ECMAScript® 2016
Language Specification
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20.3.5 Properties of Date Instances

21 Text Processing

21.1 String Objects

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21.1.2 Properties of the String Constructor

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21.1.3 Properties of the String Prototype Object

21.1.3.1 String.prototype.charAt ( pos )
21.1.3.2 String.prototype.charCodeAt ( pos )
21.1.3.3 String.prototype.codePointAt ( pos )
21.1.3.4 String.prototype.concat ( ...args )
21.1.3.5 String.prototype.constructor
21.1.3.6 String.prototype.endsWith ( searchString [ , endPosition ] )
21.1.3.7 String.prototype.includes ( searchString [ , position ] )
21.1.3.8 String.prototype.indexOf ( searchString [ , position ] )
21.1.3.9 String.prototype.lastIndexOf ( searchString [ , position ] )
21.1.3.10 String.prototype.localeCompare ( that [ , reserved1 [ , reserved2 ] ] )
21.1.3.11 String.prototype.match ( regexp )
21.1.3.12 String.prototype.normalize ([form])
21.1.3.13 String.prototype.repeat (count)
21.1.3.14 String.prototype.replace (searchValue, replaceValue)
   21.1.3.14.1 RS: GetSubstitution(matched, str, position, captures, replacement)
21.1.3.15 String.prototype.search (regexp)
21.1.3.16 String.prototype.slice (start, end)
21.1.3.17 String.prototype.split (separator, limit)
   21.1.3.17.1 RS: SplitMatch (S, q, R)
21.1.3.18 String.prototype.startsWith (searchString[, position])
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21.1.3.20 String.prototype.toLocaleLowerCase ([reserved1[, reserved2]])
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22.1.3.26 Array.prototype.splice (start, deleteCount, ...items)
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22.1.4 Properties of Array Instances
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22.2.3.4 %TypedArray%.prototype.constructor
22.2.3.5 %TypedArray%.prototype.copyWithin (target, start [ , end ])
22.2.3.5.1 RS: ValidateTypedArray ( O )
22.2.3.6 %TypedArray%.prototype.entries ()
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22.2.3.16 %TypedArray%.prototype.keys ( )
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22.2.3.20 %TypedArray%.prototype.reduce ( callbackfn [ , initialValue ] )
22.2.3.21 %TypedArray%.prototype.reduceRight ( callbackfn [ , initialValue ] )
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22.2.3.25 %TypedArray%.prototype.some ( callbackfn [ , thisArg ] )
22.2.3.26 %TypedArray%.prototype.sort ( comparefn )
22.2.3.27 %TypedArray%.prototype.subarray ( begin , end )
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22.2.5 Properties of the TypedArray Constructors
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22.2.6 Properties of TypedArray Prototype Objects
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23.1.3.5 Map.prototype.forEach ( callbackfn [ , thisArg ] )
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23.1.3.7 Map.prototype.has (key)
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23.1.4 Properties of Map Instances

23.1.5 Map Iterator Objects

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23.1.5.3 Properties of Map Iterator Instances

23.2 Set Objects

23.2.1 The Set Constructor

23.2.1.1 Set ([iterable])

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23.2.3 Properties of the Set Prototype Object

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23.2.3.5 Set.prototype.entries ()
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23.2.4 Properties of Set Instances

23.2.5 Set Iterator Objects

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23.2.5.3 Properties of Set Iterator Instances

23.3 WeakMap Objects

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23.3.2.1 WeakMap.prototype

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23.3.4 Properties of WeakMap Instances

23.4 WeakSet Objects
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23.4.2.1 WeakSet.prototype

23.4.3 Properties of the WeakSet Prototype Object
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23.4.4 Properties of WeakSet Instances

24 Structured Data
24.1 ArrayBuffer Objects
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24.1.1.1 AllocateArrayBuffer ( constructor, byteLength )
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24.1.2 The ArrayBuffer Constructor
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24.1.3 Properties of the ArrayBuffer Constructor
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24.1.5 Properties of the ArrayBuffer Instances

24.2 DataView Objects
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24.2.2 The DataView Constructor
24.2.2.1 DataView ( buffer, byteOffset, byteLength )

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24.2.4 Properties of the DataView Prototype Object
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24.2.4.7 DataView.prototype.getInt8 ( byteOffset )
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24.2.4.10 DataView.prototype.getUint8 ( byteOffset )
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24.2.4.13 DataView.prototype.setFloat32 ( byteOffset, value [, littleEndian ] )
24.2.4.14 DataView.prototype.setFloat64 (byteOffset, value [, littleEndian])
24.2.4.15 DataView.prototype.setInt8 (byteOffset, value)
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24.2.4.21 DataView.prototype [@@toStringTag]

24.2.5 Properties of DataView Instances

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   24.3.2.1 RS: SerializeJSONProperty (key, holder)
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24.3.3 JSON [@@toStringTag]

25 Control Abstraction Objects

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25.3 Generator Objects
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Introduction

This Ecma Standard defines the ECMAScript 2016 Language. It is the seventh edition of the ECMAScript Language Specification. Since publication of the first edition in 1997, ECMAScript has grown to be one of the world’s most widely used general purpose programming languages. It is best known as the language embedded in web browsers but has also been widely adopted for server and embedded applications.

ECMAScript 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.


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


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 but some of it was incorporated into the development of the sixth edition.

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. The Fifth Edition was adopted by the Ecma General Assembly of December 2009.


Focused development of the sixth edition started in 2009, as the fifth edition was being prepared for publication. However, this was preceded by significant experimentation and language enhancement design efforts dating to the publication of the third edition in 1999. In a very real sense, the completion of the sixth edition is the culmination of a fifteen year effort. The goals for this addition included providing better support for large applications, library creation, and for use of ECMAScript as a compilation target for other languages. Some of its major enhancements included 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 was expanded to support additional data abstractions including maps, sets, and arrays of binary numeric values as well as additional support for Unicode supplemental characters in strings and regular expressions. The built-ins were also made extensible via subclassing. The sixth edition provides the foundation for regular, incremental language and library enhancements. The sixth edition was adopted by the General Assembly of June 2015.

This ECMAScript specification is the first ECMAScript edition released under Ecma TC39’s new yearly release cadence and open development process. A plain-text source document was built from the ECMAScript 2015 source document to serve as the base for further development entirely on GitHub. Over the year of this standard’s development, hundreds of pull requests
and issues were filed representing thousands of bug fixes, editorial fixes and other improvements. Additionally, numerous software tools were developed to aid in this effort including Ecmarkup, Ecmarkdown, and Grammarkdown. This specification also includes support for a new exponentiation operator and adds a new method to Array.prototype called `includes`.

Dozens of individuals representing many organizations have made very significant contributions within Ecma TC39 to the development of this edition and to the prior editions. In addition, a vibrant community has emerged supporting TC39’s ECMAScript efforts. This community has reviewed numerous drafts, filed thousands of bug reports, performed implementation experiments, contributed test suites, and educated the world-wide developer community about ECMAScript. Unfortunately, it is impossible to identify and acknowledge every person and organization who has contributed to this effort.

Allen Wirfs-Brock
ECMA-262, 6th Edition Project Editor

Brian Terlson
ECMA-262, 7th Edition Project Editor

1 Scope

This Standard defines the ECMAScript 2016 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 text input in conformance with the Unicode Standard, Version 8.0.0 or later and ISO/IEC 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 16.2.

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.


ECMA-402, ECMAScript 2015 Internationalization API Specification.
http://www.ecma-international.org/publications/standards/Ecma-402.htm
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.

Large ECMAScript programs are supported by modules which allow a program to 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

Even though ECMAScript includes syntax for class definitions, 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:

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. Beginning with ECMAScript 2015, 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 source text units. Because strict mode is selected at the level of a syntactic source text unit, strict mode only imposes restrictions that have local effect within such a source text unit. Strict mode does not restrict or modify any aspect of the ECMAScript semantics that must operate consistently across multiple source text units. A complete ECMAScript program may be composed of both
strict mode and non-strict mode ECMAScript source text units. In this case, strict mode only applies when actually executing code that is defined within a strict mode source text unit.

In order to conform to this specification, an ECMAScript implementation must implement both the full unrestricted ECMAScript language and the strict variant of the ECMAScript language as defined by this specification. In addition, an implementation must support the combination of unrestricted and strict mode source text 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

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).
4.3.20 **Number value**

primitive value corresponding to a double-precision 64-bit binary format IEEE 754-2008 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).

4.3.23 **Infinity**

number value that is the positive infinite number value

4.3.24 **NaN**

number value that is an IEEE 754-2008 “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**

part of an object that associates a key (either a String value or a Symbol value) and a 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`, `InputElementTemplateTail`, or `InputElementRegExp`, or `InputElementRegExpOrTemplateTail`, 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 form syntactically correct independent components of 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 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 specified, 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 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:

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

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:

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

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:

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

is a convenient abbreviation for:

\[
VariableDeclaration : \quad \text{BindingIdentifier} \\
\quad \text{BindingIdentifier \ Initializer}
\]

and that:

\[
IterationStatement : \quad \text{for} ( \text{LexicalDeclaration \ Expression}_{\text{opt}} ; \text{Expression}_{\text{opt}} ) \text{Statement}
\]

is a convenient abbreviation for:

\[
IterationStatement : \quad \text{for} ( \text{LexicalDeclaration} ; \text{Expression}_{\text{opt}} ) \text{Statement} \\
\quad \text{for} ( \text{LexicalDeclaration \ Expression} ; \text{Expression}_{\text{opt}} ) \text{Statement}
\]

which in turn is an abbreviation for:

\[
IterationStatement : \quad \text{for} ( \text{LexicalDeclaration} ; ) \text{Statement} \\
\quad \text{for} ( \text{LexicalDeclaration \ Expression} ) \text{Statement}
\]
for ( LexicalDeclaration 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[Return] :
  ReturnStatement
  ExpressionStatement

is a convenient abbreviation for:

StatementList :
  ReturnStatement
  ExpressionStatement

StatementList_Return :
  ReturnStatement
  ExpressionStatement

and that:

StatementList[Return, In] :
  ReturnStatement
  ExpressionStatement

is an abbreviation for:

StatementList :
  ReturnStatement
  ExpressionStatement

StatementList_Return :
  ReturnStatement
  ExpressionStatement

StatementList_In :
  ReturnStatement
  ExpressionStatement

StatementList_Return_In :
  ReturnStatement
  ExpressionStatement

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[In]

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

**VariableDeclaration** :

```
BindingIdentifier Initializer[In] opt
```

is an abbreviation for:

**VariableDeclaration** :

```
BindingIdentifier  
```

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[In]** :

```
BindingIdentifier  Initializer[?In]
```

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
```
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 ∉ 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 sequence is a member of the given set. The set can be written as a comma separated list of one or two element terminal sequences 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

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

DecimalDigits ::
    DecimalDigit
    DecimalDigits DecimalDigit
```

the definition

```
LookaheadExample ::
    n [lookahead ∉ { 1 , 3 , 5 , 7 , 9 }] DecimalDigits
    DecimalDigit [lookahead ∉ DecimalDigit]
```

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

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

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

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

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:

\[ \text{Identifier} :: \]
\[ \text{IdentifierName} \text{ but not ReservedWord} \]

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:

\[ \text{SourceCharacter} :: \]
\[ \text{any Unicode code point} \]

### 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. Abstract operations are typically referenced using a functional application style such as `operationName(arg1, arg2)`. Some abstract operations are treated as polymorphically dispatched methods of class-like specification abstractions. Such method-like abstract operations are typically referenced using a method application style such as `someValue.operationName(arg1, arg2)`.

Calls to abstract operations return Completion Records. Abstract operations referenced using the functional application style and the method application style that are prefixed by `?` indicate that `ReturnIfAbrupt` should be applied to the resulting Completion Record. For example, `?operationName()` is equivalent to `ReturnIfAbrupt(operationName())`. Similarly, `?someValue.operationName()` is equivalent to `ReturnIfAbrupt(someValue.operationName())`.

The prefix `!` is used to indicate that an abstract operation will never return an abrupt completion and that the resulting Completion Record’s value field should be used in place of the return value of the operation. For example, “Let val be `!operationName()`” is equivalent to the following algorithm steps:

1. Let `val` be `operationName()`.
2. Assert: `val` is never an abrupt completion.
3. If `val` is a Completion Record, let `val` be `val.[[Value]]`.

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 source text.

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:

```
Block : { StatementList }
```

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 unless otherwise noted 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 \( \text{min}(x_1, x_2, \ldots, x_N) \) produces the mathematically smallest of \( x_1 \) through \( x_N \). The mathematical function \( \text{max}(x_1, x_2, \ldots, x_N) \) produces the mathematically largest of \( x_1 \) through \( x_N \). The domain and range of these mathematical functions include \(+\infty\) and \(-\infty\).
The notation \( x \mod y \) (\( y \) 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 \( \text{floor}(x) = x-(x \mod 1) \).

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 Contains which takes an argument named symbol whose value is a terminal or nonterminal of the grammar that includes the associated production. The default definition of Contains is:

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

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

A special kind of static semantic rule is an Early Error Rule. Early error rules define early error conditions (see clause 16) that are 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 or Module, validate all of the early error rules of the productions used to parse that Script or Module. If any of the early error rules are violated the Script or Module 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 “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”.

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 undefined. Any variable that has not been assigned a value has the value undefined.
6.1.2 The Null Type

The Null type has exactly one value, called null.

