R, "unicode")).
14. ReturnIfAbrupt(unicode).
15. If unicode is true, append "u" as the last code unit of result.
16. Let sticky be ToBoolean(Get(R, "sticky")).
17. ReturnIfAbrupt(sticky).
18. If sticky is true, append "y" as the last code unit of result.
19. Return result.

21.2.5.4 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, throw a **TypeError** exception.
3. If \(R\) does not have an \([\text{OriginalFlags}]\) internal slot throw a **TypeError** exception.
4. Let \(flags\) be the value of \(R\)'s \([\text{OriginalFlags}]\) internal slot.
5. If \(flags\) contains the code unit "g", return **true**.
6. Return **false**.

### 21.2.5.5 `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, throw a **TypeError** exception.
3. If \(R\) does not have an \([\text{OriginalFlags}]\) internal slot throw a **TypeError** exception.
4. Let \(flags\) be the value of \(R\)'s \([\text{OriginalFlags}]\) internal slot.
5. If \(flags\) contains the code unit "i", return **true**.
6. Return **false**.

### 21.2.5.6 `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, throw a **TypeError** exception.
3. Let \(S\) be ToString(\(string\)).
4. ReturnIfAbrupt(\(S\)).
5. Let \(global\) be ToBoolean(Get(\(rx\), "global")).
6. ReturnIfAbrupt(\(global\)).
7. If \(global\) is **false**, then
   a. Return the result of RegExpExec(\(rx\), \(S\)).
8. Else \(global\) is **true**,
   a. Let putStatus be Put(\(rx\), "lastIndex", 0, **true**).
   b. ReturnIfAbrupt(putStatus).
   c. Let \(A\) be ArrayCreate(0).
   d. Let \(n\) be 0.
   e. Repeat,
      i. Let result be RegExpExec(\(rx\), \(S\)).
      ii. ReturnIfAbrupt(result).
      iii. If result is **null**, then
         1. If \(n\)=0, return **null**.
         2. Else, return \(A\).
      iv. Else result is not **null**,
         1. Let matchValue be Get(result, "0").
         2. ReturnIfAbrupt(matchValue).
         3. Let matchStr be ToString(matchValue).
         4. ReturnIfAbrupt(matchStr).
         5. Let status be CreateDataProperty(\(A\), ToString(\(n\)), matchStr).
         6. Assert: status is **true**.
   f. If matchStr is the empty String, then
      a. Let thisIndex be ToLength(Get(\(rx\), "lastIndex"))
      b. ReturnIfAbrupt(thisIndex)
      c. Let putStatus be Put(\(rx\), "lastIndex", thisIndex+1, **true**).
     d. ReturnIfAbrupt(putStatus).
8. Increment n.

The value of the `name` property of this function is "[Symbol.match]".

NOTE  The @@match property is used by the IsRegExp abstract operation to identify objects that have the basic behaviour of regular expressions. The absence of a @@match property or the existence of such a property whose value does not Boolean coerce to true indicates that the object is not intended to be used as a regular expression object.

21.2.5.7 `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, throw a `TypeError` exception.
3. If `R` does not have an `[[OriginalFlags]]` internal slot throw a `TypeError` exception.
4. Let `flags` be the value of `R`'s `[[OriginalFlags]]` internal slot.
5. If `flags` contains the code unit "m", return `true`.
6. Return `false`.

21.2.5.8 `RegExp.prototype[ @@replace ]( string, replaceValue )`

When the @@replace method is called with arguments `string` and `replaceValue` the following steps are taken:

1. Let `rx` be the `this` value.
2. If `Type(rx)` is not Object, throw a `TypeError` exception.
3. Let `S` be `ToString(string)`.
4. ReturnIfAbrupt(`S`).
5. Let `lengthS` be the number of code unit elements in `S`.
6. Let `functionalReplace` be `IsCallable(replaceValue)`.
7. If `functionalReplace` is `false`, then
   a. Let `replaceValue` be `ToString(replaceValue)`.
   b. ReturnIfAbrupt(`replaceValue`).
8. Let `global` be `ToBoolean(Get(rx, "global"))`.
9. ReturnIfAbrupt(`global`).
10. If `global` is `true`, then
    a. Let `putStatus` be `Put(rx, "lastIndex", 0, true)`.
    b. ReturnIfAbrupt(`putStatus`).
11. Let `results` be a new empty List.
12. Let `done` be `false`.
13. Repeat, while `done` is `false`
   a. Let `result` be `RegExpExec(rx, S)`.
   b. ReturnIfAbrupt(`result`).
   c. If `result` is `null`, set `done` to `true`.
   d. Else `result` is not `null`,
      i. Append `result` to the end of `results`.
      ii. If `global` is `false`, set `done` to `true`.
      iii. Else,
         1. Let `matchStr` be `ToString(Get(result, "0"))`.
         2. ReturnIfAbrupt(`matchStr`).
         3. If `matchStr` is the empty String, then
a. Let thisIndex be ToLength(Get(rx, "lastIndex")).
b. ReturnIfAbrupt(thisIndex).
c. Let putStatus be Put(rx, "lastIndex", thisIndex+1, true).
d. ReturnIfAbrupt(putStatus).

14. Let accumulatedResult be the empty String value.
15. Let nextSourcePosition be 0.
16. Repeat, for each result in results,
   a. Let nCaptures be ToLength(Get(result, "length"))
   b. ReturnIfAbrupt(nCaptures).
   c. Let nCaptures be max(nCaptures − 1, 0).
   d. Let matched be ToString(Get(result, "0")).
   e. ReturnIfAbrupt(matched).
   f. Let matchLength be the number of code units in matched.
   g. Let position be ToInteger(Get(result, "index")).
   h. ReturnIfAbrupt(position).
   i. Let position be max(min(position, lengthS), 0).
   j. Let n be 1.
   k. Let captures be an empty List.
   l. Repeat while n ≤ nCaptures
      i. Let capN be Get(result, ToString(n)).
      ii. If Type(capN) is not Undefined, let capN be ToString(capN).
      iii. ReturnIfAbrupt(capN).
      iv. Append capN as the last element of captures.
      v. Let n be n+1
   m. If functionalReplace is true, then
      i. Let replacerArgs be the List (matched).
      ii. Append in list order the elements of captures to the end of the List replacerArgs.
      iii. Append position and S as the last two elements of replacerArgs.
      iv. Let replValue be Call(replaceValue, undefined, replacerArgs).
      v. Let replacement be ToString(replValue).
   n. Else,
      i. Let replacement be GetReplaceSubstitution(matched, S, position, captures, replaceValue).
      ii. ReturnIfAbrupt(replacement).
   o. ReturnIfAbrupt(replacement).
   p. If position ≥ nextSourcePosition, then
      i. NOTE position should not normally move backwards. If it does, it is in indication of a ill-behaving
         RegExp subclass or use of an access triggered side-effect to change the global flag or other
         characteristics of rx. In such cases, the corresponding substitution is ignored.
      ii. Let accumulatedResult be the String formed by concatenating the code units of the current
          value of accumulatedResult with the substring of S consisting of the code units from
          nextSourcePosition (inclusive) up to position (exclusive) and with the code units of
          replacement.
      iii. Let nextSourcePosition be position + matchLength.
   q. Return the String formed by concatenating the code units of accumulatedResult with the substring
      of S consisting of the code units from nextSourcePosition (inclusive) up through the final code unit
      of S (inclusive).

The value of the name property of this function is "[Symbol.replace]".
21.2.5.9 RegExp.prototype[ @@search ] ( string )

When the @@search 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, throw a TypeError exception.
3. Let S be ToString(string).
4. ReturnIfAbrupt(S).
5. Let previousLastIndex be Get(rx, "lastIndex").
6. ReturnIfAbrupt(previousLastIndex).
7. Let status be Put(rx, "lastIndex", 0, true)
8. ReturnIfAbrupt(status).
9. Let result be RegExpExec(rx, S).
10. ReturnIfAbrupt(result).
11. Let status be Put(rx, "lastIndex", previousLastIndex, true)
12. ReturnIfAbrupt(status).
13. If result is null, return -1.
14. Return Get(result, "index").

The value of the name property of this function is "[Symbol.search]".

NOTE The lastIndex and global properties of this RegExp object are ignored when performing the search. The lastIndex property is left unchanged.

21.2.5.10 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, throw a TypeError exception.
3. If R does not have an [[OriginalSource]] internal slot throw a TypeError exception.
4. If R does not have an [[OriginalFlags]] internal slot throw a TypeError exception.
5. Let src be the value of R’s [[OriginalSource]] internal slot.
6. Let flags be the value of R’s [[OriginalFlags]] internal slot.

21.2.5.11 RegExp.prototype[ @@split ] ( string, limit )

NOTE 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 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 index of the this String is considered, even if backtracking could yield a non-empty-substring match at that index. (For example, /a*/[Symbol.split]("ab") evaluates to the array ["a","b"], while /a*/[Symbol.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,

```
/<(\<[^<>]*\>)/g
```

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, throw a TypeError exception.
3. Let S be ToString(string).
4. ReturnIfAbrupt(S).
5. Let flags be ToString(Get(rx, "flags")).
6. ReturnIfAbrupt(flags).
7. If flags contains "u", let unicodeMatching be true.
8. Else, let newFlags be flags.
9. Let C be SpeciesConstructor(rx, %RegExp%).
10. ReturnIfAbrupt(C).
11. Let flags be the string that is the concatenation of flags and "y".
12. Let splitter be Construct(C, «rx, newFlags»).
13. ReturnIfAbrupt(splitter).
14. Let A be ArrayCreate(0).
15. Let lengthA be 0.
16. If limit is undefined, let lim = 2^31-1; else let lim = ToLength(limit).
17. Let size be the number of elements in S.
18. ReturnIfAbrupt(lim).
19. Let p = 0.
20. If lim = 0, return A.
21. If p < size, return A.
22. ReturnIfAbrupt(pStatus).
23. Let z be RegExpExec(splitter, S).
24. Repeat, while q < size
   a. Let putStatus be Put(splitter, "lastIndex", q, true).
   b. ReturnIfAbrupt(pStatus).
   c. If z is not null, return A.
   d. Assert: The following call will never result in an abrupt completion.
   e. Call CreateDataProperty(A, "0", S).
   f. Return A.
25. Let q = p.
26. Repeat, while q < size
   a. Let putStatus be Put(splitter, "lastIndex", q, true).
   b. ReturnIfAbrupt(pStatus).
   c. Let z be RegExpExec(splitter, S).
   d. ReturnIfAbrupt(pStatus).
   e. If z is null, then
      i. If unicodeMatching is true, then
         1. Let first be the code unit value of the element at index q in the String S.
         2. If first ≥ 0xD800 and first ≤ 0xDBFF and q+1 < size, then
            a. Let second be the code unit value of the element at index q+1 in the String S.
b. If \( \text{second} \geq 0xDC00 \) and \( \text{second} \leq 0xDFFF \), then
   i. Let \( q = q + 1 \).
ii. Let \( q = q + 1 \).

f. Else \( z \) is not \textbf{null}.
   i. Let \( e \) be \( \text{ToLength(} \text{splitter, "lastIndex"}) \).
   ii. \textbf{ReturnIfAbrupt}(\( e \)).
   iii. If \( e = p \), then
      1. If \( \text{unicodeMatching} \) is \textbf{true}, then
         a. Let \( \text{first} \) be the code unit value of the element at index \( q \) in the String \( S \).
         b. If \( \text{first} \geq 0xD800 \) and \( \text{first} \leq 0xDBFF \) and \( q + 1 \neq \text{size} \), then
            i. Let \( \text{second} \) be the code unit value of the element at index \( q + 1 \) in the String \( S \).
            ii. If \( \text{second} \geq 0xDC00 \) and \( \text{second} \leq 0xDFFF \), then
               1. Let \( q = q + 1 \).
               2. Let \( q = q + 1 \).
         iv. Else \( e \neq p \),
            1. Let \( T \) be a String value equal to the substring of \( S \) consisting of the elements at indices \( p \) (inclusive) through \( q \) (exclusive).
            2. Assert: The following call will never result in an abrupt completion.
            3. Call \( \text{CreateDataProperty}(A, \text{ToString}((\text{lengthA})), T) \).
            4. Let \( \text{lengthA} \) be \( \text{lengthA} + 1 \).
            5. If \( \text{lengthA} = \text{lim} \), return \( A \).
            6. Let \( p = e \).
            7. Let \( i = 0 \).
            8. Let \( \text{numberOfCaptures} \) be \( \text{ToLength(} \text{Get}(z, "length")) \).
            9. \textbf{ReturnIfAbrupt}(\( \text{numberOfCaptures} \)).
            10. Let \( \text{numberOfCaptures} \) be \( \text{max}(\text{numberOfCaptures} - 1, 0) \).
            11. Let \( i \) be 1.
            12. Repeat, while \( i \leq \text{numberOfCaptures} \).
               a. Let \( \text{nextCapture} \) be \( \text{Get}(z, \text{ToString}(i)) \).
               b. \textbf{ReturnIfAbrupt}(\( \text{nextCapture} \)).
               c. Call \( \text{CreateDataProperty}(A, \text{ToString}(\text{lengthA}), \text{nextCapture}) \).
               d. Let \( i = i + 1 \).
               e. Let \( \text{lengthA} \) be \( \text{lengthA} + 1 \).
               f. If \( \text{lengthA} = \text{lim} \), return \( A \).
            13. Let \( q = p \).

The \textit{length} property of the \texttt{@@split} method is 2.

The value of the \textit{name} property of this function is "\texttt{[Symbol.split]}".

NOTE The \texttt{@@split} method of this function uses the value of the \texttt{global} and \texttt{sticky} properties of this RegExp object.

21.2.5.12 \texttt{get RegExp.prototype.sticky}

\texttt{RegExp.prototype.sticky} is an accessor property whose set accessor function is \textbf{undefined}. Its get accessor function performs the following steps:

1. Let \( R \) be the \texttt{this} value.
2. If $\text{Type}(R)$ is not Object, throw a `TypeError` exception.
3. If $R$ does not have an `[[OriginalFlags]]` internal slot throw a `TypeError` exception.
4. Let flags be the value of $R$’s `[[OriginalFlags]]` internal slot.
5. If flags contains the code unit “y”, return `true`.
6. Return `false`.

### 21.2.5.13 `RegExp.prototype.test(S)`

The following steps are taken:

1. Let $R$ be the `this` value.
2. If $\text{Type}(R)$ is not Object, throw a `TypeError` exception.
3. Let `string` be `ToString(S)`.
4. ReturnIfAbrupt(`string`).
5. Let `match` be `RegExpExec(R, string)`.
6. ReturnIfAbrupt(`match`).
7. If `match` is not `null`, return `true`; else return `false`.

### 21.2.5.14 `RegExp.prototype.toString()`

1. Let $R$ be the `this` value.
2. If $\text{Type}(R)$ is not Object, throw a `TypeError` exception.
3. Let `pattern` be `ToString(Get(R, "source"))`.
4. ReturnIfAbrupt(`pattern`).
5. Let `flags` be `ToString(Get(R, "flags"))`.
6. ReturnIfAbrupt(`flags`).
7. Let `result` be the String value formed by concatenating “/”, `pattern`, and “/”, and `flags`.

**NOTE** The returned String has the form of a `RegularExpressionLiteral` that evaluates to another `RegExp` object with the same behaviour as this object.

### 21.2.5.15 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 $\text{Type}(R)$ is not Object, throw a `TypeError` exception.
3. If $R$ does not have an `[[OriginalFlags]]` internal slot throw a `TypeError` exception.
4. Let flags be the value of $R$’s `[[OriginalFlags]]` internal slot.
5. If flags contains the code unit “u”, return `true`.
6. Return `false`.

### 21.2.6 Properties of `RegExp` Instances

`RegExp` instances are ordinary objects that inherit properties from the `RegExp` prototype object. `RegExp` instances have internal slots `[[RegExpMatcher]]`, `[[OriginalSource]]`, and `[[OriginalFlags]]`. The value of the `[[RegExpMatcher]]` internal slot is an implementation dependent representation of the `Pattern` of the `RegExp` object.

**NOTE** Prior to the 6th Edition, `RegExp` instances were specified as having the own data properties `source`, `global`, `ignoreCase`, and `multiline`. Those properties are now specified as accessor properties of `RegExp.prototype`.

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RegExp instances also have the following property:

21.2.6.1 lastIndex

The value of the lastIndex property specifies the String index at which to start the next match. It is coerced to an integer when used (see 21.2.5.2.2). This property shall have the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }

22 Indexed Collections

22.1 Array Objects

Array objects are exotic objects that give special treatment to a certain class of property names. See 9.4.1.4 for a definition of this special treatment.

22.1.1 The Array Constructor

The Array constructor is the %Array% intrinsic object and the initial value of the Array property of the global object. When called as a constructor it creates and initializes a new exotic Array object. When Array is called as a function rather than as a constructor, it also creates and initializes a new Array object. Thus the function call Array(...) is equivalent to the object creation expression new Array(...) with the same arguments.

The Array constructor is a single function whose behaviour is overloaded based upon the number and types of its arguments.

The Array constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the exotic Array behaviour must include a super call to the Array constructor to initialize subclass instances that are exotic Array objects. However, most of the Array.prototype methods are generic methods that are not dependent upon their this value being an exotic Array object.

The length property of the Array constructor function is 1.

22.1.1.1 Array ()

This description applies if and only if the Array constructor is called with no arguments.

1. Let numberOfArgs be the number of arguments passed to this function call.
2. Assert: numberOfArgs = 0.
3. If NewTarget is undefined, let newTarget be the active function object, else let newTarget be NewTarget.
4. Let proto be GetPrototypeFromConstructor(newTarget, "%ArrayPrototype%”).
5. ReturnIfAbrupt(proto).
6. Return ArrayCreate(0, proto).

22.1.1.2 Array (len)

This description applies if and only if the Array constructor is called with exactly one argument.

1. Let numberOfArgs be the number of arguments passed to this function call.
3. If `NewTarget` is `undefined`, let `newTarget` be the active function object, else let `newTarget` be `NewTarget`.
4. Let `proto` be `GetPrototypeFromConstructor(newTarget, "%ArrayPrototype%")`.
5. ReturnIfAbrupt(`proto`).
6. Let `array` be `ArrayCreate(0, `proto`).
7. If `Type(len)` is not `Number`, then
   a. Let `defineStatus` be `CreateDataPropertyOrThrow(array, "0", `len`).
   b. `Assert: defineStatus` is not an abrupt completion.
   c. Let `intLen` be `1`.
8. Else,
   a. Let `intLen` be `ToUint32(len)`.
   b. If `intLen ≠ len`, throw a `RangeError` exception.
10. `Assert: putStatus` is not an abrupt completion.
11. Return `array`.

### 22.1.3 Array (...Items)

This description applies if and only if the `Array` constructor is called with 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 function call.
3. If `NewTarget` is `undefined`, let `newTarget` be the active function object, else let `newTarget` be `NewTarget`.
4. Let `proto` be `GetPrototypeFromConstructor(newTarget, "%ArrayPrototype%")`.
5. ReturnIfAbrupt(`proto`).
6. Let `array` be `ArrayCreate(numberOfArgs, `proto`).
7. ReturnIfAbrupt(`array`).
8. Let `k` be `0`.
9. Let `items` be a zero-originated List containing the argument items in order.
10. Repeat, while `k < numberOfArgs`:
    a. Let `Pk` be `ToString(k)`.
    b. Let `itemK` be `k`th element of `items`.
    c. Let `defineStatus` be `CreateDataPropertyOrThrow(array, `Pk`, `itemK`).`
    d. `Assert: defineStatus` is not an abrupt completion.
    e. Increase `k` by `1`.
11. `Assert: the value of array’s length property is numberOfArgs`.
12. Return `array`.

### 22.1.2 Properties of the Array Constructor

The value of the [[Prototype]] internal slot of the Array constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the `length` property (whose value is 1), the Array constructor has the following properties:

#### 22.1.2.1 Array.from ( items [, mapfn [, thisArg ]] )

When the `from` method is called with argument `items` and optional arguments `mapfn` and `thisArg` the following steps are taken:
1. Let C be the this value.
2. If mapfn is undefined, let mapping be false.
3. else
   a. If IsCallable(mapfn) is false, throw a TypeError exception.
   b. If thisArg was supplied, let T be thisArg; else let T be undefined.
   c. Let mapping be true
4. Let usingIterator be GetMethod(items, @@iterator).
5. ReturnIfAbrupt(usingIterator).
6. If usingIterator is not undefined, then
   a. If Constructor(C) is true, then
      i. Let A be Construct(C).
   Else,
      i. Let A be ArrayCreate(0).
   c. ReturnIfAbrupt(A).
   d. Let iterator be GetIterator(items, usingIterator).
   e. ReturnIfAbrupt(iterator).
   f. Let k be 0.
   g. Repeat
      i. Let Pk be ToString(k).
      ii. Let next be IteratorStep(iterator).
      iii. If next is an abrupt completion, return IteratorClose(iterator, next).
      iv. If next.[[value]] is false, then
          i. Let putStatus be Put(A, "length", k, true).
          ii. ReturnIfAbrupt(putStatus).
          iii. Otherwise, let mappedValue be nextValue.
          iv. Let defineStatus be CreateDataPropertyOrThrow(A, Pk, mappedValue).
          v. If defineStatus is an abrupt completion, return IteratorClose(iterator, defineStatus).
          vi. Increase k by 1.
   h. Repeat, while k < len
      a. Let Pk be ToString(k).
      b. Let kValue be Get(arrayLike, Pk).
      c. ReturnIfAbrupt(kValue).
      d. If mapping is true, then
         i. Let mappedValue be Call(mapfn, T, «kValue, k»).
         ii. ReturnIfAbrupt(mappedValue).
      end
5. Assert: items is not an iterable so assume it is an array-like object.
8. Let arrayLike be ToObject(items).
9. ReturnIfAbrupt(arrayLike).
10. Let len be ToLength(Get(arrayLike, "length")).
11. ReturnIfAbrupt(len).
12. If Constructor(C) is true, then
    a. Let A be Construct(C, «len»).
13. Else,
    a. Let A be ArrayCreate(len).
14. ReturnIfAbrupt(A).
15. Let k be 0.
16. Repeat, while k < len
    a. Let Pk be ToString(k).
    b. Let kValue be Get(arrayLike, Pk).
    c. ReturnIfAbrupt(kValue).
    d. If mapping is true, then
       i. Let mappedValue be Call(mapfn, T, «kValue, k»).
       ii. ReturnIfAbrupt(mappedValue).
The length property of the from method is 1.

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.

22.1.2.2 Array.isArray ( arg )

The isArray function takes one argument arg, and performs the following steps:

1. Return IsArray(arg).

22.1.2.3 Array.of ( ...items )

When the of method is called with any number of arguments, the following steps are taken:

1. Let len be the actual number of arguments passed to this function.
2. Let items be the List of arguments passed to this function.
3. Let C be the this value.
4. If IsConstructor(C) is true, then
   a. Let A be Construct(C, «len»).
5. Else,
   a. Let A be ArrayCreate(len).
6. ReturnIfAbrupt(A).
7. Let k be 0.
8. Repeat, while k < len
   a. Let kValue be element k of items.
   b. Let Pk be ToString(k).
   c. Let defineStatus be CreateDataPropertyOrThrow(A, Pk, kValue.[[value]]).
   d. ReturnIfAbrupt(defineStatus).
   e. Increase k by 1.
10. ReturnIfAbrupt(putStatus).
11. Return A.

The length property of the of method is 0.

NOTE 1 The items argument is assumed 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.

22.1.2.4 Array.prototype

The value of Array.prototype is %ArrayPrototype%, the intrinsic Array prototype object (22.1.3).
This property has the attributes {[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}.

### 22.1.2.5 get Array [@@species]

Array[@@species] is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is "get [Symbol.species]."

**NOTE**  Array prototype methods normally use their this object's constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

### 22.1.3 Properties of the Array Prototype Object

The value of the [[Prototype]] internal slot of the Array prototype object is the intrinsic object %ObjectPrototype%.

The Array prototype object is itself an ordinary object. It is not an Array instance and does not have a length property.

**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.

### 22.1.3.1 Array.prototype.concat (...arguments)

When the concat method is called with zero or more arguments, 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 ArraySpeciesCreate(O, 0).
4. ReturnIfAbrupt(A).
5. Let n be 0.
6. Let items be a 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.
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 spreadable be IsConcatSpreadable(E).
   c. ReturnIfAbrupt(spreadable).
   d. If spreadable is true, then
      i. Let k be 0.
      ii. Let len be ToLength(Get(E, "length")).
      iii. ReturnIfAbrupt(len).
      iv. If n + len > $2^{31}$ - 1, throw a TypeError exception.
     v. Repeat, while k < len
        1. Let P be ToString(k).
        2. Let exists be HasProperty(E, P).
        3. ReturnIfAbrupt(exists).
        4. If exists is true, then
a. Let `subElement` be `Get(E, P)`.
b. ReturnIfAbrupt(`subElement`).
c. Let `status` be `CreateDataPropertyOrThrow(A, ToString(n), subElement)`.
d. ReturnIfAbrupt(`status`).

5. Increase `n` by 1.
6. Increase `k` by 1.

e. Else `E` is added as a single item rather than spread,
   i. If `n ≥ 2^{31}-1`, throw a `TypeError` exception.
   ii. Let `status` be `CreateDataPropertyOrThrow(A, ToString(n), E)`.
   iii. ReturnIfAbrupt(`status`).
   iv. Increase `n` by 1.

8. Let `putStatus` be `Put(A, "length", n, true)`.
9. ReturnIfAbrupt(`putStatus`).
10. Return `A`.

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

**NOTE 1** The explicit setting of the `length` property in step 10 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.

### 22.1.3.1.1 `IsConcatSpreadable ( O )` Abstract Operation

The abstract operation `IsConcatSpreadable` with argument `O` performs the following steps:

1. If `Type(O)` is not `Object`, return `false`.
2. Let `spreadable` be `Get(O, @@isConcatSpreadable)`.
3. ReturnIfAbrupt(`spreadable`).
4. If `spreadable` is not `undefined`, return `ToBoolean(spreadable)`.
5. Return `IsArray(O)`.

### 22.1.3.2 `Array.prototype.constructor`

The initial value of `Array.prototype.constructor` is the intrinsic object `%Array%`.

### 22.1.3.3 `Array.prototype.copyWithin (target, start [, end ])`

The `copyWithin` method takes up to three arguments `target`, `start` and `end`.

**NOTE** The `end` argument is optional with the length of the `this` object as its default value. If `target` is negative, it is treated as `length+target` where `length` is the length of the array. If `start` is negative, it is treated as `length+start`. If `end` is negative, it is treated as `length+end`.

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 `len` be `ToLengthGet(O, "length")`.
4. ReturnIfAbrupt(`len`).
5. Let `relativeTarget` be `ToInteger(target)`.
6. ReturnIfAbrupt(`relativeTarget`).
7. If `relativeTarget < 0`, let `to` be `max(0, relativeTarget)`; else let `to` be `min(relativeTarget, len)`.
8. Let relativeStart be ToInteger(start).
9. ReturnIfAbrupt(relativeStart).
10. If relativeStart < 0, let from be  max((len + relativeStart),0); else let from be min(relativeStart, len).
11. If end is undefined, let relativeEnd be len; else let relativeEnd be ToInteger(end).
12. ReturnIfAbrupt(relativeEnd).
13. If relativeEnd < 0, let final be max((len + relativeEnd),0); else let final be min(relativeEnd, len).
14. Let count be min(final-from, len-to).
15. If from<to and to<from+count
   a. Let direction = -1.
   b. Let from = from + count -1.
   c. Let to = to + count -1.
16. Else,
   a. Let direction = 1.
17. Repeat, while count > 0
   a. Let fromKey be ToString(from).
   b. Let toKey be ToString(to).
   c. Let fromPresent be HasProperty(O, fromKey).
   d. ReturnIfAbrupt(fromPresent).
   e. If fromPresent is true, then
      i. Let fromVal be Get(O, fromKey).
      ii. ReturnIfAbrupt(fromVal).
      iii. Let putStatus be Put(O, toKey, fromVal, true).
      iv. ReturnIfAbrupt(putStatus).
   f. Else fromPresent is false,
      i. Let deleteStatus be DeletePropertyOrThrow(O, toKey).
      ii. ReturnIfAbrupt(deleteStatus).
   g. Let from be from + direction.
   h. Let to be to + direction.
   i. Let count be count - 1.
18. Return O.

The length property of the copyWithin method is 2.

NOTE 1 The copyWithin 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.

22.1.3.4 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 CreateArrayIterator(O, “key+value”).

22.1.3.5 Array.prototype.every ( callbackfn [ , thisArg ] )

NOTE 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.
2. ReturnIfAbrupt(`O`).
3. Let `len` be ToLength(\(O, \text{"length"}\)).
4. ReturnIfAbrupt(`len`).
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 `k` be `0`.
8. Repeat, while `k` < `len`
   a. Let `Pk` be ToString(`k`).
   b. Let `kPresent` be HasProperty(`O, Pk`).
   c. ReturnIfAbrupt(`kPresent`).
   d. If `kPresent` is `true`, then
      i. Let `kValue` be Get(`O, Pk`).
      ii. ReturnIfAbrupt(`kValue`).
      iii. Let `testResult` be ToBoolean(Call(`callbackfn`, `T, \langle kValue, k, O \rangle`)).
      iv. ReturnIfAbrupt(`testResult`).
      v. If `testResult` is `false`, return `false`.
   e. Increase `k` by `1`.
9. 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.

22.1.3.6 `Array.prototype.fill` (value [, start [, end ]])

The `fill` method takes up to three arguments `value`, `start` and `end`.

NOTE. The `start` and `end` arguments are optional with default values of `0` and the length of the `this` object. 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`.

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 `len` be ToLength(\(O, \text{"length"}\)).
4. ReturnIfAbrupt(`len`).
5. Let `relativeStart` be ToInteger(`start`).

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6. ReturnIfAbrupt(relativeStart).
7. If relativeStart < 0, let k be max((len + relativeStart), 0); else let k 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 < 0, let final be max((len + relativeEnd), 0); else let final be min(relativeEnd, len).
11. Repeat, while k < final
   a. Let Pk be ToString(k).
   b. Let putStatus be Put(O, Pk, value, true).
   c. ReturnIfAbrupt(putStatus).
   d. Increase k by 1.
12. Return O.

The length property of the fill method is 1.

NOTE 1 The fill 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.

22.1.3.7 Array.prototype.filter ( callbackfn [, thisArg ])

NOTE 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 len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
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 A be ArraySpeciesCreate(O, 0).
8. ReturnIfAbrupt(A).
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 HasProperty(O, Pk).
    c. ReturnIfAbrupt(kPresent).
    d. If kPresent is true, then
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.

22.1.3.8 Array.prototype.find (predicate [, thisArg ])

The find method is called with one or two arguments, predicate and thisArg.

NOTE predicate should be a function that accepts three arguments and returns a value that is coercible to a Boolean value. find calls predicate once for each element of 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.

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 correspond to non-existent properties are treated as if they the existed and have the value undefined.

When the find 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. ReturnIfAbrupt(O).
3. Let len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
5. If IsCallable(predicate) is false, throw a TypeError exception.
6. If thisArg was supplied, let T be thisArg; else let T be undefined.
7. Let k be 0.
8. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kValue be Get(O, Pk).
   c. ReturnIfAbrupt(kValue).
   d. Let testResult be ToBoolean(Call(predicate, T, «kValue, k, O»)).
   e. ReturnIfAbrupt(testResult).
   f. If testResult is true, return kValue.
   g. Increase k by 1.
9. 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.

22.1.3.9 `Array.prototype.findIndex (predicate [, thisArg ] )`

NOTE `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 of 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`.

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.

`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 `findIndex` 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 `len` be `ToLength(Get(O, "length")).`
4. ReturnIfAbrupt(`len`).
5. If `IsCallable(predicate)` is `false`, throw a `TypeError` exception.
6. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
7. Let `k` be `0`.
8. Repeat, while `k < len`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kValue` be `Get(O, Pk)`.
   c. ReturnIfAbrupt(`kValue`).
   d. Let `testResult` be `ToBoolean(Call(predicate, T, «kValue, k, O»))`.
   e. ReturnIfAbrupt(`testResult`).
   f. If `testResult` is `true`, return `k`.
   g. Increase `k` by 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.
22.1.3.10 Array.prototype.forEach (callbackfn [, thisArg ])

NOTE  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 callback 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. ReturnIfAbrupt(O).
3. Let len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
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 k be 0.
8. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let funcResult be Call(callbackfn, T, «kValue, k, O»).
   e. Increase k by 1.
9. 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.

22.1.3.11 Array.prototype.indexOf (searchElement [, fromIndex ])

NOTE  indexOf compares searchElement to the elements of the array, in ascending order, using the Strict Equality Comparison algorithm (7.2.11), and if found at one or more indices, returns the smallest such index; 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 `len` be `ToLength(Get(O, "length")).`
4. ReturnIfAbrupt(`len`).
5. If `len` is 0, return -1.
6. If argument `fromIndex` was passed let `n` be `ToInteger(fromIndex); else let `n` be 0.
7. ReturnIfAbrupt(`n`).
8. If `n ≥ len`, return -1.
9. If `n ≥ 0`, then
   a. Let `k` be `n`.
   b. If `k < 0`, let `k` be 0.
10. Else `n<0`,
    a. Let `k` be `len - abs(n)`.
    b. If `k < 0`, let `k` be 0.
11. Repeat, while `k<len`
    a. Let `kPresent` be `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 `searchElement === elementK`.
       iv. If `same` is `true`, return `k`.
    d. Increase `k` by 1.
12. 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.

22.1.3.12 `Array.prototype.join` (separator)

NOTE 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 `len` be the result of `ToLength(Get(O, "length")).`
4. ReturnIfAbrupt(`len`).
5. If `separator` is `undefined`, let `separator` be the single-element String ",".
6. Let `sep` be `ToString(separator)`.
7. ReturnIfAbrupt(`sep`).
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 `Get(O, ToString(k)).`
c. If `element` is `undefined` or `null`, 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.


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.

### 22.1.3.13 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 `CreateArrayIterator(O, "key")`.

### 22.1.3.14 Array.prototype.lastIndexOf (searchElement [, fromIndex ])

NOTE `lastIndexOf` compares `searchElement` to the elements of the array in descending order using the Strict Equality Comparison algorithm (7.2.11), and if found at one or more indices, returns the largest such index; 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 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 `len` be `ToLowerintValue(Object(O, "length"))`.
4. ReturnIfAbrupt(`len`).
5. If `len` is `0`, return `-1`.
6. If argument `fromIndex` was passed let `n` be `ToInteger(fromIndex)`; else let `n` be `len-1`.
7. ReturnIfAbrupt(`n`).
8. If `n ≥ 0`, let `k` be `min(n, len – 1)`.
9. Else `n < 0`.
   a. Let `k` be `len - abs(n)`.
10. Repeat, while `k ≥ 0`.
   a. Let `kPresent` be `HasProperty(O, ToString(k))`.
   b. ReturnIfAbrupt(`kPresent`).
   c. If `kPresent` is `true`, then
      i. Let `elementK` be `Get(O, ToString(k))`.
      ii. ReturnIfAbrupt(`elementK`).
      iii. Let `same` be the result of performing Strict Equality Comparison `searchElement === elementK`.
      iv. If `same` is `true`, return `k`.
   d. Decrease `k` by 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.

22.1.3.15 `Array.prototype.map ( callbackfn [ , thisArg ] )`

NOTE `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.
2. ReturnIfAbrupt(O).
3. Let len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
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 A be ArraySpeciesCreate(O, len).
8. ReturnIfAbrupt(A).
9. Let k be 0.
10. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
   e. Let mappedValue be Call(callbackfn, T, «kValue, k, O»).
   f. ReturnIfAbrupt(mappedValue).
   g. Let status be CreateDataPropertyOrThrow (A, Pk, mappedValue).
   h. ReturnIfAbrupt(status).
   i. Increase k by 1.
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.
22.1.3.16 Array.prototype.pop ( )

NOTE The last element of the array is removed from the array and returned.

When the `pop` 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. ReturnIfAbrupt(`O`).
3. Let `len` be ToLength(Get(`O`, "length")).
4. ReturnIfAbrupt(`len`).
5. If `len` is zero,
   a. Let `putStatus` be Put(`O`, "length", 0, true).
   b. ReturnIfAbrupt(`putStatus`).
   c. Return undefined.
6. Else `len` > 0,
   a. Let `newLen` be `len`–1.
   b. Let `indx` be ToString(`newLen`).
   c. Let `element` be Get(`O`, `indx`).
   d. ReturnIfAbrupt(`element`).
   e. Let `deleteStatus` be DeletePropertyOrThrow(`O`, `indx`).
   f. ReturnIfAbrupt(`deleteStatus`).
   g. Let `putStatus` be 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.

22.1.3.17 Array.prototype.push ( ...items )

NOTE 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 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 `len` be ToLength(Get(`O`, "length")).
4. ReturnIfAbrupt(`len`).
5. Let `items` be a List whose elements are, in left to right order, the arguments that were passed to this function invocation.
6. Let `argCount` be the number of elements in `items`.
7. If `len + argCount` ≥ 2^53-1, throw a `TypeError` exception.
8. 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 Put(`O`, ToString(`len`), `E`, true).
   c. ReturnIfAbrupt(`putStatus`).
   d. Let `len` be `len`+1.
10. ReturnIfAbrupt(`putStatus`).
11. Return `len`.