6.1.3 The Boolean Type

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

6.1.4 The String Type

The String type is the set of all ordered sequences of zero or more 16-bit unsigned integer values (“elements”) up to a maximum length of $2^{53} - 1$ 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. The function `String.prototype.normalize` (see 21.1.3.12) can be used to explicitly normalize a String value. `String.prototype.localeCompare` (see 21.1.3.10) internally normalizes String values, but no other operations implicitly normalize the strings upon which they operate. Only operations that are explicitly specified to be language or locale sensitive produce language-sensitive results.

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

- A code unit in the range 0 to 0xD7FF or in the range 0xE000 to 0xFFFF is interpreted as a code point with the same value.
- A sequence of two code units, where the first code unit $c_1$ 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 $((c_1 - 0xD800) \times 0x400) + (c_2 - 0xDC00) + 0x10000$. (See 10.1.2)
- A code unit that is in the range 0xD800 to 0xDFFF, 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 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 function valued property that 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 String valued property that is used in the creation of the default string description of an object. Accessed by the built-in method <code>Object.prototype.toString</code>.</td>
</tr>
<tr>
<td>@@unscopables</td>
<td>&quot;Symbol.unscopables&quot;</td>
<td>An object valued property whose own and inherited 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 754-2008 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 18437736874454810622 (that is, \(2^{64}.2^{54}\)) finite nonzero values are of two kinds:

- 18428729675200069632 (that is, \(2^{64}.2^{54}\)) 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 \(2^{53}\) are representable in the Number type (indeed, the integer 0 has two representations, `+0` and `-0`).

A finite number has an **odd significand** if it is nonzero and the integer \(m\) used to express it (in one of the two forms shown above) is odd. Otherwise, it has an **even significand**.

In this specification, the phrase “the Number value for \(x\)” where \(x\) represents an exact nonzero real mathematical quantity (which might even be an irrational number such as \(\pi\)) 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 \(+1 \times 2^{53} \times 2^{971}\) and \(-2^{1024}\) (which is \(-1 \times 2^{53} \times 2^{971}\)). Choose the member of this set that is closest in value to \(x\). If two values of the set are equally close, then the one with an even significand is chosen; for this purpose, the two extra values \(2^{1024}\) and \(-2^{1024}\) are considered to have even significands. Finally, if \(2^{1024}\) was chosen, replace it with `+∞`; 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 754-2008 “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 property 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. A **property name** is a property key that is a String value.
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 \( \leq 2^{53} - 1 \). 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>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Value]]</td>
<td>Any ECMAStand 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 13.7.5). 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</td>
<td>Undefined</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>Object</td>
<td>Undefined</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>Boolean</td>
<td>If true, the property is to be enumerated by a for-in enumeration (see 13.7.5). 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.

Table 4: Default Attribute Values

<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>

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. That actual object upon which an internal method is invoked is the “target” of the invocation. 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. In addition to its parameters, an internal method always has access to the object that is the target of the method invocation.
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</td>
<td>Determine the object that provides inherited properties for this object. A <strong>null</strong> value indicates that there are no inherited properties.</td>
</tr>
<tr>
<td>[[SetPrototypeOf]]</td>
<td>(Object</td>
<td>Associate this object with another object that provides inherited properties. Passing <strong>null</strong> indicates that there are no inherited properties. Returns <strong>true</strong> indicating that the operation was completed successfully or <strong>false</strong> 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 <strong>true</strong> if the operation was successful or <strong>false</strong> if the operation was unsuccessful.</td>
</tr>
<tr>
<td>[[GetOwnProperty]]</td>
<td>(propertyKey) →</td>
<td>Return a <strong>PropertyDescriptor</strong> for the own property of this object whose key is <strong>propertyKey</strong>, or <strong>undefined</strong> if no such property exists.</td>
</tr>
<tr>
<td>[[HasProperty]]</td>
<td>(propertyKey) → Boolean</td>
<td>Return a Boolean value indicating whether this object already has either an own or inherited property whose key is <strong>propertyKey</strong>.</td>
</tr>
<tr>
<td>[[Get]]</td>
<td>(propertyKey, Receiver) → any</td>
<td>Return the value of the property whose key is <strong>propertyKey</strong> from this object. If any ECMAScript code must be executed to retrieve the property value, <strong>Receiver</strong> is used as the <strong>this</strong> value when evaluating the code.</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>(propertyKey, value, Receiver) → Boolean</td>
<td>Set the value of the property whose key is <strong>propertyKey</strong> to <strong>value</strong>. If any ECMAScript code must be executed to set the property value, <strong>Receiver</strong> is used as the <strong>this</strong> value when evaluating the code. Returns <strong>true</strong> if the property value was set or <strong>false</strong> if it could not be set.</td>
</tr>
<tr>
<td>[[Delete]]</td>
<td>(propertyKey) → Boolean</td>
<td>Remove the own property whose key is <strong>propertyKey</strong> from this object. Return <strong>false</strong> if the property was not deleted and is still present. Return <strong>true</strong> if the property was deleted or is not present.</td>
</tr>
<tr>
<td>[[DefineOwnProperty]]</td>
<td>(propertyKey, PropertyDescriptor) → Boolean</td>
<td>Create or alter the own property, whose key is <strong>propertyKey</strong>, to have the state described by <strong>PropertyDescriptor</strong>. Return <strong>true</strong> if that property was successfully created/updated or <strong>false</strong> if the property could not be created or updated.</td>
</tr>
<tr>
<td>[[OwnPropertyKeys]]</td>
<td>() → List of propertyKey</td>
<td>Return a <strong>List</strong> 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. A **function object** is an object that supports the [[Call]] internal methods. A **constructor** (also referred to as a **constructor function**) is a function object that supports the [[Construct]] internal method.
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><code>[[Call]]</code></td>
<td><code>(any, a List of any) → any</code></td>
<td>Executes code associated with this object. Invoked via a function call expression. The arguments to the internal method are a <code>this</code> value and a list containing the arguments passed to the function by a call expression. Objects that implement this internal method are <code>callable</code>.</td>
</tr>
<tr>
<td><code>[[Construct]]</code></td>
<td><code>(a List of any, Object) → Object</code></td>
<td>Creates an object. Invoked via the <code>new</code> or <code>super</code> operators. The first argument to the internal method is a list containing the arguments of the operator. The second argument is the object to which the <code>new</code> operator was initially applied. Objects that implement this internal method are called <code>constructors</code>. A function object is not necessarily a constructor and such non-constructor function objects do not have a <code>[[Construct]]</code> internal method.</td>
</tr>
</tbody>
</table>

The semantics of the essential internal methods for ordinary objects and standard exotic objects are specified in clause 9. 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.

An implementation must not allow these invariants to be circumvented in any manner such as by providing alternative interfaces that implement the functionality of the essential internal methods without enforcing their invariants.

#### Definitions:

- The target of an internal method is the object upon which the internal method is called.
- 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 the `SameValue` algorithm.

`[[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 1** 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.
[[IsExtensible]] ( )

- The Type of the return value must be Boolean.
- If [[IsExtensible]] returns false, all future calls to [[IsExtensible]] on the target must return false.

[[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 2  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 \[\text{[[Set]]}\] must return false unless V is the SameValue as P's \[\text{[[Value]]}\] attribute.
- If P was previously observed as a non-configurable own accessor property of the target whose \[\text{[[Set]]}\] attribute is undefined, the \[\text{[[Set]]}\] operation must return false.

\[\text{[[Delete]]} (P)\]

- 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, \[\text{[[Delete]]}\] must return false.

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

- 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 \[\text{[[GetOwnProperty]]}\].

\[\text{[[Construct]]} ()\]

- The Type of the return value must be Object.

6.1.7.4 Well-Known Intrinsic Objects

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

Within this specification a reference such as %name% means the intrinsic object, associated with the current realm, corresponding to the name. Determination of the current realm and its intrinsics is described in 8.3. The well-known intrinsics are listed in Table 7.
<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>Global Name</th>
<th>ECMAScript Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>%Array%</code></td>
<td><code>Array</code></td>
<td>The <code>Array</code> constructor (22.1.1)</td>
</tr>
<tr>
<td><code>%ArrayBuffer%</code></td>
<td><code>ArrayBuffer</code></td>
<td>The <code>ArrayBuffer</code> constructor (24.1.2)</td>
</tr>
<tr>
<td><code>%ArrayBufferPrototype%</code></td>
<td><code>ArrayBuffer.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%ArrayBuffer%</code>.</td>
</tr>
<tr>
<td><code>%ArrayIteratorPrototype%</code></td>
<td></td>
<td>The prototype of Array iterator objects (22.1.5)</td>
</tr>
<tr>
<td><code>%ArrayPrototype%</code></td>
<td><code>Array.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Array%</code> (22.1.1)</td>
</tr>
<tr>
<td><code>%ArrayProto_values%</code></td>
<td><code>Array.prototype.values</code></td>
<td>The initial value of the <code>values</code> data property of <code>%ArrayPrototype%</code> (22.1.3.30)</td>
</tr>
<tr>
<td><code>%Boolean%</code></td>
<td><code>Boolean</code></td>
<td>The <code>Boolean</code> constructor (19.3.1)</td>
</tr>
<tr>
<td><code>%BooleanPrototype%</code></td>
<td><code>Boolean.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Boolean%</code> (19.3.3)</td>
</tr>
<tr>
<td><code>%DataView%</code></td>
<td><code>DataView</code></td>
<td>The <code>DataView</code> constructor (24.2.2)</td>
</tr>
<tr>
<td><code>%DataViewPrototype%</code></td>
<td><code>DataView.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%DataView%</code></td>
</tr>
<tr>
<td><code>%Date%</code></td>
<td><code>Date</code></td>
<td>The <code>Date</code> constructor (20.3.2)</td>
</tr>
<tr>
<td><code>%DatePrototype%</code></td>
<td><code>Date.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Date%</code></td>
</tr>
<tr>
<td><code>%decodeURI%</code></td>
<td><code>decodeURI</code></td>
<td>The <code>decodeURI</code> function (18.2.6.2)</td>
</tr>
<tr>
<td><code>%decodeURIComponent%</code></td>
<td><code>decodeURIComponent</code></td>
<td>The <code>decodeURIComponent</code> function (18.2.6.3)</td>
</tr>
<tr>
<td><code>%encodeURI%</code></td>
<td><code>encodeURI</code></td>
<td>The <code>encodeURI</code> function (18.2.6.4)</td>
</tr>
<tr>
<td><code>%encodeURIComponent%</code></td>
<td><code>encodeURIComponent</code></td>
<td>The <code>encodeURIComponent</code> function (18.2.6.5)</td>
</tr>
<tr>
<td><code>%Error%</code></td>
<td><code>Error</code></td>
<td>The <code>Error</code> constructor (19.5.1)</td>
</tr>
<tr>
<td><code>%ErrorPrototype%</code></td>
<td><code>Error.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Error%</code></td>
</tr>
<tr>
<td><code>%eval%</code></td>
<td><code>eval</code></td>
<td>The <code>eval</code> function (18.2.1)</td>
</tr>
<tr>
<td><code>%EvalError%</code></td>
<td><code>EvalError</code></td>
<td>The <code>EvalError</code> constructor (19.5.5.1)</td>
</tr>
<tr>
<td><code>%EvalErrorPrototype%</code></td>
<td><code>EvalError.prototype</code></td>
<td>The initial value of the <code>prototype</code> property of <code>%EvalError%</code></td>
</tr>
<tr>
<td><code>%Float32Array%</code></td>
<td><code>Float32Array</code></td>
<td>The <code>Float32Array</code> constructor (22.2)</td>
</tr>
<tr>
<td><code>%Float32ArrayPrototype%</code></td>
<td><code>Float32Array.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Float32Array%</code></td>
</tr>
<tr>
<td><code>%Float64Array%</code></td>
<td><code>Float64Array</code></td>
<td>The <code>Float64Array</code> constructor (22.2)</td>
</tr>
<tr>
<td><code>%Float64ArrayPrototype%</code></td>
<td><code>Float64Array.prototype</code></td>
<td>The initial value of the <code>prototype</code> data property of <code>%Float64Array%</code></td>
</tr>
<tr>
<td><code>%Function%</code></td>
<td><code>Function</code></td>
<td>The <code>Function</code> constructor (19.2.1)</td>
</tr>
<tr>
<td>%FunctionPrototype%</td>
<td>Function.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Function%</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>%Generator%</td>
<td></td>
<td>The initial value of the <code>prototype</code> property of %Generator%</td>
</tr>
<tr>
<td>%GeneratorFunction%</td>
<td></td>
<td>The constructor of generator objects (25.2.1)</td>
</tr>
<tr>
<td>%GeneratorPrototype%</td>
<td></td>
<td>The initial value of the <code>prototype</code> property of %Generator%</td>
</tr>
<tr>
<td>%Int8Array%</td>
<td>Int8Array</td>
<td>The <code>Int8Array</code> constructor (22.2)</td>
</tr>
<tr>
<td>%Int8ArrayPrototype%</td>
<td>Int8Array.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Int8Array%</td>
</tr>
<tr>
<td>%Int16Array%</td>
<td>Int16Array</td>
<td>The <code>Int16Array</code> constructor (22.2)</td>
</tr>
<tr>
<td>%Int16ArrayPrototype%</td>
<td>Int16Array.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Int16Array%</td>
</tr>
<tr>
<td>%Int32Array%</td>
<td>Int32Array</td>
<td>The <code>Int32Array</code> constructor (22.2)</td>
</tr>
<tr>
<td>%Int32ArrayPrototype%</td>
<td>Int32Array.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Int32Array%</td>
</tr>
<tr>
<td>%isFinite%</td>
<td>isFinite</td>
<td>The <code>isFinite</code> function (18.2.2)</td>
</tr>
<tr>
<td>%isNaN%</td>
<td>isNaN</td>
<td>The <code>isNaN</code> function (18.2.3)</td>
</tr>
<tr>
<td>%IteratorPrototype%</td>
<td></td>
<td>An object that all standard built-in iterator objects indirectly inherit from</td>
</tr>
<tr>
<td>%JSON%</td>
<td>JSON</td>
<td>The <code>JSON</code> object (24.3)</td>
</tr>
<tr>
<td>%Map%</td>
<td>Map</td>
<td>The <code>Map</code> constructor (23.1.1)</td>
</tr>
<tr>
<td>%MapIteratorPrototype%</td>
<td></td>
<td>The prototype of Map iterator objects (23.1.5)</td>
</tr>
<tr>
<td>%MapPrototype%</td>
<td>Map.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Map%</td>
</tr>
<tr>
<td>%Math%</td>
<td>Math</td>
<td>The <code>Math</code> object (20.2)</td>
</tr>
<tr>
<td>%Number%</td>
<td>Number</td>
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<td>Object</td>
<td>The <code>Object</code> constructor (19.1.1)</td>
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<td>parseFloat</td>
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<td>%parseInt%</td>
<td>parseInt</td>
<td>The <code>parseInt</code> function (18.2.5)</td>
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<td>Promise</td>
<td>The <code>Promise</code> constructor (25.4.3)</td>
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<td>The initial value of the prototype data property of %Promise%</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
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<td>The Proxy constructor (26.2.1)</td>
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<tr>
<td>%Proxy%</td>
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<td></td>
</tr>
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<td>RangeError</td>
<td>The RangeError constructor (19.5.5.2)</td>
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<td>ReferenceError</td>
<td>The ReferenceError constructor (19.5.5.3)</td>
</tr>
<tr>
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<td>ReferenceError.prototype</td>
<td>The initial value of the prototype property of %ReferenceError%</td>
</tr>
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<td>Reflect</td>
<td>The Reflect object (26.1)</td>
</tr>
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<td>RegExp</td>
<td>The RegExp constructor (21.2.3)</td>
</tr>
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<td>RegExp.prototype</td>
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<td></td>
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<td>%SetPrototype%</td>
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<td>The Set constructor (23.2.1)</td>
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<td></td>
</tr>
<tr>
<td>%SetPrototype%</td>
<td>Set.prototype</td>
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<tr>
<td>%Set%</td>
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<td></td>
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<td></td>
</tr>
<tr>
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</tr>
<tr>
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<td></td>
</tr>
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<td>The Symbol constructor (19.4.1)</td>
</tr>
<tr>
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<td>Symbol.prototype</td>
<td>The initial value of the prototype data property of %Symbol%. (19.4.3)</td>
</tr>
<tr>
<td>%Symbol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%SyntaxError%</td>
<td>SyntaxError</td>
<td>The SyntaxError constructor (19.5.5.4)</td>
</tr>
<tr>
<td>%SyntaxErrorPrototype%</td>
<td>SyntaxError.prototype</td>
<td>The initial value of the prototype property of %SyntaxError%</td>
</tr>
<tr>
<td>%ThrowTypeError%</td>
<td></td>
<td>A function object that unconditionally throws a new instance of %TypeError%</td>
</tr>
<tr>
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<td></td>
<td>The super class of all typed Array constructors (22.2.1)</td>
</tr>
<tr>
<td>%TypedArrayPrototype%</td>
<td></td>
<td>The initial value of the prototype property of %TypedArray%</td>
</tr>
<tr>
<td>%TypedArray%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%TypedArrayPrototype%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%TypeError%</td>
<td>TypeError</td>
<td>The TypeError constructor (19.5.5.5)</td>
</tr>
<tr>
<td>%TypeErrorPrototype%</td>
<td>TypeError.prototype</td>
<td>The initial value of the prototype property of %TypeError%</td>
</tr>
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<td>Uint8Array</td>
<td>The Uint8Array constructor (22.2)</td>
</tr>
<tr>
<td>%Uint8ArrayPrototype%</td>
<td></td>
<td>The initial value of the prototype property of %Uint8Array%</td>
</tr>
<tr>
<td>%Uint8Array%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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`, `PropertyDescriptor`, `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 Types

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 3"rd 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]]`. 

---

<table>
<thead>
<tr>
<th>%Uint8ClampedArray%</th>
<th>Uint8ClampedArray</th>
<th>The <code>Uint8ClampedArray</code> constructor (22.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Uint8ClampedArrayPrototype%</td>
<td>Uint8ClampedArray.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Uint8ClampedArray%</td>
</tr>
<tr>
<td>%Uint16Array%</td>
<td>Uint16Array</td>
<td>The <code>Uint16Array</code> constructor (22.2)</td>
</tr>
<tr>
<td>%Uint16ArrayPrototype%</td>
<td>Uint16Array.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Uint16Array%</td>
</tr>
<tr>
<td>%Uint32Array%</td>
<td>Uint32Array</td>
<td>The <code>Uint32Array</code> constructor (22.2)</td>
</tr>
<tr>
<td>%Uint32ArrayPrototype%</td>
<td>Uint32Array.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %Uint32Array%</td>
</tr>
<tr>
<td>%URIError%</td>
<td>URIError</td>
<td>The <code>URIError</code> constructor (19.5.5.6)</td>
</tr>
<tr>
<td>%URIErrorPrototype%</td>
<td>URIError.prototype</td>
<td>The initial value of the <code>prototype</code> property of %URIError%</td>
</tr>
<tr>
<td>%WeakMap%</td>
<td>WeakMap</td>
<td>The <code>WeakMap</code> constructor (23.3.1)</td>
</tr>
<tr>
<td>%WeakMapPrototype%</td>
<td>WeakMap.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %WeakMap%</td>
</tr>
<tr>
<td>%WeakSet%</td>
<td>WeakSet</td>
<td>The <code>WeakSet</code> constructor (23.4.1)</td>
</tr>
<tr>
<td>%WeakSetPrototype%</td>
<td>WeakSet.prototype</td>
<td>The initial value of the <code>prototype</code> data property of %WeakSet%</td>
</tr>
</tbody>
</table>
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
}```.

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. Such values are referred to as Completion Records.

<table>
<thead>
<tr>
<th>Field</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 NormalCompletion

The abstract operation NormalCompletion with a single argument `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 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".

means the same thing as:

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

However, if the value expression of a "return" statement is a Completion Record construction literal, the resulting Completion Record is returned. If the value expression is a call to an abstract operation, the "return" statement simply returns the Completion Record produced by the abstract operation.

The abstract operation ```Completion(completionRecord)``` is used to emphasize that a previously computed Completion Record is being returned. The Completion abstract operation takes a single argument, `completionRecord`, and performs the following steps:
1. Assert: `completionRecord` is a Completion Record.
2. Return `completionRecord` as the Completion Record of this abstract operation.

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

1. Return `NormalCompletion(undefined)`.

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 or are otherwise equivalent to:

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]]`.

Algorithms steps that say or are otherwise equivalent to:

1. `ReturnIfAbrupt(AbstractOperation())`.

mean the same thing as:

1. Let `hygienicTemp` be `AbstractOperation()`.
2. If `hygienicTemp` is an abrupt completion, return `hygienicTemp`.
3. Else if `hygienicTemp` is a Completion Record, let `hygienicTemp` be `hygienicTemp.[[Value]]`.

Where `hygienicTemp` is ephemeral and visible only in the steps pertaining to ReturnIfAbrupt.

### 6.2.2.5 UpdateEmpty (completionRecord, value)

The abstract operation `UpdateEmpty` with arguments `completionRecord` and `value` performs the following steps:

1. Assert: If `completionRecord.[[Type]]` is either `return` or `throw`, then `completionRecord.[[Value]]` is not empty.
2. If `completionRecord.[[Value]]` is not empty, return `Completion(completionRecord)`.
3. Return `Completion({[[Type]]: completionRecord.[[Type]], [[Value]]: value, [[Target]]: completionRecord.[[Target]]})`.

### 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. 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 represent 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:

1. ReturnIfAbrupt(V).
2. If Type(V) is not Reference, return V.
3. Let base be GetBase(V).
4. If IsUnresolvableReference(V) is true, throw a ReferenceError exception.
5. If IsPropertyReference(V) is true, 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 ? base.[[Get]](GetReferencedName(V), GetThisValue(V)).
6. Else base must be an Environment Record,
   a. Return ? base.GetMutableBinding(GetReferencedName(V), W, IsStrictReference(V)) (see 8.1.1).

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) is true, then
   a. If IsStrictReference(V) is true, then
      i. Throw a ReferenceError exception.
   b. Let globalObj be GetGlobalObject().
   c. Return ? Set(globalObj, GetReferencedName(V), W, false).
6. Else if IsPropertyReference(V) is true, 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 ? base.[[Set]](GetReferencedName(V), W, GetThisValue(V)).
   c. If succeeded is false and IsStrictReference(V) is true, throw a TypeError exception.
   d. Return.
7. Else base must be an Environment Record,
   a. Return ? base.SetMutableBinding(GetReferencedName(V), W, IsStrictReference(V)) (see 8.1.1).
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) is true, 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 base.InitializeBinding(GetReferencedName(V), W).

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”.

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 `PropertyDescriptor 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. Perform `CreateDataProperty(obj, "value", Desc.[[Value]])`.
5. If `Desc` has a `[[Writable]]` field, then
   a. Perform `CreateDataProperty(obj, "writable", Desc.[[Writable]])`.
6. If `Desc` has a `[[Get]]` field, then
   a. Perform `CreateDataProperty(obj, "get", Desc.[[Get]])`.
7. If `Desc` has a `[[Set]]` field, then
   a. Perform `CreateDataProperty(obj, "set", Desc.[[Set]])`.
8. If `Desc` has an `[[Enumerable]]` field, then
   a. Perform `CreateDataProperty(obj, "enumerable", Desc.[[Enumerable]])`.
9. If `Desc` has a `[[Configurable]]` field, then
   a. Perform `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. If `Type(Obj)` is not Object, throw a `TypeError` exception.
2. Let `desc` be a new `PropertyDescriptor` that initially has no fields.
3. Let `hasEnumerable` be `HasProperty(Obj, "enumerable")`.
4. If `hasEnumerable` is `true`, then
   a. Let `enum` be `ToBoolean(? Get(Obj, "enumerable"))`.
   b. Set the `[[Enumerable]]` field of `desc` to `enum`.
5. Let `hasConfigurable` be `HasProperty(Obj, "configurable")`.
6. If `hasConfigurable` is `true`, then
   a. Let `conf` be `ToBoolean(? Get(Obj, "configurable"))`.
   b. Set the `[[Configurable]]` field of `desc` to `conf`.
7. Let `hasValue` be `HasProperty(Obj, "value")`.
8. If `hasValue` is `true`, then
   a. Let `value` be `Get(Obj, "value")`.
   b. Set the `[[Value]]` field of `desc` to `value`.
9. Let `hasWritable` be `HasProperty(Obj, "writable")`.
10. If `hasWritable` is `true`, then
    a. Let `writable` be `ToBoolean(? Get(Obj, "writable"))`.
    b. Set the `[[Writable]]` field of `desc` to `writable`.
11. Let `hasGet` be `HasProperty(Obj, "get")`.
12. If `hasGet` is `true`, then
    a. Let `getter` be `Get(Obj, "get")`.
    b. If `IsCallable getter` is `false` and `getter` is not `undefined`, throw a `TypeError` exception.
    c. Set the `[[Get]]` field of `desc` to `getter`.
13. Let `hasSet` be `HasProperty(Obj, "set")`.
14. If `hasSet` is `true`, then
    a. Let `setter` be `Get(Obj, "set")`.
b. If `IsCallable(setter)` is `false` and `setter` is not `undefined`, throw a `TypeError` exception.

c. Set the `[[Set]]` field of `desc` to `setter`.

15. If either `desc.[[Get]]` or `desc.[[Set]]` is present, then
   a. If either `desc.[[Value]]` or `desc.[[Writable]]` is present, throw a `TypeError` exception.

16. Return `desc`.

6.2.4.6 CompletePropertyDescriptor (Desc)

When the abstract operation `CompletePropertyDescriptor` is called with `PropertyDescriptor Desc`, the following steps are taken:

1. Assert: `Desc` is a `PropertyDescriptor`.

2. Let `like` be `Record` with `[[Value]]: undefined, [[Writable]]: false, [[Get]]: undefined, [[Set]]: undefined, [[Enumerable]]: false, [[Configurable]]: false).

3. If either `IsGenericDescriptor(Desc)` or `IsDataDescriptor(Desc)` is `true`, then
   a. If `Desc` does not have a `[[Value]]` field, set `Desc.[[Value]]` to `like.[[Value]]`.
   b. If `Desc` does not have a `[[Writable]]` field, set `Desc.[[Writable]]` to `like.[[Writable]]`.

4. Else,
   a. If `Desc` does not have a `[[Get]]` field, set `Desc.[[Get]]` to `like.[[Get]]`.
   b. If `Desc` does not have a `[[Set]]` field, set `Desc.[[Set]]` to `like.[[Set]]`.

5. If `Desc` does not have an `[[Enumerable]]` field, set `Desc.[[Enumerable]]` to `like.[[Enumerable]]`.

6. If `Desc` does not have a `[[Configurable]]` field, set `Desc.[[Configurable]]` to `like.[[Configurable]]`.

7. Return `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 access 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 `db` is a 5 byte Data Block value then `db[2]` can be used to access 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 `size`, the following steps are taken:

1. Assert: `size` ≥ 0.

2. Let `db` be a new `Data Block` value consisting of `size` bytes. If it is impossible to create such a `Data Block`, throw a `RangeError` exception.