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.

22.1.3.18 `Array.prototype.reduce(callbackfn [, initialValue])`

NOTE `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 visiting 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 `len` be ToLength(GetValue(`O`, "length")).
4. ReturnIfAbrupt(`len`).
5. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
6. If `len` is 0 and `initialValue` is not present, throw a `TypeError` exception.
7. Let `k` be 0.
8. If `initialValue` is present, then
   a. Set `accumulator` to `initialValue`.
   b. Repeat, while `k Present` is `false` and `k < len`
      i. Let `Pk` be ToString(`k`).
      ii. Let `k Present` be HasProperty(`O`, `Pk`).
      iii. ReturnIfAbrupt(`k Present`).
      iv. If `k Present` is `true`, then
          1. Let `accumulator` be GetValue(`O`, `Pk`).
          2. ReturnIfAbrupt(`accumulator`).
          v. Increase `k` by 1.
   c. If `k Present` is `false`, throw a `TypeError` exception.
10. Repeat, while `k < len`
    a. Let `Pk` be ToString(`k`).
    b. Let `k Present` be HasProperty(`O`, `Pk`).
    c. ReturnIfAbrupt(`k Present`).
    d. If `k Present` is `true`, then
        i. Let `k Value` be GetValue(`O`, `Pk`).
        ii. ReturnIfAbrupt(`k Value`).
        iii. Let `accumulator` be Call(`callbackfn`, `undefined`, «`accumulator`, `k Value`, `k`, `O»`).
        iv. ReturnIfAbrupt(`accumulator`).
    e. Increase `k` by 1.
11. Return accumulator.

The length property of the reduce method is 1.

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.

22.1.3.19 Array.prototype.reduceRight (callbackfn [, initialValue])

NOTE  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 len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
5. If IsCallable(callbackfn) is false, throw a TypeError exception.
6. If len is 0 and initialValue is not present, throw a TypeError exception.
7. Let k be len - 1.
8. If initialValue is present, then
   a. Set accumulator to initialValue.
9. Else initialValue is not present, then
   a. Let kPresent be false.
   b. Repeat, while kPresent is false and k ≥ 0
      i. Let Pk be ToString(k).
      ii. Let kPresent be HasProperty(O, Pk).
      iii. ReturnIfAbrupt(kPresent).
      iv. If kPresent is true, then
         1. Let accumulator be Get(O, Pk).
         2. ReturnIfAbrupt(accumulator).
         v. Decrease k by 1.
   c. If kPresent is false, throw a TypeError exception.
10. Repeat, while k ≥ 0
    a. Let Pk be ToString(k).
    b. Let kPresent be HasProperty(O, Pk).
    c. ReturnIfAbrupt(kPresent).
    d. If kPresent is true, then
i. Let kValue be Get(O, Pk).
ii. ReturnIfAbrupt(kValue).
iii. Let accumulator be Call(callbackfn, undefined, «accumulator, kValue, k, »).
iv. ReturnIfAbrupt(accumulator).
e. Decrease k by 1.
11. 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.

22.1.3.20 Array.prototype.reverse()

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

When the reverse 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. ReturnIfAbrupt(O).
3. Let len be ToLength(Get(O, "length"));
4. ReturnIfAbrupt(len).
5. Let middle be floor(len/2).
6. Let lower be 0.
7. 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 lowerExists be HasProperty(O, lowerP).
   e. ReturnIfAbrupt(lowerExists).
   f. If lowerExists is true, then
      i. Let lowerValue be Get(O, lowerP).
      ii. ReturnIfAbrupt(lowerValue).
   g. Let upperExists be HasProperty(O, upperP).
   h. ReturnIfAbrupt(upperExists).
   i. If upperExists is true, then
      i. Let upperValue be Get(O, upper).
      ii. ReturnIfAbrupt(upperValue).
   j. If lowerExists is true and upperExists is true, then
      i. Let putStatus be Put(O, lowerP, upperValue, true).
      ii. ReturnIfAbrupt(putStatus).
      iii. Let putStatus be Put(O, upperP, lowerValue, true).
      iv. ReturnIfAbrupt(putStatus).
   k. Else if lowerExists is false and upperExists is true, then
      i. Let putStatus be Put(O, lowerP, upperValue, true).
      ii. ReturnIfAbrupt(putStatus).
      iii. Let deleteStatus be DeletePropertyOrThrow(O, upperP).
      iv. ReturnIfAbrupt(deleteStatus).
   l. Else if lowerExists is true and upperExists is false, then
      i. Let deleteStatus be DeletePropertyOrThrow(O, lowerP).
      ii. ReturnIfAbrupt(deleteStatus).
      iii. Let putStatus be Put(O, upperP, lowerValue, true).
iv. ReturnIfAbrupt(putStatus).

m. Else both lowerExists and upperExists are false.
   i. No action is required.
   n. Increase lower by 1.

8. Return 0.

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.

22.1.3.21 Array.prototype.shift()

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

When the shift 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. ReturnIfAbrupt(O).
3. Let len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
5. If len is zero, then
   a. Let putStatus be Put(O, "length", 0, true).
   b. ReturnIfAbrupt(putStatus).
   c. Return undefined.
6. Let first be Get(O, "0").
7. ReturnIfAbrupt(first).
8. Let k be 1.
9. Repeat, while k < len
   a. Let from be ToString(k).
   b. Let to be ToString(k - 1).
   c. Let fromPresent be HasProperty(O, from).
   d. ReturnIfAbrupt(fromPresent).
   e. If fromPresent is true, then
      i. Let fromVal be Get(O, from).
      ii. ReturnIfAbrupt(fromVal).
      iii. Let putStatus be Put(O, to, fromVal, true).
      iv. ReturnIfAbrupt(putStatus).
   f. Else fromPresent is false.
      i. Let deleteStatus be DeletePropertyOrThrow(O, to).
      ii. ReturnIfAbrupt(deleteStatus).
   g. Increase k by 1.
10. Let deleteStatus be DeletePropertyOrThrow(O, ToString(len - 1)).
11. ReturnIfAbrupt(deleteStatus).
12. Let putStatus be Put(O, "length", len - 1, true).
13. ReturnIfAbrupt(putStatus).

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.

22.1.3.22 Array.prototype.slice(start, end)

NOTE 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 \( \text{start} \) is negative, it is treated as \( \text{length} + \text{start} \) where \( \text{length} \) is the length of the array. If \( \text{end} \) is negative, it is treated as \( \text{length} + \text{end} \) where \( \text{length} \) is the length of the array.

The following steps are taken:

1. Let \( O \) be the result of calling \( \text{ToObject} \) passing the \( \text{this} \) value as the argument.
2. ReturnIfAbrupt(\( O \)).
3. Let \( \text{len} \) be \( \text{ToLength} (\text{Get}(O, \text{"length"})) \).
4. ReturnIfAbrupt(\( \text{len} \)).
5. Let \( \text{relativeStart} \) be \( \text{ToInteger}(\text{start}) \).
6. ReturnIfAbrupt(\( \text{relativeStart} \)).
7. If \( \text{relativeStart} < 0 \), let \( k \) be \( \max((\text{len} + \text{relativeStart}), 0) \); else let \( k \) be \( \min(\text{relativeStart}, \text{len}) \).
8. If \( \text{end} \) is \( \text{undefined} \), let \( \text{relativeEnd} \) be \( \text{len} \); else let \( \text{relativeEnd} \) be \( \text{ToInteger}(\text{end}) \).
9. ReturnIfAbrupt(\( \text{relativeEnd} \)).
10. If \( \text{relativeEnd} < 0 \), let \( \text{final} \) be \( \max((\text{len} + \text{relativeEnd}), 0) \); else let \( \text{final} \) be \( \min(\text{relativeEnd}, \text{len}) \).
11. Let \( \text{count} \) be \( \max(\text{final} - k, 0) \).
12. Let \( A \) be \( \text{ArraySpeciesCreate}(O, \text{count}) \).
13. ReturnIfAbrupt(\( A \)).
14. Let \( n \) be 0.
15. Repeat, while \( k < \text{final} \)
   a. Let \( Pk \) be \( \text{ToString}(k) \).
   b. Let \( kp\text{Present} \) be \( \text{HasProperty}(O, Pk) \).
   c. ReturnIfAbrupt(\( kp\text{Present} \)).
   d. If \( kp\text{Present} \) is \( \text{true} \), then
      i. Let \( k\text{Value} \) be \( \text{Get}(O, Pk) \).
      ii. ReturnIfAbrupt(\( k\text{Value} \)).
      iii. Let \( status \) be \( \text{CreateDataPropertyOrThrow}(A, \text{ToString}(n), k\text{Value}) \).
      iv. ReturnIfAbrupt(\( status \)).
   e. Increase \( k \) by 1.
   f. Increase \( n \) by 1.
16. Let \( p\text{utStatus} \) be \( \text{Put}(A, \text{"length"}, n, \text{true}) \).
17. ReturnIfAbrupt(\( p\text{utStatus} \)).
18. Return \( A \).

The \( \text{length} \) property of the \( \text{slice} \) method is \( 2 \).

**NOTE 1** The explicit setting of the \( \text{length} \) property of the result Array in step 19 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 \( \text{slice} \) function is intentionally generic; it does not require that its \( \text{this} \) value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

22.1.3.23 Array.prototype.some ( callbackfn [ , thisArg ] )

**NOTE** \( \text{callbackfn} \) should be a function that accepts three arguments and returns a value that is coercible to the Boolean value \( \text{true} \) or \( \text{false} \). \( \text{some} \) calls \( \text{callbackfn} \) once for each element present in the array, in ascending order, until it finds one where \( \text{callbackfn} \) returns \( \text{true} \). If such an element is found, \( \text{some} \) immediately returns \( \text{true} \). Otherwise, \( \text{some} \) returns \( \text{false} \). \( \text{callbackfn} \) is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a \( \text{thisArg} \) parameter is provided, it will be used as the \( \text{this} \) value for each invocation of \( \text{callbackfn} \). If it is not provided, \( \text{undefined} \) 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 len be ToLength(Get(O, "length")).
4. ReturnIfAbrupt(len).
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 k be 0.
8. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let testResult be ToBoolean(Call(callbackfn, T, « kValue, k, and O »)).
      iv. ReturnIfAbrupt(testResult).
      v. If testResult is true, return true.
   e. Increase k by 1.
9. 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.

22.1.3.24 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.

Within this specification of the sort method, an Array object, obj, is said to be sparse if the following algorithm returns true:

1. Let len be Get(obj, "length").
2. For each integer i in the range 0 ≤ i < ToUint32(len)
   a. Let elem be the result of calling the [[GetOwnProperty]] internal method of obj with argument ToString(i).
   b. If elem is undefined, return true.
3. Return false.
Upon entry, the following steps are performed to initialize evaluation of the sort function:

1. Let obj be the result of calling ToObject passing the this value as the argument.
2. Let len be ToLength(Get(obj, "length"));
3. ReturnIfAbrupt(len).

The sort order is the ordering of the array index property values of obj after completion of this function. The result of the sort function is then determined as follows:

- If comparefn is not undefined and is not a consistent comparison function for the elements of this array (see below), the sort order is implementation-defined. The sort order is also implementation-defined if comparefn is undefined and SortCompare (22.1.3.24.1) does not act as a consistent comparison function.

Let proto be the result of calling the [[GetPrototypeOf]] 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 sort order is implementation-defined:
- obj is sparse (22.1)
- 0 ≤ j < len
- The result of HasProperty(proto, ToString(j)) is true.

The sort order 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 sort order is also implementation defined if any of the following conditions are true:
- If obj is an exotic object (including Proxy exotic objects) whose behaviour for [[Get]], [[Set]], [[Delete]], and [[GetPropertyOwnProperty]] is different from the ordinary object behaviour for these internal methods.
- 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.

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 and HasOwnProperty abstract operation with obj as the first argument, and to SortCompare (described below), such that:
   - The property key argument for each call to [[Get]], [[Set]], HasOwnProperty, or DeletePropertyOrThrow is the string representation of a nonnegative integer less than len.
   - The arguments for calls to SortCompare are values returned by a previous call to the [[Get]] internal method, unless the properties accessed by those previous calls did not exist according to [[HasOwnProperty]]. If both perspective arguments to SortCompare correspond to non-existent properties, use +0 instead of calling SortCompare. If only the first perspective argument is non-existent use +1. If only the second perspective argument is non-existent use −1.
   - 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.
Unless the sort order is specified above to be implementation-defined, the returned object must have the following two characteristics:

- There must be some mathematical permutation \( \pi \) of the nonnegative integers less than \( len \), such that for every nonnegative integer \( j \) less than \( len \), if property \( \text{old}[j] \) existed, then \( \text{new}[\pi(j)] \) is exactly the same value as \( \text{old}[j] \). But if property \( \text{old}[j] \) did not exist, then \( \text{new}[\pi(j)] \) does not exist.
- Then for all nonnegative integers \( j \) and \( k \), each less than \( len \), if \( \text{SortCompare} \text{old}[j], \text{old}[k] < 0 \) (see SortCompare below), then \( \text{new}[\pi(j)] < \text{new}[\pi(k)] \).

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

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

- Calling \( \text{comparefn}(a,b) \) always returns the same value \( v \) when given a specific pair of values \( a \) and \( b \) as its two arguments. Furthermore, \( \text{Type}(v) \) is Number, and \( v \) is not NaN. Note that this implies that exactly one of \( a \prec_S b, a \equiv_S b, \) and \( a \succ_S b \) will be true for a given pair of \( a \) and \( b \).
- Calling \( \text{comparefn}(a,b) \) does not modify \( \text{obj} \) or any object on \( \text{obj}'s \) prototype chain.
- \( a \equiv_S a \) (reflexivity)
- If \( a \equiv_S b \), then \( b \equiv_S a \) (symmetry)
- If \( a \equiv_S b \) and \( b \equiv_S c \), then \( a \equiv_S c \) (transitivity of \( \equiv_S \))
- If \( a \prec_S b \) and \( b \prec_S c \), then \( a \prec_S c \) (transitivity of \( \prec_S \))
- If \( a \succ_S b \) and \( b \succ_S c \), then \( a \succ_S c \) (transitivity of \( \succ_S \))

**NOTE 1** The above conditions are necessary and sufficient to ensure that \( \text{comparefn} \) divides the set \( S \) into equivalence classes and that these equivalence classes are totally ordered.

**NOTE 2** The \( \text{sort} \) function is intentionally generic; it does not require that its \( \text{this} \) value be an Array object. Therefore, it can be transferred to other kinds of objects for use as a method.

### 22.1.3.24.1 Runtime Semantics: SortCompare Abstract Operation

When the SortCompare abstract operation is called with two arguments \( x \) and \( y \), the following steps are taken:

1. If \( x \) and \( y \) are both \text{undefined}, return \(-1\).
2. If \( x \) is \text{undefined}, return \(1\).
3. If \( y \) is \text{undefined}, return \(-1\).
4. If the argument \( \text{comparefn} \) is not \text{undefined}, then
   a. Let \( v \) be \Call\(\text{comparefn, undefined, »x, y»}\)
   b. ReturnIfAbrupt\(\(v\).
   c. If \( v \) is \text{NaN}, return \(-1\).
   d. Return \(v\).
5. Let \( x\text{String} \) be To\(\text{String}(x)\).
6. ReturnIfAbrupt\(\(x\text{String}\).
7. Let \( y\text{String} \) be To\(\text{String}(y)\).
8. ReturnIfAbrupt\(\(y\text{String}\).
9. If \( x\text{String} \lt y\text{String} \), return \(-1\).
10. If \( x\text{String} \gt y\text{String} \), return \(1\).
11. 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 Method calls performed by the ToString abstract operations in steps 5 and 7 have the potential to cause SortCompare to not behave as a consistent comparison function.

22.1.3.25 `Array.prototype.splice (start, deleteCount , ...items )`

NOTE When the `splice` method is called with two or more arguments `start`, `deleteCount` and zero or more `items`, the `deleteCount` elements of the array starting at integer index `start` are replaced by the arguments `items`. 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 `len` be ToLength(Get(`O`, "length")).
4. ReturnIfAbrupt(`len`).
5. Let `relativeStart` be ToInteger(start).
6. ReturnIfAbrupt(`relativeStart`).
7. If `relativeStart` < 0, let `actualStart` be max((`len` + `relativeStart`), 0); else let `actualStart` be min(`relativeStart`, `len`).
8. If the number of actual arguments is 0, then
   a. Let `insertCount` be 0.
   b. Let `actualDeleteCount` be 0.
9. Else if the number of actual arguments is 1, then
   a. Let `insertCount` be 0.
   b. Let `actualDeleteCount` be `len` - `actualStart`.
10. Else,
    a. Let `insertCount` be the number of actual arguments minus 2.
    b. Let `dc` be ToInteger(`deleteCount`).
    c. ReturnIfAbrupt(`dc`).
    d. Let `actualDeleteCount` be min(max(`dc`, 0), `len` - `actualStart`).
11. If `len` - `insertCount` - `actualDeleteCount` > 2**31-1, throw a `TypeError` exception.
12. Let `A` be ArraySpeciesCreate(`O`, `actualDeleteCount`).
13. ReturnIfAbrupt(`A`).
14. Let `k` be 0.
15. Repeat, while `k` < `actualDeleteCount`
    a. Let `from` be ToString(`actualStart` + `k`).
    b. Let `fromPresent` be HasProperty(`O`, `from`).
    c. ReturnIfAbrupt(`fromPresent`).
    d. If `fromPresent` is `true`, then
       i. Let `fromValue` be Get(`O`, `from`).
       ii. ReturnIfAbrupt(`fromValue`).
       iii. Let `status` be CreateDataPropertyOrThrow(`A`, ToString(`k`), `fromValue`).
       iv. ReturnIfAbrupt(`status`).
    e. Increment `k` by 1.
16. Let `putStatus` be PutA(, "length", `actualDeleteCount`, `true`).
17. ReturnIfAbrupt(`putStatus`).
18. Let `items` be a List whose elements are, in left to right order, the portion of the actual argument list starting with the third argument. The list is empty if fewer than three arguments were passed.
19. Let `addItemCount` be the number of elements in `items`.
20. 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 `HasProperty(O, from)`.
      iv. ReturnIfAbrupt(`fromPresent`).
      v. If `fromPresent` is `true`, then
          1. Let `fromValue` be `Get(O, from)`.
          2. ReturnIfAbrupt(`fromValue`).
          3. Let `putStatus` be `Put(O, to, fromValue, true)`.
          4. ReturnIfAbrupt(`putStatus`).
      vi. Else `fromPresent` is `false`, 1.
          1. Let `deleteStatus` be `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 `DeletePropertyOrThrow(O, ToString(k-1))`.
      ii. ReturnIfAbrupt(`deleteStatus`).
      iii. Decrease `k` by 1.
21. 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 `HasProperty(O, from)`.
      iv. ReturnIfAbrupt(`fromPresent`).
      v. If `fromPresent` is `true`, then
          1. Let `fromValue` be `Get(O, from)`.
          2. ReturnIfAbrupt(`fromValue`).
          3. Let `putStatus` be `Put(O, to, fromValue, true)`.
          4. ReturnIfAbrupt(`putStatus`).
      vi. Else `fromPresent` is `false`, 1.
          1. Let `deleteStatus` be `DeletePropertyOrThrow(O, to)`.
          2. ReturnIfAbrupt(`deleteStatus`).
      vii. Decrease `k` by 1.
22. Let `k` be `actualStart`.
23. 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 `Put(O, ToString(k), E, true)`.
   c. ReturnIfAbrupt(`putStatus`).
   d. Increase `k` by 1.
24. Let `putStatus` be `Put(O, "length", len – actualDeleteCount + itemCount, true)`.
25. ReturnIfAbrupt(`putStatus`).

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

NOTE 1  The explicit setting of the `length` property of the result Array in step 18 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.

22.1.3.26 `Array.prototype.toLocaleString ([ reserved1 [, reserved2 ] ])

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the `Array.prototype.toLocaleString` method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the `toLocaleString` method is used.

NOTE The first edition of ECMA-402 did not include a replacement specification for the `Array.prototype.toLocaleString` method.

The meanings of the optional parameters to this method are defined in the ECMA-402 specification; implementations that do not include ECMA-402 support must not use those parameter positions for anything else.

The following steps are taken:

1. Let `array` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`array`).
3. Let `len` be `ToLength(Get(array, "length")).`
4. ReturnIfAbrupt(`len`).
5. 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).
6. If `len` is zero, return the empty String.
7. Let `firstElement` be `Get(array, "0")`.
8. ReturnIfAbrupt(`firstElement`).
9. If `firstElement` is `undefined` or `null`, then
   a. Let `R` be the empty String.
   10. Else
      a. Let `R` be `ToString(Invoke(firstElement, "toLocaleString"))`.
      b. ReturnIfAbrupt(`R`).
   11. Let `k` be 1.
12. Repeat, while `k` < `len`
   a. Let `S` be a String value produced by concatenating `R` and `separator`.
   b. Let `nextElement` be `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 `ToString(Invoke(nextElement, "toLocaleString"))`.
      ii. ReturnIfAbrupt(`R`).
   f. Let `R` be a String value produced by concatenating `S` and `R`.
   g. Increase `k` by 1.
13. Return `R`.

NOTE 1 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.
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.

22.1.3.27 `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 `Get(array, "join")`.
4. ReturnIfAbrupt(`func`).
5. If `IsCallable(func)` is `false`, let `func` be the intrinsic function `%ObjProto_toString%` (19.1.3.6).
6. Return `Call(func, array)`.

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.

22.1.3.28 `Array.prototype.unshift(...items)`

NOTE 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. ReturnIfAbrupt(`O`).
3. Let `len` be `ToLength(Get(O, "length")).`
4. ReturnIfAbrupt(`len`).
5. Let `argCount` be the number of actual arguments.
6. If `argCount > 0`, then
   a. If `len+argCount > 2^{53}-1`, throw a `TypeError` exception.
   b. Let `k` be `len`.
   c. Repeat, while `k > 0`,
      i. Let `from` be `ToString(k-1)`.
      ii. Let `to` be `ToString(k+argCount-1)`.
      iii. Let `fromPresent` be `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 `Put(O, to, fromValue, true)`.
         4. ReturnIfAbrupt(`putStatus`).
      vi. Else `fromPresent` is `false`,
         1. Let `deleteStatus` be `DeletePropertyOrThrow(O, to)`.
         2. ReturnIfAbrupt(`deleteStatus`).
      vii. Decrease `k` by `1`.
   d. Let `j` be `0`.
   e. Let `items` be a List whose elements are, in left to right order, the arguments that were passed to this function invocation.
   f. Repeat, while `items` is not empty
      i. Remove the first element from `items` and let `E` be the value of that element.
      ii. Let `putStatus` be `Put(O, ToString(j), E, true)`.© Ecma International 2015
iii. ReturnIfAbrupt(putStatus).
iv. Increase j by 1.
7. Let putStatus be Put(O, "length", len+argCount, true).
8. ReturnIfAbrupt(putStatus).
9. Return len+argCount.

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.

22.1.3.29 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 CreateArrayIterator(O, "value").

This function is the %ArrayProto_values% intrinsic object.

22.1.3.30 Array.prototype[@@iterator] ()

The initial value of the @@iterator property is the same function object as the initial value of the Array.prototype.values property.

22.1.3.31 Array.prototype[@@unscopables] 

The initial value of the @@unscopables data property is an object created by the following steps:
1. Let blacklist be ObjectCreate(null).
2. Perform CreateDataProperty(blacklist, "copyWithin", true).
3. Perform CreateDataProperty(blacklist, "entries", true).
4. Perform CreateDataProperty(blacklist, "fill", true).
5. Perform CreateDataProperty(blacklist, "find", true).
6. Perform CreateDataProperty(blacklist, "findIndex", true).
7. Perform CreateDataProperty(blacklist, "keys", true).
8. Perform CreateDataProperty(blacklist, "values", true).
9. Assert: Each of the above calls will return true.
10. Return blacklist.

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

NOTE The own property names of this object are property names that were not included as standard properties of Array.prototype prior to the sixth edition of this specification. These names are ignored for with statement binding purposes in order to preserve the behaviour of existing code that might use one of these names as a binding in an outer scope that is shadowed by a with statement whose binding object is an Array object.

22.1.4 Properties of Array Instances

Array instances are Array exotic objects and have the internal methods specified for such objects. Array instances inherit properties from the Array prototype object.
Array instances have a `length` property, and a set of enumerable properties with array index names.

### 22.1.4.1 length

The `length` property of an Array instance is a data property whose value is always numerically greater than the name of every configurable own 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 own property name of an existing array indexed configurable property of the array will result in the `length` being set to a numeric value that is one greater than that largest numeric own property name. See 9.4.2.1.

### 22.1.5 Array Iterator Objects

An Array Iterator is an object, that represents 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.

#### 22.1.5.1 CreateArrayIterator Abstract Operation

Several methods of Array objects return Iterator objects. The abstract operation `CreateArrayIterator` with arguments `array` and `kind` is used to create such iterator objects. It performs the following steps:

1. **Assert:** Type(`array`) is Object.
2. Let `iterator` be ObjectCreate(%ArrayIteratorPrototype%, «[[IteratedObject]],[[ArrayIteratorNextIndex]],[[ArrayIterationKind]]»).
3. Set `iterator`'s [[IteratedObject]] internal slot to `array`.
4. Set `iterator`'s [[ArrayIteratorNextIndex]] internal slot to 0.
5. Set `iterator`'s [[ArrayIterationKind]] internal slot to `kind`.
6. Return `iterator`.

#### 22.1.5.2 The %ArrayIteratorPrototype% Object

All Array Iterator Objects inherit properties from the %ArrayIteratorPrototype% intrinsic object. The %ArrayIteratorPrototype% object is an ordinary object and its [[Prototype]] internal slot is the %IteratorPrototype% intrinsic object (25.1.2). In addition, %ArrayIteratorPrototype% has the following properties:

##### 22.1.5.2.1 %ArrayIteratorPrototype%.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 slots of an Array Iterator Instance (22.1.5.3), throw a `TypeError` exception.
4. Let `a` be the value of the [[IteratedObject]] internal slot of `O`.
5. If `a` is `undefined`, return CreateIterResultObject(undefined, true).
6. Let `index` be the value of the [[ArrayIteratorNextIndex]] internal slot of `O`.
7. Let `itemKind` be the value of the [[ArrayIterationKind]] internal slot of `O`.
8. If `a` has a [[TypedArrayName]] internal slot, then
   a. Let `len` be the value of `O`'s [[ArrayLength]] internal slot.
9. Else,
a. Let len be ToLength(Get(a, "length")).
   b. ReturnIfAbrupt(len).

10. If index ≥ len, then
    a. Set the value of the [[IteratedObject]] internal slot of O to undefined.
    b. Return CreateIterResultObject(undefined, true).

11. Set the value of the [[ArrayIteratorNextIndex]] internal slot of O to index+1.

12. If itemKind is "key", CreateIterResultObject(index, false).

13. Let elementKey be ToString(index).

14. Let elementValue be Get(a, elementKey).

15. ReturnIfAbrupt(elementValue).

16. If itemKind is "value", let result be elementValue.

17. Else,
    a. Assert itemKind is "key+value".
    b. Let result be ArrayCreate(2).
    c. Assert: result is a new, well-formed Array object so the following operations will never fail.
    d. Call CreateDataProperty(result, "0", index).
    e. Call CreateDataProperty(result, "1", elementValue).

18. Return CreateIterResultObject(result, false).

22.1.5.2.2 %ArrayIteratorPrototype% [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value "Array Iterator".

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

22.1.5.3 Properties of Array Iterator Instances

Array Iterator instances are ordinary objects that inherit properties from the %ArrayIteratorPrototype% intrinsic object. Array Iterator instances are initially created with the internal slots listed in Table 45.

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[IteratedObject]]</td>
<td>The object whose array elements are being iterated.</td>
</tr>
<tr>
<td>[[ArrayIteratorNextIndex]]</td>
<td>The integer index of the next array index to be examined by this iteration.</td>
</tr>
<tr>
<td>[[ArrayIterationKind]]</td>
<td>A string value that identifies what is to be returned for each element of the iteration. The possible values are: &quot;key&quot;, &quot;value&quot;, &quot;key+value&quot;.</td>
</tr>
</tbody>
</table>

22.2 TypedArray Objects

TypedArray objects present an array-like view of an underlying binary data buffer (24.1). Each element of a TypedArray instance has the same underlying binary scalar data type. There is a distinct TypedArray constructor, listed in Table 46, for each of the nine supported element types. Each constructor in Table 46 has a corresponding distinct prototype object.
Table 46 – The TypedArray Constructors

<table>
<thead>
<tr>
<th>Constructor Name and Intrinsic</th>
<th>Element Type</th>
<th>Element Size</th>
<th>Conversion Operation</th>
<th>Description</th>
<th>Equivalent C Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int8Array %Int8Array%</td>
<td>Int8</td>
<td>1</td>
<td>ToInt8</td>
<td>8-bit 2’s complement signed integer</td>
<td>signed char</td>
</tr>
<tr>
<td>Uint8Array %Uint8Array%</td>
<td>Uint8</td>
<td>1</td>
<td>ToUint8</td>
<td>8-bit unsigned integer</td>
<td>unsigned char</td>
</tr>
<tr>
<td>Uint8ClampedArray %Uint8ClampedArray%</td>
<td>Uint8C</td>
<td>1</td>
<td>ToUint8Clamp</td>
<td>8-bit unsigned integer (clamped conversion)</td>
<td>unsigned char</td>
</tr>
<tr>
<td>Int16Array %Int16Array%</td>
<td>Int16</td>
<td>2</td>
<td>ToInt16</td>
<td>16-bit 2’s complement signed integer</td>
<td>short</td>
</tr>
<tr>
<td>Uint16Array %Uint16Array%</td>
<td>Uint16</td>
<td>2</td>
<td>ToUint16</td>
<td>16-bit unsigned integer</td>
<td>unsigned short</td>
</tr>
<tr>
<td>Int32Array %Int32Array%</td>
<td>Int32</td>
<td>4</td>
<td>ToInt32</td>
<td>32-bit 2’s complement signed integer</td>
<td>int</td>
</tr>
<tr>
<td>Uint32Array %Uint32Array%</td>
<td>Uint32</td>
<td>4</td>
<td>ToUint32</td>
<td>32-bit unsigned integer</td>
<td>unsigned int</td>
</tr>
<tr>
<td>Float32Array %Float32Array%</td>
<td>Float32</td>
<td>4</td>
<td>ToFloat32</td>
<td>32-bit IEEE floating point</td>
<td>float</td>
</tr>
<tr>
<td>Float64Array %Float64Array%</td>
<td>Float64</td>
<td>8</td>
<td></td>
<td>64-bit IEEE floating point</td>
<td>double</td>
</tr>
</tbody>
</table>

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.

22.2.1 The %TypedArray% Intrinsic Object

The %TypedArray% intrinsic object is a constructor function object that all of the TypedArray constructor object inherit from. %TypedArray% and its corresponding prototype object provide common properties that are inherited by all TypedArray constructors and their instances. The %TypedArray% intrinsic does not have a global name or appear as a property of the global object.

The %TypedArray% intrinsic function object is designed to act as the superclass of the various TypedArray constructors. Those constructors use %TypedArray% to initialize their instances by invoking %TypedArray% as if by making a super call. The %TypedArray% intrinsic function is not designed to be directly called in any other way. If %TypedArray% is directly called or called as part of a new expression an exception is thrown.

The %TypedArray% intrinsic function constructor is a single function whose behaviour is overloaded based upon the number and types of its arguments. The actual behaviour of a super call of %TypedArray% depends upon the number and kind of arguments that are passed to it.

22.2.1.1 %TypedArray% ( length )

This description applies only if the %TypedArray% function is called and the Type of the first argument is not Object.
%TypedArray% called with argument length performs the following steps:

1. Assert: Type(length) is not Object.
2. If NewTarget is undefined, throw a TypeError exception.
3. Let numberLength be ToNumber(length).
4. Let elementLength be ToLength(numberLength).
5. ReturnIfAbrupt(elementLength).
6. If SameValueZero(numberLength, elementLength) is false, throw a RangeError exception.

22.2.1.1 Runtime Semantics: AllocateTypedArray (newTarget, length)

The abstract operation AllocateTypedArray with argument newTarget and optional argument length is used to validate and create an instance of a TypedArray constructor. If the length argument is passed an ArrayBuffer of that length is also allocated and associated with the new TypedArray instance. AllocateTypedArray provides common semantics that is used by all of the %TypeArray% overloads and other methods. AllocateTypedArray performs the following steps:

1. If SameValue(%TypedArray%, newTarget) is true, throw a TypeError exception.
2. Let constructorName be undefined.
3. Let subclass be newTarget.
4. Repeat while constructorName is undefined
   a. If subclass is null, throw a TypeError exception.
   b. If SameValue(%TypedArray%, subclass) is true, throw a TypeError exception.
   c. If subclass has a [[TypedArrayConstructorName]] internal slot, let constructorName be the value of subclass’s [[TypedArrayConstructorName]] internal slot.
   d. Let subclass be the result of calling the [[GetPrototypeOf]] internal method of subclass with no arguments.
   e. ReturnIfAbrupt(subclass).
5. Let proto be GetPrototypeOf(constructorName, "%TypedArrayPrototype").
6. ReturnIfAbrupt(proto).
7. Let obj be INTEGERINDEXEDOBJECTCREATE(proto, [[ViewedArrayBuffer]], [[TypedArrayName]], [[ByteLength]], [[ByteOffset]], [[ArrayLength]]).
8. Assert: The [[ViewedArrayBuffer]] internal slot of obj is undefined.
9. Set obj’s [[TypedArrayName]] internal slot to constructorName.
10. If length was not passed, then
    a. Set obj’s [[ByteLength]] internal slot to 0.
    b. Set obj’s [[ByteOffset]] internal slot to 0.
    c. Set obj’s [[ArrayLength]] internal slot to 0.
11. Else,
    a. Let elementSize be the Element Size value in Table 46 for constructorName.
    b. Let byteLength be elementSize × length.
    c. Let data be AllocatoreArrayBuffer(%ArrayBuffer%, byteLength).
    d. ReturnIfAbrupt(data).
    e. Set obj’s [[ViewedArrayBuffer]] internal slot to data.
    f. Set obj’s [[ByteLength]] internal slot to byteLength.
    g. Set obj’s [[ByteOffset]] internal slot to 0.
    h. Set obj’s [[ArrayLength]] internal slot to length.
12. Return obj.
22.2.1.2 `%TypedArray% ( typedArray )`

This description applies only if the `%TypedArray%` function is called with at least one argument and the Type of the first argument is `Object` and that object has a `[[TypedArrayName]]` internal slot.

`%TypedArray%` called with argument `typedArray` performs the following steps:

1. Assert: Type(typedArray) is Object and typedArray has a `[[TypedArrayName]]` internal slot.
2. If `NewTarget` is `undefined`, throw a `TypeError` exception.
3. Let `O` be `AllocateTypedArray`(`NewTarget`).
4. ReturnIfAbrupt(`O`).
5. Let `srcArray` be `typedArray`.
6. Let `srcData` be the value of `srcArray`'s `[[ViewedArrayBuffer]]` internal slot.
7. If `IsDetachedBuffer(srcData)` is `true`, throw a `TypeError` exception.
8. Let `constructorName` be the string value of `O`'s `[[TypedArrayName]]` internal slot.
9. Let `elementType` be the string value of the `Element Type` value in Table 46 for `constructorName`.
10. Let `elementLength` be the value of `srcArray`'s `[[ArrayLength]]` internal slot.
11. Let `srcName` be the string value of `srcArray`'s `[[TypedArrayName]]` internal slot.
12. Let `elementSize` be the value of the `Element Size` value in Table 46 for `srcName`.
13. Let `srcByteOffset` be the value of `srcArray`'s `[[ByteOffset]]` internal slot.
14. Let `srcByteLength` be the value of `srcArray`'s `[[ByteLength]]` internal slot.
15. Let `elementSize` be the `Element Size` value in Table 46 for `constructorName`.
16. Let `byteLength` be `elementSize` × `elementLength`.
17. If `SameValue(elementType, srcType)` is `true`, then
   a. Let `data` be `CloneArrayBuffer`(`srcData`, `srcByteOffset`).
   b. ReturnIfAbrupt(`data`).
18. Else,
   a. Let `bufferConstructor` be `SpeciesConstructor`(`srcData`, `%ArrayBuffer%`).
   b. ReturnIfAbrupt(`bufferConstructor`).
   c. Let `data` be `AllocateArrayBuffer`(`bufferConstructor`, `byteLength`).
   d. If `IsDetachedBuffer(srcData)` is `true`, throw a `TypeError` exception.
   e. Let `srcByteIndex` be `srcByteOffset`.
   f. Let `targetByteIndex` be 0.
   g. Let `count` be `elementLength`.
   h. Repeat, while `count` > 0
      i. Let `value` be `GetValueFromBuffer`(`srcData`, `srcByteIndex`, `srcType`).
      ii. Let `status` be `SetValueInBuffer`(`data`, `targetByteIndex`, `elementType`, `value`).
      iii. Set `srcByteIndex` to `srcByteIndex` + `elementSize`.
      iv. Set `targetByteIndex` to `targetByteIndex` + `elementSize`.
   i. Decrement `count` by 1.
19. Set `O`'s `[[ViewedArrayBuffer]]` internal slot to `data`.
20. Set `O`'s `[[ByteLength]]` internal slot to `byteLength`.
21. Set `O`'s `[[ByteOffset]]` internal slot to 0.
22. Set `O`'s `[[ArrayLength]]` internal slot to `elementLength`.
23. Return `O`.