3. Set all of the bytes of `db` to 0.

4. Return `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: `fromBlock` and `toBlock` are distinct `Data Block` values.

2. Assert: `fromIndex, toIndex,`, and `count` are integer values ≥ 0.

3. Let `fromSize` be the number of bytes in `fromBlock`.

4. Assert: `fromIndex+count ≤ fromSize`. 
5. Let `toSize` be the number of bytes in `toBlock`.
6. Assert: `toIndex + count ≤ toSize`.
7. Repeat, while `count > 0`
   a. Set `toBlock[toIndex]` to the value of `fromBlock[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. 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>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. If `exoticToPrim` is not `undefined`, then
   a. Let `result` be `? Call(exoticToPrim, input, « hint »)`.
   b. If `Type(result)` is not Object, return `result`.
   c. Throw a `TypeError` exception.
6. If `hint` is "default", let `hint` be "number".
7. Return `? OrdinaryToPrimitive(input, hint)`.

When the abstract operation `OrdinaryToPrimitive` is called with arguments `O` and `hint`, the following steps are taken:
1. Assert: Type(0) 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 "toString","valueOf".
4. Else,
   a. Let methodNames be "valueOf","toString".
5. For each name in methodNames in List order, do
   a. Let method be ?Get(O, name).
      b. If IsCallable(method) is true, then
         i. Let result be ?Call(method, O).
         ii. 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>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 11: ToNumber Conversions

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<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 <code>argument</code> is true. Return +0 if <code>argument</code> is false.</td>
</tr>
<tr>
<td>Number</td>
<td>Return <code>argument</code> (no conversion).</td>
</tr>
<tr>
<td>String</td>
<td>See grammar and conversion algorithm below.</td>
</tr>
<tr>
<td>Symbol</td>
<td>Throw a <strong>TypeError</strong> 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 (6.1.4). If the grammar cannot interpret the String as an expansion of *StringNumericLiteral*, then the result of _**ToNumber**_ is NaN.

**NOTE 1** 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**:
  - `StrWhiteSpace opt`
  - `StrWhiteSpace opt StrNumericLiteral StrWhiteSpace opt`

- **StrWhiteSpace**:  
  - `StrWhiteSpaceChar StrWhiteSpace opt`

- **StrWhiteSpaceChar**:  
  - `WhiteSpace`
  - `LineTerminator`

- **StrNumericLiteral**:  
  - `StrDecimalLiteral`
  - `BinaryIntegerLiteral`
  - `OctalIntegerLiteral`
  - `HexIntegerLiteral`

- **StrDecimalLiteral**:  
  - `StrUnsignedDecimalLiteral`
  - `+ StrUnsignedDecimalLiteral`
  - `- StrUnsignedDecimalLiteral`

- **StrUnsignedDecimalLiteral**:  
  - `Infinity`
  - `DecimalDigits . DecimalDigits opt`  
  - `ExponentPart opt`
All grammar symbols not explicitly defined above have the definitions used in the Lexical Grammar for numeric literals (11.8.3)

Note 2 Some differences should be noted between the syntax of a StringNumericLiteral and a NumericLiteral:

- 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 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 StringNumericLiteral StrWhiteSpace is the MV of StringNumericLiteral, no matter whether white space is present or not.
- The MV of StringNumericLiteral :: StrDecimalLiteral is the MV of StrDecimalLiteral.
- The MV of StringNumericLiteral :: BinaryIntegerLiteral is the MV of BinaryIntegerLiteral.
- The MV of StringNumericLiteral :: OctalIntegerLiteral is the MV of OctalIntegerLiteral.
- The MV of StringNumericLiteral :: HexIntegerLiteral is the MV of HexIntegerLiteral.
- The MV of StringNumericLiteral :: StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.
- The MV of StringNumericLiteral :: + StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.
- The MV of StringNumericLiteral :: – 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 10⁴⁺⁰⁰⁰ (a value so large that it will round to +∞).
- The MV of StrUnsignedDecimalLiteral :: DecimalDigits is the MV of DecimalDigits.
- The MV of StringNumericLiteral :: 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 10⁶, where e is the MV of ExponentPart.
- The MV of StrUnsignedDecimalLiteral :: DecimalDigits . DecimalDigits ExponentPart is (the MV of the first DecimalDigits plus (the MV of the second DecimalDigits times 10⁻ⁿ)) times 10⁶, 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 10⁻⁶, where n is the number of code points in DecimalDigits.
- The MV of StrUnsignedDecimalLiteral :: . DecimalDigits ExponentPart is the MV of DecimalDigits times 10⁶⁻ⁿ, 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 10⁶, where e is the MV of ExponentPart.

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 \textit{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 \textit{ExponentPart} and

- it is not 0;
- there is a nonzero digit to its left and there is a nonzero digit, not in the \textit{ExponentPart}, to its right.

7.1.4 \texttt{ToInteger ( argument )}

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

1. Let \texttt{number} be \texttt{ToNumber(argument)}.
2. If \texttt{number} is \texttt{NaN}, return \texttt{+0}.
3. If \texttt{number} is \texttt{+0}, \texttt{-0}, \texttt{+∞}, or \texttt{-∞}, return \texttt{number}.
4. Return the number value that is the same sign as \texttt{number} and whose magnitude is \texttt{floor(abs(number))}.

7.1.5 \texttt{ToInt32 ( argument )}

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

1. Let \texttt{number} be \texttt{ToNumber(argument)}.
2. If \texttt{number} is \texttt{NaN}, \texttt{+0}, \texttt{-0}, \texttt{+∞}, or \texttt{-∞}, return \texttt{+0}.
3. Let \texttt{int} be the mathematical value that is the same sign as \texttt{number} and whose magnitude is \texttt{floor(abs(number))}.
4. Let \texttt{int32bit} be \texttt{int} modulo \texttt{2^{32}}.
5. If \texttt{int32bit} ≥ \texttt{2^{31}}, return \texttt{int32bit} - \texttt{2^{32}}, otherwise return \texttt{int32bit}.

\textbf{NOTE} Given the above definition of \texttt{ToInt32}:

- The \texttt{ToInt32} abstract operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.
- \texttt{ToInt32(ToUint32(x))} is equal to \texttt{ToInt32(x)} for all values of \texttt{x}. (It is to preserve this latter property that \texttt{+∞} and \texttt{-∞} are mapped to \texttt{+0}.)
- \texttt{ToInt32} maps \texttt{-0} to \texttt{+0}.

7.1.6 \texttt{ToUint32 ( argument )}

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

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

\textbf{NOTE} Given the above definition of \texttt{ToUint32}:

- Step 5 is the only difference between \texttt{ToUint32} and \texttt{ToInt32}.
- The \texttt{ToUint32} abstract operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.
- \texttt{ToUint32(ToUint32(x))} is equal to \texttt{ToUint32(x)} for all values of \texttt{x}. (It is to preserve this latter property that \texttt{+∞} and \texttt{-∞} are mapped to \texttt{+0}.)
- \texttt{ToUint32} maps \texttt{-0} to \texttt{+0}.
7.1.7_ToInt16 (argument)

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

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

7.1.8_ToUint16 (argument)

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

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

NOTE Given the above definition of ToUint16:

- The substitution of \(2^{16}\) for \(2^{32}\) in step 4 is the only difference between ToUint32 and ToUint16.
- ToUint16 maps \(-0\) to \(+0\).

7.1.9_ToInt8 (argument)

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

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

7.1.10_ToUint8 (argument)

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

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

7.1.11_ToUint8Clamp (argument)

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

1. Let \(number\) be ?ToNumber(argument).
2. If \(number\) is NaN, return \(+0\).
3. If \(number \leq 0\), return \(+0\).
4. If \( \text{number} \geq 255 \), return 255.
5. Let \( f \) be \( \text{floor}(\text{number}) \).
6. If \( f + 0.5 < \text{number} \), return \( f + 1 \).
7. If \( \text{number} < f + 0.5 \), return \( f \).
8. If \( f \) is odd, return \( f + 1 \).
9. Return \( f \).

NOTE Unlike the other ECMAScript integer conversion abstract operation, ToUint8Clamp rounds rather than truncates non-integer values and does not convert \(+\infty\) to 0. ToUint8Clamp does “round half to even” tie-breaking. This differs from \( \text{Math.round} \) which does “round half up” tie-breaking.

7.1.12 ToString (\( \text{argument} \))

The abstract operation ToString converts \( \text{argument} \) 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>Undefined</td>
<td>Return “undefined”.</td>
</tr>
<tr>
<td>Null</td>
<td>Return “null”.</td>
</tr>
</tbody>
</table>
| Boolean       | If \( \text{argument} \) is true, return “true”.
               | If \( \text{argument} \) is false, return “false”. |
| Number        | See 7.1.12.1. |
| String        | Return \( \text{argument} \). |
| Symbol        | Throw a TypeError exception. |
| Object        | Apply the following steps:
               | 1. Let \( \text{primValue} \) be ? ToPrimitive(\( \text{argument} \), hint String).
               | 2. Return ? ToString(\( \text{primValue} \)). |

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 \( \text{NaN} \), return the String “NaN”.
2. If \( m \) is \( +0 \) or \( -0 \), return the String “0”.
3. If \( m \) is less than zero, return the String concatenation of the String “-” and ToString(-\( m \)).
4. If \( m \) is \( +\infty \), return the String “Infinity”.
5. Otherwise, let \( n, k, \) and \( s \) be integers such that \( k \geq 1, 10^{k-1} \leq s < 10^k \), the Number value for \( s \times 10^{n-k} \) is \( m \), and \( k \) is as small as possible. Note that \( k \) is the number of digits in the decimal representation of \( s \), that \( s \) is not divisible by 10, and that the least significant digit of \( s \) is not necessarily uniquely determined by these criteria.
6. If \( k \leq n \leq 21 \), return the String consisting of the code units of the \( k \) digits of the decimal representation of \( s \) (in order, with no leading zeroes), followed by \( n-k \) occurrences of the code unit 0x0030 (DIGIT ZERO).
7. If \( 0 < n \leq 21 \), return the String consisting of the code units of the most significant \( n \) digits of the decimal representation of \( s \), followed by the code unit 0x002E (FULL STOP), followed by the code units 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 unit 0x0030 (DIGIT ZERO), followed by the code unit 0x002E (FULL STOP), followed by \( -n \) occurrences of the code unit 0x0030 (DIGIT ZERO), followed by the code units of the \( k \) digits of
the decimal representation of \( s \).

9. Otherwise, if \( k = 1 \), return the String consisting of the code unit of the single digit of \( s \), followed by code unit 0x0065 (LATIN SMALL LETTER E), followed by the code unit 0x002B (PLUS SIGN) or the code unit 0x002D (HYPHEN-MINUS) according to whether \( n-1 \) is positive or negative, followed by the code units of the decimal representation of the integer \( \text{abs}(n-1) \) (with no leading zeroes).

10. Return the String consisting of the code units of the most significant digit of the decimal representation of \( s \), followed by code unit 0x002E (FULL STOP), followed by the code units of the remaining \( k-1 \) digits of the decimal representation of \( s \), followed by code unit 0x0065 (LATIN SMALL LETTER E), followed by code unit 0x002B (PLUS SIGN) or the code unit 0x002D (HYPHEN-MINUS) according to whether \( n-1 \) is positive or negative, followed by the code units of the decimal representation of the integer \( \text{abs}(n-1) \) (with no leading zeroes).

NOTE 1

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

- If \( x \) is any Number value other than \(-0\), then \( \text{ToNumber(ToString(x))} \) 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:

5. Otherwise, let \( n, k, \) and \( s \) be integers such that \( k \geq 1 \), \( 10^{k-1} \leq s < 10^k \), the Number value for \( s \times 10^{n-k} \) is \( m \), and \( k \) is as small as possible. If there are multiple possibilities for \( s \), choose the value of \( s \) for which \( s \times 10^{n-k} \) is closest in value to \( m \). If there are two such possible values of \( s \), choose the one that is even. Note that \( k \) is the number of digits in the decimal representation of \( s \) and that \( s \) is not divisible by 10.

NOTE 3

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


7.1.13 ToObject (argument)

The abstract operation ToObject converts 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>Undefined</td>
<td>Throw a <strong>TypeError</strong> exception.</td>
</tr>
<tr>
<td>Null</td>
<td>Throw a <strong>TypeError</strong> 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. If `Type(key)` is Symbol, then
   a. Return `key`.
3. 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. Let `len` be ? `ToInteger(argument)`.
2. If `len` ≤ +0, return +0.
3. If `len` is +∞, return $2^{53} - 1$.
4. Return `min(len, 2^{53} - 1)`.

#### 7.1.16 CanonicalNumericIndexString (argument)

The abstract operation `CanonicalNumericIndexString` returns `argument` converted 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` abstract 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>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. If the value of the [[ProxyHandler]] internal slot of argument is null, throw a TypeError exception.
   b. Let target be the value of the [[ProxyTarget]] internal slot of argument.
4. Return false.

7.2.3 IsCallable (argument)

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

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

7.2.4 IsConstructor (argument)

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

1. If Type(argument) is not Object, return false.
2. If argument has a [[Construct]] internal method, return true.
3. 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 `O[[IsExtensible]]()`.

### 7.2.6 IsInteger (argument)

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

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

### 7.2.7 IsPropertyKey (argument)

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

1. If `Type(argument)` is String, return `true`.
2. If `Type(argument)` is Symbol, return `true`.
3. 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. If `isRegExp` is not `undefined`, return `ToBoolean(isRegExp)`.
4. If `argument` has a `[[RegExpMatcher]]` internal slot, return `true`.
5. 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. If `Type(x)` is different from `Type(y)`, return `false`.
2. 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`.
3. Return `SameValueNonNumber(x, y)`.