22.2.1.3 `%TypedArray% ( object )`

This description applies only if the `%TypedArray%` function is called with at least one argument and the Type of first argument is `Object` and that object does not have either a `[[TypedArrayName]]` or an `[[ArrayBufferData]]` internal slot.

`%TypedArray%` called with argument `object` performs the following steps:
1. Assert: Type(object) is Object and object does not have either a [[TypedArrayName]] or an [[ArrayBufferData]] internal slot.
2. If NewTarget is undefined, throw a TypeError exception.
3. Return TypedArrayFrom(NewTarget, object, undefined, undefined).

22.2.1.4 %TypedArray% ( buffer [ , byteOffset [ , length ] ] )

This description applies only if the %TypedArray% function is called with at least one argument and the Type of the first argument is Object and that object has an [[ArrayBufferData]] internal slot.

%TypedArray% called with arguments buffer, byteOffset, and length performs the following steps:

1. Assert: Type(buffer) is Object and buffer has an [[ArrayBufferData]] internal slot.
2. If NewTarget is undefined, throw a TypeError exception.
3. Let O be AllocateTypedArray(NewTarget).
4. ReturnIfAbrupt(O).
5. Let constructorName be the string value of O's [[TypedArrayName]] internal slot.
6. Let elementSize be the Number value of the Element Size value in Table 46 for constructorName.
7. Let offset be ToInteger(byteOffset).
8. ReturnIfAbrupt(offset).
9. If offset < 0, throw a RangeError exception.
10. If offset modulo elementSize ≠ 0, throw a RangeError exception.
11. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
12. Let bufferByteLength be the value of buffer's [[ArrayBufferByteLength]] internal slot.
13. If length is undefined, then
   a. If bufferByteLength modulo elementSize ≠ 0, throw a RangeError exception.
   b. Let newByteLength be bufferByteLength – offset.
   c. If newByteLength < 0, throw a RangeError exception.
14. Else,
   a. Let newLength be ToLength(length).
   b. ReturnIfAbrupt(newLength).
   c. Let newByteLength be newLength × elementSize.
   d. If offset + newByteLength > bufferByteLength, throw a RangeError exception.
15. Set O's [[ViewedArrayBuffer]] internal slot to buffer.
16. Set O's [[ByteLength]] internal slot to newByteLength.
17. Set O's [[ByteOffset]] internal slot to offset.
18. Set O's [[ArrayLength]] internal slot to newByteLength / elementSize.
19. Return O.

22.2.1.5 %TypedArray% ( all other argument combinations )

If the %TypedArray% function is called with arguments that do not match any of the preceding argument descriptions a TypeError exception is thrown.

22.2.2 Properties of the %TypedArray% Intrinsic Object

The %TypedArray% intrinsic object is a built-in function object. The value of the [[Prototype]] internal slot of %TypedArray% is the intrinsic object %FunctionPrototype% (19.2.3).

Besides a length property whose value is 3 and a name property whose value is "TypedArray", %TypedArray% has the following properties:
22.2.2.1 `%TypedArray%.from ( source [, mapfn [, thisArg ]])`  

When the `from` method is called with argument `source`, and optional arguments `mapfn` and `thisArg`, the following steps are taken:

1. Let `C` be the this value.
2. If `IsConstructor(C)` is false, throw a `TypeError` exception.
3. If `mapfn` was supplied, let `f` be `mapfn`; otherwise let `f` be `undefined`.
4. If `f` is not `undefined`, then
   a. If `IsCallable(f)` is false, throw a `TypeError` exception.
5. If `thisArg` was supplied, let `t` be `thisArg`; else let `t` be `undefined`.
6. Return `TypedArrayFrom(C, source, f, t)`.

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

NOTE The `from` function is an intentionally generic factory method; it does not require that its this value be a `Typed Array` constructor. Therefore it can be transferred to or inherited by any other constructors that may be called with a single numeric argument. This function uses `[[Set]]` to store elements into a newly created object and assume that the constructor sets the `length` property of the new object to the argument value passed to it.

22.2.2.1.1 Runtime Semantics: `TypedArrayFrom( constructor, items, mapfn, thisArg )`  

When the `TypedArrayFrom` abstract operation is called with arguments `constructor`, `items`, `mapfn`, and `thisArg`, the following steps are taken:

1. Let `C` be `constructor`.
2. Assert: `IsConstructor(C)` is `true`.
3. Assert: `Type(mapfn)` is either a callable `Object` or `Undefined`.
4. If `mapfn` is `undefined`, let `mapping` be `false`.
5. else
   a. Let `T` be `thisArg`.
   b. Let `mapping` be `true`
6. Let `usingIterator` be `GetMethod(items, @@iterator)`.
7. ReturnIfAbrupt(`usingIterator`).
8. If `usingIterator` is not `undefined`, then
   a. Let `iterator` be `GetIterator(items, usingIterator)`.
   b. ReturnIfAbrupt(`iterator`).
   c. Let `values` be a new empty List.
   d. Let `next` be `true`.
   e. Repeat, while `next` is not `false`
      i. Let `next` be `IteratorStep(iterator)`.
      ii. If `next` is an abrupt completion, return `IteratorClose(iterator, next)`.
      f. Let `next` be `next.[[value]]`.
   j. Let `len` be the number of elements in `values`.
   k. Let `targetObj` be `AllocateTypedArray(C, len)`.
   l. Repeat, while `k < len`
      i. Let `Pk` be `ToString(k)`.
ii. Let kValue be the first element of values and remove that element from list.
iii. If mapping is true, then
   1. Let mappedValue be Call(mapfn, T, «kValue, k»).
   2. ReturnIfAbrupt(mappedValue).
iv. Else, let mappedValue be kValue.
v. Let putStatus be Put(targetObj, Pk, mappedValue, true).
vi. ReturnIfAbrupt(putStatus).
vii. Increase k by 1.
m. Assert: values is now an empty List.
n. Return targetObj.
9. Assert: items is not an Iterable so assume it is an array-like object.
10. Let arrayLike be ToObject(items).
11. ReturnIfAbrupt(arrayLike).
12. Let len be ToLength(Get(arrayLike, "length")).
13. ReturnIfAbrupt(len).
14. Let targetObj be AllocateTypedArray(C, len).
15. ReturnIfAbrupt(targetObj).
16. Let k be 0.
17. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kValue be Get(arrayLike, Pk).
   c. ReturnIfAbrupt(kValue).
   d. If mapping is true, then
      i. Let mappedValue be Call(mapfn, T, «kValue, k»).
      ii. ReturnIfAbrupt(mappedValue).
   e. Else, let mappedValue be kValue.
   f. Let putStatus be Put(targetObj, Pk, mappedValue, true).
   g. ReturnIfAbrupt(putStatus).
   h. Increase k by 1.
18. Return targetObj.

22.2.2.2 %TypedArray%.of ( ...items )

When the of method is called with any number of arguments, the following steps are taken:

1. Let len be the actual number of arguments passed to this function.
2. Let items be the List of arguments passed to this function.
3. Let C be the this value.
4. If IsConstructor(C) is false, throw a TypeError exception.
5. Let newObj be AllocateTypedArray(C, len).
6. ReturnIfAbrupt(newObj).
7. Let k be 0.
8. Repeat, while k < len
   a. Let kValue be items[k],
   b. Let Pk be ToString(k).
   c. Let status be Put(newObj, Pk, kValue, true).
   d. ReturnIfAbrupt(status).
   e. Increase k by 1.
9. Return newObj.

The length property of the of method is 0.

NOTE 1 The items argument is assumed to be a well-formed rest argument value.
22.2.2.3 %TypedArray%.prototype

The initial value of %TypedArray%.prototype is the %TypedArrayPrototype% intrinsic object (22.2.3).

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

22.2.2.4 get %TypedArray% [ @@species ]

%TypedArray%[@@species] is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is "get [Symbol.species]".

NOTE  Typed Array prototype methods normally their this object's constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

22.2.3 Properties of the %TypedArrayPrototype% Object

The value of the [[Prototype]] internal slot of the %TypedArrayPrototype% object is the intrinsic object %ObjectPrototype% (19.1.3). The %TypedArrayPrototype% object is an ordinary object. It does not have a [[ViewedArrayBuffer]] or or any other of the internal slots that are specific to TypedArray instance objects.

22.2.3.1 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 this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have a [[ViewedArrayBuffer]] internal slot throw a TypeError exception.
4. Let buffer be the value of O's [[ViewedArrayBuffer]] internal slot.
5. Return buffer.

Comment [AWB1345]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

22.2.3.2 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 this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have a [[ViewedArrayBuffer]] internal slot throw a TypeError exception.
4. Let buffer be the value of O's [[ViewedArrayBuffer]] internal slot.
5. If IsDetachedBuffer(buffer) is true, return 0.
6. Let size be the value of O's [[ByteLength]] internal slot.
7. Return size.

Comment [AWB1346]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.

22.2.3.3 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:

Comment [AWB1347]: buffer needs to be an accessor both to comply with WebIDL requirements and to support the Kronos neutering strawman requirements.
1. Let $O$ be the this value.
2. If $\text{Type}(O)$ is not Object, throw a $\text{TypeError}$ exception.
3. If $O$ does not have a $[\text{ViewedArrayBuffer}]$ internal slot throw a $\text{TypeError}$ exception.
4. Let $\text{buffer}$ be the value of $O$’s $[\text{ViewedArrayBuffer}]$ internal slot.
5. If $\text{IsDetachedBuffer}(\text{buffer})$ is true, return 0.
6. Let $\text{offset}$ be the value of $O$’s $[\text{ByteOffset}]$ internal slot.
7. Return $\text{offset}$.

22.2.3.4 %TypedArray%.prototype.constructor

The initial value of %TypedArray%.prototype.constructor is the %TypedArray% intrinsic object.

22.2.3.5 %TypedArray%.prototype.copyWithin (target, start [ , end ])

%TypedArray%.prototype.copyWithin is a distinct function that implements the same algorithm as Array.prototype.copyWithin as defined in 22.1.3.3 except that the this object’s $[\text{ArrayLength}]$ internal slot is accessed in place of performing a $[\text{Get}]$ of “length”. The implementation of the algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

The length property of the copyWithin method is 2.

22.2.3.6 Runtime Semantics: ValidateTypedArray (O)

When called with argument $O$ the following steps are taken:
1. If $\text{Type}(O)$ is not Object, throw a $\text{TypeError}$ exception.
2. If $O$ does not have a $[\text{TypedArrayName}]$ internal slot, throw a $\text{TypeError}$ exception.
3. If $O$ does not have a $[\text{ViewedArrayBuffer}]$ internal slot throw a $\text{TypeError}$ exception.
4. Let $\text{buffer}$ be the value of $O$’s $[\text{ViewedArrayBuffer}]$ internal slot.
5. If $\text{IsDetachedBuffer}(\text{buffer})$ is true, throw a $\text{TypeError}$ exception.
6. Return $\text{buffer}$.

22.2.3.7 %TypedArray%.prototype.entries ()

When entries is called with this value $O$, the following steps are taken:
1. Let $O$ be the this value.
2. Let valid be ValidateTypedArray($O$).
3. ReturnIfAbrupt(valid).
4. Return CreateArrayIterator($O$, “key+value”).

22.2.3.8 %TypedArray%.prototype.every (callbackfn [ , thisArg ])

%TypedArray%.prototype.every is a distinct function that implements the same algorithm as Array.prototype.every as defined in 22.1.3.5 except that the this object’s $[\text{ArrayLength}]$ internal slot is accessed in place of performing a $[\text{Get}]$ of “length”. The implementation of the algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and whose integer
indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to `callbackfn` may cause the `this` value to become detached.

This function is not generic. ValidateTypedArray is applied to the `this` value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.8 `%TypedArray%.prototype.fill (value [, start [, end ]])`

 `%TypedArray%.prototype.fill` is a distinct function that implements the same algorithm as `Array.prototype.fill` as defined in 22.1.3.6 except that the `this` object’s `[[ArrayLength]]` internal slot is accessed in place of performing a `[[Get]]` of “length”. The implementation of the algorithm may be optimized with the knowledge that the `this` value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the `this` value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.9 `%TypedArray%.prototype.filter (callbackfn [, thisArg])`

The interpretation and use of the arguments of `%TypedArray%.prototype.filter` are the same as for `Array.prototype.filter` as defined in 22.1.3.7.

When the `filter` method is called with one or two arguments, the following steps are taken:

1. Let `O` be the `this` value.
2. Let `valid` be `ValidatedTypedArray(`O`).` ReturnIfAbrupt `valid`.
3. Let `len` be the value of `O`'s `[[ArrayLength]]` internal slot.
4. If `IsCallable(`callbackfn`)` is `false`, throw a `TypeError` exception.
5. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
6. Let `defaultConstructor` be the intrinsic object listed in column one of Table 46 for the value of `O`'s `[[TypedArrayName]]` internal slot.
7. Let `C` be `SpeciesConstructor(`O`, `defaultConstructor`)`. ReturnIfAbrupt `C`.
8. Let `kept` be a new empty List.
9. Let `k` be 0.
10. Let `captured` be 0.
11. Repeat, while `k < len`
   a. Let `Pk` be `ToString(`k`)`.
   b. Let `kValue` be `Get(`O`, `Pk`)`. ReturnIfAbrupt `kValue`.
   c. Let `selected` be `ToBoolean`(`Call(`callbackfn`, `T`, «`kValue`, `k`, `O»)`). ReturnIfAbrupt `selected`.
   d. If `selected` is `true`, then
      i. Append `kValue` to the end of `kept`.
      ii. Increase `captured` by 1.
g. Increase \( k \) by 1.

14. Let \( A \) be AllocateTypedArray(\( C, \text{captured} \)).
15. ReturnIfAbrupt(\( A \)).
16. Let \( n \) be 0.
17. For each element \( e \) of \( \text{kept} \)
   a. Let \( \text{status} \) be Put(\( A, \text{ToString}(n), e, \text{true} \)).
   b. ReturnIfAbrupt(\( \text{status} \)).
   c. Increment \( n \) by 1.
18. Return \( A \).

This function is not generic. The \texttt{this} value must be an object with a [[TypedArrayName]] internal slot.

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

22.2.3.10 %TypedArray%.prototype.find (predicate [ , thisArg ])

%TypedArray%.prototype.find is a distinct function that implements the same algorithm as Array.prototype.find as defined in 22.1.3.8 except that the \texttt{this} object's [[ArrayLength]] internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the algorithm may be optimized with the knowledge that the \texttt{this} value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to \texttt{predicate} may cause the \texttt{this} value to become detached.

This function is not generic. ValidateTypedArray is applied to the \texttt{this} value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.11 %TypedArray%.prototype.findIndex (predicate [ , thisArg ])

%TypedArray%.prototype.findIndex is a distinct function that implements the same algorithm as Array.prototype.findIndex as defined in 22.1.3.9 except that the \texttt{this} object's [[ArrayLength]] internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the algorithm may be optimized with the knowledge that the \texttt{this} value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to \texttt{predicate} may cause the \texttt{this} value to become detached.

This function is not generic. ValidateTypedArray is applied to the \texttt{this} value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.12 %TypedArray%.prototype.forEach (callbackFn [ , thisArg ])

%TypedArray%.prototype.forEach is a distinct function that implements the same algorithm as Array.prototype.forEach as defined in 22.1.3.10 except that the \texttt{this} object's [[ArrayLength]] internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the algorithm may be optimized with the knowledge that the \texttt{this} value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any
observable changes in the specified behaviour of the algorithm and must take into account the possibility
that calls to callbackfn may cause the this value to become detached.

This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the
algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

The length property of the forEach method is 1.

22.2.3.13 %TypedArray%.prototype.indexOf (searchElement [, fromIndex ])

%TypedArray%.prototype.indexOf is a distinct function that implements the same algorithm as
Array.prototype.indexOf as defined in 22.1.3.11 except that the this object's [[ArrayLength]]
internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the
algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and
whose integer indexed properties are not sparse. However, such optimization must not introduce any
observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the
algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

The length property of the indexOf method is 1.

22.2.3.14 %TypedArray%.prototype.join (separator)

%TypedArray%.prototype.join is a distinct function that implements the same algorithm as
Array.prototype.join as defined in 22.1.3.12 except that the this object's [[ArrayLength]]
internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the
algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and
whose integer indexed properties are not sparse. However, such optimization must not introduce any
observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the
algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

22.2.3.15 %TypedArray%.prototype.keys ()

The following steps are taken:
1. Let O be the this value.
2. Let valid be ValidateTypedArray(O).
3. ReturnIfAbrupt(valid).
4. Return CreateArrayIterator(O, "key").

22.2.3.16 %TypedArray%.prototype.lastIndexOf (searchElement [, fromIndex ])

%TypedArray%.prototype.lastIndexOf is a distinct function that implements the same algorithm as
Array.prototype.lastIndexOf as defined in 22.1.3.14 except that the this object's [[ArrayLength]]
internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the
algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and
whose integer indexed properties are not sparse. However, such optimization must not introduce any
observable changes in the specified behaviour of the algorithm.
This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

The length property of the lastIndexOf method is 1.

22.2.3.17 ⏤ %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 this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have a [[TypedArrayName]] internal slot, throw a TypeError exception.
4. Assert: O has [[ViewedArrayBuffer]] and [[ArrayLength]] internal slots.
5. Let buffer be the value of O’s [[ViewedArrayBuffer]] internal slot.
6. If IsDetachedBuffer(buffer) is true, return 0.
7. Let length be the value of O’s [[ArrayLength]] internal slot.
8. Return length.

This function is not generic. The this value must be an object with a [[TypedArrayName]] internal slot.

22.2.3.18 %TypedArray%.prototype.map (callbackfn [,.thisArg])

The interpretation and use of the arguments of %TypedArray%.prototype.map are the same as for Array.prototype.map as defined in 22.1.3.15.

When the map method is called with one or two arguments, the following steps are taken:

1. Let O be the this value.
2. Let valid be ValidateTypedArray(O).
3. ReturnIfAbrupt(valid).
4. Let len be the value of O’s [[ArrayLength]] internal slot.
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 defaultConstructor be the intrinsic object listed in column one of Table 46 for the value of O’s [[TypedArrayName]] internal slot.
8. Let C be SpeciesConstructor(O, defaultConstructor).
9. ReturnIfAbrupt(C).
10. Let A be AllocateTypedArray(C, len).
11. ReturnIfAbrupt(A).
12. Let k be 0.
13. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kValue be Get(O, Pk).
   c. ReturnIfAbrupt(kValue).
   d. Let mappedValue be Call(callbackfn, T, «kValue, k, O»).
   e. ReturnIfAbrupt(mappedValue).
   f. Let status be Put(A, Pk, mappedValue, true).
   g. ReturnIfAbrupt(status).
   h. Increase k by 1.
14. Return A.

This function is not generic. The this value must be an object with a [[TypedArrayName]] internal slot.
The `length` property of the `map` method is 1.

22.2.3.19 `%TypedArray%.prototype.reduce (callbackFn [, initialValue ])

`%TypedArray%.prototype.reduce` is a distinct function that implements the same algorithm as `Array.prototype.reduce` as defined in 22.1.3.18 except that the `this` object's `[[ArrayLength]]` internal slot is accessed in place of performing a `[[Get]]` of "length". The implementation of the algorithm may be optimized with the knowledge that the `this` value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to `callbackFn` may cause the `this` value to become detached.

This function is not generic. ValidateTypedArray is applied to the `this` value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.20 `%TypedArray%.prototype.reduceRight (callbackFn [, initialValue ])

`%TypedArray%.prototype.reduceRight` is a distinct function that implements the same algorithm as `Array.prototype.reduceRight` as defined in 22.1.3.19 except that the `this` object's `[[ArrayLength]]` internal slot is accessed in place of performing a `[[Get]]` of "length". The implementation of the algorithm may be optimized with the knowledge that the `this` value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to `callbackFn` may cause the `this` value to become detached.

This function is not generic. ValidateTypedArray is applied to the `this` value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.21 `%TypedArray%.prototype.reverse ()

`%TypedArray%.prototype.reverse` is a distinct function that implements the same algorithm as `Array.prototype.reverse` as defined in 22.1.3.20 except that the `this` object's `[[ArrayLength]]` internal slot is accessed in place of performing a `[[Get]]` of "length". The implementation of the algorithm may be optimized with the knowledge that the `this` value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the `this` value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

22.2.3.22 `%TypedArray%.prototype.set (overloaded [, offset])

`%TypedArray%.prototype.set` is a single function whose behaviour is overloaded based upon the type of its first argument.

This function is not generic. The `this` value must be an object with a `[[TypedArrayName]]` internal slot.
The `length` property of the `set` method is 1.

### 22.2.3.2.1.1 `%TypedArray%.prototype.set (array [, offset ])

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: `array` does not have a `[[TypedArrayName]]` internal slot. If it does, the definition in 22.2.3.22.2 applies.
2. Let `target` be the `this` value.
3. If `Type(target)` is not `Object`, throw a `TypeError` exception.
4. If `target` does not have a `[[TypedArrayName]]` internal slot, throw a `TypeError` exception.
5. Assert: `target` has a `[[ViewedArrayBuffer]]` internal slot.
6. Let `targetOffset` be `ToInteger(offset)`.
7. ReturnIfAbrupt(`targetOffset`).
8. If `targetOffset < 0`, throw a `RangeError` exception.
9. If `IsDetachedBuffer(targetBuffer)` is `true`, throw a `TypeError` exception.
10. Let `targetName` be the string value of `target`'s `[[TypedArrayName]]` internal slot.
11. Let `targetElementSize` be the number value of the Element Size value specified in Table 46 for `targetName`.
12. Let `targetType` be the string value of the Element Type value in Table 46 for `targetName`.
13. Let `targetByteOffset` be the value of `target`'s `[[ByteOffset]]` internal slot.
14. Let `src` be `ToObject(array)`.
15. ReturnIfAbrupt(`src`).
16. Let `srcLen` be `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`, throw a `TypeError` exception.
21. If `srcLength + targetOffset > targetLength`, throw a `RangeError` exception.
22. Let `targetByteIndex` be `targetOffset × targetElementSize + targetByteOffset`.
23. If `k ≤ 0`, set `k` to 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 `Get(src, Pk)`.
   c. Let `kNumber` be `ToNumber(kValue)`.
   d. ReturnIfAbrupt(`kNumber`).
   e. If `IsDetachedBuffer(targetBuffer)` is `true`, throw a `TypeError` exception.
   f. Perform `SetValueInBuffer(targetBuffer, targetByteIndex, targetType, kNumber)`.
   g. Set `k` to `k + 1`.
   h. Set `targetByteIndex` to `targetByteIndex + targetElementSize`.

### 22.2.3.2.2.2 %TypedArray%.prototype.set(typedArray [, offset ])

Set multiple values in this `TypedArray`, reading the values from the `typedArray` argument 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 `[[TypedArrayName]]` internal slot. If it does not, the definition in 22.2.3.22.1 applies.
2. Let `target` be the `this` value.
3. If `Type(target)` is not `Object`, throw a `TypeError` exception.
4. If `target` does not have a `[[TypedArrayName]]` internal slot, throw a `TypeError` exception.
5. Assert: `target` has a `[[ViewedArrayBuffer]]` internal slot.
6. Let `targetOffset` be `ToInteger(offset)`.
7. ReturnIfAbrupt(`targetOffset`).
8. If `targetOffset < 0`, throw a `RangeError` exception.
9. Let `targetBuffer` be the value of `target`’s `[[ViewedArrayBuffer]]` internal slot.
10. If `IsDetachedBuffer(targetBuffer)` is `true`, throw a `TypeError` exception.
11. Let `srcLength` be the value of `target`’s `[[ArrayLength]]` internal slot.
12. Let `srcBuffer` be the value of `typedArray`’s `[[ViewedArrayBuffer]]` internal slot.
13. If `IsDetachedBuffer(srcBuffer)` is `true`, throw a `TypeError` exception.
14. Let `srcName` be the string value of `target`’s `[[TypedArrayName]]` internal slot.
15. Let `targetName` be the string value of the Element Type value in Table 46 for `targetName`.
16. Let `targetElementSize` be the Number value of the Element Size value specified in Table 46 for `targetName`.
17. Let `targetByteOffset` be the value of `target`’s `[[ByteOffset]]` internal slot.
18. Let `srcName` be the string value of `typedArray`’s `[[TypedArrayName]]` internal slot.
19. Let `srcType` be the string value of the Element Type value in Table 46 for `srcName`.
20. Let `srcElementSize` be the Number value of the Element Size value specified in Table 46 for `srcName`.
21. Let `srcLength` be the value of `typedArray`’s `[[ArrayLength]]` internal slot.
22. Let `srcByteOffset` be the value of `typedArray`’s `[[ByteOffset]]` internal slot.
23. If `srcLength + targetOffset > targetLength`, throw a `RangeError` exception.
24. If `SameValue(srcBuffer, targetBuffer)` is `true`, then
   a. Let `srcBuffer` be `ClonedArrayBuffer(targetBuffer, srcByteOffset, %ArrayPrototype%)`.
   b. NOTE: %ArrayPrototype% is used to clone `targetBuffer` because it is known to not have any observable side-effects.
   c. ReturnIfAbrupt(`srcBuffer`).
   d. Let `srcByteIndex` be `0`.
25. Else, let `srcByteIndex` be `srcByteOffset`.
26. Let `targetByteIndex` be `targetOffset × targetElementSize + targetByteOffset`.
27. Let `limit` be `targetByteIndex + targetElementSize × min(srcLength, targetLength – targetOffset)`.
28. Repeat, while `targetByteIndex < limit`
   a. Let `value` be `GetValueFromBuffer(srcBuffer, srcByteIndex, srcType)`.
   b. Let `status` be `SetValueInBuffer(targetBuffer, targetByteIndex, targetType, value)`.
   c. Set `srcByteIndex` to `srcByteIndex + srcElementSize`.
   d. Set `targetByteIndex` to `targetByteIndex + targetElementSize`.
29. Return undefined.

22.2.3.23 `%TypedArray%.prototype.slice` ( start, end )

The interpretation and use of the arguments of `%TypedArray%.prototype.slice` are the same as for `Array.prototype.slice` as defined in 22.1.3.22. The following steps are taken:
1. Let `O` be the `this` value.
2. Let `valid` be `ValidateTypedArray(O)`.
3. ReturnIfAbrupt(`valid`).
4. Let `len` be the value of `O`’s `[[ArrayLength]]` internal slot.
5. Let `relativeStart` be `ToInteger(start)`.
6. ReturnIfAbrupt(`relativeStart`).
7. If `relativeStart` < 0, let `k` be \( \max((\text{len} + \text{relativeStart}), 0) \); else let `k` be \( \min(\text{relativeStart}, \text{len}) \).
8. If `end` is `undefined`, let `relativeEnd` be `len`; else let `relativeEnd` be `ToInteger(end)`.
9. ReturnIfAbrupt(`relativeEnd`).
10. If `relativeEnd` < 0, let `final` be \( \max((\text{len} + \text{relativeEnd}), 0) \); else let `final` be \( \min(\text{relativeEnd}, \text{len}) \).
11. Let `count` be \( \max(\text{final} – k, 0) \).
12. Let `defaultConstructor` be the intrinsic object listed in column one of Table 46 for the value of `O`’s `[[TypedArrayName]]` internal slot.
13. Let `C` be `SpeciesConstructor(O, defaultConstructor)`.
14. ReturnIfAbrupt(`C`).
15. Let `A` be `AllocateTypedArray(C, count)`.
16. ReturnIfAbrupt(`A`).
17. Let `n` be 0.
18. Repeat, while `k` < `final`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kValue` be `Get(O, Pk)`.
   c. ReturnIfAbrupt(`kValue`).
   d. Let `status` be `Put(A, ToString(n), kValue, true)`.
   e. ReturnIfAbrupt(`status`).
   f. Increase `k` by 1.
   g. Increase `n` by 1.

This function is not generic. The **this** value must be an object with a `[[TypedArrayName]]` internal slot.

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

22.2.3.24 `%TypedArray%.prototype.some (callbackfn [, thisArg ] )`

 `%TypedArray%.prototype.some` is a distinct function that implements the same algorithm as `Array.prototype.some` as defined in 22.1.3.23 except that the **this** object’s `[[ArrayLength]]` internal slot is accessed in place of performing a `[[Get]]` of “length”. The implementation of the algorithm may be optimized with the knowledge that the **this** value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm and must take into account the possibility that calls to `callbackfn` may cause the **this** value to become detached.

This function is not generic. ValidateTypedArray is applied to the **this** value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

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

22.2.3.25 `%TypedArray%.prototype.sort (compareFn )`

 `%TypedArray%.prototype.sort` is a distinct function that, except as described below, implements the same requirements as those of `Array.prototype.sort` as defined in 22.1.3.24. The implementation of the `%TypedArray%.prototype.sort` specification may be optimized with the knowledge that the **this** value is an object that has a fixed length and whose integer indexed properties are not sparse. The only internal methods of the **this** object that the algorithm may call are `[[Get]]` and `[[Set]]`.

This function is not generic. The **this** value must be an object with a `[[TypedArrayName]]` internal slot.
Upon entry, the following steps are performed to initialize evaluation of the \texttt{sort} function. These steps are used instead of the entry steps in 22.1.3.24:

1. Let \texttt{obj} be the \texttt{this} value as the argument.
2. Let \texttt{buffer} be \texttt{ValidateTypedArray(obj)}.
3. ReturnIfAbrupt(buffer).
4. Let \texttt{len} be the value of \texttt{obj}'s [[ArrayLength]] internal slot.

The following version of \texttt{SortCompare} is used by \texttt{%TypedArray%\_prototype.sort}. It performs a numeric comparison rather than the string comparison used in 22.1.3.24.

The \texttt{TypedArray SortCompare} abstract operation is called with two arguments \texttt{x} and \texttt{y}, the following steps are taken:

1. Assert: Both Type(\texttt{x}) and Type(\texttt{y}) is Number.
2. If the argument \texttt{comparefn} is not \texttt{undefined}, then
   a. Let \texttt{v} be Call(comparefn, undefined, «\texttt{x}, \texttt{y}»).
   b. ReturnIfAbrupt(v).
   c. If IsDetachedBuffer(buffer) is true, throw a \texttt{TypeError} exception.
   d. If \texttt{v} is \texttt{NaN}, return +0.
   e. Return \texttt{v}.
3. If \texttt{x} and \texttt{y} are both \texttt{NaN}, return +0.
4. If \texttt{x} is \texttt{NaN}, return 1.
5. If \texttt{y} is \texttt{NaN}, return -1.
6. If \texttt{x} < \texttt{y}, return -1.
7. If \texttt{x} > \texttt{y}, return 1.
8. Return +0.

\textbf{NOTE 1} Because \texttt{NaN} always compares greater than any other value, \texttt{NaN} property values always sort to the end of the result when \texttt{comparefn} is not provided.

\texttt{%.\_prototype.subarray( [begin[, end]] )}

Returns a new \texttt{TypedArray} object whose element types is the same as this \texttt{TypedArray} and whose ArrayBuffer is the same as the ArrayBuffer of this \texttt{TypedArray}, referencing the elements at \texttt{begin}, inclusive, up to \texttt{end}, exclusive. If either \texttt{begin} or \texttt{end} is negative, it refers to an index from the end of the array, as opposed to from the beginning.

1. Let \texttt{O} be the \texttt{this} value.
2. If Type(\texttt{O}) is not Object, throw a \texttt{TypeError} exception.
3. If \texttt{O} does not have a [[TypedArrayName]] internal slot, throw a \texttt{TypeError} exception.
4. Assert: \texttt{O} has a [[ViewedArrayBuffer]] internal slot.
5. Let \texttt{buffer} be the value of \texttt{O}'s [[ViewedArrayBuffer]] internal slot.
6. Let \texttt{srcLength} be the value of \texttt{O}'s [[ArrayLength]] internal slot.
7. Let \texttt{beginInt} be ToInteger(begin)
8. ReturnIfAbrupt(beginInt).
9. If beginInt < 0, let beginInt be srcLength + beginInt.
10. Let beginIndex be min(srcLength, max(0, beginInt)).
11. If end is \texttt{undefined}, let end be srcLength.
12. Let endInt be ToInteger(end).
13. ReturnIfAbrupt(endInt).
14. If endInt < 0, let endInt be srcLength + endInt.
15. Let endIndex be max(0, min(srcLength, endInt)).
16. If endIndex < beginIndex, let endIndex be beginIndex.
17. Let newLength be endIndex - beginIndex.
18. Let constructorName be the string value of O’s [[TypedArrayName]] internal slot.
19. Let elementSize be the Number value of the Element Size value specified in Table 46 for constructorName.
20. Let srcByteOffset be the value of O’s [[ByteOffset]] internal slot.
21. Let beginIndex be srcByteOffset + beginIndex × elementSize.
22. Let defaultConstructor be the intrinsic object listed in column one of Table 46 for constructorName.
23. Let constructor be SpeciesConstructor(O, defaultConstructor).
24. ReturnIfAbrupt(constructor).
25. Let argumentsList be «buffer, beginByteOffset, newLength».

This function is not generic. The this value must be an object with a [[TypedArrayName]] internal slot.

The length property of the subarray method is 2.

22.2.3.27 %TypedArray%.prototype.toLocaleString ([ reserved1 [, reserved2 ] ])

%TypedArray%.prototype.toLocaleString is a distinct function that implements the same algorithm as Array.prototype.toLocaleString as defined in 22.1.3.26 except that the this object’s [[ArrayLength]] internal slot is accessed in place of performing a [[Get]] of "length". The implementation of the algorithm may be optimized with the knowledge that the this value is an object that has a fixed length and whose integer indexed properties are not sparse. However, such optimization must not introduce any observable changes in the specified behaviour of the algorithm.

This function is not generic. ValidateTypedArray is applied to the this value prior to evaluating the algorithm. If its result is an abrupt completion that exception is thrown instead of evaluating the algorithm.

22.2.3.28 %TypedArray%.prototype.toString ()

The initial value of the %TypedArray%.prototype.toString data property is the same built-in function object as the Array.prototype.toString method defined in 22.1.3.27.

22.2.3.29 %TypedArray%.prototype.values ()

The following steps are taken:
1. Let O be the this value.
2. Let valid be ValidateTypedArray(O).
3. ReturnIfAbrupt(valid).
4. Return CreateArrayIterator(O, "value").

22.2.3.30 %TypedArray%.prototype [[ @@iterator ]] ()

The initial value of the @@iterator property is the same function object as the initial value of the %TypedArray%.prototype.values property.

22.2.3.31 get %TypedArray%.prototype [[ @@toStringTag ]] %TypedArray%.prototype[[ @@toStringTag ]] is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:
1. Let \( O \) be the this value.
2. If \( \text{Type}(O) \) is not Object, return **undefined**.
3. If \( O \) does not have a \([[\text{TypedArrayName}]]\) internal slot, return **undefined**.
4. Let \( \text{name} \) be the value of \( O'[[\text{TypedArrayName}]] \) internal slot.
5. Assert: \( \text{name} \) is a String value.
6. Return \( \text{name} \).

This property has the attributes { [[Enumerable]]: false, [[Configurable]]: true }.

The initial value of the \( \text{name} \) property of this function is "get [Symbol.toStringTag]."

### 22.2.4 The **TypedArray** Constructors

Each of these **TypedArray** constructor objects is an intrinsic object that has the structure described below, differing only in the name used as the constructor name instead of **TypedArray**, in Table 46.

The **TypedArray** constructors are not intended to be called as a function and will throw an exception when called in that manner.

The **TypedArray** constructors are designed to be subclassable. They may be used as the value of an **extends** clause of a class definition. Subclass constructors that intend to inherit the specified **TypedArray** behaviour must include a **super** call to the **TypedArray** constructor to create and initialize the subclass instance with the internal state necessary to support the %TypedArray% .prototype built-in methods.

### 22.2.4.1 **TypedArray**( ... **argumentsList**)  

A **TypedArray** constructor with a list of arguments **argumentsList** performs the following steps:

1. If NewTarget is **undefined**, throw a **TypeError** exception.
2. Let \( \text{here} \) be the active function.
3. Let \( \text{super} \) be the result of calling the [[GetPrototypeOf]] internal method of \( \text{here} \) with no arguments.
4. ReturnIfAbrupt(\( \text{super} \)).
5. If IsConstructor(\( \text{constructor} \)) is false, throw a **TypeError** exception.
6. Let **argumentsList** be the **argumentsList** argument of the [[Construct]] internal method that invoked the active function.
7. Return Construct(\( \text{super} \), **argumentsList**, NewTarget).

### 22.2.5 Properties of the **TypedArray** Constructors

The value of the [[Prototype]] internal slot of each **TypedArray** constructor is the %TypedArray% intrinsic object (22.2.1).

Each **TypedArray** constructor has a [[ TypedArrayConstructorName ]] internal slot property whose value is the String value of the constructor name specified for it in Table 46.

Each **TypedArray** constructor has a **name** property whose value is the String value of the constructor name specified for it in Table 46.

Besides a **length** property (whose value is 3), each **TypedArray** constructor has the following properties:
22.2.5.1 **TypedArray.BYTES_PER_ELEMENT**

The value of `TypedArray.BYTES_PER_ELEMENT` is the Number value of the Element Size value specified in Table 46 for `TypedArray`.

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

22.2.5.2 **TypedArray.prototype**

The initial value of `TypedArray.prototype` is the corresponding `TypedArray` prototype object (22.2.6).

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

22.2.6 Properties of **TypedArray** Prototype Objects

The value of the `[Prototype]` internal slot of a `TypedArray` prototype object is the intrinsic object `%TypedArrayPrototype%` (22.2.3). A `TypedArray` prototype object is an ordinary object. It does not have a `[[ViewedArrayBuffer]]` or any other of the internal slots that are specific to `TypedArray` instance objects.

22.2.6.1 **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 46 for `TypedArray`.

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

22.2.6.2 **TypedArray.prototype.constructor**

The initial value of a `TypedArray.prototype.constructor` is the corresponding `%TypedArray%` intrinsic object.

22.2.7 Properties of **TypedArray** Instances

`TypedArray` instances are Integer Indexed exotic objects. Each `TypedArray` instances inherits properties from the corresponding `TypedArray` prototype object. Each `TypedArray` instances have the following internal slots: `[[TypedArrayName]]`, `[[ViewedArrayBuffer]]`, `[[ByteLength]]`, `[[ByteOffset]]`, and `[[ArrayLength]]`.

23 **Keyed Collection**

23.1 **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 the SameValueZero comparison algorithm.

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.
23.1.1 The Map Constructor

The Map constructor is the %Map% intrinsic object and the initial value of the Map property of the global object. When called as a constructor it creates and initializes a new Map object. Map is not intended to be called as a function and will throw an exception when called in that manner.

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 the Map constructor to create and initialize the subclass instance with the internal state necessary to support the Map.prototype built-in methods.

23.1.1.1 Map ([ iterable ])

When the Map function is called with optional argument the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let map be OrdinaryCreateFromConstructor(NewTarget, "%MapPrototype", "[[MapData]]").
3. ReturnIfAbrupt(map).
4. Set map’s [[MapData]] internal slot to a new empty List.
5. If iterable is not present, let iterable be undefined.
6. Else, a. Let adder be the result of Get(map, "set").
   b. ReturnIfAbrupt(adder).
   c. If IsCallable(adder) is false, throw a TypeError Exception.
   d. Let iter be the result of GetIterator(iterable).
   e. ReturnIfAbrupt(iter).
7. If iter is undefined, return map.
8. Repeat
   a. Let next be the result of IteratorStep(iter).
   b. If next is an abrupt completion, return IteratorClose(iter, next).
   c. If next.[[value]] is false, return map.
   d. Let nextItem be IteratorValue(next.[[value]]).
   e. If nextItem is an abrupt completion, return IteratorClose(iter, nextItem).
   f. If Type(nextItem.[[value]]) is not Object,
      i. Let error be Completion{[[type]]: throw, [[value]]: a newly created TypeError object, 
         [[target]]: empty}.
      ii. Return IteratorClose(iter, error).
   g. Let k be the result of Get(nextItem.[[value]], "0").
   h. If k is an abrupt completion, return IteratorClose(iter, k).
   i. Let v be the result of Get(nextItem.[[value]], "1").
   j. If v is an abrupt completion, return IteratorClose(iter, v).
   k. Let status be Call(adder, map, "k", v).[value]]).
   l. If status is an abrupt completion, return IteratorClose(iter, 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 a two element array-like object whose first element is a value that will be used as a Map key and whose second element is the value to associate with that key.
23.1.2 Properties of the Map Constructor

The value of the [[Prototype]] internal slot of the Map constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the Map constructor has the following properties:

23.1.2.1 Map.prototype

The initial value of Map.prototype is the Map prototype object (23.1.3).

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false ).

23.1.2.2 get Map @@species

Map @@species is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is "get [Symbol.species]".

NOTE Map prototype methods normally use their this object’s constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

23.1.3 Properties of the Map Prototype Object

The value of the [[Prototype]] internal slot of the Map prototype object is the intrinsic object %ObjectPrototype% (19.1.3). The Map prototype object is an ordinary object. It does not have a [[MapData]] internal slot.

23.1.3.1 Map.prototype.clear ()

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a TypeError exception.
3. If M does not have a [[MapData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[MapData]] internal slot.
5. 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.
6. Return undefined.

NOTE The existing [[MapData]] List is preserved because there may be existing MapIterator objects that are suspended midway through iterating over that List.

23.1.3.2 Map.prototype.constructor

The initial value of Map.prototype.constructor is the intrinsic object %Map%. 
23.1.3.3 Map.prototype.delete(key)

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a TypeError exception.
3. If M does not have a [[MapData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[MapData]] internal slot.
5. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] is not empty and SameValueZero(p.[[key]], key) is true, then
      i. Set p.[[key]] to empty.
      ii. Set p.[[value]] to empty.
      iii. Return true.
6. Return false.

NOTE The value empty is used as a specification device to indicate that an entry has been deleted. Actual implementations may take other actions such as physically removing the entry from internal data structures.

23.1.3.4 Map.prototype.entries()

The following steps are taken:

1. Let M be the this value.
2. Return CreateMapIterator(M, "key+value").

23.1.3.5 Map.prototype.forEach(callbackfn[, thisArg])

NOTE 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.

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.

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 Type(M) is not Object, throw a TypeError exception.
3. If M does not have a [[MapData]] internal slot throw a TypeError exception.
4. If IsCallable(callbackfn) is false, throw a TypeError exception.
5. If thisArg was supplied, let T be thisArg; else let T be undefined.
6. Let entries be the List that is the value of M’s [[MapData]] internal slot.
7. 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 Call(callbackfn, T, « e.[[value]], e.[[key]], M »).
      ii. ReturnIfAbrupt(funcResult).
8. Return undefined.
The `length` property of the `forEach` method is 1.

23.1.3.6 Map.prototype.get (key)

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal slot throw a `TypeError` exception.
4. Let entries be the List that is the value of M's `[[MapData]]` internal slot.
5. Repeat for each Record `[[key]], [[value]]` p that is an element of entries,
   a. If `p.[[key]]` is not empty and SameValueZero(p.[[key]], key) is true, return p.[[value]].
6. Return undefined.

23.1.3.7 Map.prototype.has (key)

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal slot throw a `TypeError` exception.
4. Let entries be the List that is the value of M's `[[MapData]]` internal slot.
5. Repeat for each Record `[[key]], [[value]]` p that is an element of entries,
   a. If `p.[[key]]` is not empty and SameValueZero(p.[[key]], key) is true, return true.
6. Return false.

23.1.3.8 Map.prototype.keys ()

The following steps are taken:

1. Let M be the this value.
2. Return CreateMapIterator(M, "key").

23.1.3.9 Map.prototype.set (key, value)

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a `TypeError` exception.
3. If M does not have a `[[MapData]]` internal slot throw a `TypeError` exception.
4. Let entries be the List that is the value of M's `[[MapData]]` internal slot.
5. Repeat for each Record `[[key]], [[value]]` p that is an element of entries,
   a. If `p.[[key]]` is not empty and SameValueZero(p.[[key]], key) is true, then
      i. Set p.[[value]] to value.
      ii. Return M.
6. If key is −0, let key be +0.
7. Let p be the Record `[[key]]: key, [[value]]: value`.
8. Append p as the last element of entries.
9. Return M.

23.1.3.10 Map.prototype.size

Map.prototype.size is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

Deleted: the result of calling the
Deleted: abstract operation with arguments
Deleted: and
1. Let \( M \) be the \texttt{this} value.
2. If \( \text{Type}(M) \) is not \texttt{Object}, throw a \texttt{TypeError} exception.
3. If \( M \) does not have a \([\text{MapData}]\) internal slot throw a \texttt{TypeError} exception.
4. Let \( \text{entries} \) be the List that is the value of \( M \)'s \([\text{MapData}]\) internal slot.
5. Let \( \text{count} \) be 0.
6. For each Record \( \{\text{key}, \text{value}\} \) \( p \) that is an element of \( \text{entries} \)
   a. If \( p.\text{key} \) is not empty, set \text{count} to \text{count}+1.
7. Return \text{count}.

23.1.3.11 \texttt{Map.prototype.values()} ( )

The following steps are taken:

1. Let \( M \) be the \texttt{this} value.
2. Return \texttt{CreateMapIterator} abstract(\( M \), \"value\`).

23.1.3.12 \texttt{Map.prototype[@@iterator]} ( )

The initial value of the \@@\texttt{iterator} property is the same function object as the initial value of the \texttt{entries} property.

23.1.3.13 \texttt{Map.prototype[@@toStringTag]} 

The initial value of the \@@\texttt{toStringTag} property is the string value “Map”.

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

23.1.4 Properties of Map Instances

Map instances are ordinary objects that inherit properties from the Map prototype. Map instances also have a \([\text{MapData}]\) internal slot.

23.1.5 Map Iterator Objects

A Map Iterator is an object, that represents 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.

23.1.5.1 \texttt{CreateMapIterator} Abstract Operation

Several methods of Map objects return Iterator objects. The abstract operation \texttt{CreateMapIterator} with arguments \texttt{map} and \texttt{kind} is used to create such iterator objects. It performs the following steps:

1. If \( \text{Type}(\text{map}) \) is not \texttt{Object}, throw a \texttt{TypeError} exception.
2. If \( \text{map} \) does not have a \([\text{MapData}]\) internal slot throw a \texttt{TypeError} exception.
3. Let \( \text{iterator} \) be the result of \texttt{ObjectCreate}(%MapIteratorPrototype%, \"[\text{Map}]", \([\text{MapNextIndex}]\), \([\text{MapIterationKind}]\))
4. Set \text{iterator}'s \([\text{Map}]\) internal slot to \text{map}.
5. Set \text{iterator}'s \([\text{MapNextIndex}]\) internal slot to 0.
6. Set \text{iterator}'s \([\text{MapIterationKind}]\) internal slot to \texttt{kind}.
7. Return \text{iterator}.
23.1.5.5 The %MapIteratorPrototype% Object

All Map Iterator Objects inherit properties from the %MapIteratorPrototype% intrinsic object. The %MapIteratorPrototype% intrinsic object is an ordinary object and its [[Prototype]] internal slot is the %IteratorPrototype% intrinsic object (25.1.2). In addition, %MapIteratorPrototype% has the following properties:

23.1.5.5.1 %MapIteratorPrototype%.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 slots of a Map Iterator Instance (23.1.5.3), throw a TypeError exception.
4. Let m be the value of the [[Map]] internal slot of O.
5. Let index be the value of the [[MapNextIndex]] internal slot of O.
6. Let itemKind be the value of the [[MapIterationKind]] internal slot of O.
7. If m is undefined, return CreateIterResultObject(undefined, true).
8. Assert: m has a [[MapData]] internal slot.
9. Let entries be the List that is the value of the [[MapData]] internal slot of m.
10. Repeat while index is less than the total number of elements of entries. The number of elements must be reetermined each time this method is evaluated.
  a. Let e be the Record {[[key]], [[value]]} that is the value of entries[index].
  b. Set index to index + 1;
  c. Set the [[MapNextIndex]] internal slot of O to index.
  d. If e.[[key]] is not empty, then
     i. If itemKind is "key", let result be e.[[key]].
     ii. Else if itemKind is "value", let result be e.[[value]].
     iii. Else,
          1. Assert: itemKind is "key+value".
          2. Let result be the result of performing ArrayCreate(2).
          3. Assert: result is a new, well-formed Array object so the following operations will never fail.
          4. Call CreateDataProperty(result, "0", e.[[key]]).
          5. Call CreateDataProperty(result, "1", e.[[value]]).
     iv. Return CreateIterResultObject(result, false).
 11. Set the [[Map]] internal slot of O to undefined.
 12. Return CreateIterResultObject(undefined, true).

23.1.5.5.2 %MapIteratorPrototype%. @@toStringTag

The initial value of the @@toStringTag property is the string value "Map Iterator".

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

23.1.5.3 Properties of Map Iterator Instances

Map Iterator instances are ordinary objects that inherit properties from the %MapIteratorPrototype% intrinsic object. Map Iterator instances are initially created with the internal slots described in Table 47.

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
</table>

Deleted: and m has been initialized so the value of [[MapData]] is not undefined
23.2 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 the SameValueZero comparison algorithm.

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.

23.2.1 The Set Constructor

The Set constructor is the %Set% intrinsic object and the initial value of the Set property of the global object. When called as a constructor it creates and initializes a new Set object. Set is not intended to be called as a function and will throw an exception when called in that manner.

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 the Set constructor to create and initialize the subclass instance with the internal state necessary to support the Set.prototype built-in methods.

23.2.1.1 Set ([Iterable])

When the Set function is called with optional argument iterable the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let set be OrdinaryCreateFromConstructor(NewTarget, "%SetPrototype", { [[SetData]] }).
3. ReturnIfAbrupt(set).
4. Set set's [[SetData]] internal slot to a new empty List.
5. If iterable is not present, let iterable be undefined.
6. If iterable is either undefined or null, let iter be undefined.
7. Else,
   a. Let adder be the result of Get(set, "add").
   b. ReturnIfAbrupt(adder).
   c. If IsCallable(adder) is false, throw a TypeError Exception.
   d. Let iter be the result of GetIterator(iterable).
   e. ReturnIfAbrupt(iter).
8. If iter is undefined, return set.
9. Repeat
   a. Let next be the result of IteratorStep(iter).
   b. If next is an abrupt completion, return IteratorClose(iter, next).
   c. If next.[[value]] is false, return set.
   d. Let nextValue be IteratorValue(next.[[value]]).
23.2.2 Properties of the Set Constructor

The value of the [[Prototype]] internal slot of the Set constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the Set constructor has the following properties:

23.2.2.1 Set.prototype

The initial value of Set.prototype is the intrinsic %SetPrototype% object (23.2.3).

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

23.2.2.2 get Set[@@species]

Set[@@species] is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is “get [Symbol.species]”.

NOTE Set prototype methods normally use their this object’s constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

23.2.3 Properties of the Set Prototype Object

The value of the [[Prototype]] internal slot of the Set prototype object is the intrinsic object %ObjectPrototype% (19.1.3). The Set prototype object is an ordinary object. It does not have a [[SetData]] internal slot.

23.2.3.1 Set.prototype.add (value)

The following steps are taken:

1. Let S be the this value.
2. If Type(S) is not Object, throw a TypeError exception.
3. If S does not have a [[SetData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of S’s [[SetData]] internal slot.
5. Repeat for each e that is an element of entries,
   a. If e is not empty and SameValueZero(e, value) is true, then
      i. Return S.
6. If value is −0, let value be +0.
7. Append value as the last element of entries.
8. Return S.
23.2.3.2 Set.prototype.clear ()

The following steps are taken:

1. Let $S$ be this value.
2. If Type($S$) is not Object, throw a TypeError exception.
3. If $S$ does not have a [[SetData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of $S$'s [[SetData]] internal slot.
5. Repeat for each $e$ that is an element of entries,
   a. Replace the element of entries whose value is $e$ with an element whose value is empty.
6. Return undefined.

23.2.3.3 Set.prototype.constructor

The initial value of Set.prototype.constructor is the intrinsic object %Set%.

23.2.3.4 Set.prototype.delete ( value )

The following steps are taken:

1. Let $S$ be the this value.
2. If Type($S$) is not Object, throw a TypeError exception.
3. If $S$ does not have a [[SetData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of $S$'s [[SetData]] internal slot.
5. Repeat for each $e$ that is an element of entries,
   a. If $e$ is not empty and SameValueZero($e$, value) is true, then
      i. Replace the element of entries whose value is $e$ with an element whose value is empty.
      ii. Return true.
6. Return false.

NOTE The value empty is used as a specification device to indicate that an entry has been deleted. Actual implementations may take other actions such as physically removing the entry from internal data structures.

23.2.3.5 Set.prototype.entries ()

The following steps are taken:

1. Let $S$ be the this value.
2. Return CreateSetIterator($S$, "key+value").

NOTE For iteration purposes, a Set appears similar to a Map where each entry has the same value for its key and value.

23.2.3.6 Set.prototype.forEach ( callbackfn [ , thisArg ] )

NOTE 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.

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 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.
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`.

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.

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 Type($S$) is not Object, throw a `TypeError` exception.
3. If $S$ does not have a `[[SetData]]` internal slot throw a `TypeError` exception.
4. If `IsCallable(callbackfn)` is false, throw a `TypeError` exception.
5. If `thisArg` was supplied, let $T$ be `thisArg`; else let $T$ be `undefined`.
6. Let `entries` be the List that is the value of $S$’s `[[SetData]]` internal slot.
7. 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 `Call(callbackfn, T, «e, e, S»)`.
      ii. ReturnIfAbrupt(`funcResult`).
8. Return `undefined`.

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

### 23.2.3.7 Set.prototype.has ( value )

The following steps are taken:

1. Let $S$ be the this value.
2. If Type($S$) is not Object, throw a `TypeError` exception.
3. If $S$ does not have a `[[SetData]]` internal slot throw a `TypeError` exception.
4. Let `entries` be the List that is the value of $S$’s `[[SetData]]` internal slot.
5. Repeat for each $e$ that is an element of `entries`, in original insertion order
   a. If $e$ is not empty and SameValueZero($e, value$) is true, return true.
6. Return false.

### 23.2.3.8 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.

### 23.2.3.9 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, throw a `TypeError` exception.
3. If $S$ does not have a `[[SetData]]` internal slot throw a `TypeError` exception.

Comment [AWB1049]: Do we really want to do this sort of method sharing.
4. Let entries be the List that is the value of S’s [[SetData]] internal slot.
5. Let count be 0.
6. For each e that is an element of entries
   a. If e is not empty, set count to count + 1.
7. Return count.

23.2.3.10 Set.prototype.values ( )

The following steps are taken:
1. Let S be the this value.
2. Return CreateSetIterator(S, “value”).

23.2.3.11 Set.prototype [ @@iterator ] ( )

The initial value of the @@iterator property is the same function object as the initial value of the values property.

23.2.3.12 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 }.

23.2.4 Properties of Set Instances

Set instances are ordinary objects that inherit properties from the Set prototype. After initialization by the Set constructor, Set instances also have a [[SetData]] internal slot.

23.2.5 Set Iterator Objects

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.

23.2.5.1 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:
1. If Type(set) is not Object, throw a TypeError exception.
2. If set does not have a [[SetData]] internal slot throw a TypeError exception.
3. Let iterator be the result of ObjectCreate(%SetIteratorPrototype%, « [[IteratedSet]], [[SetNextIndex]], [[SetIterationKind]] »).
4. Set iterator’s [[IteratedSet]] internal slot to set.
5. Set iterator’s [[SetNextIndex]] internal slot to 0.
6. Set iterator’s [[SetIterationKind]] internal slot to kind.
7. Return iterator.

23.2.5.2 The %SetIteratorPrototype% Object

All Set Iterator Objects inherit properties from the %SetIteratorPrototype% intrinsic object. The %SetIteratorPrototype% intrinsic object is an ordinary object and its [[Prototype]] internal slot is the
%IteratorPrototype% intrinsic object (25.1.2). In addition, %SetIteratorPrototype% has the following properties:

23.2.5.2.1 `%SetIteratorPrototype%.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 slots of a Set Iterator Instance (23.2.5.3), throw a TypeError exception.
4. Let s be the value of the [[IteratedSet]] internal slot of O.
5. Let index be the value of the [[SetNextIndex]] internal slot of O.
6. Let itemKind be the value of the [[SetIterationKind]] internal slot of O.
7. If s is undefined, return CreateIterResultObject(undefined, true).
8. Assert: s has a [[SetData]] internal slot.
9. Let entries be the List that is the value of the [[SetData]] internal slot of s.
10. 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 entries[index].
   b. Set index to index+1;
   c. Set the [[SetNextIndex]] internal slot 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 performing ArrayCreate(2).
         2. Assert: result is a new, well-formed Array object so the following operations will never fail.
         3. Call CreateDataProperty(result, "0", e).
         4. Call CreateDataProperty(result, "1", e).
         5. Return CreateIterResultObject(result, false).
      ii. Return CreateIterResultObject(e, false).
11. Set the [[IteratedSet]] internal slot of O to undefined.
12. Return CreateIterResultObject(undefined, true).

23.2.5.2.2 `%SetIteratorPrototype%[@@toStringTag]`

The initial value of the @@toStringTag property is the string value "Set Iterator".

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

23.2.5.3 Properties of Set Iterator Instances

Set Iterator instances are ordinary objects that inherit properties from the %SetIteratorPrototype% intrinsic object. Set Iterator instances are initially created with the internal slots specified in Table 48.

### Table 48 — Internal Slots of Set Iterator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[IteratedSet]]</td>
<td>The Set object that is being iterated.</td>
</tr>
<tr>
<td>[[SetNextIndex]]</td>
<td>The integer index of the next Set data element to be examined by this iterator</td>
</tr>
<tr>
<td>[[SetIterationKind]]</td>
<td>A string value that identifies what is to be returned for each element of the iteration. The possible values are: &quot;key&quot;, &quot;value&quot;</td>
</tr>
</tbody>
</table>
23.3 WeakMap Objects

WeakMap objects are collections of key/value pairs where the keys are 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.

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 structure 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 and WeakSets are intended to provide mechanisms for dynamically associating state with an object in a manner that does not “leak” memory resources if, in the absence of the WeakMap or WeakSet, the object otherwise became inaccessible and subject to resource reclamation by the implementation’s garbage collection mechanisms. Achieving this characteristic can be achieved by using an inverted per-object mapping of weak map instances to keys. Alternatively each weak map may internally store its key to value mappings but this approach requires coordination between the WeakMap or WeakSet implementation and the garbage collector. The following references describe mechanism that may be useful to implementations of WeakMap and WeakSets:


http://www.jucs.org/jucs_14_21/eliminating_cycles_in_weak

23.3.1 The WeakMap Constructor

The WeakMap constructor is the %WeakMap% intrinsic object and the initial value of the WeakMap property of the global object. When called as a constructor it creates and initializes a new WeakMap object. WeakMap is not intended to be called as a function and will throw an exception when called in that manner.

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 the WeakMap constructor to create and initialize the subclass instance with the internal state necessary to support the WeakMap.prototype built-in methods.
23.3.1 WeakMap ( [ iterable ] )

When the WeakMap function is called with optional argument iterable the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let map be OrdinaryCreateFromConstructor(NewTarget, "%WeakMapPrototype%", «[WeakMapData]»).
3. ReturnIfAbrupt(map).
4. Set map’s [[WeakMapData]] internal slot to a new empty List.
5. If iterable is not present, let iterable be undefined.
6. If iterable is either undefined or null, let iter be undefined.
7. Else.
   a. Let adder be the result of Get(map, "set").
   b. ReturnIfAbrupt(adder).
   c. If IsCallable(adder) is false, throw a TypeError Exception.
   d. Let iter be the result of GetIterator(iterable).
   e. ReturnIfAbrupt(iter).
8. If iter is undefined, return map.
9. Repeat
   a. Let next be the result of IteratorStep(iter).
   b. If next is an abrupt completion, return IteratorClose(iter, next).
   c. If next[[value]] is false, return map.
   d. Let nextItem be IteratorValue(next[[value]]).
   e. If nextItem is an abrupt completion, return IteratorClose(iter, nextItem).
   f. If Type(nextItem[[value]]) is not Object,
      i. Let error be Completion([[type]: throw, [[value]]: a newly created TypeError object, [[target]]: map]].
      ii. Return IteratorClose(iter, error).
   g. Let k be the result of Get(nextItem[[value]], "0").
   h. If k is an abrupt completion, return IteratorClose(iter, k).
   i. Let v be the result of Get(nextItem[[value]], "1").
   j. If v is an abrupt completion, return IteratorClose(iter, v).
   k. Let status be Call(adder, map, «k, v, [[value]], v, [[value]]»).
   l. If status is an abrupt completion, return IteratorClose(iter, 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 a two element array-like object 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.

23.3.2 Properties of the WeakMap Constructor

The value of the [[Prototype]] internal slot of the WeakMap constructor is the intrinsic object %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the WeakMap constructor has the following properties:

23.3.2.1 WeakMap.prototype

The initial value of WeakMap.prototype is the WeakMap prototype object (23.3.3).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 
23.3.3 Properties of the WeakMap Prototype Object

The value of the [[Prototype]] internal slot of the WeakMap prototype object is the intrinsic object `%ObjectPrototype%` (19.1.3). The WeakMap prototype object is an ordinary object. It does not have a [[WeakMapData]] internal slot.

23.3.3.1 WeakMap.prototype.constructor

The initial value of `WeakMap.prototype.constructor` is the intrinsic object `%WeakMap%`.

23.3.3.2 WeakMap.prototype.delete ( key )

The following steps are taken:

1. Let `M` be the `this` value.
2. If `Type(M)` is not `Object`, throw a `TypeError` exception.
3. If `M` does not have a `[[WeakMapData]]` internal slot throw a `TypeError` exception.
4. Let `entries` be the List that is the value of `M`'s `[[WeakMapData]]` internal slot.
5. If `Type(key)` is not `Object`, return `false`.
6. Repeat for each Record `[[key]], [[value]]` `p` that is an element of `entries`,
   a. If `p.[[key]]` is not `empty` and `SameValue(p.[[key]], key)` is `true`, then
      i. Set `p.[[key]]` to `empty`.
      ii. Set `p.[[value]]` to `empty`.
      iii. Return `true`.
7. Return `false`.

**NOTE** The value `empty` is used as a specification device to indicate that an entry has been deleted. Actual implementations may take other actions such as physically removing the entry from internal data structures.

23.3.3.3 WeakMap.prototype.get ( key )

The following steps are taken:

1. Let `M` be the `this` value.
2. If `Type(M)` is not `Object`, throw a `TypeError` exception.
3. If `M` does not have a `[[WeakMapData]]` internal slot throw a `TypeError` exception.
4. Let `entries` be the List that is the value of `M`’s `[[WeakMapData]]` internal slot.
5. If `Type(key)` is not `Object`, return `undefined`.
6. Repeat for each Record `[[key]], [[value]]` `p` that is an element of `entries`,
   a. If `p.[[key]]` is not `empty` and `SameValue(p.[[key]], key)` is `true`, return `p.[[value]]`.
7. Return `undefined`.

23.3.3.4 WeakMap.prototype.has ( key )

The following steps are taken:

1. Let `M` be the `this` value.
2. If `Type(M)` is not `Object`, throw a `TypeError` exception.
3. If `M` does not have a `[[WeakMapData]]` internal slot throw a `TypeError` exception.
4. Let `entries` be the List that is the value of `M`’s `[[WeakMapData]]` internal slot.
5. If `Type(key)` is not `Object`, return `false`.
6. Repeat for each Record `[[key]], [[value]]` `p` that is an element of `entries`,
   a. If `p.[[key]]` is not `empty` and `SameValue(p.[[key]], key)` is `true`, return `true`.
7. Return `false`.

** Deleted: **// If `entries` is `undefined`, then throw, throw a `TypeError` exception. //
23.3.3.5 WeakMap.prototype.set (key, value)

The following steps are taken:

1. Let M be the this value.
2. If Type(M) is not Object, throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal slot throw a TypeError exception.
4. Let entries be the List that is the value of M's [[WeakMapData]] internal slot.
5. If Type(key) is not Object, throw a TypeError exception.
6. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] is not empty and SameValue(p.#[key], key) is true, then
      i. Set p.[[value]] to value.
      ii. Return M.
6. Let p be the Record {[[key]]: key, [[value]]: value}.
7. Append p as the last element of entries.
8. Return M.

23.3.3.6 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 }.

23.3.4 Properties of WeakMap Instances

WeakMap instances are ordinary objects that inherit properties from the WeakMap prototype. WeakMap instances also have a [[WeakMapData]] internal slot.

23.4 WeakSet Objects

WeakSet objects are collections of objects. A distinct object may only occur once as an element of a WeakSet's collection. A WeakSet may be queried to see if it contains a specific object, but no mechanisms is provided for enumerating the objects it holds. If an object that is contain by a WeakSet is only reachable by following a chain of references that start within that WeakSet, then that object is inaccessible and is automatically removed from the WeakSet. WeakSet implementations must detect and remove such objects and any associated resources.

An implementation may impose an arbitrarily determined latency between the time an object contained in a WeakSet becomes inaccessible and the time when the object is removed from the WeakSet. 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 determine if a WeakSet contains a particular object that does not require the observer to present the observed object.

WeakSet 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 structure used in this WeakSet objects specification is only intended to describe the required observable semantics of WeakSet objects. It is not intended to be a viable implementation model.

NOTE See the NOTE in 23.3.
23.4.1 The WeakSet Constructor

The WeakSet constructor is the %WeakSet% intrinsic object and the initial value of the WeakSet property of the global object. When called as a constructor it creates and initializes a new WeakSet object. WeakSet is not intended to be called as a function and will throw an exception when called in that manner.

The WeakSet 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 WeakSet behaviour must include a super call to the WeakSet constructor to create and initialize the subclass instance with the internal state necessary to support the WeakSet.prototype built-in methods.

23.4.1.1 WeakSet ([ iterable ])

When the WeakSet function is called with optional argument iterable the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let set be OrdinaryCreateFromConstructor(NewTarget, "%WeakSetPrototype%", «[WeakSetData]»).
3. ReturnIfAbrupt(set).
4. Set set's [[WeakSetData]] internal slot to a new empty List.
5. If iterable is not present, let iterable be undefined.
6. If iterable is either undefined or null, let iter be undefined.
7. Else.
   a. Let adder be the result of Get(set, "add").
   b. ReturnIfAbrupt(adder).
   c. If IsCallable(adder) is false, throw a TypeError Exception.
   d. Let iter be the result of GetIterator(iterable).
   e. ReturnIfAbrupt(iter).
8. If iter is undefined: return set.
9. Repeat
   a. Let next be the result of IteratorStep(iter).
   b. If next.[[value]] is an abrupt completion, return IteratorClose(iter, next).
   c. If next is false: return set.
   d. Let nextValue be IteratorValue(next.[[value]]).
   e. If nextValue is an abrupt completion, return IteratorClose(iter, nextValue).
   f. Let status be Call(adder, set, «nextValue.[[value]]»).
   g. If status is an abrupt completion, return IteratorClose(iter, status).

23.4.2 Properties of the WeakSet Constructor

The value of the [[Prototype]] internal slot of the WeakSet constructor is the intrinsic %FunctionPrototype% (19.2.3).

Besides the length property (whose value is 1), the WeakSet constructor has the following properties:

23.4.2.1 WeakSet.prototype

The initial value of WeakSet.prototype is the intrinsic %WeakSetPrototype% object (23.4.3).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }. 
23.4.3 Properties of the WeakSet Prototype Object

The value of the [[Prototype]] internal slot of the WeakSet prototype object is the intrinsic object %ObjectPrototype% (19.1.3). The WeakSet prototype object is an ordinary object. It does not have a [[WeakSetData]] internal slot.

23.4.3.1 WeakSet.prototype.add ( value )

The following steps are taken:

1. Let \( S \) be the this value.
2. If Type(\( S \)) is not Object, throw a TypeError exception.
3. If \( S \) does not have a [[WeakSetData]] internal slot throw a TypeError exception.
4. If Type(\( value \)) is not Object, throw a TypeError exception.
5. Let \( entries \) be the List that is the value of \( S \)'s [[WeakSetData]] internal slot.
6. Repeat for each \( e \) that is an element of \( entries \),
   a. If \( e \) is not empty and SameValue(\( e \), \( value \)) is true, then
      i. Return \( S \).
7. Append \( value \) as the last element of \( entries \).
8. Return \( S \).

NOTE The value empty is used as a specification device to indicate that an entry has been deleted. Actual implementations may take other actions such as physically removing the entry from internal data structures.

23.4.3.2 WeakSet.prototype.constructor

The initial value of WeakSet.prototype.constructor is the %WeakSet% intrinsic object.

23.4.3.3 WeakSet.prototype.delete ( value )

The following steps are taken:

1. Let \( S \) be the this value.
2. If Type(\( S \)) is not Object, throw a TypeError exception.
3. If \( S \) does not have a [[WeakSetData]] internal slot throw a TypeError exception.
4. If Type(\( value \)) is not Object, return false.
5. Let \( entries \) be the List that is the value of \( S \)'s [[WeakSetData]] internal slot.
6. Repeat for each \( e \) that is an element of \( entries \),
   a. If \( e \) is not empty and SameValue(\( e \), \( value \)) is true, then
      i. Replace the element of \( entries \) whose value is \( e \) with an element whose value is empty.
      ii. Return true.
7. Return false.

23.4.3.4 WeakSet.prototype.has ( value )

The following steps are taken:

1. Let \( S \) be the this value.
2. If Type(\( S \)) is not Object, throw a TypeError exception.
3. If \( S \) does not have a [[WeakSetData]] internal slot throw a TypeError exception.
4. Let \( entries \) be the List that is the value of \( S \)'s [[WeakSetData]] internal slot.
5. If Type(\( value \)) is not Object, return false.
6. Repeat for each \( e \) that is an element of \( entries \),
   a. If \( e \) is not empty and SameValue(\( e \), \( value \)), return true.
7. Return `false`.

23.4.3.5 `WeakSet.prototype @@toStringTag`  
The initial value of the `@@toStringTag` property is the string value "WeakSet".

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

23.4.4 Properties of WeakSet Instances  
WeakSet instances are ordinary objects that inherit properties from the WeakSet prototype. After initialization by the WeakSet constructor, WeakSet instances also have a `[[WeakSetData]]` internal slot.

24 Structured Data  
24.1 ArrayBuffer Objects  
24.1.1 Abstract Operations For ArrayBuffer Objects  
24.1.1.1 `AllocateArrayBuffer( constructor, byteLength )`  
The abstract operation `AllocateArrayBuffer` with arguments `constructor` and `byteLength` is used to create an ArrayBuffer object. It performs the following steps:

1. Let `obj` be `OrdinaryCreateFromConstructor(constructor, "%ArrayBufferPrototype", «[[ArrayBufferData]], [[ArrayBufferByteLength]]» )`.  
2. ReturnIfAbrupt(`obj`).  
3. Assert: `byteLength` is a positive integer.  
4. Let `block` be `CreateByteDataBlock(byteLength)`.  
5. ReturnIfAbrupt(`block`).  
6. Set `obj`'s `[[ArrayBufferData]]` internal slot to `block`.  
7. Set `obj`'s `[[ArrayBufferByteLength]]` internal slot to `byteLength`.  
8. Return `obj`.

24.1.1.2 `IsDetachedBuffer( arrayBuffer )`  
The abstract operation `IsDetachedBuffer` with argument `arrayBuffer` performs the following steps:

1. Assert: Type(`arrayBuffer`) is Object and it has `[[ArrayBufferData]]` internal slot.  
2. If `arrayBuffer`'s `[[ArrayBufferData]]` internal slot is `null`, return `true`.  
3. Return `false`.

24.1.1.3 `DetachArrayBuffer( arrayBuffer )`  
The abstract operation `DetachArrayBuffer` with argument `arrayBuffer` performs the following steps:

1. Assert: Type(`arrayBuffer`) is Object and it has `[[ArrayBufferData]]` and `[[ArrayBufferByteLength]]` internal slots.  
2. Set `arrayBuffer`'s `[[ArrayBufferData]]` internal slot to `null`.  
3. Set `arrayBuffer`'s `[[ArrayBufferByteLength]]` internal slot to `0`.  
4. Return NormalCompletion(`null`).
NOTE Detaching an ArrayBuffer instance disassociates the Data Block used as its backing store from the instance and sets the byte length of the buffer to 0. No operations defined by this specification uses the DetachArrayBuffer abstract operation. However, an ECMAScript implementation or host environment may define such operations.

24.1.1.5 GetValueFromBuffer (arrayBuffer, byteIndex, type, isLittleEndian)

The abstract operation GetValueFromBuffer takes four parameters, an ArrayBuffer arrayBuffer, an integer byteIndex, a String type, and optionally a Boolean isLittleEndian. This operation performs the following steps:

1. Assert: IsDetachedBuffer(arrayBuffer) is false.
2. Assert: There are sufficient bytes in arrayBuffer starting at byteIndex to represent a value of type.
3. Assert: byteIndex is a positive integer.
4. Let block be arrayBuffer’s [[ArrayBufferData]] internal slot.
5. Let elementsSize be the Number value of the Element Size value specified in Table 46 for Element Type type.
6. Let rawValue be a List of elementsSize containing, in order, the elementsSize sequence of bytes starting with block[byteIndex].
7. If isLittleEndian is not present, set isLittleEndian 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 abstract operation.
8. If isLittleEndian is false, reverse the order of the elements of rawValue.
9. If type is “Float32”, then
   a. Let value be the byte elements of rawValue concatenated and interpreted as a little-endian bit string encoding of an IEEE 754-2008 binary32 value.
   b. If value is an IEEE 754-2008 binary32 NaN value, return the NaN Number value.
   c. Return the Number value that corresponds to value.
10. If type is “Float64”, then
Let value be the byte elements of rawValue concatenated and interpreted as a little-endian bit string encoding of an IEEE 754-2008 binary64 value.

b. If value is an IEEE 754-2008 binary64 NaN value, return the NaN Number value.

c. Return the Number value that corresponds to value.

11. If the first code unit of type is "U", then
   a. Let intValue be the byte elements of rawValue concatenated and interpreted as a bit string encoding of an unsigned little-endian binary number.
   Else
      a. Let intValue be the byte elements of rawValue concatenated and interpreted as a bit string encoding of a binary little-endian 2’s complement number of bit length elementSize × 8.
   13. Return the Number value that corresponds to intValue.