**NOTE** This algorithm differs from the [Strict Equality Comparison](https://es.spec.net) Algorithm in its treatment of signed zeroes and NaNs.

### 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. If `Type(x)` is different from `Type(y)`, return `false`.
2. 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`. 
7.2.11 **SameValueNonNumber** \((x, y)\)

The internal comparison abstract operation `SameValueNonNumber(x, y)`, where neither \(x\) nor \(y\) are Number values, produces `true` or `false`. Such a comparison is performed as follows:

1. Assert: `Type(x)` is not Number.
2. Assert: `Type(x)` is the same as `Type(y)`.
3. If `Type(x)` is Undefined, return `true`.
4. If `Type(x)` is Null, return `true`.
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 `true`; otherwise, return `false`.
6. If `Type(x)` is Boolean, then
   a. If \(x\) and \(y\) are both `true` or both `false`, return `true`; otherwise, return `false`.
7. If `Type(x)` is Symbol, then
   a. If \(x\) and \(y\) are both the same Symbol value, return `true`; otherwise, return `false`.
8. Return `true` if \(x\) and \(y\) are the same Object value. Otherwise, return `false`.

7.2.12 **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. If the `LeftFirst` flag is `true`, then
   a. Let \(px\) be \(? ToPrimitive(x, \text{hint Number})\).
   b. Let \(py\) be \(? ToPrimitive(y, \text{hint Number})\).
2. Else the order of evaluation needs to be reversed to preserve left to right evaluation
   a. Let \(py\) be \(? ToPrimitive(y, \text{hint Number})\).
   b. Let \(px\) be \(? ToPrimitive(x, \text{hint Number})\).
3. 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`.
4. Else,
   a. Let \(nx\) be \(? ToNumber(px)\). Because \(px\) and \(py\) are primitive values evaluation order is not important.
   b. Let \(ny\) be \(? ToNumber(py)\).
   c. If \(nx\) is `NaN`, return `undefined`.
   d. If \(ny\) is `NaN`, return `undefined`.
   e. If \(nx\) and \(ny\) are the same Number value, return `false`.
   f. If \(nx\) is `+0` and \(ny\) is `-0`, return `false`.

**NOTE** SameValueZero differs from `SameValue` only in its treatment of `+0` and `-0`.
7.2.13 Abstract Equality Comparison

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

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

7.2.14 Strict Equality Comparison

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

1. If \texttt{Type}(\( x \)) is different from \texttt{Type}(\( y \)), return \texttt{false}.
2. If \texttt{Type}(\( x \)) is Number, then
   a. If \( x \) is \texttt{NaN}, return \texttt{false}.
   b. If \( y \) is \texttt{NaN}, return \texttt{false}.
   c. If \( x \) is the same Number value as \( y \), return \texttt{true}.
   d. If \( x \) is \texttt{+0} and \( y \) is \texttt{-0}, return \texttt{true}.
   e. If \( x \) is \texttt{-0} and \( y \) is \texttt{+0}, return \texttt{true}.
   f. Return \texttt{false}.
3. Return \texttt{SameValueNonNumber}(\( x, y \)).

NOTE This algorithm differs from the \texttt{SameValue} Algorithm in its treatment of signed zeroes and NaNs.

7.3 Operations on Objects

7.3.1 Get \((O, P)\)

The abstract operation 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`.

### 7.3.2 GetV \((V, P)\)

The abstract operation `GetV` is used to retrieve the value of a specific property of an ECMA Script 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)`.

### 7.3.3 Set \((O, P, V, \text{Throw})\)

The abstract operation `Set` is used to set the value of a specific property of an object. The operation is called with arguments \(O, P, V, \text{and Throw}\) 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.
5. If `success` is `false` and `Throw` is `true`, throw a `TypeError` exception.

### 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 `O.[[DefineOwnProperty]](P, newDesc)`.

**NOTE** This abstract operation creates a property whose attributes are set to the same defaults used for properties created by the ECMA Script 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 CreateMethodProperty \((O, P, V)\)

The abstract operation `CreateMethodProperty` 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]]: false, [[Configurable]]: true}`.
4. Return `O.[[DefineOwnProperty]](P, newDesc)`.

**NOTE** This abstract operation creates a property whose attributes are set to the same defaults used for built-in methods and methods defined using class declaration syntax. 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`.
7.3.6 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. If success is false, throw a TypeError exception.
5. Return success.

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.

7.3.7 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 ? O. [[DefineOwnProperty]]\((P, desc)\).
4. If success is false, throw a TypeError exception.
5. Return success.

7.3.8 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 ? O. [[Delete]]\((P)\).
4. If success is false, throw a TypeError exception.
5. Return success.

7.3.9 GetMethod \((V, P)\)

The abstract operation GetMethod is used to get the value of a specific property of an ECMAScript language value when the value of the property is expected to be a function. The operation is called with arguments \(V\) and \(P\) where \(V\) is the ECMAScript language value, \(P\) is the property key. This abstract operation performs the following steps:

1. Assert: IsPropertyKey\((P)\) is true.
2. Let func be ? GetV\((V, P)\).
3. If func is either undefined or null, return undefined.
4. If IsCallable\((func)\) is false, throw a TypeError exception.
5. Return func.

7.3.10 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: \( \text{Type}(O) \) is Object.
2. Assert: \( \text{IsPropertyKey}(P) \) is true.
3. Return \( O.[[\text{HasProperty}}][P] \).

### 7.3.11 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: \( \text{Type}(O) \) is Object.
2. Assert: \( \text{IsPropertyKey}(P) \) is true.
3. Let \( \text{desc} \) be \( O.[[\text{GetOwnProperty}}][P] \).
4. If \( \text{desc} \) is undefined, return false.
5. Return true.

### 7.3.12 Call \((F, V [, argumentsList ])\)

The abstract operation Call is used to call the \([\text{Call}]\) 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 \([\text{Call}]\), and \( argumentsList \) is the value passed to the corresponding argument of the internal method. If \( argumentsList \) is not present, a new empty List is used as its value. This abstract operation performs the following steps:

1. If \( argumentsList \) was not passed, let \( argumentsList \) be a new empty List.
2. If \( \text{IsCallable}(F) \) is false, throw a TypeError exception.
3. Return \( F.[[\text{Call}}][V, argumentsList] \).

### 7.3.13 Construct \((F [, argumentsList [, newTarget ]])\)

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

1. If \( newTarget \) was not passed, let \( newTarget \) be \( F \).
2. If \( argumentsList \) was not passed, let \( argumentsList \) be a new empty List.
3. Assert: \( \text{IsConstructor}(F) \) is true.
4. Assert: \( \text{IsConstructor}(newTarget) \) is true.
5. Return \( F.[[\text{Construct}}][argumentsList, newTarget] \).

NOTE If \( newTarget \) 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: \( level \) is either "sealed" or "frozen".
3. Let \( status \) be \( O.[[\text{PreventExtensions}}]() \).
4. If \( status \) is false, return false.
5. Let \( keys \) be \( O.[[\text{OwnPropertyKeys}}] \).
6. If \( level \) is "sealed", then
a. Repeat for each element \( k \) of \( \text{keys} \),
   i. Perform ? \text{DefinePropertyOrThrow}( \text{O}, k, \text{PropertyDescriptor}([[\text{Configurable}]]: \text{false})).
7. Else \( \text{level} \) is "\text{frozen}",
   a. Repeat for each element \( k \) of \( \text{keys} \),
      i. Let \( \text{currentDesc} \) be \( \text{O}[[\text{GetOwnProperty}]](k) \).
      ii. If \( \text{currentDesc} \) is not \text{undefined}, then
         1. If \text{IsAccessorDescriptor}(\text{currentDesc}) is \text{true}, then
            a. Let \( \text{desc} \) be the \text{PropertyDescriptor} { [[\text{Configurable}]]: \text{false} }.
         2. Else, let \( \text{desc} \) be the \text{PropertyDescriptor} { [[\text{Configurable}]]: \text{false}, [[\text{Writable}]]: \text{false} }.
      3. Perform ? \text{DefinePropertyOrThrow}(\text{O}, k, \text{desc}).
8. Return \text{true}.

### 7.3.15 TestIntegrityLevel (\text{O}, \text{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}(\text{O}) is Object.
2. Assert: \text{level} is either "\text{sealed}" or "\text{frozen}".
3. Let \( \text{status} \) be ? \text{IsExtensible}(\text{O}).
4. If \( \text{status} \) is \text{true}, return \text{false}.
5. NOTE If the object is extensible, none of its properties are examined.
6. Let \( \text{keys} \) be \( \text{O}.[[\text{OwnPropertyKeys}]]() \).
7. Repeat for each element \( k \) of \( \text{keys} \),
   a. Let \( \text{currentDesc} \) be \( \text{O}[[\text{GetOwnProperty}]](k) \).
      b. If \( \text{currentDesc} \) is not \text{undefined}, then
         1. If \( \text{IsAccessorDescriptor}(\text{currentDesc}) \) is \text{true}, then
            1. If \( \text{currentDesc}.[[\text{Writable}]] \) is \text{true}, return \text{false}.
         2. Else, return \text{false}.
     3. Perform ? \text{DefinePropertyOrThrow}(\text{O}, k, \text{desc}).
8. Return \text{true}.

### 7.3.16 CreateArrayFromList (elements)

The abstract operation CreateArrayFromList is used to create an Array object whose elements are provided by a \text{List}\. This abstract operation performs the following steps:

1. Assert: \( \text{elements} \) is a \text{List} whose elements are all ECMAScript language values.
2. Let \( \text{array} \) be \text{ArrayCreate}(0).
3. Let \( n \) be 0.
4. For each element \( e \) of \( \text{elements} \)
   a. Let \( \text{status} \) be \text{CreateDataProperty}(\text{array}, !\text{ToString}(n), e).
      b. Assert: \( \text{status} \) is \text{true}.
      c. Increment \( n \) by 1.
5. Return \( \text{array} \).

### 7.3.17 CreateListFromArrayLike (obj [, elementTypes ])

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

1. If \text{elementTypes} was not passed, let \text{elementTypes} be « \text{Undefined}, \text{Null}, \text{Boolean}, \text{String}, \text{Symbol}, \text{Number}, \text{Object} ».\n2. If \text{Type}(\text{obj}) is not Object, throw a \text{TypeError} exception.
3. Let \( \text{len} \) be ? \text{ToLength}(? \text{Get}(\text{obj}, "\text{length}")).
4. Let list be a new empty List.
5. Let index be 0.
6. Repeat while index < len
   a. Let indexName be ! ToString(index).
   b. Let next be ? Get(obj, indexName).
   c. If Type(next) is not an element of elementTypes, throw a TypeError exception.
   d. Append next as the last element of list.
   e. Set index to index + 1.
7. Return list.

7.3.18 Invoke (V, P [ , argumentsList ])

The abstract operation Invoke is used to call a method property of an ECMAScript language value. The operation is called with arguments V, P, and optionally argumentsList where V 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, a new empty List is used as its value. This abstract operation performs the following steps:

1. Assert: IsPropertyKey(P) is true.
2. If argumentsList was not passed, let argumentsList be a new empty List.

7.3.19 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.
3. If Type(O) is not Object, return false.
4. Let P be ? Get(C, "prototype").
5. If Type(P) is not Object, throw a TypeError exception.
6. Repeat
   a. Let O be ? O.[[GetPrototypeOf]]().
   b. If O is null, return false.
   c. If SameValue(P, O) is true, return true.

7.3.20 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 a constructor @@species property cannot be found starting from O. This abstract operation performs the following steps:

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

7.3.21 EnumerableOwnNames (O)

When the abstract operation EnumerableOwnNames is called with Object O, the following steps are taken:
1. Assert: \texttt{Type}(O) is \texttt{Object}.
2. Let \texttt{ownKeys} be \texttt{[OwnPropertyKeys]}(O).
3. Let \texttt{names} be a new empty \texttt{List}.
4. Repeat, for each element \texttt{key} of \texttt{ownKeys} in \texttt{List} order
   a. If \texttt{Type}(\texttt{key}) is \texttt{String}, then
      i. Let \texttt{desc} be \texttt{GetOwnProperty}()(	exttt{key}).
      ii. If \texttt{desc} is not \texttt{undefined}, then
          a. If \texttt{desc}[[\texttt{Enumerable}]] is \texttt{true}, append \texttt{key} to \texttt{names}.
5. Order the elements of \texttt{names} so they are in the same relative order as would be produced by the \texttt{EnumerateObjectProperties} internal method was invoked with \texttt{O}.
6. Return \texttt{names}.

\textbf{7.3.22 GetFunctionRealm ( obj )}

The abstract operation \texttt{GetFunctionRealm} with argument \texttt{obj} performs the following steps:

1. Assert: \texttt{obj} is a callable object.
2. If \texttt{obj} has a \texttt{[[Realm]]} internal slot, then
   a. Return \texttt{obj}'s \texttt{[[Realm]]} internal slot.
3. If \texttt{obj} is a Bound Function exotic object, then
   a. Let \texttt{target} be \texttt{obj}'s \texttt{[[BoundTargetFunction]]} internal slot.
   b. Return \texttt{GetFunctionRealm(}\texttt{target)}.
4. If \texttt{obj} is a Proxy exotic object, then
   a. If the value of the \texttt{[[ProxyHandler]]} internal slot of \texttt{obj} is \texttt{null}, throw a \texttt{TypeError} exception.
   b. Let \texttt{proxyTarget} be the value of \texttt{obj}'s \texttt{[[ProxyTarget]]} internal slot.
   c. Return \texttt{GetFunctionRealm(}\texttt{proxyTarget)}.
5. Return the current Realm Record.