24.1.1.6 SetValueInBuffer (arrayBuffer, byteIndex, type, value, isLittleEndian)

The abstract operation SetValueInBuffer takes five parameters, an ArrayBuffer arrayBuffer, an integer byteIndex, a String type, a Number value, and optionally a Boolean isLittleEndian. This operation performs the following steps:

1. Assert: IsDetachedBuffer(arrayBuffer) is false.
2. Assert: There are sufficient bytes in arrayBuffer starting at byteIndex to represent a value of type.
3. Assert: byteIndex is a positive integer.
4. Assert: Type(value) is Number.
5. Let block be arrayBuffer’s [[ArrayBufferData]] internal slot.
6. Assert: block is not undefined.
7. Let elementSize be the Number value of the Element Size specified in Table 46 for Element Type type.
8. If isLittleEndian is not present, set isLittleEndian 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 abstract operation.
9. If type is “Float32”, then
   a. Set rawValue to a List containing the 4 bytes that are the result of converting value to IEEE-754-2008 binary32 format using “Round to nearest, ties to even” rounding mode. If isLittleEndian is false, 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. An implementation must always choose the same non-signaling NaN encoding for a distinct Not-a-Number value.
10. Else, if type is “Float64”, then
    a. Set rawValue to a List containing the 8 bytes that are the IEEE-754-2008 binary64 format encoding of value. If isLittleEndian is false, 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. An implementation must always choose the same non-signaling NaN encoding for a distinct Not-a-Number value.
11. Else,
    a. Let n be the Number value of the Element Size specified in Table 46 for Element Type type.
    b. Let convOp be the abstract operation named in the Conversion Operation column in Table 46 for Element Type type.
    c. Let intValue be the result of calling convOp with value as its argument.
    d. If intValue ≥ 0, then
       i. Let rawBytes be a List containing the n-byte binary encoding of intValue. If isLittleEndian is false, the bytes are ordered in big endian order. Otherwise, the bytes are ordered in little endian order.
    e. Else,
Let `rawBytes` be a List containing the `n`-byte binary 2’s complement encoding of `intValue`. If `isLittleEndian` is `false`, the bytes are ordered in big endian order. Otherwise, the bytes are ordered in little endian order.

12. Store the individual bytes of `rawBytes` into `block`, in order, starting at `block[byteIndex]`.
13. Return NormalCompletion (undefined).

### 24.1.2 The ArrayBuffer Constructor

The `ArrayBuffer` constructor is the `%ArrayBuffer%` intrinsic object and the initial value of the `ArrayBuffer` property of the global object. When called as a constructor it creates and initializes a new `ArrayBuffer` object. `ArrayBuffer` is not intended to be called as a function and will throw an exception when called in that manner.

The `ArrayBuffer` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified `ArrayBuffer` behaviour must include a `super` call to the `ArrayBuffer` constructor to create and initialize subclass instances with the internal state necessary to support the `ArrayBuffer.prototype` built-in methods.

#### 24.1.2.1 ArrayBuffer( length )

`ArrayBuffer` called with argument `length` performs the following steps:

1. If `NewTarget` is `undefined`, throw a `TypeError` exception.
2. Let `numberLength` be `ToNumber(length)`.
3. Let `byteLength` be `ToLength(numberLength)`.
4. ReturnIfAbrupt(`byteLength`).
5. If `SameValueZero(numberLength, byteLength)` is `false`, throw a `RangeError` exception.
6. Return `AllocateArrayBuffer(NewTarget, byteLength)`.

### 24.1.3 Properties of the ArrayBuffer Constructor

The value of the `[[Prototype]]` internal slot of the `ArrayBuffer` constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides its `length` property (whose value is 1), the `ArrayBuffer` constructor has the following properties:

#### 24.1.3.1 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` has a `[[ViewedArrayBuffer]]` internal slot, return `true`.
3. Return `false`.

#### 24.1.3.2 ArrayBuffer.prototype

The initial value of `ArrayBuffer.prototype` is the `ArrayBuffer` prototype object (24.1.4).

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.
24.1.3.3 get ArrayBuffer @@species 

ArrayBuffer@@species is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Return this.

The value of the name property of this function is "get [Symbol.species]."

NOTE ArrayBuffer prototype methods normally use their this object's constructor to create a derived object. However, a subclass constructor may over-ride that default behavior by redefining its @@species property.

24.1.4 Properties of the ArrayBuffer Prototype Object

The value of the [[Prototype]] internal slot of the ArrayBuffer prototype object is the intrinsic object %ObjectPrototype%. The ArrayBuffer prototype object is an ordinary object. It does not have an [[ArrayBufferData]] or [[ArrayBufferByteLength]] internal slot.

24.1.4.1 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 this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have an [[ArrayBufferData]] internal slot throw a TypeError exception.
4. If IsDetachedBuffer(O) is true, throw a TypeError exception.
5. Let length be the value of O's [[ArrayBufferByteLength]] internal slot.
6. Return length.

24.1.4.2 ArrayBuffer.prototype.constructor

The initial value of ArrayBuffer.prototype.constructor is the intrinsic object %ArrayBuffer%.

24.1.4.3 ArrayBuffer.prototype.slice ( start , end )

The following steps are taken:

1. Let O be the this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have an [[ArrayBufferData]] internal slot throw a TypeError exception.
4. If IsDetachedBuffer(O) is true, throw a TypeError exception.
5. Let len be the value of O's [[ArrayBufferByteLength]] internal slot.
6. Let relativeStart be ToInteger(start).
7. ReturnIfAbrupt(relativeStart).
8. If relativeStart < 0, let first be max((len + relativeStart),0); else let first be min(relativeStart, len).
9. If end is undefined, let relativeEnd be ToInteger(end).
10. ReturnIfAbrupt(relativeEnd).
11. If relativeEnd < 0, let final be max((len + relativeEnd),0); else let final be min(relativeEnd, len).
12. Let newLen be max(final-first,0).
13. Let ctor be SpeciesConstructor(O, %ArrayBuffer%).
14. ReturnIfAbrupt(ctor).
15. Let new be Construct(ctor, «newLen»).
16. ReturnIfAbrupt(new).
17. If `new` does not have an `[[ArrayBufferData]]` internal slot throw a `TypeError` exception.
18. If `IsDetachedBuffer(new)` is `true`, throw a `TypeError` exception.
19. If `SameValue(new, O)` is `true`, throw a `TypeError` exception.
20. If the value of `new`’s `[[ArrayBufferByteLength]]` internal slot < `newLen`, throw a `TypeError` exception.
21. NOTE: Side-effects of the above steps may have detached `O`.
22. If `IsDetachedBuffer(O)` is `true`, throw a `TypeError` exception.
23. Let `fromBuf` be the value of `O`’s `[[ArrayBufferData]]` internal slot.
24. Let `toBuf` be the value of `new`’s `[[ArrayBufferData]]` internal slot.
25. Perform `CopyDataBlockBytes(toBuf, 0, fromBuf, first, newLen)`.

24.1.4.4 `ArrayBuffer.prototype` `[ @@toStringTag ]`

The initial value of the `@@toStringTag` property is the string value "ArrayBuffer".

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true`.

24.1.5 Properties of the ArrayBuffer Instances

ArrayBuffer instances inherit properties from the ArrayBuffer prototype object. ArrayBuffer instances each have an `[[ArrayBufferData]]` internal slot and an `[[ArrayBufferByteLength]]` internal slot.

ArrayBuffer instances whose `[[ArrayBufferData]]` is `null` are considered to be detached and all operators to access or modify data contained in the ArrayBuffer instance will fail.

24.2 DataView Objects

24.2.1 Abstract Operations For DataView Objects

24.2.1.1 `GetViewValue` ( `view`, `requestIndex`, `isLittleEndian`, `type` )

The abstract operation `GetViewValue` with arguments `view`, `requestIndex`, `isLittleEndian`, and `type` is used by functions on DataView instances to retrieve values from the view’s buffer. It performs the following steps:

1. If `Type(view)` is not Object, throw a `TypeError` exception.
2. If `view` does not have a `[[DataView]]` internal slot, throw a `TypeError` exception.
3. Let `numberIndex` be `ToNumber(requestIndex)`.
4. Let `getIndex` be `ToInteger(numberIndex)`.
5. ReturnIfAbrupt(getIndex).
6. If `numberIndex ≠ getIndex` or `getIndex < 0`, throw a `RangeError` exception.
7. Let `isLittleEndian` be `ToBoolean(isLittleEndian)`.
8. Let `buffer` be the value of `view`’s `[[ViewedArrayBuffer]]` internal slot.
9. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
10. Let `viewOffset` be the value of `view`’s `[[ByteOffset]]` internal slot.
11. Let `viewSize` be the value of `view`’s `[[ByteLength]]` internal slot.
12. Let `elementSize` be the Number value of the Element Size value specified in Table 46 for Element Type `type`.
13. If `getIndex + elementSize > viewSize`, throw a `RangeError` exception.
14. Let `bufferIndex` be `getIndex + viewOffset`.
15. Return `GetValueFromBuffer(buffer, bufferIndex, type, isLittleEndian)`.
24.2.1.2 SetViewValue (view, requestIndex, isLittleEndian, type, value)

The abstract operation SetViewValue with arguments view, requestIndex, isLittleEndian, type, and value is used by functions on DataView instances to store values into the view’s buffer. It performs the following steps:

1. If Type(view) is not Object, throw a TypeError exception.
2. If view does not have a [[DataView]] internal slot, throw a TypeError exception.
3. Let numberIndex be ToNumber(requestIndex).
4. Let getIndex be ToInteger(numberIndex).
5. ReturnIfAbrupt(getIndex).
6. If numberIndex ≠ getIndex or getIndex < 0, throw a RangeError exception.
7. Let isLittleEndian be ToBoolean(isLittleEndian).
8. Let buffer be the value of view’s [[ViewedArrayBuffer]] internal slot.
9. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
10. Let viewOffset be the value of view’s [[ByteOffset]] internal slot.
11. Let viewSize be the value of view’s [[ByteLength]] internal slot.
12. Let elementsize be the number value of the Element size value specified in Table 46 for Element Type type.
13. If getIndex + elementsize > viewSize, throw a RangeError exception.
14. Let bufferIndex be getIndex + viewOffset.
15. Return SetValueInBuffer(buffer, bufferIndex, type, value, isLittleEndian).

NOTE The algorithms for GetViewValue and SetViewValue are identical except for their final steps.

24.2.2 The DataView Constructor

The DataView constructor is the DataView% intrinsic object and the initial value of the DataView property of the global object. When called as a constructor it creates and initializes a new DataView object. DataView is not intended to be called as a function and will throw an exception when called in that manner.

The DataView constructor is designed to be subclassable. It may be used as the value of an extends clause of a class definition. Subclass constructors that intend to inherit the specified DataView behaviour must include a super call to the DataView constructor to create and initialize subclass instances with the internal state necessary to support the DataView.prototype built-in methods.

24.2.2.1 DataView (buffer [, byteOffset [, byteLength ]])

DataView called with arguments buffer, byteOffset, and length performs the following steps:

1. If NewTarget is undefined, throw a TypeError exception.
2. If type(buffer) is not Object, throw a TypeError exception.
3. If buffer does not have an [[ArrayBufferData]] internal slot, throw a TypeError exception.
4. Let numberOffset be ToNumber(byteOffset).
5. Let offset be ToInteger(numberOffset).
6. ReturnIfAbrupt(offset).
7. If numberOffset ≠ offset or offset < 0, throw a RangeError exception.
8. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
9. Let bufferByteLength be the value of buffer’s [[ArrayBufferByteLength]] internal slot.
10. If offset > bufferByteLength, throw a RangeError exception.
11. If byteLength is undefined, then
   a. Let viewByteLength be bufferByteLength – offset.

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12. Else,
   a. Let numberLength be ToNumber(byteLength).
   b. Let viewLength be ToInteger(numberLength).
   c. ReturnIfAbrupt(viewLength).
   d. If numberLength ≠ viewLength or viewLength < 0, throw a `RangeError` exception.
   e. Let viewByteLength be viewLength.
   f. If offset+viewByteLength > bufferByteLength, throw a `RangeError` exception.
13. Let O be OrdinaryCreateFromConstructor(NewTarget, "%DataViewPrototype%",
   «[[DataView]], [[ViewedArrayBuffer]], [[ByteLength]], [[ByteOffset]]»).
14. ReturnIfAbrupt(O).
15. Set O's [[DataView]] internal slot to `true`.
16. Set O's [[ViewedArrayBuffer]] internal slot to `buffer`.
17. Set O's [[ByteLength]] internal slot to `viewByteLength`.
18. Set O's [[ByteOffset]] internal slot to `offset`.
19. Return O.

24.2.3 Properties of the DataView Constructor

The value of the [[Prototype]] internal slot of the DataView constructor is the intrinsic object
%FunctionPrototype% (19.2.3).

Besides the length property (whose value is 3), the DataView constructor has the following properties:

24.2.3.1 DataView.prototype

The initial value of DataView.prototype is the DataView prototype object (24.2.4).

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

24.2.4 Properties of the DataView Prototype Object

The value of the [[Prototype]] internal slot of the DataView prototype object is the intrinsic object
%ObjectPrototype% (19.1.3). The DataView prototype object is an ordinary object. It does not have a
[[DataView]], [[ViewedArrayBuffer]], [[ByteLength]], or [[ByteOffset]] internal slot.

24.2.4.1 `get DataView.prototype.buffer`

DataView.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 this value.
2. If Type(O) is not Object, throw a `TypeError` exception.
3. If O does not have a [[ViewedArrayBuffer]] internal slot throw a `TypeError` exception.
4. Let buffer be the value of O's [[ViewedArrayBuffer]] internal slot.
5. Return buffer.

24.2.4.2 `get DataView.prototype.byteLength`

DataView.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 this value.
2. If Type(O) is not Object, throw a `TypeError` exception.
3. If `O` does not have a `[ViewedArrayBuffer]` internal slot throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[ViewedArrayBuffer]` internal slot.
5. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
7. Return `size`.

24.2.4.3 `getDataView.prototype.byteOffset`

`getDataView.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 `this` value.
2. If `Type(O)` is not `Object`, throw a `TypeError` exception.
3. If `O` does not have a `[ViewedArrayBuffer]` internal slot throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[ViewedArrayBuffer]` internal slot.
5. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
7. Return `offset`.

24.2.4.4 `getDataView.prototype.constructor`

The initial value of `getDataView.prototype.constructor` is the intrinsic object `%DataView%`.

24.2.4.5 `getDataView.prototype.getFloat32 (byteOffset [, littleEndian])`

When the `getFloat32` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:
1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Float32")`.

24.2.4.6 `getDataView.prototype.getFloat64 (byteOffset [, littleEndian])`

When the `getFloat64` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:
1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Float64")`.

24.2.4.7 `getDataView.prototype.getInt8 (byteOffset)`

When the `getInt8` method is called with argument `byteOffset` the following steps are taken:
1. Let `v` be the `this` value.
2. Return the result of `GetViewValue(v, byteOffset, true, "Int8")`.

24.2.4.8 `getDataView.prototype.getInt16 (byteOffset [, littleEndian])`

When the `getInt16` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:
1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Int16")`.

24.2.4.9 `DataView.prototype.getInt32 (byteOffset [, littleEndian])`

When the `getInt32` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the this value.
2. If `littleEndian` is not present, let `littleEndian` be `undefined`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Int16")`.

24.2.4.10 `DataView.prototype.getUint8 (byteOffset)`

When the `getUint8` method is called with argument `byteOffset` the following steps are taken:

1. Let `v` be the this value.
2. Return the result of `GetViewValue(v, byteOffset, true, "Uint8")`.

24.2.4.11 `DataView.prototype.getUint16 (byteOffset [, littleEndian])`

When the `getUint16` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the this value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Uint16")`.

24.2.4.12 `DataView.prototype.getUint32 (byteOffset [, littleEndian])`

When the `getUint32` method is called with argument `byteOffset` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the this value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `GetViewValue(v, byteOffset, littleEndian, "Uint32")`.

24.2.4.13 `DataView.prototype.setFloat32 (byteOffset, value [, littleEndian])`

When the `setFloat32` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the this value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Float32", value)`.

24.2.4.14 `DataView.prototype.setFloat64 (byteOffset, value [, littleEndian])`

When the `setFloat64` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the this value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Float64", value)`.
24.2.4.15 DataView.prototype.setInt8 ( byteOffset, value )

When the `getInt8` method is called with arguments `byteOffset` and `value` the following steps are taken:

1. Let `v` be the `this` value.
2. Return the result of `SetViewValue(v, byteOffset, true, "Int8", value)`. 

24.2.4.16 DataView.prototype.setInt16 ( byteOffset, value [ , littleEndian ] )

When the `getInt16` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Int16", value)`. 

24.2.4.17 DataView.prototype.setInt32 ( byteOffset, value [ , littleEndian ] )

When the `getInt32` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Int32", value)`. 

24.2.4.18 DataView.prototype.setUint8 ( byteOffset, value )

When the `setUint8` method is called with arguments `byteOffset` and `value` the following steps are taken:

1. Let `v` be the `this` value.
2. Return the result of `SetViewValue(v, byteOffset, true, "Uint8", value)`. 

24.2.4.19 DataView.prototype.setUint16 ( byteOffset, value [ , littleEndian ] )

When the `setUint16` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Uint16", value)`. 

24.2.4.20 DataView.prototype.setUint32 ( byteOffset, value [ , littleEndian ] )

When the `setUint32` method is called with arguments `byteOffset` and `value` and optional argument `littleEndian` the following steps are taken:

1. Let `v` be the `this` value.
2. If `littleEndian` is not present, let `littleEndian` be `false`.
3. Return the result of `SetViewValue(v, byteOffset, littleEndian, "Uint32", value)`. 

24.2.4.21 DataView.prototype[ @@toStringTag ]

The initial value of the `@@toStringTag` property is the string value "%DataView".
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

24.2.5 Properties of DataView Instances

DataView instances are ordinary objects that inherit properties from the DataView prototype object. DataView instances each have a [[DataView]], [[ViewedArrayBuffer]], [[ByteLength]], and [[ByteOffset]] internal slots.

NOTE The value of the [[DataView]] internal slot is not used within this specification. The simple presence of that internal slot is used within the specification to identify objects created using the DataView constructor.

24.3 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 defined in ECMA-404. The JSON interchange format used in this specification is exactly that described by ECMA-404.

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.

The value of the [[Prototype]] internal slot of the JSON object is the intrinsic object %ObjectPrototype% (19.1.3). The value of the [[Extensible]] internal slot 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.

24.3.1 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 subset of the syntax for ECMAScript literals, Array Initializers and Object Initializers. After parsing, JSON objects are realized as ECMAScript objects. JSON arrays are realized as ECMAScript Array instances. JSON strings, numbers, booleans, and null are realized as ECMAScript Strings, Numbers, Booleans, and null.

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(JText).
3. Parse JText interpreted as UTF-16 encoded Unicode points (6.1.4) as a JSON text as specified in ECMA-404. Throw a SyntaxError exception if JText is not a valid JSON text as defined in that specification.
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 the alternative definition of DoubleStringCharacter provided below. The extended PropertyDefinitionEvaluation semantics defined in B.3.1 must not be used during the evaluation.
6. Let unfiltered be completion.([value]).
7. Assert: unfiltered will be either a primitive value or an object that is defined by either an ArrayLiteral or an ObjectLiteral.
8. If IsCallable(reviver) is true, then
   a. Let root be ObjectCreate(%ObjectPrototype%).
   b. Let rootName be the empty String.
   c. Let status be CreateDataProperty(root, rootName, unfiltered).
   d. Assert: status is true.
   e. Return Walk(root, rootName).
9. Else
   a. Return unfiltered.

JSON allows Unicode code points U+2028 and U+2029 to directly appear in String literals without using an escape sequence. This is enabled by using the following alternative definition of DoubleStringCharacter when parsing scriptText in step 5:

DoubleStringCharacter ::
   SourceCharacter but not one of " \ or U+0000 through U+001F
   \ EscapeSequence

• The SV of DoubleStringCharacter :: SourceCharacter but not one of " \ or U+0000 through U+001F is the UTF-16 Encoding (10.1.1) of the code point value of SourceCharacter.

NOTE The syntax of a valid JSON text is a subset of the ECMAScript PrimaryExpression syntax. Hence a valid JSON text is also a valid PrimaryExpression. Step 3 above verifies that Text conforms to that subset. When scriptText is parsed and evaluated as a Script the result will be either a String, Number, Boolean, or Null primitive value or an Object defined as if by an ArrayLiteral or ObjectLiteral.

24.3.1.1 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 Get(holder, name).
2. ReturnIfAbrupt(val).
3. If Type(val) is Object, then
   a. If IsArray(val) is true, then
      i. Set I to 0.
      ii. Let len be the result of ToLength(Get(val, "length")).
      iii. ReturnIfAbrupt(len).
      iv. Repeat while I < len,
         1. Let newElement be Walk(val, ToString(I)).
         2. ReturnIfAbrupt(newElement).
         3. 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.
         4. Else
            a. Let status be CreateDataProperty(val, ToString(I), newElement).
            b. NOTE This algorithm intentionally does not throw an exception if status is false.
         5. ReturnIfAbrupt(status).
         6. Add 1 to I.
   b. Else
i. Let keys be EnumerableOwnNames(val).
ii. ReturnIfAbrupt(keys).
iii. For each String P in keys do,
   1. Let newElement be Walk(val, P).
   2. ReturnIfAbrupt(newElement).
   3. If newElement is undefined, then
      a. Let status be the result of calling the [[Delete]] internal method of val with P as the argument.
      4. Else
         a. Let status be CreateDataProperty(val, P, newElement).
         b. NOTE This algorithm intentionally does not throw an exception if status is false.
   5. ReturnIfAbrupt(status).
4. Return Call(reviver, holder, «name, val»).

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.

24.3.2 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.

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 IsArray(replacer) is true, then
      i. Let PropertyList be an empty List
      ii. Let len be ToLength(Get(replacer, "length")).
      iii. ReturnIfAbrupt(len).
      iv. Let k be 0.
   v. Repeat while k < len.
      1. Let v be Get(replacer, ToString(k)).
      2. ReturnIfAbrupt(v).
      3. Let item be undefined.
      4. If Type(v) is String, let item be v.
      5. Else if Type(v) is Number, let item be ToString(v).
      6. Else if Type(v) is Object, then
         a. If v has a [[StringData]] or [[NumberData]] internal slot, let item be ToString(v).
         b. ReturnIfAbrupt(item).
7. If \texttt{item} is not \texttt{undefined} and \texttt{item} is not currently an element of \texttt{PropertyList}, then
   a. Append \texttt{item} to the end of \texttt{PropertyList}.
8. Let \( k \) be \( k+1 \).
5. If \texttt{Type(space)} is \texttt{Object}, then
   a. If \texttt{space} has a [[\texttt{NumberData}]] internal slot, then
      i. Let \texttt{space} be \texttt{ToNumber(space)}.
      ii. ReturnIfAbrupt(\texttt{space}).
   b. Else if \texttt{space} has a [[\texttt{StringData}]] internal slot, then
      i. Let \texttt{space} be \texttt{ToString(space)}.
      ii. ReturnIfAbrupt(\texttt{space}).
6. If \texttt{Type(space)} is \texttt{Number}, then
   a. Let \texttt{space} be \texttt{min(10, ToInteger(space))}.
   b. Set \texttt{gap} to a String containing \texttt{space} occurrences of code unit \texttt{0x0020} (SPACE). This will be the empty String if \texttt{space} is less than 1.
7. Else if Type(\texttt{space}) is String, then
   a. If the number of elements in \texttt{space} is 10 or less, set \texttt{gap} to \texttt{space} otherwise set \texttt{gap} to a String consisting of the first 10 elements of \texttt{space}.
8. Else
   a. Set \texttt{gap} to the empty String.
9. Let \texttt{wrapper} be \texttt{ObjectCreate(%ObjectPrototype%)}.
10. Let \texttt{status} be \texttt{CreateDataProperty(wrapper, the empty String, value)}.
11. Assert: \texttt{status} is \texttt{true}.
12. Return \texttt{Str(\texttt{the empty String}, \texttt{wrapper})}.

\textbf{NOTE 1} JSON structures are allowed to be nested to any depth, but they must be acyclic. If \texttt{value} is or contains a cyclic structure, then the stringify function must throw a \texttt{TypeError} exception. This is an example of a value that cannot be stringified:
   \begin{verbatim}
   a = []; a[0] = a; my_text = JSON.stringify(a); // This must throw a TypeError.
   \end{verbatim}

\textbf{NOTE 2} Symbolic primitive values are rendered as follows:
- The \texttt{null} value is rendered in JSON text as the String \texttt{null}.
- The \texttt{undefined} value is not rendered.
- The \texttt{true} value is rendered in JSON text as the String \texttt{true}.
- The \texttt{false} value is rendered in JSON text as the String \texttt{false}.

\textbf{NOTE 3} String values are wrapped in QUOTATION MARK (") code units. The code units " and \texttt{\textbackslash} are escaped with \texttt{\textbackslash} prefixes. Control characters code units are replaced with escape sequences \texttt{\textbackslashhhhh}, or with the shorter forms, \texttt{\textbackslashb} (BACKSPACE), \texttt{\textbackslashf} (FORM FEED), \texttt{\textbackslashn} (LINE FEED), \texttt{\textbacklar} (CARRIAGE RETURN), \texttt{\textbacklt} (CHARACTER TABULATION).

\textbf{NOTE 4} Finite numbers are stringified as if by calling \texttt{ToString(number)}. \texttt{NaN} and Infinity regardless of sign are represented as the String \texttt{null}.

\textbf{NOTE 5} Values that do not have a JSON representation (such as \texttt{undefined} and functions) do not produce a String. Instead they produce the \texttt{undefined} value. In arrays these values are represented as the String \texttt{null}. In objects an unrepresentable value causes the property to be excluded from stringification.

\textbf{NOTE 6} An object is rendered as an LEFT CURLY BRACKET followed by zero or more properties, separated with a COMMA, closed with a RIGHT CURLY BRACKET. 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 SQUARE BRACKET followed by zero or more values, separated with a COMMA, closed with a RIGHT SQUARE BRACKET.
24.3.2.1 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 Get(holder, key).
2. ReturnIfAbrupt(value).
3. If Type(value) is Object, then
   a. Let toJSON be Get(value, "toJSON").
      i. Let value be Call(toJSON, value, «key»).
      ii. ReturnIfAbrupt(value).
   b. ReturnIfAbrupt(value).
4. If ReplacerFunction is not undefined, then
   a. Let value be Call(ReplacerFunction, holder, «key, value»).
      i. Let value be ToNumber(value).
      ii. ReturnIfAbrupt(value).
   b. Else if value has a [[StringData]] internal slot, then
      i. Let value be ToString(value).
      ii. ReturnIfAbrupt(value).
   c. Else if value has a [[BooleanData]] internal slot, then
      i. Let value be the value of the [[BooleanData]] internal slot of value.
5. If value is null, return "null".
6. If value is true, return "true".
7. If value is false, return "false".
8. If Type(value) is String, return Quote(value).
9. If Type(value) is Number, then
   a. If value is finite, return ToNumber(value).
   b. Else, return "null".
10. If Type(value) is Object, and IsCallable(value) is false, then
    a. If IsArray(value) is true, then
       i. Return JA(value).
    b. Else, return JO(value).
11. Return undefined.

24.3.2.2 Runtime Semantics: Quote Abstract Operation

The abstract operation Quote(value) wraps a String value in QUOTATION MARK code units and escapes certain other code units within it.

1. Let product be code unit U+0022 (QUOTATION MARK).
2. For each code unit C in value
   a. If C is U+0002 (QUOTATION MARK) or U+005C (REVERSE SOLIDUS)
      i. Let product be the concatenation of product and code unit U+005C (REVERSE SOLIDUS).
      ii. Let product be the concatenation of product and C.
   b. Else if C is U+0008 (BACKSPACE), U+000C (FORM FEED), U+000A (LINE FEED), U+000D (CARRIAGE RETURN), or U+000B (LINE TABULATION)
      i. Let product be the concatenation of product and code unit U+005C (REVERSE SOLIDUS).
ii. Let \( \text{abbrev} \) be the string value corresponding to the value of \( C \) as follows:
   - BACKSPACE \( "b" \)
   - FORM FEED (FF) \( "f" \)
   - LINE FEED (LF) \( "n" \)
   - CARRIAGE RETURN (CR) \( "r" \)
   - LINE TABULATION \( "t" \)
iii. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( \text{abbrev} \).
   c. Else if \( C \) has a code unit value less than \( U+0020 \) (SPACE)
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( \text{U+005C} \) (REVERSE SOLIDUS).
      ii. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( "u" \).
      iii. Let \( \text{hex} \) 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 Latin letters.
      iv. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( \text{hex} \).
   d. Else
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( C \).

3. Let \( \text{product} \) be the concatenation of \( \text{product} \) and code unit \( U+0022 \) (QUOTATION MARK).
4. Return \( \text{product} \).

### 24.3.2.3 Runtime Semantics: JO Abstract Operation

The abstract operation \( \text{JO}(\text{value}) \) serializes an object. It has access to the \( \text{stack} \), \( \text{indent} \), \( \text{gap} \), and \( \text{PropertyList} \) of the invocation of the \textit{stringify} method.

1. If \( \text{stack} \) contains \( \text{value} \), throw a \textit{TypeError} exception because the structure is cyclical.
2. Append \( \text{value} \) to \( \text{stack} \).
3. Let \( \text{stepback} \) be \( \text{indent} \).
4. Let \( \text{indent} \) be the concatenation of \( \text{indent} \) and \( \text{gap} \).
5. If \( \text{PropertyList} \) is not \textit{undefined}, then
   a. Let \( K \) be \( \text{PropertyList} \).
6. Else
   a. Let \( K \) be \textit{EnumerableOwnNames}(\( \text{value} \)).
7. Let \( \text{partial} \) be an empty List.
8. For each element \( P \) of \( K \),
   a. Let \( \text{strP} \) be \( \text{Str}(P, \text{value}) \).
   b. ReturnIfAbrupt(\( \text{strP} \)).
   c. If \( \text{strP} \) is not \textit{undefined}, then
      i. Let \( \text{member} \) be \( \text{Quote}(P) \).
      ii. Let \( \text{member} \) be the concatenation of \( \text{member} \) and the string \( " : " \).
      iii. If \( \text{gap} \) is not the empty String, then
         i. Let \( \text{member} \) be the concatenation of \( \text{member} \) and code unit \( U+0020 \) (SPACE).
         iv. Let \( \text{member} \) be the concatenation of \( \text{member} \) and \( \text{strP} \).
         v. Append \( \text{member} \) to \( \text{partial} \).
9. If \( \text{partial} \) is empty, then
   a. Let \( \text{final} \) be \( "\{\}" \).
10. Else
    a. If \( \text{gap} \) is the empty String
       i. Let \( \text{properties} \) be a String formed by concatenating all the element Strings of \( \text{partial} \) with each adjacent pair of Strings separated with code unit \( U+002C \) (COMMA). A comma is not inserted either before the first String or after the last String.
       ii. Let \( \text{final} \) be the result of concatenating \( "\{", \text{properties}, \text{and } "\}" \).
    b. Else \( \text{gap} \) is not the empty String
i. Let separator be the result of concatenating code unit U+002C (COMMA), code unit U+000A (LINE FEED), 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 U+000A (LINE FEED), indent, properties, code unit U+000A, stepback, and "}".

11. Remove the last element of stack.
12. Let indent be stepback.

24.3.2.4 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 opening LEFT SQUARE BRACKET code point, elements separated by COMMA, and a closing RIGHT SQUARE BRACKET.

1. If stack contains value, 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. Let len be ToLength(Get(value, "length")).
7. ReturnIfAbrupt(len).
8. Let index be 0.
9. Repeat while index < len:
   a. Let strP be Str(ToString(index), value).
   b. ReturnIfAbrupt(strP).
   c. If strP is undefined, then
      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, then
      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 U+002C (COMMA). 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 U+002C (COMMA), code unit U+000A (LINE FEED), 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 U+000A (LINE FEED), indent, properties, code unit U+000A, stepback, and "] ".
12. Remove the last element of stack.
13. Let `indent` be `stepback`.

24.3.3 JSON [ @@toStringTag ]

The initial value of the `@@toStringTag` property is the string value "JSON".

This property has the attributes { [[Writable]]: `false`, [[Enumerable]]: `false`, [[Configurable]]: `true` }.

25 Control Abstraction Objects

25.1 Iteration

25.1.1 Common Iteration Interfaces

An interface is a set of property keys whose associated values match a specific specification. Any object that provides all the properties as described by an interface’s specification conforms to that interface. An interface is not represented by a distinct object. There may be many separately implemented objects that conform to any interface. An individual object may conform to multiple interfaces.

25.1.1.1 The `Iterable` interface

The `Iterable` interface includes the following property:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>@@iterator</code></td>
<td>A zero arguments function that returns an object.</td>
<td>The function returns an object that conforms to the <code>iterator</code> interface.</td>
</tr>
</tbody>
</table>

25.1.1.2 The `Iterator` interface

The `Iterator` interface includes the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>next</code></td>
<td>A function that returns an object.</td>
<td>The function returns an object that conforms to the <code>IteratorResult</code> interface. If a previous call to the <code>next</code> method of an <code>Iterator</code> has returned an <code>IteratorResult</code> object whose <code>done</code> property is <code>true</code>, then all subsequent calls to the <code>next</code> method of that object must also return an <code>IteratorResult</code> object whose <code>done</code> property is <code>true</code>.</td>
</tr>
</tbody>
</table>

NOTE Arguments may be passed to the `next` function but their interpretation and validity is dependent upon the target `Iterator`. The `for-of` statement and other common users of `Iterators` do not pass any arguments, so `Iterators` that expect to be used in such a manner must be prepared to deal with being called with no arguments.

25.1.1.3 The `IteratorResult` interface

The `IteratorResult` interface includes the following properties:
### Property | Value | Requirements
---|---|---
done | Either true or false. | This is the result status of an `iterator.next` 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. If a `done` property (either own or inherited does not exist), it is considered to have the value false.
value | Any ECMAScript language value. | 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.

#### 25.1.2 The `%IteratorPrototype% Object

The value of the [[Prototype]] internal slot of the `%IteratorPrototype% object is the intrinsic object `%ObjectPrototype% (19.1.3). The `%IteratorPrototype% object is an ordinary object. The initial value of the [[Extensible]] internal slot of the `%IteratorPrototype% object is true.

NOTE All objects defined in this specification that implement the Iterator interface also inherit from `%IteratorPrototype%`. ECMAScript code may also define objects that inherit from `%IteratorPrototype%`. The `%IteratorPrototype% object provides a place where additional methods that are applicable to all iterator objects may be added.

The following expression is one way that ECMAScript code can access the `%IteratorPrototype% object:

```
Object.getPrototypeOf(Object.getPrototypeOf([[[Symbol.iterator]()])))
```

#### 25.1.2.1 `%IteratorPrototype%[@@iterator]`

The following steps are taken:

1. Return the this value.

The value of the `name` property of this function is "[Symbol.iterator]."

#### 25.2 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% intrinsic.
25.2.1 The GeneratorFunction Constructor

The `GeneratorFunction` constructor is the `%GeneratorFunction%` intrinsic. 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.

`GeneratorFunction` is designed to be subclassable. It may be used as the value of an `extends` clause of a class definition. Subclass constructors that intend to inherit the specified
**GeneratorFunction** behaviour must include a `super` call to the `GeneratorFunction` constructor to create and initialize subclass instances with the internal slots necessary for built-in `GeneratorFunction` behaviour. All ECMAScript syntactic forms for defining generator function objects create direct instances of `GeneratorFunction`. There is no syntactic means to create instances of `GeneratorFunction` subclasses.

### 25.2.1 `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 `p1, p2, ..., pn, body` (where `n` might be 0, that is, there are no "p" arguments, and where `body` might also not be provided), the following steps are taken:

1. Let `C` be the active function object.
2. Let `args` be the `argumentsList` that was passed to this function by `[[Call]]` or `[[Construct]]`.

**NOTE** See NOTE for 19.2.1.1.

### 25.2.2 Properties of the `GeneratorFunction` Constructor

The `GeneratorFunction` constructor is a standard built-in function object that inherits from the `Function` constructor. The value of the `[[Prototype]]` internal slot of the `GeneratorFunction` constructor is the intrinsic object `%Function%`.

The value of the `[[Extensible]]` internal slot of the `GeneratorFunction` constructor is `true`.

The value of the `name` property of the `GeneratorFunction` is “`GeneratorFunction`”.

The `GeneratorFunction` constructor has the following properties:

#### 25.2.2.1 `GeneratorFunction.length`

This is a data property with a value of 1. This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

#### 25.2.2.2 `GeneratorFunction.prototype`

The initial value of `GeneratorFunction.prototype` is the intrinsic object `%Generator%`.

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

### 25.2.3 Properties of the `GeneratorFunction` Prototype Object

The `GeneratorFunction` prototype object is an ordinary object. It is not a function object and does not have an `[[ECMAScriptCode]]` internal slot or any other of the internal slots listed in Table 28 or Table 49. 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 slot of the GeneratorFunction prototype object is the %FunctionPrototype% intrinsic object. The initial value of the [[Extensible]] internal slot of the GeneratorFunction prototype object is true.

25.2.3.1 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 }.