\textbf{NOTE}  
Step 5 will only be reached if \texttt{target} is a non-standard exotic function object that does not have a \texttt{[[Realm]]} internal slot.

\textbf{7.4 Operations on Iterator Objects}

See Common Iteration Interfaces (25.1).

\textbf{7.4.1 GetIterator ( obj [, method ] )}

The abstract operation \texttt{GetIterator} with argument \texttt{obj} and optional argument \texttt{method} performs the following steps:

1. If \texttt{method} was not passed, then
   a. Let \texttt{method} be \texttt{GetMethod(}\texttt{obj, @@iterator)}.
2. Let \texttt{iterator} be \texttt{Call(}\texttt{method, obj)}.
3. If \texttt{Type(iterator)} is not Object, throw a \texttt{TypeError} exception.
4. Return \texttt{iterator}.

\textbf{7.4.2 IteratorNext ( iterator [, value ] )}

The abstract operation \texttt{IteratorNext} with argument \texttt{iterator} and optional argument \texttt{value} performs the following steps:

1. If \texttt{value} was not passed, then
   a. Let \texttt{result} be \texttt{Invoke(iterator, "next", « »)}.
2. Else,
   a. Let \texttt{result} be \texttt{Invoke(iterator, "next", « value »)}.
3. If \texttt{Type(result)} is not Object, throw a \texttt{TypeError} exception.
4. Return \texttt{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. Let done be ? IteratorComplete(result).
3. If done is true, return false.
4. Return result.

7.4.6 IteratorClose (iterator, completion)

The abstract operation IteratorClose with arguments iterator and completion is used to notify an iterator that it 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. If return is undefined, return Completion(completion).
5. Let innerResult be Call(return, iterator, « »).
6. If Type(innerResult[[Type]]) is throw, return Completion(completion).
7. If Type(innerResult[[Value]]) is throw, return Completion(innerResult).
8. If Type(innerResult[[Value]]) is not Object, throw a TypeError exception.
9. Return Completion(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.
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 an [[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.

8 Executable Code and Execution Contexts

8.1 Lexical Environments

A Lexical Environment is a specification type used to define the association of Identifiers to specific variables and functions based upon the lexical nesting structure of ECMAScript code. A Lexical Environment consists of 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. It is referred to as the Lexical Environment’s EnvironmentRecord.

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 EnvironmentRecord may be prepopulated with identifier bindings and includes an associated global object whose properties provide some of the global environment’s identifier bindings. 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 FunctionDeclaration, VariableDeclaration, 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 are values of the Record specification type and 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 15. These abstract methods have distinct concrete algorithms for each of the concrete subclasses.
Table 15: 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 true if it does and false 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 Boolean argument D is true the binding 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 true then attempts to access the value of the binding before it is initialized or set it after it has been initialized will always throw an exception, regardless of the strict mode setting of operations that reference that binding.</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 ECMAScript 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 ECMAScript language type. S is a Boolean flag. If S is true and the binding cannot be set throw a TypeError 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 references originating in strict mode code or that otherwise require strict mode reference semantics. If S is true and the binding does not exist throw a ReferenceError exception. If the binding exists but is uninitialized a ReferenceError 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 true. If the binding exists but cannot be removed return false. If the binding does not exist return true.</td>
</tr>
<tr>
<td>HasThisBinding()</td>
<td>Determine if an Environment Record establishes a this binding. Return true if it does and false if it does not.</td>
</tr>
<tr>
<td>HasSuperBinding()</td>
<td>Determine if an Environment Record establishes a super method binding. Return true if it does and false 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 ECMAScript program scope containing variable, constant, let, class, module, import, and/or function declarations. A declarative Environment Record binds the set of identifiers defined by the declarations contained within its scope.

The behaviour of the concrete specification methods for declarative Environment Records is defined by the following algorithms.

8.1.1.1.1 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 \textit{envRec} has a binding for the name that is the value of \textit{N}, return \textbf{true}.
3. Return \textbf{false}.

\subsection{8.1.1.1.2 CreateMutableBinding \((N, D)\)}

The concrete \texttt{Environment Record} method \texttt{CreateMutableBinding} for declarative Environment Records creates a new mutable binding for the name \textit{N} that is uninitialized. A binding must not already exist in this \texttt{Environment Record} for \textit{N}. If the Boolean argument \textit{D} has the value \textbf{true} the new binding is marked as being subject to deletion.

1. Let \textit{envRec} be the declarative \texttt{Environment Record} for which the method was invoked.
2. Assert: \textit{envRec} does not already have a binding for \textit{N}.
3. Create a mutable binding in \textit{envRec} for \textit{N} and record that it is uninitialized. If \textit{D} is \textbf{true}, record that the newly created binding may be deleted by a subsequent \texttt{DeleteBinding} call.
4. Return \texttt{NormalCompletion}(empty).

\subsection{8.1.1.1.3 CreateImmutableBinding \((N, S)\)}

The concrete \texttt{Environment Record} method \texttt{CreateImmutableBinding} for declarative Environment Records creates a new immutable binding for the name \textit{N} that is uninitialized. A binding must not already exist in this \texttt{Environment Record} for \textit{N}. If the Boolean argument \textit{S} has the value \textbf{true} the new binding is marked as a strict binding.

1. Let \textit{envRec} be the declarative \texttt{Environment Record} for which the method was invoked.
2. Assert: \textit{envRec} does not already have a binding for \textit{N}.
3. Create an immutable binding in \textit{envRec} for \textit{N} and record that it is uninitialized. If \textit{S} is \textbf{true}, record that the newly created binding is a strict binding.
4. Return \texttt{NormalCompletion}(empty).

\subsection{8.1.1.1.4 InitializeBinding \((N, V)\)}

The concrete \texttt{Environment Record} method \texttt{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 \textit{N} to the value of argument \textit{V}. An uninitialized binding for \textit{N} must already exist.

1. Let \textit{envRec} be the declarative \texttt{Environment Record} for which the method was invoked.
2. Assert: \textit{envRec} must have an uninitialized binding for \textit{N}.
3. Set the bound value for \textit{N} in \textit{envRec} to \textit{V}.
4. Record that the binding for \textit{N} in \textit{envRec} has been initialized.
5. Return \texttt{NormalCompletion}(empty).

\subsection{8.1.1.1.5 SetMutableBinding \((N, V, S)\)}

The concrete \texttt{Environment Record} method \texttt{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 \textit{N} to the value of argument \textit{V}. A binding for \textit{N} normally already exist, but in rare cases it may not. If the binding is an immutable binding, a \texttt{TypeError} is thrown if \textit{S} is \textbf{true}.

1. Let \textit{envRec} be the declarative \texttt{Environment Record} for which the method was invoked.
2. If \textit{envRec} does not have a binding for \textit{N}, then
   a. If \textit{S} is \textbf{true}, throw a \texttt{ReferenceError} exception.
   b. Perform \textit{envRec}.CreateMutableBinding\((N, \textbf{true})\).
   c. Perform \textit{envRec}.InitializeBinding\((N, V)\).
   d. Return \texttt{NormalCompletion}(empty).
3. If the binding for \textit{N} in \textit{envRec} is a strict binding, let \textit{S} be \textbf{true}.
4. If the binding for \textit{N} in \textit{envRec} has not yet been initialized, throw a \texttt{ReferenceError} exception.
5. Else if the binding for \textit{N} in \textit{envRec} is a mutable binding, change its bound value to \textit{V}.
6. Else this must be an attempt to change the value of an immutable binding so if \textit{S} is \textbf{true}, throw a \texttt{TypeError} exception.
7. Return \texttt{NormalCompletion}(empty).
An example of ECMAScript code that results in a missing binding at step 2 is:

```javascript
function f(){eval("var x; x = (delete x, 0);")}
```

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`.

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. Assert: `envRec` has a binding for the name that is the value of \( N \).
3. If the binding for \( N \) in `envRec` cannot be deleted, return `false`.
4. Remove the binding for \( N \) from `envRec`.
5. Return `true`.

Regular declarative Environment Records do not provide a `this` binding.

1. Return `false`.

Regular declarative Environment Records do not provide a `super` binding.

1. Return `false`.

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

1. Return `undefined`.

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 (13.11) 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. If \( foundBinding \) is \( false \), return \( false \).
5. If the \( withEnvironment \) flag of \( envRec \) is \( false \), return \( true \).
6. Let \( unscopables \) be \( ? \) Get(\( bindings \), \( @@unscopables \)).
7. If Type(\( unscopables \)) is Object, then
   a. Let \( blocked \) be ToBoolean(\( ? \) Get(\( unscopables \), \( N \))).
   b. If \( blocked \) is \( true \), return \( false \).
8. 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 \( D \) has the value \( true \) the new property’s [[Configurable]] attribute is set to \( true \); otherwise it is set to \( false \).

1. Let \( envRec \) be the object Environment Record for which the method was invoked.
2. Let \( bindings \) be the binding object for \( envRec \).
3. If \( D \) is \( true \), let \( configValue \) be \( true \); otherwise let \( configValue \) be \( false \).
4. Return ? DefinePropertyOrThrow(\( bindings \), \( N \), PropertyDescriptor{[[Value]]: \( undefined \), [[Writable]]: \( true \), [[Enumerable]]: \( true \), [[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 \( ? \) \( envRec \).SetMutableBinding(\( N \), \( V \), \( false \)).

**NOTE** In this specification, all uses of CreateMutableBinding for object Environment Records are immediately followed by a call to InitializeBinding for the same name. Hence, implementations do not need to explicitly track the initialization state of individual object Environment Record bindings.

### 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 $\text{Set}(bindings, N, V, S)$.

### 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 $\text{HasProperty}(bindings, N)$.
4. If $value$ is false, then
   a. If $S$ is false, return the value $\text{undefined}$; otherwise throw a ReferenceError exception.
5. Return $\text{Get}(bindings, N)$.

### 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 $[[\text{Configurable}]]$ 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 $\text{bindings}[[\text{Delete}]](N)$.

### 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 $\text{undefined}$ 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 16.
Table 16: Additional Fields of Function Environment Records

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[ThisValue]]</td>
<td>Any</td>
<td>This is the <code>this</code> value used for this invocation of the function.</td>
</tr>
<tr>
<td>[[ThisBindingStatus]]</td>
<td>&quot;lexical&quot;</td>
<td>If the value is &quot;lexical&quot;, this is an <code>ArrowFunction</code> and does not have a local this value.</td>
</tr>
<tr>
<td></td>
<td>&quot;initialized&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot;uninitialized&quot;</td>
<td></td>
</tr>
<tr>
<td>[[FunctionObject]]</td>
<td>Object</td>
<td>The function object whose invocation caused this Environment Record to be created.</td>
</tr>
<tr>
<td>[[HomeObject]]</td>
<td>Object</td>
<td>If the associated function has <code>super</code> property accesses and is not an <code>ArrowFunction</code>, [[HomeObject]] is the object that the function is bound to as a method. The default value for [[HomeObject]] is <code>undefined</code>.</td>
</tr>
<tr>
<td></td>
<td>undefined</td>
<td></td>
</tr>
<tr>
<td>[[NewTarget]]</td>
<td>Object</td>
<td>If this Environment Record was created by the [[Construct]] internal method, [[NewTarget]] is the value of the [[Construct]] <code>newTarget</code> parameter. Otherwise, its value is <code>undefined</code>.</td>
</tr>
<tr>
<td></td>
<td>undefined</td>
<td></td>
</tr>
</tbody>
</table>

Function Environment Records support all of the declarative Environment Record methods listed in Table 15 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 17:

Table 17: Additional Methods of Function Environment Records

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>BindThisValue(V)</td>
<td>Set the <code>[[ThisValue]]</code> and record that it has been initialized.</td>
</tr>
<tr>
<td>GetThisBinding()</td>
<td>Return the value of this Environment Record’s <code>this</code> binding. Throws a <code>ReferenceError</code> if the <code>this</code> binding has not been initialized.</td>
</tr>
<tr>
<td>GetSuperBase()</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:

8.1.1.3.1 BindThisValue (V)

1. Let `envRec` be the function Environment Record for which the method was invoked.
2. Assert: `envRec.[[ThisBindingStatus]]` is not "lexical".
3. If `envRec.[[ThisBindingStatus]]` is "initialized", throw a `ReferenceError` exception.
4. Set `envRec.[[ThisValue]]` to `V`.
5. Set `envRec.[[ThisBindingStatus]]` to "initialized".
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.[[ThisBindingStatus]]` is "lexical", 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.[[ThisBindingStatus]]` is "lexical", 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. Assert: `envRec.[[ThisBindingStatus]]` is not "lexical".
3. If `envRec.[[ThisBindingStatus]]` is "uninitialized", throw a **ReferenceError** exception.
4. 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.

### 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`. A global `Environment Record` provides the bindings for built-in globals (clause 18), properties of the `global object`, and for all top-level declarations (13.2.8, 13.2.10) that occur within a `Script`.

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 Record`. This `global object` is the value returned by 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 bindings 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 `CreateGlobalVarBinding` and `CreateGlobalFunctionBinding` concrete methods.