25.2.3.2 GeneratorFunction.prototype.prototype

The value of GeneratorFunction.prototype.prototype is the %GeneratorPrototype% intrinsic object.

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

25.2.3.3 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 }.

25.2.4 GeneratorFunction Instances

Every GeneratorFunction instance is an ECMA-Script function object and has the internal slots listed in Table 28. The value of the [[FunctionKind]] internal slot for all such instances is "generator".

Each GeneratorFunction instance has the following own properties:

25.2.4.1 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 }.

25.2.4.2 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 initialize the [[Prototype]] internal slot 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.
25.3 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%.

25.3.1 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 slot.

The value of the [[Prototype]] internal slot of the Generator prototype object is the intrinsic object %IteratorPrototype% (25.1.2). The initial value of the [[Extensible]] internal slot of the Function prototype object is true.

All Generator instances indirectly inherit properties of the Generator prototype object.

25.3.1.1 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 }.

25.3.1.2 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).

25.3.1.3 Generator.prototype.return ( value )

The return method performs the following steps:
1. Let g be the this value.
2. Let C be Completion{[[type]]: return, [[value]]: value, [[target]]: empty}.
3. Return GeneratorResumeAbrupt(g, C).

25.3.1.4 Generator.prototype.throw ( exception )

The throw method performs the following steps:
1. Let g be the this value.
2. Let C be Completion{[[type]]: throw, [[value]]: exception, [[target]]: empty}.
3. Return GeneratorResumeAbrupt(g, C).
25.3.1.5 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 }.

25.3.2 Properties of Generator Instances

Generator instances are initially created with the internal slots described in Table 49.

Table 49 — Internal Slots of Generator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[GeneratorState]]</td>
<td>The current execution state of the generator. The possible values are: undefined, &quot;suspendedStart&quot;, &quot;suspendedYield&quot;, &quot;executing&quot;, and &quot;completed&quot;.</td>
</tr>
<tr>
<td>[[GeneratorContext]]</td>
<td>The execution context that is used when executing the code of this generator.</td>
</tr>
</tbody>
</table>

25.3.3 Generator Abstract Operations

25.3.3.1 GeneratorStart (generator, generatorBody)

The abstract operation GeneratorStart with arguments generator and generatorBody performs the following steps:

1. Assert: The value of generator's [[GeneratorState]] internal slot is undefined.
2. Let genContext be the running execution context.
3. Set the Generator component of genContext to generator.
4. Set the code evaluation state of genContext such that when evaluation is resumed for that execution context the following steps will be performed:
   1. Let result be the result of evaluating generatorBody.
   2. Assert: If we return here, the generator either threw an exception or performed either an implicit or explicit return.
   3. 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.
   4. Set generator's [[GeneratorState]] internal slot to "completed".
   5. 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.
   6. If result is a normal completion, let resultValue be undefined.
   7. Else.
      a. If result.[[type]] is return, let resultValue be result.[[value]].
      b. Else, return result.
   8. Return CreateIterResultObject(resultValue, true).
5. Set generator's [[GeneratorContext]] internal slot to genContext.
6. Set generator's [[GeneratorState]] internal slot to "suspendedStart".
7. Return NormalCompletion(generator).
25.3.3.2 GeneratorValidate ( generator )

The abstract operation GeneratorValidate with argument generator performs the following steps:
1. If Type(generator) is not Object, throw a TypeError exception.
2. If generator does not have a [[GeneratorState]] internal slot, throw a TypeError exception.
3. Assert: generator also has a [[GeneratorContext]] internal slot.
4. Let state be the value of generator’s [[GeneratorState]] internal slot.
5. If state is "executing", throw a TypeError exception.
6. Return state.

25.3.3.3 GeneratorResume ( generator, value )

The abstract operation GeneratorResume with arguments generator and value performs the following steps:
1. Let state be GeneratorValidate(generator).
2. ReturnIfAbrupt(state).
3. If state is "completed", return CreateIterResultObject(undefined, true).
4. Assert: state is either "suspendedStart" or "suspendedYield".
5. Let genContext be the value of generator’s [[GeneratorContext]] internal slot.
6. Let methodContext be the running execution context.
7. Suspend methodContext.
8. Set generator’s [[GeneratorState]] internal slot to "executing".
9. Push genContext onto the execution context stack; genContext is now the running execution context.
10. Resume the suspended evaluation of genContext using NormalCompletion(value) as the result of the operation that suspended it. Let result be the value returned by the resumed computation.
11. Assert: When we return here, genContext has already been removed from the execution context stack and methodContext is the currently running execution context.
12. Return result.

25.3.3.4 GeneratorResumeAbrupt(generator, abruptCompletion)

The abstract operation GeneratorResumeAbrupt with arguments generator and abruptCompletion performs the following steps:
1. Let state be GeneratorValidate(generator).
2. ReturnIfAbrupt(state).
3. If state is "suspendedStart", then
   a. Set generator’s [[GeneratorState]] internal slot 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. Let state be "completed".
4. If state is "completed", then
   a. If abruptCompletion.[[type]] is return, then
      i. Return CreateIterResultObject(abruptCompletion.[[value]], true).
   b. Return abruptCompletion.
5. Assert: state is "suspendedYield".
6. Let genContext be the value of generator’s [[GeneratorContext]] internal slot.
7. Let methodContext be the running execution context.
9. Set generator’s [[GeneratorState]] internal slot to "executing".
10. Push genContext onto the execution context stack; genContext is now the running execution context.
11. Resume the suspended evaluation of genContext using abruptCompletion as the result of the operation that suspended it. Let result be the value returned by the resumed computation.
12. Assert: When we return here, genContext has already been removed from the execution context stack and methodContext is the currently running execution context.
13. Return result.

25.3.5 GeneratorYield ( iterNextObj )

The abstract operation GeneratorYield with argument iterNextObj performs the following steps:

1. Assert: iterNextObj is an Object that implements the IteratorResult 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 slot 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:
   1. Return resumptionValue.
   2. NOTE: This returns to the evaluation of the YieldExpression production that originally called this abstract operation.
8. Return NormalCompletion(iterNextObj).
9. NOTE: This returns to the evaluation of the operation that had most previously resumed evaluation of genContext.

25.4 Promise Objects

A Promise is an object that is used as a placeholder for the eventual results of a deferred (and possibly asynchronous) computation.

Any Promise object is in one of three mutually exclusive states: fulfilled, rejected, and pending:

- A promise p is fulfilled if p.then(f, r) will immediately enqueue a Job to call the function f.
- A promise p is rejected if p.then(f, r) will immediately enqueue a Job to call the function r.
- A promise is pending if it is neither fulfilled nor rejected.

A promise is said to be settled if it is not pending, i.e. if it is either fulfilled or rejected.

A promise is resolved if it is settled or if it has been "locked in" to match the state of another promise. Attempting to resolve or reject a resolved promise has no effect. A promise is unresolved if it is not resolved. An unresolved promise is always in the pending state. A resolved promise may be pending, fulfilled or rejected.
25.4.1 Promise Abstract Operations

25.4.1.1 PromiseCapability Records

A PromiseCapability is a Record value used to encapsulate a promise object along with the functions that are capable of resolving or rejecting that promise object. PromiseCapability records are produced by the `NewPromiseCapability` abstract operation.

PromiseCapability Records have the fields listed in Table 50.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Promise]]</code></td>
<td>An object</td>
<td>An object that is usable as a promise.</td>
</tr>
<tr>
<td><code>[[Resolve]]</code></td>
<td>A function object</td>
<td>The function that is used to resolve the given promise object.</td>
</tr>
<tr>
<td><code>[[Reject]]</code></td>
<td>A function object</td>
<td>The function that is used to reject the given promise object.</td>
</tr>
</tbody>
</table>

25.4.1.1.1 `IfAbruptRejectPromise (value, capability)`

`IfAbruptRejectPromise` is a shorthand for a sequence of algorithm steps that use a PromiseCapability record. An algorithm step of the form:

1. `IfAbruptRejectPromise(value, capability).`

means the same thing as:

1. If `value` is an abrupt completion,
   a. Let `rejectResult` be `Call(capability.[[Reject]], undefined, «value.[[value]]»)`.
   b. Return `IfAbruptrejectResult(rejectResult)`.
   c. Return `capability.[[Promise]]`.
2. Else if `value` is a Completion Record, let `value` be `value.[[value]]`.

25.4.1.2 PromiseReaction Records

The PromiseReaction is a Record value used to store information about how a promise should react when it becomes resolved or rejected with a given value. PromiseReaction records are created by the `then` method of the Promise prototype, and are used by a PromiseReactionJob.

PromiseReaction records have the fields listed in Table 51.
### Table 51 — PromiseReaction Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Capabilities]]</td>
<td>A PromiseCapability record</td>
<td>The capabilities of the promise for which this record provides a reaction handler.</td>
</tr>
<tr>
<td>[[Handler]]</td>
<td>A function object or a String</td>
<td>The function that should be applied to the incoming value, and whose return value will govern what happens to the derived promise. If [[Handler]] is &quot;Identity&quot; it is equivalent to a function that simply returns its first argument. If [[Handler]] is &quot;Thrower&quot; it is equivalent to a function that throws its first argument as an exception.</td>
</tr>
</tbody>
</table>

#### 25.4.1.3 CreateResolvingFunctions (promise)

When CreateResolvingFunctions is performed with argument promise, the following steps are taken:

1. Let alreadyResolved be a new Record { [[value]]: false }.
2. Let resolve be a new built-in function object as defined in Promise Resolve Functions (25.4.1.4.2).
3. Set the [[Promise]] internal slot of resolve to promise.
4. Set the [[AlreadyResolved]] internal slot of resolve to alreadyResolved.
5. Let reject be a new built-in function object as defined in Promise Reject Functions (25.4.1.4.1).
6. Set the [[Promise]] internal slot of reject to promise.
7. Set the [[AlreadyResolved]] internal slot of reject to alreadyResolved.
8. Return a new Record { [[Resolve]]: resolve, [[Reject]]: reject }.

#### 25.4.1.3.1 Promise Reject Functions

A promise reject function is an anonymous built-in function that has [[Promise]] and [[AlreadyResolved]] internal slots.

When a promise reject function F is called with argument reason, the following steps are taken:

1. Assert: F has a [[Promise]] internal slot whose value is an Object.
2. Let promise be the value of F's [[Promise]] internal slot.
3. Let alreadyResolved be the value of F's [[AlreadyResolved]] internal slot.
4. If alreadyResolved.[[value]] is true, return undefined.
5. Set alreadyResolved.[[value]] to true.
6. Return RejectPromise(promise, reason).

#### 25.4.1.3.2 Promise Resolve Functions

A promise resolve function is an anonymous built-in function that has [[Promise]] and [[AlreadyResolved]] internal slots.

When a promise resolve function F is called with argument resolution, the following steps are taken:

1. Assert: F has a [[Promise]] internal slot whose value is an Object.
2. Let promise be the value of F's [[Promise]] internal slot.
3. Let alreadyResolved be the value of F's [[AlreadyResolved]] internal slot.
4. If alreadyResolved.[[value]] is true, return undefined.
5. Set alreadyResolved.[[value]] to true.
6. If SameValue(resolution, promise) is true, then
   a. Let selfResolutionError be a newly-created TypeError object.
   b. Return RejectPromise(promise, selfResolutionError).
7. If Type(resolution) is not Object, then
   a. Return FulfillPromise(promise, resolution).
8. Let then be Get(resolution, "then").
9. If then is an abrupt completion, then
   a. Return RejectPromise(promise, then.[[value]]).
10. Let then be then.[[value]].
11. If IsCallable(then) is false, then
    a. Return FulfillPromise(promise, resolution).
12. Perform EnqueueJob ("PromiseJobs", PromiseResolveThenableJob, «promise, resolution, then»).
13. Return undefined.

25.4.1.4 FulfillPromise ( promise, value)

When the FulfillPromise abstract operation is called with arguments promise and value the following steps are taken:
1. Assert: the value of promise's [[PromiseState]] internal slot is "pending".
2. Let reactions be the value of promise's [[PromiseFulfillReactions]] internal slot.
3. Set the value of promise's [[PromiseResult]] internal slot to value.
4. Set the value of promise's [[PromiseFulfillReactions]] internal slot to undefined.
5. Set the value of promise's [[PromiseRejectReactions]] internal slot to undefined.
6. Set the value of promise's [[PromiseState]] internal slot to "fulfilled".
7. Return TriggerPromiseReactions(reactions, value).

25.4.1.5 NewPromiseCapability ( C )

The abstract operation NewPromiseCapability takes a constructor function, and attempts to use that constructor function in the fashion of the built-in Promise constructor to create a Promise object and extract its resolve and reject functions. The promise plus the resolve and reject functions are used to initialize a new PromiseCapability record which is returned as the value of this abstract operation.
1. If IsConstructor(C) is false, throw a TypeError exception.
2. NOTE C is assumed to be a constructor function that supports the parameter conventions of the Promise constructor (see 25.4.3.1).
3. Let promiseCapability be a new PromiseCapability { [[Promise]]: undefined, [[Resolve]]: undefined, [[Reject]]: undefined }.
4. Let executor be a new built-in function object as defined in GetCapabilitiesExecutor Functions (25.4.1.6.1).
5. Set the [[Capability]] internal slot of executor to promiseCapability.
6. Let promise be Construct(constructor, «executor»).
7. ReturnIfAbrupt(promise).
8. If IsCallable(promiseCapability.[[Resolve]]) is false, throw a TypeError exception.
9. If IsCallable(promiseCapability.[[Reject]]) is false, throw a TypeError exception.
10. Set promiseCapability.[[Promise]] to promise.

NOTE This abstract operation supports Promise subclassing, as it is generic on any constructor that calls a passed executor function argument in the same way as the Promise constructor. It is used to generalize static methods of the Promise constructor to any subclass.
25.4.1.5.1 GetCapabilitiesExecutor Functions

A GetCapabilitiesExecutor function is an anonymous built-in function that has a [[Capability]] internal slot.

When a GetCapabilitiesExecutor function $F$ is called with arguments $\text{resolve}$ and $\text{reject}$ the following steps are taken:

1. Assert: $F$ has a [[Capability]] internal slot whose value is a PromiseCapability Record.
2. Let $\text{promiseCapability}$ be the value of $F$'s [[Capability]] internal slot.
3. If $\text{promiseCapability}.\text{[[Resolve]]}$ is not $\text{undefined}$, throw a $\text{TypeError}$ exception.
4. If $\text{promiseCapability}.\text{[[Reject]]}$ is not $\text{undefined}$, throw a $\text{TypeError}$ exception.
5. Set $\text{promiseCapability}.\text{[[Resolve]]}$ to $\text{resolve}$.
6. Set $\text{promiseCapability}.\text{[[Reject]]}$ to $\text{reject}$.
7. Return $\text{undefined}$.

25.4.1.6 IsPromise ( x )

The abstract operation IsPromise checks for the promise brand on an object.

1. If Type($x$) is not Object, return $\text{false}$.
2. If $x$ does not have a [[PromiseState]] internal slot, return $\text{false}$.
3. Return $\text{true}$.

25.4.1.7 RejectPromise ( promise, reason )

When the RejectPromise abstract operation is called with arguments $\text{promise}$ and $\text{reason}$ the following steps are taken:

1. Assert: the value of $\text{promise}$'s [[PromiseState]] internal slot is "pending".
2. Let $\text{reactions}$ be the value of $\text{promise}$'s [[PromiseRejectReactions]] internal slot.
3. Set the value of $\text{promise}$'s [[PromiseResult]] internal slot to $\text{reason}$.
4. Set the value of $\text{promise}$'s [[PromiseFulfillReactions]] internal slot to $\text{undefined}$.
5. Set the value of $\text{promise}$'s [[PromiseRejectReactions]] internal slot to $\text{undefined}$.
6. Set the value of $\text{promise}$'s [[PromiseState]] internal slot to "rejected".
7. Return TriggerPromiseReactions($\text{reactions}$, $\text{reason}$).

25.4.1.8 TriggerPromiseReactions ( reactions, argument )

The abstract operation TriggerPromiseReactions takes a collection of functions to trigger in the next Job, and calls them, passing each the given argument. Typically, these reactions will modify a previously-returned promise, possibly calling in to a user-supplied handler before doing so.

1. Repeat for each $\text{reaction}$ in $\text{reactions}$, in original insertion order
   a. Perform EnqueueJob("
      PromiseJobs", PromiseReactionJob, «$\text{reaction}$, $\text{argument}$»).
2. Return $\text{undefined}$. 
25.4.2 Promise Jobs

25.4.2.1 PromiseReactionJob (reaction, argument)

The job PromiseReactionJob with parameters reaction and argument applies the appropriate handler to the incoming value, and uses the handler’s return value to resolve or reject the derived promise associated with that handler.

1. Assert: reaction is a PromiseReaction Record.
2. Let promiseCapability be reaction.[[Capabilities]].
3. Let handler be reaction.[[Handler]].
4. If handler is "Identity", let handlerResult be NormalCompletion(argument).
5. Else if handler is "Thrower", let handlerResult be Completion([[[type]]: throw, [[value]]: argument, [[target]]: empty]).
6. Else, let handlerResult be Call(handler, undefined, «argument»).
7. If handlerResult is an abrupt completion, then
   a. Let status be Call(promiseCapability.[[Reject]], undefined, «handlerResult.[[value]]»).
   b. NextJob status.
8. Let handlerResult be handlerResult.[[value]].
9. Let status be Call(promiseCapability.[[Resolve]], undefined, «handlerResult»).

25.4.2.2 PromiseResolveThenableJob (promiseToResolve, thenable, then)

The job PromiseResolveThenableJob with parameters promiseToResolve, thenable, and then performs the following steps:

1. Let resolvingFunctions be CreateResolvingFunctions(promiseToResolve).
2. Let thenCallResult be Call(then, thenable, «resolvingFunctions.[[Resolve]], resolvingFunctions.[[Reject]]»).
3. If thenCallResult is an abrupt completion, then
   a. Let status be Call(resolvingFunctions.[[Reject]], undefined, «thenCallResult.[[value]]»).
   b. NextJob status.
4. NextJob thenCallResult.

NOTE  This Job uses the supplied thenable and its then method to resolve the given promise. This process must take place as a Job to ensure that the evaluation of the then method occurs after evaluation of any surrounding code has completed.

25.4.3 The Promise Constructor

The Promise constructor is the %Promise% intrinsic object and the initial value of the Promise property of the global object. When called as a constructor it creates and initializes a new Promise object. Promise is not intended to be called as a function and will throw an exception when called in that manner.

The Promise 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 Promise behaviour must include a super call to the Promise constructor to create and initialize the subclass instance with the internal state necessary to support the Promise and Promise.prototype built-in methods.
25.4.3.1 Promise (executor)

When the Promise function is called with argument `executor` the following steps are taken:

1. If `NewTarget` is `undefined`, throw a TypeError exception.
2. If `IsCallable(executor)` is `false`, throw a TypeError exception.
3. Let `promise` be OrdinaryCreateFromConstructor(`NewTarget`, `%PromisePrototype%`, «[[PromiseState]], [[PromiseConstructor]], [[PromiseResult]], [[PromiseFulfillReactions]], [[PromiseRejectReactions]]»).
4. ReturnIfAbrupt(promise).
5. Set the value of `promise`'s `[[PromiseConstructor]]` internal slot to `NewTarget`.
6. Set `promise`'s `[[PromiseState]]` internal slot to "pending".
7. Set `promise`'s `[[PromiseFulfillReactions]]` internal slot to a new empty List.
8. Set `promise`'s `[[PromiseRejectReactions]]` internal slot to a new empty List.
9. Let `resolvingFunctions` be CreateResolvingFunctions(`promise`).
10. Let `completion` be Call(`executor`, `undefined`, «resolvingFunctions.«[Resolve]», resolvingFunctions.«[Reject]»»).
11. If `completion` is an abrupt completion, then
   a. Let `status` be Call(resolvingFunctions.«[Reject]», `undefined`, «completion.«[value]»»).
   b. ReturnIfAbrupt(status).
12. Return `promise`.

NOTE The `executor` argument must be a function object. It is called for initiating and reporting completion of the possibly deferred action represented by this Promise object. The executor is called with two arguments: `resolve` and `reject`. These are functions that may be used by the `executor` function to report eventual completion or failure of the deferred computation. Returning from the `executor` function does not mean that the deferred action has been completed but only that the request to eventually perform the deferred action has been accepted.

The `resolve` function that is passed to an `executor` function accepts a single argument. The `executor` code may eventually call the `resolve` function to indicate that it wishes to resolve the associated Promise object. The argument passed to the `resolve` function represents the eventual value of the deferred action and can be either the actual fulfillment value or another Promise object which will provide the value if it is fulfilled.

The `reject` function that is passed to an `executor` function accepts a single argument. The `executor` code may eventually call the `reject` function to indicate that the associated Promise is rejected and will never be fulfilled. The argument passed to the `reject` function is used as the rejection value of the promise. Typically it will be an Error object.

The `resolve` and `reject` functions passed to an `executor` function by the Promise constructor have the capability to actually resolve and reject the associated promise. Subclasses may have different constructor behaviour that passes in customized values for resolve and reject.

25.4.4 Properties of the Promise Constructor

The value of the `[[Prototype]]` internal slot of the Promise constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the `length` property (whose value is 1), the Promise constructor has the following properties:

25.4.4.1 Promise.all (iterable)

The `all` function returns a new promise which is fulfilled with an array of fulfillment values for the passed promises, or rejects with the reason of the first passed promise that rejects. It resolves all elements of the passed iterable to promises as it runs this algorithm.
Let \( C \) be the \textbf{this} value.
1. If Type\((C)\) is not Object, throw a \textbf{TypeError} exception.
2. Let \( S \) be Get\((C, \circ \text{species})\).
3. ReturnIfAbrupt\((S)\).
4. If \( S \) is neither \textbf{undefined} nor \textbf{null}, let \( C \) be \( S \).
5. Let promiseCapability be NewPromiseCapability\((C)\).
6. Let \( \text{iterator} \) be GetIterator\((\text{iterable})\).
7. ReturnIfAbrupt\(\text{promiseCapability}\).
8. Let \( \text{next} \) be \( \text{GetIterator}\)\((\text{iterable})\).
9. IfAbruptRejectPromise\((\text{iterator}, \text{promiseCapability})\).
10. Let \( \text{result} \) be PerformPromiseAll\((\text{iterator}, C, \text{promiseCapability})\).
11. If \( \text{result} \) is an abrupt completion.
   a. Let \( \text{result} \) be \( \text{IteratorClose}\)\((\text{iterator, result})\).
   b. IfAbruptRejectPromise\((\text{result, promiseCapability})\).
12. Return \( \text{result}[[\text{value}]]\).

Note: The \textbf{all} function requires its \textbf{this} value to be a constructor function that supports the parameter conventions of the \textbf{Promise} constructor.

### 25.4.4.1.1 \texttt{PerformPromiseAll}(\texttt{iterator, constructor, resultCapability}) Abstract Operation

When the \texttt{PerformPromiseAll} abstract operation is called with arguments \texttt{iterator, constructor, and resultCapability} the following steps are taken:

1. Assert: \texttt{iterator} is an object that supports the Iterator interface.
2. Assert: \texttt{constructor} is a constructor function.
3. Assert: \texttt{resultCapability} is a PromiseCapability record.
4. Let \( \text{values} \) be a new empty List.
5. Let remainingElementsCount be a new Record \{ [[\text{value}]]: \( 1 \) \}.
6. Let \( \text{index} \) be \( 0 \).
7. Repeat
   a. Let \( \text{next} \) be \( \text{IteratorStep}\)\((\text{iterator})\).
   b. ReturnIfAbrupt\((\text{next})\).
   c. If \( \text{next} \) is \textbf{false}.
      i. Set remainingElementsCount[[\text{value}]] to remainingElementsCount.[[\text{value}]] + 1.
      ii. If remainingElementsCount.[[\text{value}]] is \( 0 \),
          1. Let \( \text{valuesArray} \) be \( \text{CreateArrayFromList}\)\((\text{values})\).
          2. Let \( \text{resolveResult} \) be \( \text{Call}\)\((\text{resultCapability}.[[\text{Resolve}]], \textbf{undefined}, \textbf{«valuesArray»})\).
          3. If \( \text{resolveResult} \) is an abrupt completion, \text{return NormalCompletion}\(\text{resolveResult}\).
      iii. Return resultCapability.[[\text{Promise}]].
   d. Let \( \text{nextValue} \) be \( \text{IteratorValue}\)\((\text{next})\).
   e. ReturnIfAbrupt\((\text{nextValue})\).
   f. Append \textbf{undefined} to \( \text{values} \).
   g. Let \( \text{nextPromise} \) be \( \text{Invoke}\)\((\text{constructor, "resolve", \text{«nextValue»}})\).
   h. ReturnIfAbrupt\((\text{nextPromise})\).
   i. Let \( \text{resolveElement} \) be a new built-in function object as defined in Promise.all Resolve Element Functions.
   j. Set the [[\text{AlreadyCalled}]] internal slot of \( \text{resolveElement} \) to a new Record \{ [[\text{value}]]: \textbf{false} \}.
   k. Set the [[\text{Index}]] internal slot of \( \text{resolveElement} \) to \( \text{index} \).
   l. Set the [[\text{Values}]] internal slot of \( \text{resolveElement} \) to \( \text{values} \).
   m. Set the [[\text{Capabilities}]] internal slot of \( \text{resolveElement} \) to \text{resultCapability}.
   n. Set the [[\text{RemainingElements}]] internal slot of \( \text{resolveElement} \) to remainingElementsCount.
   o. Set remainingElementsCount.[[\text{value}]] to remainingElementsCount.[[\text{value}]] + 1.
   p. Let \( \text{result} \) be \( \text{Invoke}\)\((\text{nextPromise}, \"then\", \textbf{«resolveElement, resultCapability:[[\text{Reject}]]})\).
25.4.4.1.2 Promise.all Resolve Element Functions

A Promise.all resolve element function is an anonymous built-in function that is used to resolve a specific Promise.all element. Each Promise.all resolve element function has [[Index]], [[Values]], [[Capabilities]], [[RemainingElements]], and [[AlreadyCalled]] internal slots.

When a Promise.all resolve element function F is called with argument x, the following steps are taken:

1. Let alreadyCalled be the value of F's [[AlreadyCalled]] internal slot.
2. If alreadyCalled.[[value]] is true, return undefined.
3. Set alreadyCalled.[[value]] to true.
4. Let index be the value of F's [[Index]] internal slot.
5. Let values be the value of F's [[Values]] internal slot.
6. Let promiseCapability be the value of F's [[Capabilities]] internal slot.
7. Let remainingElementsCount be the value of F's [[RemainingElements]] internal slot.
8. Set values[index] to x.
9. Set remainingElementsCount.[[value]] to remainingElementsCount.[[value]] - 1.
10. If remainingElementsCount.[[value]] is 0,
    a. Let valuesArray be CreateArrayFromList(values).
    b. Return Call(promiseCapability.[[Resolve]], undefined, «valuesArray»).
11. Return undefined.

25.4.4.2 Promise.prototype

The initial value of Promise.prototype is the Promise prototype object (25.4.5).

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

25.4.4.3 Promise.race ( iterable )

The race function returns a new promise which is settled in the same way as the first passed promise to settle. It resolves all elements of the passed iterable to promises as it runs this algorithm.

1. Let C be the this value.
2. If Type(C) is not Object, throw a TypeError exception.
3. Let S be Get(C, @@species).
4. ReturnIfAbrupt(S).
5. If S is neither undefined nor null, let C be S.
7. ReturnIfAbrupt(promiseCapability).
8. Let iterator be GetIterator(iterable).
9. IfAbruptRejectPromise(iterator, promiseCapability).
10. Let result be PerformPromiseRaceLoop(iterator, promiseCapability, C).
11. If result is an abrupt completion, then let result be IteratorClose(iterator, result).
12. IfAbruptRejectPromise(result, promiseCapability).
13. Return promiseCapability.[[Promise]].

NOTE 1 If the iterable argument is empty or if none of the promises in iterable ever settle then the pending promise returned by this method will never be settled.
NOTE 2 The `race` function expects its `this` value to be a constructor function that supports the parameter conventions of the `Promise` constructor. It also expects that its `this` value provides a `resolve` method.

### 25.4.4.3.1 PerformPromiseRaceLoop( iterator, promiseCapability, C )

When the `PerformPromiseRaceLoop` abstract operation is called with arguments `iterator`, `promiseCapability`, and `C` the following steps are taken:

1. Repeat
   a. Let `next` be `IteratorStep(iterator)`.
   b. ReturnIfAbrupt(`next`).
   c. If `next` is `false`, return `promiseCapability`.\[\[Promise\]\].
   d. Let `nextValue` be `IteratorValue(next)`.
   e. ReturnIfAbrupt(`nextValue`).
   f. Let `nextPromise` be `Invoke(C, "resolve", «nextValue»)`.
   g. ReturnIfAbrupt(`nextPromise`).
   h. Let `result` be `Invoke(nextPromise, "then", «promiseCapability.\[\[Resolve\]\], promiseCapability.\[\[Reject\]\]»)`.
   i. ReturnIfAbrupt(`result`).

### 25.4.4 Promise.reject( r )

The `reject` function returns a new promise rejected with the passed argument.

1. Let `C` be the `this` value.
2. If `Type(C)` is not `Object`, throw a `TypeError` exception.
3. Let `S` be `Get(C, @@species)`.
4. ReturnIfAbrupt(`S`).
5. If `S` is neither `undefined` nor `null`, let `C` be `S`.
6. Let `promiseCapability` be `NewPromiseCapability(C)`.
7. ReturnIfAbrupt(`promiseCapability`).
8. Let `rejectResult` be `Call(promiseCapability.\[\[Reject\]\], undefined, «r»)`.
9. ReturnIfAbrupt(`rejectResult`).
10. Return `promiseCapability.\[\[Promise\]\]`.

NOTE The `reject` function requires that its `this` value to be a constructor function that supports the parameter conventions of the `Promise` constructor.

### 25.4.4.5 Promise.resolve( x )

The `resolve` function returns either a new promise resolved with the passed argument, or the argument itself if the argument is a promise produced by this constructor.

1. Let `C` be the `this` value.
2. If `IsPromise(c)` is `true`.
   a. Let `constructor` be the value of `x`'s `\[\[PromiseConstructor\]\]` internal slot.
   b. If `SameValue(constructor, C)` is `true`, return `x`.
3. If `Type(C)` is not `Object`, throw a `TypeError` exception.
4. Let `S` be `Get(C, @@species)`.
5. ReturnIfAbrupt(`S`).
6. If `S` is neither `undefined` nor `null`, let `C` be `S`.
7. Let `promiseCapability` be `NewPromiseCapability(C)`.
8. ReturnIfAbrupt(`promiseCapability`).
9. Let \(\text{resolveResult}\) be Call(\(\text{promiseCapability}.[[\text{Resolve}]], \text{undefined}, \langle x \rangle\)).
10. ReturnIfAbrupt(\(\text{resolveResult}\)).
11. Return \(\text{promiseCapability}.[[\text{Promise}]]\).

NOTE The \(\text{resolve}\) function requires that its \(\text{this}\) value to be a constructor function that supports the parameter conventions of the \(\text{Promise}\) constructor.

25.4.4.6 \text{get Promise} [ @@species ]

\(\text{Promise}[@@species]\) is an accessor property whose set accessor function is \text{undefined}. Its get accessor function performs the following steps:
1. Return \(\text{this}\).

The value of the \text{name} property of this function is \text{"get [Symbol.species]"}.

NOTE \(\text{Promise}\) prototype methods normally use their \(\text{this}\) object's constructor to create a derived object. However, a subclass constructor may over-ride that default behaviour by redefining its @@species property.

25.4.5 Properties of the Promise Prototype Object

The value of the [[Prototype]] internal slot of the Promise prototype object is the intrinsic object %\text{Object}Prototype% (19.1.3). The Promise prototype object is an ordinary object. It does not have a [[PromiseState]] internal slot or any of the other internal slots of Promise instances.

25.4.5.1 \text{Promise.prototype.catch ( onRejected )}

When the \(\text{catch}\) method is called with argument \(\text{onRejected}\) the following steps are taken:
1. Let \(\text{promise}\) be the \(\text{this}\) value.
2. Return Invoke(\(\text{promise}\), \"then\", \langle undefined, onRejected\rangle).

25.4.5.2 \text{Promise.prototype.constructor}

The initial value of \(\text{Promise.prototype.constructor}\) is the intrinsic object %\text{Promise}%.

25.4.5.3 \text{Promise.prototype.then ( onFulfilled, onRejected )}

When the \(\text{then}\) method is called with arguments \(\text{onFulfilled}\) and \(\text{onRejected}\) the following steps are taken:
1. Let \(\text{promise}\) be the \(\text{this}\) value.
2. If \(\text{IsPromise(promise)}\) is \text{false}, throw a \text{TypeError} exception.
3. Let \(\text{C}\) be \text{SpeciesConstructor}(\(\text{promise}\), %\text{Promise}%).
4. ReturnIfAbrupt(\(\text{C}\)).
5. Let \(\text{resultCapability}\) be \text{NewPromiseCapability}(\(\text{C}\)).
6. ReturnIfAbrupt(\(\text{resultCapability}\)).
7. Return PerformPromiseThen(\(\text{promise}\), \(\text{onFulfilled}\), \(\text{onRejected}\), \(\text{resultCapability}\)).

25.4.5.3.1 \text{PerformPromiseThen ( promise, onFulfilled, onRejected, resultCapability )}

The abstract operation \text{PerformPromiseThen} performs the \"then\" operation on \(\text{promise}\) using \(\text{onFulfilled}\) and \(\text{onRejected}\) as its settlement actions. The result is \(\text{resultCapability}'s\) promise.
1. Assert: IsPromise(promise) is true.
2. Assert: resultCapability is a PromiseCapability record.
3. If IsCallable(onFulfilled) is false, then
   a. Let onFulfilled be "Identity".
4. If IsCallable(onRejected) is false, then
   a. Let onRejected be "Thrower".
5. Let fulfillReaction be the PromiseReaction { [[Capabilities]]: resultCapability, [[Handler]]: onFulfilled }.
6. Let rejectReaction be the PromiseReaction { [[Capabilities]]: resultCapability, [[Handler]]: onRejected }.
7. If the value of promise's [[PromiseState]] internal slot is "pending",
   a. Append fulfillReaction as the last element of the List that is the value of promise's
      [[PromiseFulfillReactions]] internal slot.
   b. Append rejectReaction as the last element of the List that is the value of promise's
      [[PromiseRejectReactions]] internal slot.
8. Else if the value of promise's [[PromiseState]] internal slot is "fulfilled",
   a. Let value be the value of promise's [[PromiseResult]] internal slot.
9. Else if the value of promise's [[PromiseState]] internal slot is "rejected",
   a. Let reason be the value of promise's [[PromiseResult]] internal slot.
   b. Perform EnqueueJob("PromiseJobs", PromiseReactionJob, rejectReaction, reason).
10. Return resultCapability.[[Promise]].

25.4.5.4 Promise.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value "Promise".

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

25.4.6 Properties of Promise Instances

Promise instances are ordinary objects that inherit properties from the Promise prototype object (the
intrinsic, %PromisePrototype%). Promise instances are initially created with the internal slots described in
Table 52.
Table 52 — Internal Slots of Promise Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[PromiseState]]</td>
<td>A string value that governs how a promise will react to incoming calls to its then method. The possible values are: undefined, &quot;pending&quot;, &quot;fulfilled&quot;, and &quot;rejected&quot;.</td>
</tr>
<tr>
<td>[[PromiseConstructor]]</td>
<td>The function object that was used to construct this promise. Checked by the resolve method of the Promise constructor.</td>
</tr>
<tr>
<td>[[PromiseResult]]</td>
<td>The value with which the promise has been fulfilled or rejected, if any. Only meaningful if [[PromiseState]] is not &quot;pending&quot;.</td>
</tr>
<tr>
<td>[[PromiseFulfillReactions]]</td>
<td>A List of PromiseReaction records to be processed when/if the promise transitions from the &quot;pending&quot; state to the &quot;fulfilled&quot; state.</td>
</tr>
<tr>
<td>[[PromiseRejectReactions]]</td>
<td>A List of PromiseReaction records to be processed when/if the promise transitions from the &quot;pending&quot; state to the &quot;rejected&quot; state.</td>
</tr>
</tbody>
</table>

26 Reflection

26.1 The Reflect Object

The Reflect object is a single ordinary object.

The value of the [[Prototype]] internal slot of the Reflect object is the intrinsic object %ObjectPrototype% (19.1.3).

The Reflect object is not a function object. It does not have a [[Construct]] internal method; it is not possible to use the Reflect object as a constructor with the new operator. The Reflect object also does not have a [[Call]] internal method; it is not possible to invoke the Reflect object as a function.

26.1.1 Reflect.apply ( target, thisArgument, argumentsList )

When the apply function is called with arguments target, thisArgument, and argumentsList the following steps are taken:

1. If IsCallable(target) is false, throw a TypeError exception.
2. Let args be CreateListFromArrayLike(argumentsList).
3. ReturnIfAbrupt(args).
4. Perform the PrepareForTailCall abstract operation.
5. Return Call(target, thisArgument, args).

26.1.2 Reflect.construct ( target, argumentsList [, newTarget] )

When the construct function is called with arguments target, argumentsList, and newTarget the following steps are taken:

1. If IsConstructor(target) is false, throw a TypeError exception.
2. If newTarget is not present, let newTarget be target.