Global Environment Records have the additional fields listed in Table 18 and the additional methods listed in Table 19.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[ObjectRecord]]</code></td>
<td><code>Object FunctionRecord</code></td>
<td>Binding object is the <code>global object</code>. It contains global built-in bindings as well as <code>FunctionDeclaration</code>, <code>GeneratorDeclaration</code>, and <code>VariableDeclaration</code> bindings in global code for the associated <code>realm</code>.</td>
</tr>
<tr>
<td><code>[[GlobalThisValue]]</code></td>
<td><code>Object</code></td>
<td>The value returned by <code>this</code> in global scope. Hosts may provide any ECMAScript Object value.</td>
</tr>
<tr>
<td><code>[[DeclarativeRecord]]</code></td>
<td><code>Declarative Environment Record</code></td>
<td>Contains bindings for all declarations in global code for the associated <code>realm</code> code except for <code>FunctionDeclaration</code>, <code>GeneratorDeclaration</code>, and <code>VariableDeclaration bindings</code>.</td>
</tr>
<tr>
<td><code>[[VarNames]]</code></td>
<td>List of String</td>
<td>The string names bound by <code>FunctionDeclaration</code>, <code>GeneratorDeclaration</code>, and <code>VariableDeclaration</code> declarations in global code for the associated <code>realm</code>.</td>
</tr>
</tbody>
</table>
### Table 19: 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 and initialize to undefined a global var binding in the [[ObjectRecord]] 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 the bound name. If D is true the binding may be deleted. Logically equivalent to CreateMutableBinding followed by a SetMutableBinding but it allows var declarations to receive special treatment.</td>
</tr>
<tr>
<td>CreateGlobalFunctionBinding(N, V, D)</td>
<td>Create and initialize a global function binding in the [[ObjectRecord]] 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 bound name. V is the initialization value. If the Boolean argument D is true the binding may be deleted. 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.[[DeclarativeRecord]].
3. If DclRec.HasBinding(N) is true, return true.
4. Let ObjRec be envRec.[[ObjectRecord]].

#### 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 has the value 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.[[DeclarativeRecord]].
3. If DclRec.HasBinding(N) is true, throw a TypeError exception.
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 the Boolean argument \(S\) has the value `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. If \(DclRec.\text{HasBinding}(N)\) is `true`, throw a `TypeError` exception.
4. Return \(DclRec.\text{CreateImmutableBinding}(N, S)\).

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 \(DclRec.\text{HasBinding}(N)\) is `true`, then
   a. Return \(DclRec.\text{InitializeBinding}(N, V)\).
4. Assert: If the binding exists, it must be in the object `Environment Record`.
5. Let \(ObjRec\) be `envRec`.\([\text{ObjectRecord}]\).
6. Return \(? ObjRec.\text{InitializeBinding}(N, V)\).

8.1.1.4.5 SetMutableBinding \((N, V, S)\)

The concrete `Environment Record` method `SetMutableBinding` for global Environment Records attempts to change the bound value of the current binding of the identifier whose name is the value of the argument \(N\) to the value of argument \(V\). If the binding is an immutable binding, a `TypeError` is thrown if \(S\) is `true`. A property named \(N\) normally already exists but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument \(S\).

1. Let \(envRec\) be the global `Environment Record` for which the method was invoked.
2. Let \(DclRec\) be `envRec`.\([\text{DeclarativeRecord}]\).
3. If \(DclRec.\text{HasBinding}(N)\) is `true`, then
   a. Return \(DclRec.\text{SetMutableBinding}(N, V, S)\).
4. Let \(ObjRec\) be `envRec`.\([\text{ObjectRecord}]\).
5. Return \(? ObjRec.\text{SetMutableBinding}(N, V, S)\).

8.1.1.4.6 GetBindingValue \((N, S)\)

The concrete `Environment Record` method `GetBindingValue` for global Environment Records returns the value of its bound identifier whose name is the value of the argument \(N\). If the binding is an uninitialized binding throw a `ReferenceError` exception. A property named \(N\) normally already exists but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument \(S\).

1. Let \(envRec\) be the global `Environment Record` for which the method was invoked.
2. Let \(DclRec\) be `envRec`.\([\text{DeclarativeRecord}]\).
3. If \(DclRec.\text{HasBinding}(N)\) is `true`, then
   a. Return \(DclRec.\text{GetBindingValue}(N, S)\).
4. Let \(ObjRec\) be `envRec`.\([\text{ObjectRecord}]\).
5. Return \(? ObjRec.\text{GetBindingValue}(N, S)\).

8.1.1.4.7 DeleteBinding \((N)\)

The concrete `Environment Record` method `DeleteBinding` for global Environment Records can only delete bindings that have been explicitly designated as being subject to deletion.

1. Let \(envRec\) be the global `Environment Record` for which the method was invoked.
2. Let `DclRec` be `envRec. [[DeclarativeRecord]]`.
3. If `DclRec.HasBinding(N)` is `true`, then
   a. Return `DclRec.DeleteBinding(N)`.
4. Let `ObjRec` be `envRec. [[ObjectRecord]]`.
5. Let `globalObject` be the binding object for `ObjRec`.
6. Let `existingProp` be `? HasOwnProperty(globalObject, N)`.
7. If `existingProp` is `true`, then
   a. Let `status` be `? ObjRec.DeleteBinding(N)`.
      i. If `status` is `true`, then
         ii. Let `varNames` be `envRec. [[VarNames]]`.
            ii. If `N` is an element of `varNames`, remove that element from the `varNames`.
   c. Return `status`.
8. Return `true`.

8.1.1.4.8 HasThisBinding ()

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. Return `envRec. [[GlobalThisValue]]`.

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. [[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 `DclRec` be `envRec. [[DeclarativeRecord]]`.

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 \( \text{globalObject} \) be the binding object for \( \text{ObjRec} \).
4. Let \( \text{existingProp} \) be \( ? \ \text{globalObject}.[[\text{GetOwnProperty}]](N) \).
5. If \( \text{existingProp} \) is \text{undefined}, return \text{false}.
6. If \( \text{existingProp}.[[\text{Configurable}]] \) is \text{true}, return \text{false}.
7. Return \text{true}.

NOTE Properties may exist upon a \text{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 \text{global object}. The global property \text{undefined} is an example of such a property.

### 8.1.1.4.15 CanDeclareGlobalVar (\( N \))

The concrete \text{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 \text{global object} properties are allowed.

1. Let \( \text{envRec} \) be the global \text{Environment Record} for which the method was invoked.
2. Let \( \text{ObjRec} \) be \( \text{envRec}.[[\text{ObjectRecord}]] \).
3. Let \( \text{globalObject} \) be the binding object for \( \text{ObjRec} \).
4. Let \( \text{hasProperty} \) be \( ? \ \text{HasOwnProperty}(\text{globalObject}, N) \).
5. If \( \text{hasProperty} \) is \text{true}, return \text{true}.
6. Return \( ? \ \text{IsExtensible}(\text{globalObject}) \).

### 8.1.1.4.16 CanDeclareGlobalFunction (\( N \))

The concrete \text{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 \( \text{envRec} \) be the global \text{Environment Record} for which the method was invoked.
2. Let \( \text{ObjRec} \) be \( \text{envRec}.[[\text{ObjectRecord}]] \).
3. Let \( \text{globalObject} \) be the binding object for \( \text{ObjRec} \).
4. Let \( \text{existingProp} \) be \( ? \ \text{globalObject}.[[\text{GetOwnProperty}]](N) \).
5. If \( \text{existingProp} \) is \text{undefined}, return \( ? \ \text{IsExtensible}(\text{globalObject}) \).
6. If \( \text{existingProp}.[[\text{Configurable}]] \) is \text{true}, return \text{true}.
7. If \( \text{IsDataDescriptor}(\text{existingProp}) \) is \text{true} and \( \text{existingProp} \) has attribute values \{[[\text{Writable}]]: \text{true}, [[\text{Enumerable}]]: \text{true} \}, return \text{true}.
8. Return \text{false}.

### 8.1.1.4.17 CreateGlobalVarBinding (\( N, D \))

The concrete \text{Environment Record} method CreateGlobalVarBinding for global Environment Records creates and initializes a mutable binding in the associated object \text{Environment Record} and records the bound name in the associated \([\text{VarNames}]\) List. If a binding already exists, it is reused and assumed to be initialized.

1. Let \( \text{envRec} \) be the global \text{Environment Record} for which the method was invoked.
2. Let \( \text{ObjRec} \) be \( \text{envRec}.[[\text{ObjectRecord}]] \).
3. Let \( \text{globalObject} \) be the binding object for \( \text{ObjRec} \).
4. Let \( \text{hasProperty} \) be \( ? \ \text{HasOwnProperty}(\text{globalObject}, N) \).
5. Let \( \text{extensible} \) be \( ? \ \text{IsExtensible}(\text{globalObject}) \).
6. If \( \text{hasProperty} \) is \text{false} and \( \text{extensible} \) is \text{true}, then
   a. Perform \( ? \ \text{ObjRec}.\text{CreateMutableBinding}(N, D) \).
   b. Perform \( ? \ \text{ObjRec}.\text{InitializeBinding}(N, \text{undefined}) \).
7. Let \( \text{varDeclaredNames} \) be \( \text{envRec}.[[\text{VarNames}]] \).
8. If \( \text{varDeclaredNames} \) does not contain the value of \( N \), then
   a. Append \( N \) to \( \text{varDeclaredNames} \).
9. Return \text{NormalCompletion}(\text{empty}).
8.1.1.4.18 CreateGlobalFunctionBinding \((N, V, D)\)

The concrete Environment Record method CreateGlobalFunctionBinding for global Environment Records creates and initializes 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 \(globalObject.[[GetOwnProperty]](N)\).
5. If \(existingProp\) is undefined or \(existingProp.[[Configurable]]\) is true, then
   a. Let \(desc\) be the PropertyDescriptor\{[[Value]]: \(V\), [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: \(D\)\}.
6. Else, a. Let \(desc\) be the PropertyDescriptor\{[[Value]]: \(V\)\}.
7. Perform \(DefinePropertyOrThrow(globalObject, N, desc)\).
8. Perform \(Set(globalObject, N, V, false)\).
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\(\emptyset\).

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. Steps 10-12 are equivalent to what calling the InitializeBinding concrete method would do and if \(globalObject\) is a Proxy will produce the same sequence of Proxy trap calls.

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 addition 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 15 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 20:

<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, 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 are 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` is an indirect binding, then
   a. Let `M` and `N2` be the indirection values provided when this binding for `N` was created.
   b. Let `targetEnv` be `M`[[Environment]].
   c. If `targetEnv` is `undefined`, throw a `ReferenceError` exception.
   d. Let `targetER` be `targetEnv`'s `EnvironmentRecord`.
   e. Return `targetER.GetBindingValue(N2, 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 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`, 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 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)

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 `EnvironmentRecord`.

3. Let `exists` be `? envRec.HasBinding(name)`.

4. If `exists` is `true`, then
   a. Return a value of type `Reference` whose base value is `envRec`, whose referenced name is `name`, and whose strict reference flag is `strict`.

5. Else,
   a. Let `outer` be the value of `lex`'s outer environment reference.
   b. Return `? GetIdentifierReference(outer, name, strict)`.

8.1.2.2 NewDeclarativeEnvironment (E)

When the abstract operation `NewDeclarativeEnvironment` is called with a `Lexical Environment` 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 `EnvironmentRecord` to `envRec`.
4. Set the outer lexical environment reference of `env` to `E`.
5. Return `env`.

8.1.2.3 NewObjectEnvironment (O, E)

When the abstract operation `NewObjectEnvironment` is called with an `Object` `O` and a `Lexical Environment` `E` 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 `EnvironmentRecord` to `envRec`.
4. Set the outer lexical environment reference of `env` to `E`.
5. Return `env`.

8.1.2.4 NewFunctionEnvironment (F, newTarget)

When the abstract operation `NewFunctionEnvironment` is called with arguments `F` and `newTarget` the following steps are performed:

1. Assert: `F` is an ECMAScript function.
2. Assert: `Type(newTarget)` is Undefined or Object.
3. Let `env` be a new `Lexical Environment`.
4. Let `envRec` be a new function `Environment Record` containing no bindings.
5. Set `envRec.([FunctionObject])` to `F`.
6. If `F`'s `[[ThisMode]]` internal slot is `lexical`, set `envRec.([ThisBindingStatus])` to `"lexical"`.
7. Else, set `envRec.([ThisBindingStatus])` to `"uninitialized"`.
8. Let `home` be the value of `F`'s `[[HomeObject]]` internal slot.
9. Set `envRec.([HomeObject])` to `home`.
10. Set `envRec.([NewTarget])` to `newTarget`.
11. Set `env`'s `EnvironmentRecord` to `envRec`.
12. Set the outer lexical environment reference of `env` to the value of `F`'s `[[Environment]]` internal slot.

8.1.2.5 NewGlobalEnvironment (G, thisValue)

When the abstract operation `NewGlobalEnvironment` is called with arguments `G` and `thisValue`, 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. Let dclRec be a new declarative Environment Record containing no bindings.
4. Let globalRec be a new global Environment Record.
5. Set globalRec.[[ObjectRecord]] to objRec.
6. Set globalRec.[[GlobalThisValue]] to thisValue.
7. Set globalRec.[[DeclarativeRecord]] to dclRec.
8. Set env’s EnvironmentRecord to globalRec.
9. Set the outer lexical environment reference of env to null.
10. Return env.

8.1.2.6 NewModuleEnvironment (E)

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

8.2 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 represented in this specification as a Realm Record with the fields specified in Table 21:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Intrinsics]]</td>
<td>Record whose field names are intrinsic keys and whose values are objects</td>
<td>The intrinsic values used by code associated with this realm</td>
</tr>
<tr>
<td>[[GlobalObject]]</td>
<td>Object</td>
<td>The global object for this realm</td>
</tr>
<tr>
<td>[[GlobalEnv]]</td>
<td>Lexical Environment</td>
<td>The global environment for this realm</td>
</tr>
<tr>
<td>[[TemplateMap]]</td>
<td>A List of Record {</td>
<td>Template objects are canonicalized separately for each realm using its Realm Record’s [[TemplateMap]]. Each [[Strings]] value is a List containing, in source text 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>
</tbody>
</table>

An implementation may define other, implementation specific fields.