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3. Else, if `IsConstructor(newTarget)` is `false`, throw a `TypeError` exception.
4. Let `args` be `CreateListFromArrayLike(argumentsList)`.`
5. ReturnIfAbrupt(args).
6. Return Construct(target, args, newTarget).

26.1.3 Reflect.defineProperty (target, propertyKey, attributes)

When the `defineProperty` function is called with arguments `target`, `propertyKey`, and `attributes` the following steps are taken:

1. If `Type(target)` is not Object, throw a `TypeError` exception.
2. Let `key` be `ToPropertyKey(propertyKey)`.
3. ReturnIfAbrupt(key).
4. Let `desc` be `ToPropertyDescriptor(attributes)`.
5. ReturnIfAbrupt(desc).
6. Return the result of calling the `[[DefineOwnProperty]]` internal method of `target` with arguments `key` and `desc`.

26.1.4 Reflect.deleteProperty (target, propertyKey)

When the `deleteProperty` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. If `Type(target)` is not Object, throw a `TypeError` exception.
2. Let `key` be `ToPropertyKey(propertyKey)`.
3. ReturnIfAbrupt(key).
4. Return the result of calling the `[[Delete]]` internal method of `target` with argument `key`.

26.1.5 Reflect.enumerate (target)

When the `enumerate` function is called with argument `target` the following steps are taken:

1. If `Type(target)` is not Object, throw a `TypeError` exception.
2. Return the result of calling the `[[Enumerate]]` internal method of `target`.

26.1.6 Reflect.get (target, propertyKey [, receiver])

When the `get` function is called with arguments `target`, `propertyKey`, and `receiver` the following steps are taken:

1. If `Type(target)` is not Object, throw a `TypeError` exception.
2. Let `key` be `ToPropertyKey(propertyKey)`.
3. ReturnIfAbrupt(key).
4. If `receiver` is not present, then
   a. Let `receiver` be `target`.
5. Return the result of calling the `[[Get]]` internal method of `target` with arguments `key`, and `receiver`.

26.1.7 Reflect.getOwnPropertyDescriptor (target, propertyKey)

When the `getOwnPropertyDescriptor` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. If `Type(target)` is not Object, throw a `TypeError` exception.
2. Let `key` be `ToPropertyKey(propertyKey)`.
3. ReturnIfAbrupt(key).
4. Let desc be the result of calling the [[GetOwnProperty]] internal method of target with argument key.
5. ReturnIfAbrupt(desc).
6. Return FromPropertyDescriptor(desc).

26.1.8 Reflect.getPrototypeOf (target)

When the getPrototypeOf function is called with argument target the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Return the result of calling the [[GetPrototypeOf]] internal method of target.

26.1.9 Reflect.has (target, propertyKey)

When the has function is called with arguments target and propertyKey, the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Let key be ToPropertyKey(propertyKey).
3. ReturnIfAbrupt(key).
4. Return the result of calling the [[HasProperty]] internal method of target with argument key.

26.1.10 Reflect.isExtensible (target)

When the isExtensible function is called with argument target the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Return the result of calling the [[IsExtensible]] internal method of target.

26.1.11 Reflect.ownKeys (target)

When the ownKeys function is called with argument target the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of target.
3. ReturnIfAbrupt(keys).
4. Return CreateArrayFromList(keys).

26.1.12 Reflect.preventExtensions (target)

When the preventExtensions function is called with argument target, the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Return the result of calling the [[PreventExtensions]] internal method of target.

26.1.13 Reflect.set (target, propertyKey, V [, receiver])

When the set function is called with arguments target, V, propertyKey, and receiver the following steps are taken:

1. If Type(target) is not Object, throw a TypeError exception.
2. Let key be ToPropertyKey(propertyKey).
3. ReturnIfAbrupt(key).
4. If receiver is not present, then
   a. Let receiver be target.
5. Return the result of calling the [[Set]] internal method of `target` with arguments `key`, `V`, and `receiver`.

### 26.1.14 Reflect.setPrototypeOf (target, proto)

When the `setPrototypeOf` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. If `Type(target)` is not `Object`, throw a `TypeError` exception.
2. If `Type(proto)` is not `Object` and `proto` is not `null`, throw a `TypeError` exception.
3. Return the result of calling the `[[SetPrototypeOf]]` internal method of `target` with argument `proto`.

### 26.2 Proxy Objects

#### 26.2.1 The Proxy Constructor

The `Proxy` constructor is the `%Proxy%` intrinsic object and the initial value of the `Proxy` property of the global object. When called as a constructor it creates and initializes a new exotic proxy object. `Proxy` is not intended to be called as a function and will throw an exception when called in that manner.

`Proxy` may be used as the value in an `extends` clause of a class definition. Subclass constructors that intend to inherit the ability to create exotic proxy objects must include a `super` call to the `Proxy`.

#### 26.2.1.1 Proxy (target, handler)

When `Proxy` is called with arguments `target` and `handler` performs the following steps:

1. If `NewTarget` is `undefined`, throw a `TypeError` exception.
2. Return `ProxyCreate(target, handler)`.

#### 26.2.2 Properties of the Proxy Constructor

The value of the `[[Prototype]]` internal slot of the `Proxy` constructor is the intrinsic object `%FunctionPrototype%` (19.2.3).

Besides the `length` property (whose value is 2), the `Proxy` constructor has the following properties:

#### 26.2.2.1 Proxy.revocable (target, handler)

The `Proxy.revocable` function is used to create a revocable Proxy object. When `Proxy.revocable` is called with arguments `target` and `handler` the following steps are taken:

1. Let `p` be `ProxyCreate(target, handler)`.
2. Return `IfAbrupt(p)`.
3. Let `revoker` be a new built-in function object as defined in 26.2.2.1.1.
4. Set the `[[RevocableProxy]]` internal slot of `revoker` to `p`.
5. Let `result` be `ObjectCreate(%ObjectPrototype%)`.
6. CreateDataProperty(result, "proxy", p).
7. CreateDataProperty(result, "revoke", revoker).
8. Return `result`. 
26.2.2.1.1 Proxy Revocation Functions

A Proxy revocation function is an anonymous function that has the ability to invalidate a specific Proxy object.

Each Proxy revocation function has a [[RevokableProxy]] internal slot.

When a Proxy revocation function, \( F \), is called the following steps are taken:

1. Let \( p \) be the value of \( F \)'s [[RevokableProxy]] internal slot.
2. If \( p \) is \null, return \undefined.
3. Set the value of \( F \)'s [[RevokableProxy]] internal slot to \null.
4. Assert: \( p \) is a Proxy object.
5. Set the [[ProxyTarget]] internal slot of \( p \) to \null.
6. Set the [[ProxyHandler]] internal slot of \( p \) to \null.
7. Return \undefined.

26.3 Module Namespace Objects

A Module Namespace Object is a module namespace exotic object that provides runtime property-based access to a module's exported bindings. There is no constructor function for Module Namespace Objects. Instead, such an object is created for each module that is imported by an ImportDeclaration that includes a NameSpaceImport (See 15.2.2).

In addition to the properties specified in 15.2.2 each Module Namespace Object has the own following properties:

26.3.1 @@toStringTag

The initial value of the @@toStringTag property is the string value "Module".

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

26.3.2 [ @@iterator ] ( )

The following steps are taken:

1. Let \( N \) the this value.
2. If Type(\( N \)) is not Object, throw a TypeError exception.
3. Return the result of calling the [[Enumerate]] internal method of \( N \) with no arguments.

The value of the name property of this function is "[Symbol.iterator]".
Annex A
(informative)

Grammar Summary

A.1 Lexical Grammar

SourceCharacter ::
  any Unicode code point  See 10.1

InputElementDiv ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator
  RightBracePunctuator  See clause 11

InputElementRegExp ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  RightBracePunctuator
  RegularExpressionLiteral  See clause 11

InputElementTemplateTail ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator
  TemplateSubstitutionTail  See clause 11

WhiteSpace ::
  <TAB>
  <VT>
  <FF>
  <SP>
  <NBSP>
  <ZWNBSP>
  <USP>  See 11.2
LineTerminator ::
  <LF>
  <CR>
  <LS>
  <PS>

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

Comment ::
  MultiLineComment
  SingleLineComment

MultiLineComment ::
  /* MultiLineCommentCharsopt */

MultiLineCommentChars ::
  MultiLineNotAsteriskChar MultiLineCommentCharsopt
  PostAsteriskCommentCharsopt

PostAsteriskCommentChars ::
  MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentCharsopt
  PostAsteriskCommentCharsopt

MultiLineNotAsteriskChar ::
  SourceCharacter but not *

MultiLineNotForwardSlashOrAsteriskChar ::
  SourceCharacter but not one of / or *

SingleLineComment ::
  // SingleLineCommentCharsopt

SingleLineCommentChars ::
  SingleLineCommentChar SingleLineCommentCharsopt

SingleLineCommentChar ::
  SourceCharacter but not LineTerminator

Token ::
  IdentifierName
  Punctuator
  NumericLiteral
  StringLiteral
  Template

IdentifierName ::
  IdentifierStart
  IdentifierName IdentifierPart
IdentifierStart ::
    UnicodeIDStart
    \ UnicodeEscapeSequence
See 11.6

IdentifierPart ::
    UnicodeIDContinue
    \ UnicodeEscapeSequence
    <ZWNJ>
    <ZWJ>
See 11.6

UnicodeIDStart ::
    any Unicode code point with the Unicode property “ID_Start” or
    “Other_ID_Start”
See 11.6

UnicodeIDContinue ::
    any Unicode code point with the Unicode property “ID_Continue”, “Other_ID_Continue”, or
    “Other_ID_Start”
See 11.6

ReservedWord ::
    Keyword
    FutureReservedWord
    NullLiteral
    BooleanLiteral
See 11.6.2

Keyword :: one of
    break
doi
in
typeof
case
else
instanceof
var
catch
export
new
void
class
extends
return
while
const
finally
super
with
continue
for
switch
yield
debugger
function
this
default
if
throw
delete
import
try
See 11.6.2.1

FutureReservedWord ::
    enum
    await
See 11.6.2.2

await is only treated as a FutureReservedWord when Module is the goal symbol of the syntactic grammar.

The following tokens are also considered to be FutureReservedWords when parsing strict mode
code (see 10.2.1).

    implements
    package
    protected
    interface
    private
    public
Punctuator :: one of

{   }   (   )   [   ]   .   ;   ,   <   >   <=

>=   ==   !=   !==   !==

+   -   *   %   ++   --

<<   >>   >>>

&   |   ^

!   ~

==   +=   -=   *=   %=   <<=

>>=

>=   >>=   &=   |=   ^=   =>

DivPunctuator :: one of

/   /=

RightBracePunctuator :: one of

}

NullLiteral ::

null

BooleanLiteral ::

true

false

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

See 11.7

See 11.7

See 11.8.1

See 11.8.2

See 11.8.3

See 11.8.3

See 11.8.3

See 11.8.3

See 11.8.3

See 11.8.3

See 11.8.3

See 11.8.3
ExponentPart ::
  ExponentIndicator SignedInteger

ExponentIndicator :: one of
  e E

SignedInteger ::
  DecimalDigits
  + DecimalDigits
  - DecimalDigits

BinaryIntegerLiteral ::
  0b BinaryDigits
  0B BinaryDigits

BinaryDigits ::
  BinaryDigit
  BinaryDigits BinaryDigit

BinaryDigit :: one of
  0 1

OctalIntegerLiteral ::
  0o OctalDigits
  0O OctalDigits

OctalDigits ::
  OctalDigit
  OctalDigits OctalDigit

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

HexIntegerLiteral ::
  0x HexDigits
  0X HexDigit

HexDigits ::
  HexDigit
  HexDigits 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

StringLiteral ::
  " DoubleStringCharactersopt "
  ' SingleStringCharactersopt '

DoubleStringCharacters ::
  DoubleStringCharacter DoubleStringCharactersopt
SingleStringCharacters ::
  SingleStringCharacter SingleStringCharacters

See 11.8.4

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

See 11.8.4

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

See 11.8.4

LineContinuation ::
  \ LineTerminatorSequence

See 11.8.4

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

See 11.8.4

CharacterEscapeSequence ::
  SingleEscapeCharacter
  NonEscapeCharacter

See 11.8.4

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

See 11.8.4

NonEscapeCharacter ::
  SourceCharacter but not one of EscapeCharacter or LineTerminator

See 11.8.4

EscapeCharacter ::
  SingleEscapeCharacter
  DecimalDigit
  x
  u

HexEscapeSequence ::
  x HexDigit HexDigit

See 11.8.4

UnicodeEscapeSequence ::
  u HexDigit
  u{ HexDigits }

See 11.8.4

HexDigits ::
  HexDigit HexDigit HexDigit HexDigit
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

Template ::
    NoSubstitutionTemplate
    TemplateHead

NoSubstitutionTemplate ::
    TemplateCharactersopt

TemplateHead ::
    TemplateCharactersopt $
TemplateSubstitutionTail ::
  TemplateMiddle
  TemplateTail

TemplateMiddle ::
  ) TemplateCharacters_opt $ {

TemplateTail ::
  ) TemplateCharacters_opt 

TemplateCharacters ::
  ) TemplateCharacter TemplateCharacters_opt

TemplateCharacter ::
  $ [lookahead # ()
   \ EscapeSequence
   LineContinuation
   LineTerminatorSequence
   SourceCharacter but not one of ` or \ or $ or LineTerminator

A.2 Expressions

IdentifierReference Yield ::
  Identifier
  [-Yield] yield

BindingIdentifier Yield ::
  Identifier
  [-Yield] yield

LabelIdentifier Yield ::
  Identifier
  [-Yield] yield

Identifier ::
  IdentifierName but not ReservedWord

PrimaryExpression Yield ::
  this
  IdentifierReference Yield
  Literal
  ArrayLiteral Yield
  ObjectLiteral Yield
  FunctionExpression
  ClassExpression
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral Yield
  CoverParenthesizedExpressionAndArrowParameterList Yield

See 11.8.6

See 12.1

See 12.1

See 12.1

See 12.1

See 12.2
CoverParenthesizedExpressionAndArrowParameterList\[\text{Yield}\]  
( Expression\[\text{In}, \text{Yield}\]  
)  
( ... BindingIdentifier\[\text{Yield}\]  
( Expression\[\text{In}, \text{Yield}\], ... BindingIdentifier\[\text{Yield}\] ) 
) 

When processing the production
PrimaryExpression\[\text{Yield}\] : CoverParenthesizedExpressionAndArrowParameterList\[\text{Yield}\]
the interpretation of CoverParenthesizedExpressionAndArrowParameterList is refined using the following grammar:

ParenthesizedExpression\[\text{Yield}\] :  
( Expression\[\text{In}, \text{Yield}\] )  

Literal :  
NullLiteral  
BooleanLiteral  
NumericLiteral  
StringLiteral  

ArrayLiteral\[\text{Yield}\] :  
[ Elision\[\text{opt}\] ]  
[ ElementList\[\text{Yield}\] ]  
[ ElementList\[\text{Yield}\], Elision\[\text{opt}\] ]  

ElementList\[\text{Yield}\] :  
Elision\[\text{opt}\] AssignmentExpression\[\text{In}, \text{Yield}\]  
Elision\[\text{opt}\] SpreadElement\[\text{Yield}\]  
ElementList\[\text{Yield}\], Elision\[\text{opt}\] AssignmentExpression\[\text{In}, \text{Yield}\]  
ElementList\[\text{Yield}\], Elision\[\text{opt}\] SpreadElement\[\text{Yield}\]  

Elision :  
,  
Elision  

SpreadElement\[\text{Yield}\] :  
... AssignmentExpression\[\text{In}, \text{Yield}\]  

ObjectLiteral\[\text{Yield}\] :  
{ }  
{ PropertyDefinitionList\[\text{Yield}\] }  
{ PropertyDefinitionList\[\text{Yield}\], }  

PropertyDefinitionList\[\text{Yield}\] :  
PropertyDefinition\[\text{Yield}\]  
PropertyDefinition\[\text{Yield}\], PropertyDefinition\[\text{Yield}\]  

PropertyDefinition\[\text{Yield}\] :  
IdentifierReference\[\text{Yield}\]  
CoverInitializedName\[\text{Yield}\]  
PropertyName\[\text{Yield}\] : AssignmentExpression\[\text{In}, \text{Yield}\]  
MethodDefinition\[\text{Yield}\]
PropertyName[\Yield,GeneratorParameter] : See 12.2.5
  LiteralPropertyName
  [+GeneratorParameter] ComputedPropertyName
  [-GeneratorParameter] ComputedPropertyName

LiteralPropertyName : See 12.2.5
  IdentifierName
  StringLiteral
  NumericLiteral

ComputedPropertyName[\Yield] :
  [ AssignmentExpression\[n, \Yield\] ]

CoverInitializedName[\Yield] :
  IdentifierReference\[\Yield\] Initializer\[n, \Yield\]

Initializer\[n, \Yield\] :
  = AssignmentExpression\[n, \Yield\]

TemplateLiteral[\Yield] :
  NoSubstitutionTemplate
  TemplateHead Expression\[n, \Yield\] [ Lexical goal InputElementTemplateTail ] TemplateSpans[\Yield]

TemplateSpans[\Yield] :
  TemplateTail
  TemplateMiddleList[\Yield] [ Lexical goal InputElementTemplateTail ] TemplateTail

TemplateMiddleList[\Yield] :
  TemplateMiddle Expression\[n, \Yield\]
  TemplateMiddleList[\Yield] [ Lexical goal InputElementTemplateTail ] TemplateMiddle Expression\[n, \Yield\]

MemberExpression[\Yield] :
  [ Lexical goal InputElementRegExp ] PrimaryExpression[\Yield]
  MemberExpression[\Yield] [ Expression\[n, \Yield\] ]
  MemberExpression[\Yield] . IdentifierName
  MemberExpression[\Yield] TemplateLiteral[\Yield]
  SuperProperty[\Yield]
  MetaProperty.
  new MemberExpression[\Yield] Arguments[\Yield]

SuperProperty[\Yield] :
  super [ Expression\[n, \Yield\] ]
  super . IdentifierName

MetaProperty :
  new . target

NewExpression[\Yield] :
  MemberExpression[\Yield]
  new NewExpression[\Yield]
CallExpression: See 12.3
  
  MemberExpression Arguments
  SuperCall
  CallExpression Arguments
  CallExpression [Expression, IdentifierName]
  CallExpression TemplateLiteral

SuperCall: See 12.3
  super Arguments

Arguments: See 12.3
  ()
  (ArgumentList )

ArgumentList: See 12.3
  AssignmentExpression
  . . . AssignmentExpression
  ArgumentList, AssignmentExpression
  ArgumentList, . . . AssignmentExpression

LeftHandSideExpression: See 12.3
  NewExpression
  CallExpression

PostfixExpression: See 12.4
  LeftHandSideExpression
  LeftHandSideExpression no LineTerminator here ++
  LeftHandSideExpression no LineTerminator here --

UnaryExpression: See 12.5
  PostfixExpression
  delete UnaryExpression
  void UnaryExpression
  typeof UnaryExpression
  UnaryExpression no LineTerminator here ++
  UnaryExpression no LineTerminator here --
  UnaryExpression
  UnaryExpression
  UnaryExpression
  UnaryExpression

MultiplicativeExpression: See 12.6
  UnaryExpression
  MultiplicativeExpression MultiplicativeOperator UnaryExpression

MultiplicativeOperator: one of See 12.6
  * / %
AdditiveExpression[n, y] : See 12.7
  MultiplicativeExpression[n, y] AdditiveExpression[n, y] + MultiplicativeExpression[n, y]
  AdditiveExpression[n, y] - MultiplicativeExpression[n, y]

ShiftExpression[n, y] : See 12.8
  AdditiveExpression[n, y] ShiftExpression[n, y] << AdditiveExpression[n, y]
  ShiftExpression[n, y] >> AdditiveExpression[n, y]
  ShiftExpression[n, y] >>> AdditiveExpression[n, y]

RelationalExpression[n, y] : See 12.9
  ShiftExpression[n, y] RelationalExpression[n, y] < ShiftExpression[n, y]
  RelationalExpression[n, y] y RelationalExpression[n, y] >= ShiftExpression[n, y]
  RelationalExpression[n, y] instanceof ShiftExpression[n, y]
  [[in]] RelationalExpression[n, y] in ShiftExpression[n, y]

EqualityExpression[n, y] : See 12.10
  RelationalExpression[n, y] EqualityExpression[n, y] == RelationalExpression[n, y]
  EqualityExpression[n, y] != RelationalExpression[n, y]
  EqualityExpression[n, y] === RelationalExpression[n, y]
  EqualityExpression[n, y] !== RelationalExpression[n, y]

BitwiseANDExpression[n, y] : See 12.11
  EqualityExpression[n, y] BitwiseANDExpression[n, y] & EqualityExpression[n, y]

BitwiseXORExpression[n, y] : See 12.11
  BitwiseANDExpression[n, y] ^ BitwiseANDExpression[n, y]

BitwiseORExpression[n, y] : See 12.11
  BitwiseXORExpression[n, y] | BitwiseXORExpression[n, y]

LogicalANDExpression[n, y] : See 12.12
  BitwiseORExpression[n, y] LogicalANDExpression[n, y] & BitwiseORExpression[n, y]

LogicalORExpression[n, y] : See 12.12
  LogicalANDExpression[n, y] LogicalORExpression[n, y] || LogicalANDExpression[n, y]

ConditionalExpression[n, y] : See 12.13
AssignmentExpression[Yield] :  
  ConditionalExpression[Yield]  
  [+=Yield] YieldExpression[Yield]  
  ArrowFunction[Yield]  
  LeftHandSideExpression[Yield] = AssignmentExpression[Yield]  
  LeftHandSideExpression[Yield] AssignmentOperator AssignmentExpression[Yield]

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

Expression[Yield] :  
  AssignmentExpression[Yield]  
  Expression[Yield, Yield] + AssignmentExpression[Yield]

A.3 Statements

Statement[Yield, Return] :  
  BlockStatement[Yield, Return]  
  VariableStatement[Yield]  
  EmptyStatement  
  ExpressionStatement[Yield]  
  IfStatement[Yield, Return]  
  BreakableStatement[Yield, Return]  
  ContinueStatement[Yield]  
  BreakStatement[Yield]  
  [+=Return] ReturnStatement[Yield]  
  WithStatement[Yield, Return]  
  LabelledStatement[Yield, Return]  
  ThrowStatement[Yield]  
  TryStatement[Yield, Return]  
  DebuggerStatement

Declaration[Yield] :  
  HoistableDeclaration[Yield]  
  ClassDeclaration[Yield]  
  LexicalDeclaration[Yield, Yield]

HoistableDeclaration[Yield, Default] :  
  FunctionDeclaration[Yield, Default]  
  GeneratorDeclaration[Yield, Default]

BreakableStatement[Yield, Return] :  
  IterationStatement[Yield, Return]  
  SwitchStatement[Yield, Return]

BlockStatement[Yield, Return] :  
  Block[Yield, Return]

Block[Yield, Return] :  
  { StatementList[Yield, Return]opt }
StatementList{Yield, Return}:
  StatementListItem{Yield, ?Return}

StatementListItem{Yield, Return}:
  Statement{Yield, ?Return}
  Declaration{Yield}

LexicalDeclaration[m, Yield]::
  LetOrConst BindingList{m, ?Yield}?

LetOrConst::
  let
  const

BindingList{m, Yield}::
  LexicalBinding{m, ?Yield}
  BindingList{m, ?Yield}, LexicalBinding{m, ?Yield}

LexicalBinding{m, Yield}::
  BindingIdentifier{m, ?Yield}, Initialize{m, ?Yield}opt
  BindingPattern{m, ?Yield}, Initialize{m, ?Yield}

VariableStatement{Yield}::
  var VariableDeclarationList{m, ?Yield}?

VariableDeclarationList{m, Yield}::
  VariableDeclaration{m, ?Yield}
  VariableDeclarationList{m, ?Yield} + VariableDeclaration{m, ?Yield}

VariableDeclaration{m, Yield}::
  BindingIdentifier{m, ?Yield}, Initialize{m, ?Yield}opt
  BindingPattern{m, ?Yield}, Initialize{m, ?Yield}

BindingPattern{Yield, GeneratorParameter}::
  ObjectBindingPattern{Yield, ?GeneratorParameter}
  ArrayBindingPattern{Yield, ?GeneratorParameter}

ObjectBindingPattern{Yield, GeneratorParameter}::
  { }
  { BindingPropertyList{Yield, ?GeneratorParameter} } 
  { BindingPropertyList{Yield, ?GeneratorParameter}, } 

ArrayBindingPattern{Yield, GeneratorParameter}::
  [ Elisionopt, BindingRestElement{Yield, ?GeneratorParameter}opt ]
  [ BindingElementList{Yield, ?GeneratorParameter} ]
  [ BindingElementList{Yield, ?GeneratorParameter}, Elisionopt, BindingRestElement{Yield, ?GeneratorParameter}opt ]

BindingPropertyList{Yield, GeneratorParameter}::
  BindingProperty{Yield, ?GeneratorParameter}
  BindingPropertyList{Yield, ?GeneratorParameter} + BindingProperty{Yield, ?GeneratorParameter}
BindingElementList[Yield, GeneratorParameter] :
  BindingElisionElement[Yield, GeneratorParameter] ,
  BindingElementList[Yield, GeneratorParameter], BindingElisionElement[Yield, GeneratorParameter]

BindingElisionElement[Yield, GeneratorParameter] :
  Elision BindingElement[Yield, GeneratorParameter]

BindingProperty[Yield, GeneratorParameter] :
  SingleNameBinding[Yield, GeneratorParameter]
  PropertyName[Yield, GeneratorParameter] : BindingElement[Yield, GeneratorParameter]

BindingElement[Yield, GeneratorParameter] :
  SingleNameBinding[Yield, GeneratorParameter]
  [ +GeneratorParameter] BindingPattern[Yield, GeneratorParameter], Initialize[Yield, Opt]
  [ -GeneratorParameter] BindingPattern[Yield, Opt], Initialize[Yield, Opt]

SingleNameBinding[Yield, GeneratorParameter] :
  [ +GeneratorParameter] BindingIdentifier[Yield, Opt], Initialize[Yield, Opt]
  [ -GeneratorParameter] BindingIdentifier[Yield, Opt], Initialize[Yield, Opt]

BindingRestElement[Yield, GeneratorParameter] :
  [+GeneratorParameter] ... BindingIdentifier[Yield, Opt]
  [-GeneratorParameter] ... BindingIdentifier[Yield, Opt]

EmptyStatement[Yield] :

; See 13.3

ExpressionStatement[Yield] :
  [lookahead $ { [ . | function | class | let | ] | ] } Expression[Yield, Yield] ;

IfStatement[Yield, Return] :
  if ( Expression[Yield, Yield] ) Statement[Yield, Yield, Return]

IterationStatement[Yield, Return] :
  do Statement[Yield, Return] while ( Expression[Yield, Yield] ) : opt
  while ( Expression[Yield, Yield] ) Statement[Yield, Return]
    Statement[Yield, Return]
    Statement[Yield, Return]
  for ( ForDeclaration[Yield] in Expression[Yield, Yield] ) Statement[Yield, Yield, Return]
    Statement[Yield, Yield, Return]
  for ( ForDeclaration[Yield] of AssignmentExpression[Yield, Yield] ) Statement[Yield, Yield, Return]

ForDeclaration[Yield] :
  LetOrConst ForBinding[Yield]
ForBinding[Yield] :
BindingIdentifier[Yield]
BindingPattern[Yield]

ContinueStatement[Yield] :
continue ;
continue [no LineTerminator here] LabelIdentifier[Yield] ;

BreakStatement[Yield] :
break ;
break [no LineTerminator here] LabelIdentifier[Yield] ;

ReturnStatement[Yield] :
return ;

WithStatement[Yield, Return] :
with (Expression[Yield, Yield], ?Yield) Statement[Yield, ?Return]

SwitchStatement[Yield, Return] :
switch (Expression[Yield, Yield], ?Yield) CaseBlock[Yield, ?Return]

CaseBlock[Yield, Return] :
{ CaseClauses[Yield, Return], ?Return }

CaseClause[Yield, Return] :
CaseClause[Yield, Return], ?Return
CaseClause[Yield, ?Return]
CaseClause[Yield, Yield, ?Return]
CaseClause[Yield, Yield, Return]
CaseClause[Yield, Yield, Return, ?Return]
CaseClause[Yield, Yield, Return, ?Return] opt

CaseClauses[Yield, Return] :
CaseClauses[Yield, Return], ?Return
CaseClauses[Yield, Yield, ?Return]
CaseClauses[Yield, Yield, Return]
CaseClauses[Yield, Yield, Return, ?Return]
CaseClauses[Yield, Yield, Return, ?Return] opt

DefaultClause[Yield, Return] :

LabelledStatement[Yield, Return] :

LabelledItem[Yield, Return] :
Statement[Yield, ?Return]
FunctionDeclaration[Yield, ?Return]

ThrowStatement[Yield] :

TryStatement[Yield, Return] :
try Block[Yield, ?Return]

See 13.6
See 13.7
See 13.8
See 13.9
See 13.10
See 13.11
See 13.11
See 13.11
See 13.11
See 13.11
See 13.11
See 13.11
See 13.12
See 13.12
See 13.13
See 13.14
Catch[Yield, Return] :
catch ( CatchParameter[Yield] ) Block[Yield, ?Return] 
See 13.14

Finally[Yield, Return] :
finally Block[Yield, ?Return] 
See 13.14

CatchParameter[Yield] :
BindingIdentifier[Yield]
BindingPattern[Yield] 
See 13.14

DebuggerStatement :
debugger ; 
See 13.15

A.4 Functions and Classes

FunctionDeclaration[Yield, Default] :
function BindingIdentifier[Yield] ( FormalParameters ) { FunctionBody }
[+Default] function ( FormalParameters ) { FunctionBody }
See 14.1

FunctionExpression :
function BindingIdentifier ( FormalParameters ) { FunctionBody }
See 14.1

StrictFormalParameters[Yield, GeneratorParameter] :
FormalParameters[Yield, ?GeneratorParameter] 
FormalParameters:
FormalParameterList [empty] 
FormalParameterList[Yield, ?GeneratorParameter] :
[empty] 
FormalParameterList:
FunctionRestParameter[Yield] 
See 14.1

FormalParameterList[Yield, ?GeneratorParameter] :
See 14.1

FormalParameterList:
See 14.1

FunctionRestParameter[Yield] :
BindingRestElement[Yield] 
See 14.1

FormalParameterList[Yield, ?GeneratorParameter] :
See 14.1

FormalParameter:
FormalParameterList(Yield, ?GeneratorParameter) 
BindingElement[Yield, ?GeneratorParameter] 
See 14.1

FunctionBody[Yield] :
FunctionStatementList[Yield] 
See 14.1

FunctionStatementList[Yield] :
StatementList[Yield, Return]opt 
See 14.1

ArrowFunction[Yield, Yield] :
ArrowParameters[Yield] [no LineTerminator here] => ConciseBody[Yield] 
See 14.2
ArrowParameters[Yield]:  
  BindingIdentifier[Yield]  
  CoverParenthesizedExpressionAndArrowParameterList[Yield]

ConciseBody[Yield]:  
  [lookahead ≠ { ] AssignmentExpression[Yield]  
  { FunctionBody } 

When the production

ArrowParameters[Yield]: CoverParenthesizedExpressionAndArrowParameterList[Yield]

is recognized the following grammar is used to refine the interpretation of
CoverParenthesizedExpressionAndArrowParameterList:

ArrowFormalParameters[Yield, GeneratorParameters]:  
  ( StrictFormalParameters[Yield, ?GeneratorParameters] )

MethodDefinition[Yield]:  
  PropertyName[Yield] { StrictFormalParameters } { FunctionBody }
  GeneratorMethod[Yield]  
  get PropertyName[Yield] () { FunctionBody }  
  set PropertyName[Yield] ( PropertySetParameterList ) { FunctionBody }

PropertySetParameterList:  
  FormalParameter

GeneratorMethod[Yield]:  
  * PropertyName[Yield] ( StrictFormalParameters[Yield, GeneratorParameters] ) { GeneratorBody[Yield] }

GeneratorDeclaration[Yield, Default]:  
  function * BindingIdentifier[Yield] ( FormalParameters[Yield, GeneratorParameters] ) { GeneratorBody[Yield] }
  [ + Default ] function * ( FormalParameters[Yield, GeneratorParameters] ) { GeneratorBody[Yield] }

GeneratorExpression:  
  function * BindingIdentifier[Yield]opt ( FormalParameters[Yield, GeneratorParameters] ) { GeneratorBody[Yield] }

GeneratorBody[Yield]:  
  FunctionBody[Yield]

YieldExpression[Yield]:  
  yield  
  yield [no LineTerminator here] [Lexical goal InputElementRegExp] AssignmentExpression[Yield, Yield]

ClassDeclaration[Yield, Default]:  
  class BindingIdentifier[Yield] ClassTail[Yield]  
  [ + Default ] class ClassTail[Yield]

ClassExpression[Yield, GeneratorParameters]:  
  class BindingIdentifier[Yield]opt ClassTail[Yield, ?GeneratorParameters]
ClassTail[Yield, GeneratorParameter]: See 14.5
  [-GeneratorParameter] ClassHeritage[Yield]opt { ClassBody[Yield]opt }
  [+GeneratorParameter] ClassHeritageopt { ClassBodyopt }

ClassHeritage[Yield]:
  *extends* LeftHandSideExpression[Yield]

ClassBody[Yield]:
  ClassElementList[Yield]

ClassElementList[Yield]:
  ClassElement[Yield]
  ClassElementList[Yield] ClassElement[Yield]

ClassElement[Yield]:
  MethodDefinition[Yield]
  static MethodDefinition[Yield]
  ;

A.5 Scripts and Modules

Script:
  ScriptBodyopt

ScriptBody:
  StatementList

Module:
  ModuleBodyopt

ModuleBody:
  ModuleItemList

ModuleItemList:
  ModuleItem
  ModuleItemList ModuleItem

ModuleItem:
  ImportDeclaration
  ExportDeclaration
  StatementList

ImportDeclaration:
  import ImportClause FromClause ;
  import ModuleSpecifier ;

ImportClause:
  ImportedDefaultBinding
  NameSpaceImport
  NamedImports
  ImportedDefaultBinding, NameSpaceImport
  ImportedDefaultBinding, NamedImports
ImportedDefaultBinding : ImportedBinding

NameSpaceImport : * as ImportedBinding

NamedImports :
  { }
  { ImportsList }
  { ImportsList , }

FromClause :
  from ModuleSpecifier

ImportsList :
  ImportSpecifier ImportsList , ImportSpecifier

ImportSpecifier :
  ImportedBinding IdentifierName as ImportedBinding

ModuleSpecifier :
  StringLiteral

ImportedBinding :
  BindingIdentifier

ExportDeclaration :
  export * FromClause ;
  export ExportClause FromClause ;
  export ExportClause ;
  export VariableStatement
  export Declaration
  export default HoistableDeclaration[default]
  export default ClassDeclaration[default]
  export default [lookahead \ { function, class }] AssignmentExpression[\d] ;

ExportClause :
  { }
  { ExportsList }
  { ExportsList , }

ExportsList :
  ExportSpecifier ExportsList , ExportSpecifier

ExportSpecifier :
  IdentifierName
  IdentifierName as IdentifierName
A.6 Number Conversions

StringNumericLiteral :::
  StrWhiteSpace\opt
  StrWhiteSpace\opt StrNumericLiteral StrWhiteSpace\opt

StrWhiteSpace :::
  StrWhiteSpaceChar StrWhiteSpace\opt

StrWhiteSpaceChar :::
  StrWhiteSpaceChar
  StrWhiteSpaceChar

StrNumericLiteral :::
  StrDecimalLiteral
  BinaryIntegerLiteral
  OctalIntegerLiteral
  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

All grammar symbols not explicitly defined by the StringNumericLiteral grammar have the definitions used in the Lexical Grammar for numeric literals (11.8.3)

A.7 Universal Resource Identifier Character Classes

uri :::
  uriCharactersOpt

uriCharacters :::
  uriCharacter uriCharactersOpt

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
  _ - . ! * ' ( )

A.8 Regular Expressions

PatternOpt ::
  DisjunctionOpt

DisjunctionOpt ::
  AlternativeOpt
  AlternativeOpt | DisjunctionOpt
Alternative \[\text{[empty]}\] 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 )

SyntaxCharacter ::= \text{one of} \n  \^ \$ \. \* \+ \? \( \) \[ \] \{ \} \|

PatternCharacter ::= \text{SourceCharacter but not SyntaxCharacter}

AtomEscape ::= 
  DecimalEscape 
  CharacterEscape 
  CharacterClassEscape
CharacterEscape\u005bU\u005d::
  ControlEscape
  c ControlLetter
  HexEscapeSequence
  RegExpUnicodeEscapeSequence\u005bU\u005d
  IdentityEscape\u005bU\u005d

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

RegExpUnicodeEscapeSequence\u005bU\u005d ::
  [\u005bU\u005d| \u005bU\u005d LeadSurrogate \u005bU\u005d TrailSurrogate
  \u005bU\u005d Hex4Digits
  [\u005bU\u005d| \u005bU\u005d \{ HexDigits \}

LeadSurrogate ::
  Hex4Digits [match only if the SV of Hex4Digits is in the inclusive range 0xD800 to 0xDBFF]

TrailSurrogate ::
  Hex4Digits [match only if the SV of Hex4Digits is in the inclusive range 0xDC00 to 0xDFFF]

IdentityEscape\u005bU\u005d ::
  [\u005bU\u005d| \u005bU\u005d SyntaxCharacter
  [\u005bU\u005d| \u005bU\u005d SourceCharacter but not UnicodeIDContinue

DecimalEscape ::
  DecimalIntegerLiteral [lookahead \u005bU\u005d DecimalDigit]

CharacterClassEscape :: one of
  d D s S w W

CharacterClass\u005bU\u005d ::
  [\u005bU\u005d| \u005bU\u005d ClassRanges\u005bU\u005d ]
  [^ ClassRanges\u005bU\u005d ]

ClassRanges\u005bU\u005d ::
  [empty]
  NonemptyClassRanges\u005bU\u005d

NonemptyClassRanges\u005bU\u005d ::
  ClassAtom\u005bU\u005d
  ClassAtom\u005bU\u005d NonemptyClassRangesNoDash\u005bU\u005d
  ClassAtom\u005bU\u005d - ClassAtom\u005bU\u005d ClassRanges\u005bU\u005d

NonemptyClassRangesNoDash\u005bU\u005d ::
  ClassAtom\u005bU\u005d
  ClassAtomNoDash\u005bU\u005d NonemptyClassRangesNoDash\u005bU\u005d
  ClassAtomNoDash\u005bU\u005d - ClassAtom\u005bU\u005d ClassRanges\u005bU\u005d
ClassAtom_noDash ::
  -
  ClassAtomNoDash

ClassAtomNoDash_noDash ::
  SourceCharacter but not one of \ or } or -
  \ ClassEscape

ClassEscape_noDash ::
  DecimalEscape
  b
  [uU] -
  CharacterEscape
  CharacterClassEscape

See 21.2.1
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 11.8.3 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

DecimalIntegerLiteral ::
  0
  NonZeroDigit DecimalDigits opt
  OctalDecimalIntegerLiteral

NonOctalDecimalIntegerLiteral ::
  0 NonOctalDigit
  LegacyOctalLikeDecimalIntegerLiteral NonOctalDigit
  LegacyOctalLikeDecimalIntegerLiteral DecimalDigit

LegacyOctalLikeDecimalIntegerLiteral ::
  0 OctalDigit
  LegacyOctalLikeDecimalIntegerLiteral OctalDigit

NonOctalDigit :: one of 8 9
```

**B.1.1.1 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`.

The MV of `DecimalIntegerLiteral :: NonOctalDecimalIntegerLiteral` is the MV of `NonOctalDecimalIntegerLiteral`.

The MV of `NonOctalDecimalIntegerLiteral :: 0 NonOctalDigit` is the MV of `NonOctalDigit`.

The MV of `NonOctalDecimalIntegerLiteral :: LegacyOctalLikeDecimalIntegerLiteral NonOctalDigit` is (the MV of `LegacyOctalLikeDecimalIntegerLiteral` times 10) plus the MV of `NonOctalDigit`.

The MV of `NonOctalDecimalIntegerLiteral :: NonOctalDecimalIntegerLiteral DecimalDigit` is (the MV of `NonOctalDecimalIntegerLiteral` times 10) plus the MV of `DecimalDigit`.

The MV of `LegacyOctalLikeDecimalIntegerLiteral :: LegacyOctalLikeDecimalIntegerLiteral OctalDigit` is (the MV of `LegacyOctalLikeDecimalIntegerLiteral` times 10) plus the MV of `OctalDigit`.

The MV of `NonOctalDigit :: 8` is 8.

The MV of `NonOctalDigit :: 9` is 9.

B.1.2 String Literals

The syntax and semantics of 11.8.4 is extended as follows except that this extension is not allowed for strict mode code:

**Syntax**

```
EscapeSequence :: CharacterEscapeSequence
                   LegacyOctalEscapeSequence
                   HexEscapeSequence
                   UnicodeEscapeSequence

LegacyOctalEscapeSequence ::
  OctalDigit [lookahead ≠ OctalDigit]
  ZeroToThree OctalDigit [lookahead ≠ OctalDigit]
  FourToSeven OctalDigit
  ZeroToThree OctalDigit OctalDigit

ZeroToThree :: one of
              0 1 2 3

FourToSeven :: one of
              4 5 6 7
```

This definition of `EscapeSequence` is not used when parsing `TemplateCharacter` (11.8.6).

**B.1.2.1 Static Semantics**

- The SV of `EscapeSequence :: LegacyOctalEscapeSequence` is the SV of the `LegacyOctalEscapeSequence`.
- The SV of `LegacyOctalEscapeSequence :: OctalDigit` is code unit whose value is the MV of the `OctalDigit`.
- The SV of `LegacyOctalEscapeSequence :: ZeroToThree OctalDigit` is the code unit whose value is (8 times the MV of the `ZeroToThree`) plus the MV of the `OctalDigit`.
- The SV of `LegacyOctalEscapeSequence :: FourToSeven OctalDigit` is the code unit whose value is (8 times the MV of the `FourToSeven`) plus the MV of the `OctalDigit`. 
• The SV of LegacyOctalEscapeSequence :: ZeroToThree OctalDigit OctalDigit is the code unit whose value is \((64 \text{ (that is, } 8^2) \text{ times the MV of the ZeroToThree}) \text{ 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

The syntax and semantics of 11.4 is extended as follows except that this extension is not allowed within module code:

**Syntax**

Comment ::
   MultiLineComment
   SingleLineComment
   SingleLineHTMLOpenComment
   SingleLineHTMLCloseComment
   SingleLineDelimitedComment

MultiLineComment ::
   /* FirstCommentLine opt LineTerminator MultiLineCommentChars opt */ HTMLCloseComment

FirstCommentLine ::
   SingleLineDelimitedCommentChars

SingleLineHTMLOpenComment ::
   <!-- SingleLineCommentChars opt

SingleLineHTMLCloseComment ::
   LineTerminatorSequence HTMLCloseComment

SingleLineDelimitedComment ::
   /* SingleLineDelimitedCommentChars opt */

HTMLCloseComment ::
   WhiteSpaceSequence opt SingleLineDelimitedCommentSequence opt --> SingleLineCommentChars opt

SingleLineDelimitedCommentChars ::
   SingleLineNotAsteriskChar SingleLineDelimitedCommentChars opt
   * SingleLinePostAsteriskCommentChars opt

SingleLineNotAsteriskChar ::
   SourceCharacter **not one of \* or LineTerminator**
SingleLinePostAsteriskCommentChars ::
    SingleLineNotForwardSlashOrAsteriskChar SingleLineDelimitedCommentChars
    * SingleLinePostAsteriskCommentChars

SingleLineNotForwardSlashOrAsteriskChar ::
    SourceCharacter but not one of / or * or LineTerminator

WhiteSpaceSequence ::
    WhiteSpace WhiteSpaceSequence

SingleLineDelimitedCommentSequence ::
    SingleLineDelimitedComment WhiteSpaceSequence SingleLineDelimitedCommentSequence

Similar to a MultiLineComment that contains a line terminator code point, a SingleLineHTMLCloseComment is considered to be a LineTerminator for purposes of parsing by the syntactic grammar.

B.1.4 Regular Expressions Patterns

The syntax of 21.2.1 is modified and extended as follows. These changes introduce ambiguities that are broken by the ordering of grammar productions and by contextual information. When parsing using the following grammar, each alternative is considered only if previous production alternatives do not match.

This alternative pattern grammar and semantics only changes the syntax and semantics of BMP patterns. The following grammar extensions include productions parameterized with the [U] parameter. However, none of these extensions change the syntax of Unicode patterns recognized when parsing with the [U] parameter present on the goal symbol.

Syntax

Term[U] ::
    [+U] ExtendedTerm
    [+U] Assertion
    [+U] Atom
    [+U] AtomNoBrace Quantifier

ExtendedTerm ::
    Assertion
    AtomNoBrace Quantifier
    Atom
    QuantifiableAssertion Quantifier

AtomNoBrace ::
    PatternCharacterNoBrace
    .
    \ AtomEscape
    CharacterClass
    ( Disjunction )
    ( ? : Disjunction )
Atom\[U\] ::
  PatternCharacter
  .
  \ AtomEscape\[U\]
 CharacterClass\[U\]
  ( Disjunction\[U\] )
  ( ? : Disjunction\[U\] )

PatternCharacterNoBrace ::
  SourceCharacter but not one of
  ^ $ \ . * ? ( ) [ ] { } |

PatternCharacter ::
  SourceCharacter but not one of
  ^ $ \ . * ? ( ) [ ] |

QuantifiableAssertion ::
  ( ? = Disjunction )
  ( ? ! Disjunction )

Assertion\[U\] ::
  ^
  \ b
  \ B
  [+U] ( ? = Disjunction\[U\] )
  [+U] ( ? ! Disjunction\[U\] )
  [-U] QuantifiableAssertion

AtomEscape\[U\] ::
  [+U] DecimalEscape
  [+U] CharacterEscape\[U\]
  [+U] CharacterClassEscape
  [-U] DecimalEscape but only if the integer value of DecimalEscape is <= NCapturingParens
  [-U] CharacterClassEscape
  [-U] CharacterEscape

CharacterEscape\[U\] ::
  ControlEscape
  c ControlLetter
  HexEscapeSequence
  RegExpUnicodeEscapeSequence\[U\]
  [-U] LegacyOctalEscapeSequence
  IdentityEscape\[U\]

IdentityEscape\[U\] ::
  [+U] SyntaxCharacter
  [-U] SourceCharacter but not c
NonemptyClassRanges{U} ::
    ClassAtom{U}
    ClassAtom{U} NonemptyClassRangesNoDash{U}
    [+U] ClassAtom{U} = ClassAtom{U} ClassRanges{U}
    [-U] ClassAtomInRange = ClassAtomInRange ClassRanges

NonemptyClassRangesNoDash{U} ::
    ClassAtom{U}
    ClassAtomNoDash{U} NonemptyClassRangesNoDash{U}
    [+U] ClassAtomNoDash{U} = ClassAtomNoDash{U} ClassRanges{U}
    [-U] ClassAtomNoDashInRange = ClassAtomNoDashInRange ClassRanges

ClassAtom{U} ::
    =
    ClassAtomNoDash{U}

ClassAtomNoDash{U} ::
    SourceCharacter but not one of \ or ] or -
    \ ClassEscape{U}

ClassAtomInRange ::
    =
    ClassAtomNoDashInRange

ClassAtomNoDashInRange ::
    SourceCharacter but not one of \ or ] or -
    \ ClassEscape but only if ClassEscape evaluates to a CharSet with exactly one character
    \ IdentityEscape

ClassEscape{U} ::
    [+U] DecimalEscape
    [+U] CharacterEscape{U}
    [+U] CharacterClassEscape
    [-U] DecimalEscape but only if the integer value of DecimalEscape is <= NCapturingParens
    b
    [-U] CharacterClassEscape
    [-U] CharacterEscape

B.1.4.1 Pattern Semantics

The semantics of 21.2.2 is extended as follows:

Within 21.2.2.5 reference to "Atom :: ( Disjunction )" are to be interpreted as meaning "Atom :: ( Disjunction ) or AtomNoBrace :: ( Disjunction )".

Term (21.2.2.5) includes the following additional evaluation rule:

The production Term :: QuantifiableAssertion Quantifier evaluates the same as the production Term :: Atom Quantifier but with QuantifiableAssertion substituted for Atom.
Atom (21.2.2.8) evaluation rules for the Atom productions except for Atom :: PatternCharacter are also used for the AtomNoBrace productions, but with AtomNoBrace substituted for Atom. The following evaluation rule is also added:

The production AtomNoBrace :: PatternCharacterNoBrace evaluates as follows:

1. Let \( ch \) be the character represented by PatternCharacterNoBrace.
2. Let \( A \) be a one-element CharSet containing the character \( ch \).
3. Call CharacterSetMatcher(\( A \), \text{false}) and return its Matcher result.

CharacterEscape (21.2.2.10) includes the following additional evaluation rule:

The production CharacterEscape :: LegacyOctalEscapeSequence evaluates by evaluating the SV of the LegacyOctalEscapeSequence (see B.1.2) and returning its character result.

ClassAtom (21.2.2.17) includes the following additional evaluation rules:

The production ClassAtomInRange :: – evaluates by returning the CharSet containing the one character –.

The production ClassAtomInRange :: ClassAtomNoDashInRange evaluates by evaluating ClassAtomNoDashInRange to obtain a CharSet and returning that CharSet.

ClassAtomNoDash (21.2.2.18) includes the following additional evaluation rules:

The production ClassAtomNoDashInRange :: SourceCharacter but not one of \( \backslash \text{ or } \) or – evaluates by returning a one-element CharSet containing the character represented by SourceCharacter.

The production ClassAtomNoDashInRange :: \( \backslash \text{ ClassEscape but only if...} \) evaluates by evaluating ClassEscape to obtain a CharSet and returning that CharSet.

The production ClassAtomNoDashInRange :: \( \backslash \text{ IdentityEscape} \) evaluates by returning the character represented by IdentityEscape.

B.2 Additional Built-in 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 code units have been replaced by a hexadecimal escape sequence.

For those code units being replaced whose value is \( \text{U+00FF} \) 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 \( \text{U+00FF} \), a four-digit escape sequence of the form \( \%uxxxx \) is used.

When the escape function is called with one argument \text{string}, the following steps are taken:
1. Let \textit{string} be \texttt{ToString(string)}.
2. ReturnIfAbrupt(string).
3. Let \textit{length} be the number of code units in \textit{string}.
4. Let \textit{R} be the empty string.
5. Let \textit{k} be 0.
6. Repeat, while \textit{k} < \textit{length},
   a. Let \textit{char} be the code unit (represented as a 16-bit unsigned integer) at index \textit{k} within \textit{string}.
   b. If \textit{char} is the code point of one of the 69 nonblank code units in "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789@*_+-./", then
      i. Let \textit{S} be a String containing the single code unit \textit{char}.
   c. Else if \textit{char} ≥ 256, then
      i. Let \textit{S} be a String containing six code units "%\textit{wxyz}" where \textit{wxyz} are the code units of the four hexadecimal digits encoding the value of \textit{char}.
   d. Else, \textit{char} < 256
      i. Let \textit{S} be a String containing three code units "%\textit{xy}" where \textit{xy} are the code units of two hexadecimal digits encoding the value of \textit{char}.
   e. Let \textit{R} be a new String value computed by concatenating the previous value of \textit{R} and \textit{S}.
   f. Increase \textit{k} by 1.
7. Return \textit{R}.

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 \texttt{unescape (string)}

The \texttt{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 \texttt{escape} function is replaced with the code unit that it represents.

When the \texttt{unescape} function is called with one argument \textit{string}, the following steps are taken:

1. Let \textit{string} be \texttt{ToString(string)}.
2. ReturnIfAbrupt(string).
3. Let \textit{length} be the number of code units in \textit{string}.
4. Let \textit{R} be the empty String.
5. Let \textit{k} be 0.
6. Repeat, while \textit{k} ≠ \textit{length},
   a. Let \textit{c} be the code unit at index \textit{k} within \textit{string}.
   b. If \textit{c} is %,
      i. If \textit{k} ≤ \textit{length}−6 and the code unit at index \textit{k}+1 within \textit{string} is \texttt{u} and the four code units at indices \textit{k}+2, \textit{k}+3, \textit{k}+4, and \textit{k}+5 within \textit{string} are all hexadecimal digits, then
         1. Let \textit{c} be the code unit whose value is the integer represented by the four hexadecimal digits at indices \textit{k}+2, \textit{k}+3, \textit{k}+4, and \textit{k}+5 within \textit{string}.
         2. Increase \textit{k} by 5.
      ii. Else if \textit{k} ≤ \textit{length}−3 and the two code units at indices \textit{k}+1 and \textit{k}+2 within \textit{string} are both hexadecimal digits, then
         1. Let \textit{c} be the code unit whose value is the integer represented by two zeroes plus the two hexadecimal digits at indices \textit{k}+1 and \textit{k}+2 within \textit{string}.
         2. Increase \textit{k} by 2.
   c. Let \textit{R} be a new String value computed by concatenating the previous value of \textit{R} and \textit{c}.
d. Increase \( k \) by 1.

7. Return \( R \).

### 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.

##### B.2.2.1.1 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 result of calling ToObject passing the \( this \) value as the argument.
2. ReturnIfAbrupt(\( O \)).
3. Return the result of calling the `[[GetPrototypeOf]]` internal method of \( O \).

##### B.2.2.1.2 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 RequireObjectCoercible(\( this \) value).
2. ReturnIfAbrupt(\( O \)).
3. If Type(\( proto \)) is neither Object nor Null, return undefined.
4. If Type(\( O \)) is not Object, return undefined.
5. Let \( status \) be the result of calling the `[[SetPrototypeOf]]` internal method of \( O \) with argument \( proto \).
6. ReturnIfAbrupt(\( status \)).
7. If \( status \) is false, throw a TypeError exception.
8. Return undefined.

### 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 index `start` and running for `length` code units (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 RequireObjectCoercible(\( this \) value).
2. Let \( S \) be ToString(\( O \)).
3. ReturnIfAbrupt(\( S \)).
4. Let `intStart` be ToInteger(`start`).
5. ReturnIfAbrupt(`intStart`).
6. If `length` is undefined, let `end` be `+\infty`; otherwise let `end` be ToInteger(`length`).
7. ReturnIfAbrupt(`end`).
8. Let `size` be the number of code units in `\( S \)`.  
9. If `intStart` < 0, let `intStart` be `max(size + intStart,0)`.
10. Let resultLength be `min(max(end,0), size - intStart)`.
11. If `resultLength` \(\leq 0\), return the empty String \\
   "".
12. Return a String containing `resultLength` consecutive code units from \\
   `S` beginning with the code unit at index `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 `CreateHTML(S, "a", "name", name)`.

**B.2.3.2.1** **CreateHTML (string, tag, attribute, value) Abstract Operation**

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 `RequireObjectCoercible(string)`.
2. Let `S` be `ToString(str)`.
3. ReturnIfAbrupt(S).
4. Let `p1` be the string value that is the concatenation of \\
   "<" and `tag`.
5. If `attribute` is not the empty String, then
   a. Let `V` be `ToString(value)`.
   b. ReturnIfAbrupt(V).
   c. Let `escapedV` be the string value that is the same as `V` except \\
      that each occurrence of the code 
      unit U+0022 (QUOTATION MARK) in `V` has been replaced with 
      the six code unit sequence 
      "&quot;.
   d. Let `p1` be the string value that is the concatenation of the following 
      string values:
      - The string value of `p1`
      - Code unit U+0020 (SPACE)
      - The string value of `attribute`
      - Code unit U+003D (EQUALS SIGN)
      - Code unit U+0022 (QUOTATION MARK)
      - The string value of `escapedV`
      - Code unit U+0022 (QUOTATION MARK)
   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 
      ">".

**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 `CreateHTML(S, "big", "", ")`.
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 `CreateHTML(S, "blink", ", "").`

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 `CreateHTML(S, "b", ", "").`
B.2.3.12 String.prototype.strike()

When the `strike` method is called with no arguments, the following steps are taken:

1. Let $S$ be the this value.
2. Return `CreateHTML($S, "strike", ", ", ")`.

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 `CreateHTML($S, "sub", ", ", ")`.

B.2.3.14 String.prototype.sup()

When the `sup` method is called with no arguments, the following steps are taken:

1. Let $S$ be the this value.
2. Return `CreateHTML($S, "sup", ", ", ")`.

B.2.4 Additional Properties of the Date.prototype Object

B.2.4.1 Date.prototype.getYear()

NOTE The `getFullYear` method is preferred for nearly all purposes, because it avoids the "year 2000 problem."

When the `getYear` method is called with no arguments, the following steps are taken:

1. Let $t$ be this time value.
2. ReturnIfAbrupt($t).
3. If $t$ is NaN, return NaN.
4. Return YearFromTime(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 LocalTime(this time value); but if this time value is NaN, let $t$ be +0.
2. Let $y$ be ToNumber(year).
3. ReturnIfAbrupt($y).
4. If $y$ is NaN, set the [[DateValue]] internal slot of this Date object to NaN and return NaN.
5. If $y$ is not NaN and $0 \leq $y$ \leq 99, let yyyy be $y$ + 1900.
6. Else, let yyyy be $y$.
7. Let $d$ be MakeDay(yyy, MonthFromTime(t), DateFromTime(t)).
8. Let `date` be UTC(MakeDate($d$, TimeWithinDay($t$))).
9. Set the [[DateValue]] internal slot of this Date object to TimeClip($date$).
10. Return the value of the [[DateValue]] internal slot of this Date object.
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 arguments pattern and flags, 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 slot, then
   a. Throw a TypeError exception.
3. If Type(pattern) is Object and pattern has a [[RegExpMatcher]] internal slot, then
   a. If flags is not undefined, throw a TypeError exception.
   b. Let P be the value of pattern’s [[OriginalSource]] internal slot.
   c. Let F be the value of pattern’s [[OriginalFlags]] internal slot.
4. Else,
   a. Let P be pattern.
   b. Let F be flags.

NOTE  The compile method completely reinitializes the this object RegExp with a new pattern and flags. An implementation 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 Initializers

The following Early Error rule is added to those in 12.2.5.1:

ObjectLiteral : { PropertyDefinitionList } 

and

ObjectLiteral : { PropertyDefinitionList , } 

- It is a Syntax Error if PropertyNameList of PropertyDefinitionList contains any duplicate entries for "__proto__" and at least two of those entries were obtained from productions of the form PropertyDefinition : PropertyName : AssignmentExpression.

NOTE  The List returned by PropertyNameList does not include string literal property names defined as using a ComputedPropertyName.

In 12.2.5.9 the PropertyDefinitionEvaluation algorithm for the production PropertyDefinition : PropertyName : AssignmentExpression is replaced with the following definition:
PropertyDefinition : PropertyName : AssignmentExpression

1. Let propKey be the result of evaluating PropertyName.
2. ReturnIfAbrupt(propKey).
3. Let exprValueRef be the result of evaluating AssignmentExpression.
4. Let propValue be GetValue(exprValueRef).
5. ReturnIfAbrupt(propValue).
6. If propKey is the string value "__proto__" and if IsComputedPropertyKey(propKey) is false, then
   a. If Type(propValue) is either Object or Null, then
      i. Return the result of calling the [[SetPrototypeOf]] internal method of object with argument propValue.
   b. Return NormalCompletion(empty).
7. If IsFunctionDefinition of AssignmentExpression is true, then
   a. Assert: propValue is an ECMAScript function object.
   b. Let referencesSuper be the value of propValue’s [[NeedsSuper]] internal slot.
   c. Let thisMode be the value of propValue’s [[ThisMode]] internal slot.
   d. If thisMode is not lexical and referencesSuper is true, then
      i. If propValue’s [[HomeObject]] internal slot is undefined, then
         1. Assert: AssignmentExpression is not a class definition whose constructor references super.
      2. Set the propValue’s [[HomeObject]] internal slot to object.
   e. If IsAnonymousFunctionDefinition(AssignmentExpression) is true, then
      i. Let hasNameProperty be HasOwnProperty(propValue, "name").
      ii. ReturnIfAbrupt(hasNameProperty).
      iii. If hasNameProperty is false, perform SetFunctionName(propValue, propKey).
8. Assert: enumerable is true.
9. Return CreateDataPropertyOrThrow(object, propKey, propValue).

B.3.2 Labelled Function Declarations

Prior to the Sixth Edition, the ECMAScript specification LabelledStatement did not allow for the association of a statement label with a FunctionDeclaration. However, a labelled FunctionDeclaration was an allowable extension for non-strict mode code and most browser-hosted ECMAScript implementations supported that extension. In the Sixth Edition, the grammar productions for LabelledStatement permits use of FunctionDeclaration as a LabelledItem but 13.12.1 includes an Early Error rule that produces a Syntax Error if that occurs. For web browser compatibility, that rule is modified with the addition of the underlined text:

LabelledItem : FunctionDeclaration

- It is a Syntax Error if any strict mode source code matches this rule.

B.3.3 Block-Level Function Declarations Web Legacy Compatibility Semantics

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. Unfortunately, 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 \( f \)'s shadow 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 semantics of Block-level function declarations provided
by ECMA-262 Edition 6. Any pre-existing ECMAScript code that employees that use case will operate using
the Block level function declarations semantics defined by clauses 9, 13, and 14 of this specification.

Sixth edition interoperability for the second and third use cases requires the following extensions to the
clause 9 and clause 14 semantics. These extensions are applied to each non-strict mode function \( g \) for each
FunctionDeclaration \( f \) that is directly contained in the StatementList of a Block, CaseClause, or
DefaultClause that is part of the function code of \( g \)

1. Let \( F \) be StringValue of the BindingIdentifier of FunctionDeclaration \( f \).
2. If replacing the FunctionDeclaration \( f \) with a VariableStatement that has \( F \) as a BindingIdentifier
   would not produce any Early Errors for \( g \) and \( F \) is not an element of BoundNames of
   FormalParameters of \( g \), then
   a. During FunctionDeclarationInstantiation (9.2.13) for \( g \) perform the following steps immediately
      before performing step 27:
      i. NOTE A var binding for \( F \) is only instantiated here if it is neither a VarDeclaredName, the
         name of a formal parameter, or another FunctionDeclarations.
      ii. If instantiatedVarNames does not contain \( F \), then
        1. Let status be the result of calling \( \text{varEnvRec}'s \) CreateMutableBinding concrete method
           passing \( F \) as the argument.
        2. Assert: status is never an abrupt completion.
        3. Call the InitializeBinding concrete method of \( \text{varEnvRec} \) with arguments \( F \) and
           undefined.
        4. Append \( F \) to instantiatedVarNames.
   b. In place of the FunctionDeclaration Evaluation algorithm provided in 14.1.23, perform the
      following steps to evaluate the FunctionDeclaration \( f \):
1. Let `fenv` be the running execution context’s `VariableEnvironment`.
2. Let `benv` be the running execution context’s `LexicalEnvironment`.
3. Let `fobj` be the result of calling the `GetBindingValue` concrete method of `benv` with arguments `F` and `false`.
4. ReturnIfAbrupt(`fobj`).
5. Let `status` be the result of calling `fenv`’s `SetMutableBinding` concrete method with arguments `F`, `fobj`, and `false`.
6. Assert: `status` is never an abrupt completion.
7. Return NormalCompletion(`empty`).

If an ECMAScript implementation has a mechanism for reporting diagnostic warning messages, a warning should be produced for each function `g` whose function code contains a `FunctionDeclaration` for which steps 2.a and 2.b above will be performed.

B.3.4 FunctionDeclarations in IfStatement Statement Clauses

The following rules for `IfStatement` augment those in 13.5:

```plaintext
IfStatement[Yield, Return] :
  if ( Expression[Yield] ) FunctionDeclaration[Yield] else FunctionDeclaration[Yield]
```

The above rules are only applied when parsing non-strict mode code. If any non-strict code is match by one of these rules subsequent processing of that code takes places as if each matching occurrence of `FunctionDeclaration` was the sole `StatementListItem` of a `BlockStatement` occupying that position in the source code. The semantics of such a synthetic `BlockStatement` includes the web legacy compatibility semantics specified in B.3.3.

B.3.5 VariableStatements in Catch blocks

The content of subclause 13.14.1 is replaced with the following:

```
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`, unless that element is only bound by a `VariableStatement` or the `VariableDeclarationList` of a `for` statement, or the `ForBinding` of a `for-in` statement.

NOTE The `Block` of a `Catch` clause may contain `var` declarations that bind a name that is also bound by the `CatchParameter`. At runtime, such bindings are instantiated in the `VariableDeclarationEnvironment`. They do not shadow the same-named bindings introduced by the `CatchParameter` and hence the `Initializer` for such `var` declarations will assign to the corresponding catch parameter rather than the `var` binding. The relaxation of the normal static semantic rule does not apply to names only bound by for-of statements.
Annex C
(informative)

The Strict Mode of ECMAScript

The strict mode restriction and exceptions

- "implements", "interface", "let", "package", "private", "protected", "public", "static", and "yield" are reserved words within strict mode code (11.6.2.2).
- A conforming implementation, when processing strict mode code, may not extend the syntax of NumericLiteral (11.8.3) to include LegacyOctalIntegerLiteral as described in B.1.1.
- A conforming implementation, when processing strict mode code (see 10.2.1), may not extend the syntax of EscapeSequence to include LegacyOctalEscapeSequence 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 (6.2.3.2). 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 slot has the value false. In these cases a TypeError exception is thrown (12.14).
- The identifier eval or arguments may not appear as the LeftHandSideExpression of an Assignment operator (12.14) or of a PostfixExpression (12.14) or as the UnaryExpression operated upon by a Prefix Increment (12.5.7) or a Prefix Decrement (12.5.8) operator.
- Arguments objects for strict mode functions define non-configurable accessor properties named "caller" and "callee" which throw a TypeError exception on access (9.2.8).
- Arguments objects for strict mode functions do not dynamically share their array indexed property values with the corresponding formal parameter bindings of their functions. (9.4.4).
- 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. (9.2.13).
- It is a SyntaxError if the IdentifierName eval or the IdentifierName arguments occurs as a BindingIdentifier within strict mode code (12.1.1).
- 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 (18.2.1).
- 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 (8.3.2, 12.2.1, 19.2.3.1, 19.2.3.3).

Comment [AWB1853]: This entire section needs to be updated to include strict mode restrictions that apply to new ES6 features.

Deleted: Use of the identifiers

Deleted: and

Deleted: is prohibited
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 (12.5.4).

When a `delete` operator occurs within strict mode code, a `TypeError` is thrown if the property to be deleted has the attribute `{[[Configurable]]:false}` (12.5.4).

Strict mode code may not include a `WithStatement`. The occurrence of a `WithStatement` in such a context is a `SyntaxError` (13.10).

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` (13.14).

It is a `SyntaxError` if the same `BindingIdentifier` appears more than once in the `FormalParameters` of a strict mode function. An attempt to create such a function using a `Function` or `Generator` constructor is a `SyntaxError` (14.1.2, 19.2.1, 25.2.1).

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 (9.2.1, 9.4.4).
Annex D
(informative)

Corrections and Clarifications with Possible Compatibility Impact

D.1 In Edition 6

9.1.4.2.1, 9.1.4.2.2: The 5th Edition moved the capture of the current array length prior to the integer conversion of the array index or new length value. However, the captured length value could become invalid if the conversion process has the side-effect of changing the array length. The 6th Edition specifies that the current array length must be captured after the possible occurrence of such side-effects.

20.3.1.14: 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.

20.3.1.15: 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".

20.3.4.36: If the year cannot be represented using the Date Time String Format specified in 20.3.1.15 a RangeError exception is thrown. Previous editions did not specify the behaviour for that case.

20.3.4.41: 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".

21.2.3.1, 21.2.3.3.4: If any LineTerminator code points in the value of the source property of an RegExp instance must be expressed using an escape sequence. Edition 5.1 only required the escaping of "/".

21.2.5.6, 21.2.5.8: In previous editions, the specifications for String.prototype.match and String.prototype.replace was incorrect for cases where the pattern argument was a RegExp value whose global is flag set. The previous specifications stated that for each attempt to match the pattern, if lastIndex did not change it should be incremented by 1. The correct behaviour is that lastIndex should be incremented by one only if the pattern matched the empty string.

22.1.3.24, 22.1.3.24.1: Previous editions did not specify how a NaN value returned by a comparefn was interpreted by Array.prototype.sort. Edition 6 specifies that such as value is treated as if +0 was returned from the comparefn.

D.2 In Edition 5.1

Clause references in this list refer to the clause numbers used 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: Steps 5 and 7 of Edition 5 algorithm have been deleted because they imposed requirements upon the aryArray argument that are inconsistent with other uses of generic array-like objects.

15.4.3.12: In step 9.a, incorrect reference to relativeStart was replaced with a reference to actualStart.

15.4.3.15: Clarified that the default value for fromIndex is the length minus 1 of the array.

15.4.3.18: In step 10 (corresponding to step 8 in 5.1) of the algorithm, **undefined** is now the specified return value.

15.4.3.22: In step 11.d.iii (corresponding to 9.c.ii in 5.1) the first argument to the [[Call]] internal method has been changed to **undefined** for consistency with the definition of Array.prototype.reduce.

15.4.5.1: In Algorithm steps 3.l.ii and 3.l.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 JA abstract operation, the last element of the concatenation is “}”.

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.

D.3 In Edition 5

Clause references in this list refer to the clause numbers used 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.

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.

11.1.4: Edition 5 clarifies the fact that a trailing comma at the end of an ArrayLiteral 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 \texttt{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.
Annex E
(informative)

Additions and Changes That Introduce Incompatibilities with Prior Editions

E.1 In the 6th Edition

7.1.3.1: In Edition 6, ToNumber applied to a String value now recognizes and converts `BinaryIntegerLiteral` and `OctalIntegerLiteral` numeric strings. In previous editions such strings were converted to `NaN`.

11: In Edition 6, Function calls are not allowed to return a Reference value.

12.2.5.1: In Edition 6, it is no longer an early error to have duplicate property names in Object Initializers.

12.14.1: In Edition 6, strict mode code containing an assignment to an immutable binding such as the function name of a `FunctionExpression` does not produce an early error. Instead it produces a runtime error.

13.4: In Edition 6, a `StatementListItem` beginning with the token `let` followed by the token `if` is the start of a `LexicalDeclaration`. In previous editions such a sequence would be the start of an `ExpressionStatement`.

13.6: In Edition 6, a terminating semi-colon is no longer required at the end of a do-while statement.

13.6: Prior to Edition 6, an initialization expression could appear as part of the `VariableDeclaration` that precedes the `in` keyword. The value of that expression was always discarded. In Edition 6, the `ForBind in` that same position does not allow the occurrence of such an initializer.

13.14: In Edition 6, it is an early error for a `Catch` clause to contained 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.

14.3.9 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 and they do not have a `prototype` own property. In Edition 5, they were constructors and had a `prototype` property.

19.1.2.5: In Edition 6, if the argument to `Object.freeze` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.6: In Edition 6, if the argument to `Object.getOwnPropertyDescriptor` is not an object an attempt is made to coerce the argument using `ToObject`. If the coercion is successful the result is used in place of the original argument value. In Edition 5, a non-object argument always causes a `TypeError` to be thrown.
19.1.2.7: In Edition 6, if the argument to \texttt{Object.getOwnPropertyNames} is not an object an attempt is made to coerce the argument using ToObject. If the coercion is successful the result is used in place of the original argument value. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.9: In Edition 6, if the argument to \texttt{Object.getPrototypeOf} is not an object an attempt is made to coerce the argument using ToObject. If the coercion is successful the result is used in place of the original argument value. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.11: In Edition 6, if the argument to \texttt{Object.isExtensible} is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.12: In Edition 6, if the argument to \texttt{Object.isFrozen} is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.13: In Edition 6, if the argument to \texttt{Object.isSealed} is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.14: In Edition 6, if the argument to \texttt{Object.keys} is not an object an attempt is made to coerce the argument using ToObject. If the coercion is successful the result is used in place of the original argument value. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.15: In Edition 6, if the argument to \texttt{Object.preventExtensions} is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.1.2.17: In Edition 6, if the argument to \texttt{Object.seal} is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In Edition 5, a non-object argument always causes a \texttt{TypeError} to be thrown.

19.2.4.1: In Edition 6, the \texttt{length} property of function instances is configurable. In previous editions it was non-configurable.

19.3.3: In Edition 6, the Boolean prototype object is not a Boolean instance. In previous editions it was a Boolean instance whose Boolean value was \texttt{false}.

19.5.6.2: In Edition 6, the \texttt{[[Prototype]]} internal slot of a \texttt{NativeError} constructor is the \texttt{Error} constructor. In previous editions it was the Function prototype object.

20.1.3 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.

20.3.4 In Edition 6, the Date prototype object is not a Date instance. In previous editions it was a Date instance whose TimeValue was NaN.

22.1.3 In Edition 6, the Array prototype object is not an Array instance. In previous editions it was an Array instance with a length property whose value was +0.
21.1.3 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.

21.1.3.22 and 21.1.3.24 In Edition 6, lowercase/uppercase conversion processing operates on code points. In previous editions such the conversion processing was only applied to individual code units. The only affected code points are those in the Deseret block of Unicode.

21.1.3.25 In Edition 6, the `String.prototype.trim` method is defined to recognize white space code points that may exists outside of the Unicode BMP. However, as of Unicode 6.1 no such code points are defined. In previous editions such code points would not have been recognized as white space.

21.2.3.1 In Edition 6, if the `pattern` argument is a RegExp instance and the `flags` argument is not `undefined`, a new RegExp instance is created just like `pattern` except that `pattern`'s flags are replaced by the argument `flags`. In previous editions a `TypeError` exception was thrown when `pattern` was a RegExp instance and `flags` was not `undefined`.

21.2.5 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.

21.2.5 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.

22.1.3 In Edition 6, the Array prototype object is not an Array instance. In previous editions it was an Array instance with a length property whose value was +0.

E.2 In the 5th Edition

Clause references in this list refer to the clause numbers used in Edition 5 and 5.1.

7.1: Unicode format control \s 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 `<ZWNBSP>` 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.

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 slot 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.toString`, `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 as octal values.

15.3.3: 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.

15.3.3, 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 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.

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.

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 <ZWNBSP>.

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.
Bibliography