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

1. Let realmRec be a new Realm Record.
2. Perform CreateIntrinsics(realmRec).
3. Set realmRec.[[GlobalObject]] to undefined.
4. Set realmRec.[[GlobalEnv]] to undefined.
5. Set realmRec.[[TemplateMap]] to a new empty List.
6. Return realmRec.

8.2.2 CreateIntrinsics ( realmRec )

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 specified in 9.2.7.1 for the %ThrowTypeError% function.
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 CreateBuiltinFunction(realmRec, noSteps, objProto).
10. Set intrinsics.[[FunctionPrototype]] to funcProto.
11. Call thrower.[[SetPrototypeOf]](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 function’s 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.

8.2.3 SetRealmGlobalObject ( realmRec, globalObj, thisValue )

The abstract operation SetRealmGlobalObject with arguments realmRec, globalObj, and thisValue 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. If thisValue is undefined, let thisValue be globalObj.
4. Set realmRec.[[GlobalObject]] to globalObj.
5. Let newGlobalEnv be NewGlobalEnvironment(globalObj, thisValue).
6. Set realmRec.[[GlobalEnv]] to newGlobalEnv.
7. Return realmRec.

8.2.4 SetDefaultGlobalBindings ( realmRec )

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

1. Let global be realmRec.[[GlobalObject]].
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 listed in 18.2, 18.3, or 18.4 the value of the [[Value]] attribute is the corresponding intrinsic object from realmRec.

c. Perform \texttt{DefinePropertyOrThrow} (global, name, desc).

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.

The execution context 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 22.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>code evaluation</td>
<td>Any state needed to perform, suspend, and resume evaluation of the code associated with this execution context.</td>
</tr>
<tr>
<td>state</td>
<td></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 Record from which associated code accesses ECMAScript resources.</td>
</tr>
<tr>
<td>ScriptOrModule</td>
<td>The Module Record or Script Record from which associated code originates. If there is no originating script or module, as is the case for the original execution context created in InitializeHostDefinedRealm, the value is null.</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 a different execution context may become the running execution context and commence 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 Record. 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 23.

<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 EnvironmentRecord 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 24.

<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 GetActiveScriptOrModule ()

The GetActiveScriptOrModule abstract operation is used to determine the running script or module, based on the active function object. GetActiveScriptOrModule performs the following steps:

1. If the execution context stack is empty, return null.
2. Let ec be the topmost execution context on the execution context stack whose Function component's [[ScriptOrModule]] component is not null.
3. If such an execution context exists, return ec's Function component's [[ScriptOrModule]] slot's value.
4. Otherwise, let ec be the running execution context.
5. Assert: ec's ScriptOrModule component is not null.
6. Return ec's ScriptOrModule component.

### 8.3.2 ResolveBinding (name [, env ])

The ResolveBinding abstract operation is used to determine the binding of name passed as a String value. The optional argument env can be used to explicitly provide the Lexical Environment that is to be searched for the binding. During execution of ECMAScript code, ResolveBinding is performed using the following algorithm:

1. If env was not passed or if env is undefined, then
   a. Let env be the running execution context's LexicalEnvironment.
2. Assert: env is a Lexical Environment.
3. If the code matching the syntactic production that is being evaluated is contained in strict mode code, let strict be true, else let strict be false.

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

### 8.3.3 GetThisEnvironment ()

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 EnvironmentRecord.
   b. Let exists be envRec.HasThisBinding().
c. If \( \text{exists} \) is \textbf{true}, return \( \text{envRec} \).
d. Let \( \text{outer} \) be the value of \( \text{lex}'s \) outer environment reference.
e. Let \( \text{lex} \) be \( \text{outer} \).

NOTE The loop in step 2 will always terminate because the list of environments always ends with the \textbf{global environment} which has a \textbf{this} binding.

### 8.3.4 ResolveThisBinding ( )

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

1. Let \( \text{envRec} \) be \textit{GetThisEnvironment} ( )
2. Return \( ? \text{envRec}.\text{GetThisBinding}() \).

### 8.3.5 GetNewTarget ( )

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

1. Let \( \text{envRec} \) be \textit{GetThisEnvironment} ( )
2. Assert: \( \text{envRec} \) has a \([\text{NewTarget}]\) field.
3. Return \( \text{envRec}.[\text{NewTarget}] \).

### 8.3.6 GetGlobalObject ( )

The abstract operation GetGlobalObject returns the \textbf{global object} used by the currently \textit{running execution context}. GetGlobalObject performs the following steps:

1. Let \( \text{ctx} \) be the \textit{running execution context}.
2. Let \( \text{currentRealm} \) be \( \text{ctx}'s \) \textit{Realm}.
3. Return \( \text{currentRealm}.[[\text{GlobalObject}]] \).

### 8.4 Jobs and Job Queues

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

Execution of a \textbf{Job} can be initiated only when there is no \textit{running execution context} and the \textit{execution context stack} is empty. A \textbf{PendingJob} is a request for the future execution of a \textbf{Job}. A \textbf{PendingJob} is an internal \textbf{Record} whose fields are specified in Table 25. Once execution of a \textbf{Job} is initiated, the \textbf{Job} always executes to completion. No other \textbf{Job} may be initiated until the currently running \textbf{Job} completes. However, the currently running \textbf{Job} or external events may cause the enqueuing of additional \textbf{PendingJobs} that may be initiated sometime after completion of the currently running \textbf{Job}. 
### Table 25: 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 Record for the initial execution context when this PendingJob is initiated.</td>
</tr>
<tr>
<td>ScriptOrModule</td>
<td>A Script Record or Module Record</td>
<td>The script or module for the initial execution context when this PendingJob 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 26.

### Table 26: 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 source text. 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)

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.
7. Let `pending` be PendingJob{ [[Job]]: `job`, [[Arguments]]: `arguments`, [[Realm]]: `callerRealm`, [[ScriptOrModule]]: `callerScriptOrModule`, [[HostDefined]]: `undefined` }.
8. Perform any implementation or host environment defined processing of `pending`. This may include modifying the [[HostDefined]] field or any other field of `pending`.
9. Add `pending` at the back of the Job Queue named by `queueName`.
10. Return NormalCompletion(empty).

### 8.4.2 NextJob

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 `HostReportErrors("result.[[Value]]")`.
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 Function to null.
8. Set `newContext`'s Realm to `nextPending`.[[Realm]].
9. Set `newContext`'s ScriptOrModule to `nextPending`.[[ScriptOrModule]].
10. Push `newContext` onto the execution context stack; `newContext` is now the running execution context.
11. Perform any implementation or host environment defined job initialization using `nextPending`.
12. Perform the abstract operation named by `nextPending`.[[Job]] using the elements of `nextPending`.[[Arguments]] as its arguments.

### 8.5 InitializeHostDefinedRealm ()

The abstract operation InitializeHostDefinedRealm performs the following steps:

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. Set the ScriptOrModule of `newContext` to null.
6. Push `newContext` onto the execution context stack; `newContext` is now the running execution context.
7. If the host 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 undefined, indicating that an ordinary object should be created as the global object.
8. If the host requires that the `this` binding in `realm`'s global scope return an object other than the global object, let `thisValue` be such an object created in an implementation defined manner. Otherwise, let `thisValue` be undefined, indicating that `realm`'s global `this` binding should be the global object.
9. Perform SetRealmGlobalObject(`realm`, `global`, `thisValue`).
Let `globalObj` be \( ? \) `SetDefaultGlobalBindings(realm)`.

Create any implementation defined `global object` properties on `globalObj`.

In an implementation dependent manner, obtain the ECMAScript source texts (see clause 10) and any associated host-defined values for zero or more ECMAScript scripts and/or ECMAScript modules. For each such `sourceText` and `hostDefined`,

a. If `sourceText` is the source code of a script, then

b. Else `sourceText` is the source code of a module,

NextJob NormalCompletion(undefined).

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 `[[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.

Each ordinary object internal method delegates to a similarly-named abstract operation. If such an abstract operation depends on another internal method, then the internal method is invoked on \( O \) rather than calling the similarly-named abstract operation directly. These semantics ensure that exotic objects have their overridden internal methods invoked when ordinary object internal methods are applied to them.

9.1.1 `[[GetPrototypeOf]] ( )`

When the `[[GetPrototypeOf]]` internal method of \( O \) is called, the following steps are taken:

1. Return `! OrdinaryGetPrototypeOf(O)`.

9.1.1.1 `OrdinaryGetPrototypeOf (O)`

When the abstract operation `OrdinaryGetPrototypeOf` is called with Object \( O \), 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. Return `! OrdinarySetPrototypeOf(O, V)`.

9.1.2.1 `OrdinarySetPrototypeOf (O, V)`

When the abstract operation `OrdinarySetPrototypeOf` is called with Object \( O \) and value \( V \), 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)` is `true`, return `true`.
5. If `extensible` is `false`, return `false`.
7. Let `done` be `false`.
8. Repeat while `done` is `false`,
    a. If `p` is null, let `done` be `true`.
    b. Else, if `SameValue(p, O)` is `true`, return `false`.
    c. Else,
       i. If the `[[GetPrototypeOf]]` internal method of `p` is not the ordinary object internal method defined in 9.1.1, let `done` be `true`.
       ii. Else, let `p` be the value of `p`'s `[[Prototype]]` internal slot.
9. Set the value of the `[[Prototype]]` internal slot of `O` to `V`.
10. Return `true`.

NOTE The loop in step 8 guarantees that there will be no circularities in any prototype chain that only includes objects that use the ordinary object definitions for `[[GetPrototypeOf]]` and `[[SetPrototypeOf]]`.

9.1.3 `[[IsExtensible]]()` ()

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

1. Return ! `OrdinaryIsExtensible(O)`.

9.1.3.1 `OrdinaryIsExtensible(O)`

When the abstract operation `OrdinaryIsExtensible` is called with Object `O`, 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. Return ! `OrdinaryPreventExtensions(O)`.

9.1.4.1 `OrdinaryPreventExtensions(O)`

When the abstract operation `OrdinaryPreventExtensions` is called with Object `O`, 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 `PropertyDescriptor` 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 $D.[\text{Value}]$ to the value of $X$'s $[[\text{Value}]]$ attribute.
b. Set $D.[\text{Writable}]$ to the value of $X$'s $[[\text{Writable}]]$ attribute.
6. Else $X$ is an accessor property, so
a. Set $D.[\text{Get}]$ to the value of $X$'s $[[\text{Get}]]$ attribute.
b. Set $D.[\text{Set}]$ to the value of $X$'s $[[\text{Set}]]$ attribute.
7. Set $D.[\text{Enumerable}]$ to the value of $X$'s $[[\text{Enumerable}]]$ attribute.
8. Set $D.[\text{Configurable}]$ to the value of $X$'s $[[\text{Configurable}]]$ attribute.

9.1.6 $[[\text{DefineOwnProperty}]]$ ($P$, $Desc$)

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

1. Return $\text{? OrdinaryDefineOwnProperty}(O, P, Desc)$.

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 $O.[[\text{GetPropertyOwnProperty}]](P)$.
2. Let $extensible$ be the value of the $[[\text{Extensible}]]$ internal slot of $O$.
3. Return $\text{ValidateAndApplyPropertyDescriptor}(O, P, extensible, Desc, current)$.

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 $\text{ValidateAndApplyPropertyDescriptor}(\text{undefined}, \text{undefined}, Extensible, Desc, Current)$.

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 $Desc$ for specific values. The fields that are tested in this manner need not actually exist in $Desc$. If a field is absent then its value is considered to be $false$.

NOTE 1 If $\text{undefined}$ is passed as the $O$ argument only validation is performed and no object updates are performed.

1. Assert: If $O$ is not $\text{undefined}$, then $\text{IsPropertyKey}(P)$ is $true$.
2. If $current$ is $\text{undefined}$, then
   a. If $extensible$ is $false$, return $false$.
   b. Assert: $extensible$ is $true$.
   c. If $\text{IsGenericDescriptor}(Desc)$ is $true$ or $\text{IsDataDescriptor}(Desc)$ is $true$, then
      i. If $O$ is not $\text{undefined}$, create an own data property named $P$ of object $O$ whose $[[\text{Value}]]$, $[[\text{Writable}]]$, $[[\text{Enumerable}]]$ and $[[\text{Configurable}]]$ attribute values are described by $Desc$. If the value of an attribute field of $Desc$ is absent, the attribute of the newly created property is set to its default value.
   d. Else $Desc$ must be an accessor Property Descriptor,
      i. If $O$ is not $\text{undefined}$, create an own accessor property named $P$ of object $O$ whose $[[\text{Get}]]$, $[[\text{Set}]]$, $[[\text{Enumerable}]]$ and $[[\text{Configurable}]]$ attribute values are described by $Desc$. If the value of an attribute field of $Desc$ is absent, the attribute of the newly created property is set to its default value.
   e. Return $true$.
3. Return $true$, if every field in $Desc$ is absent.
4. Return $true$, if every field in $Desc$ also occurs in $current$ and the value of every field in $Desc$ is the same value as the corresponding field in $current$ when compared using the $\text{SameValue}$ algorithm.
5. If the [[Configurable]] field of current is false, then
   a. Return false, if the [[Configurable]] field of Desc is true.
   b. Return false, if the [[Enumerable]] field of Desc is present and the [[Enumerable]] fields of current and Desc are the Boolean negation of each other.

6. If IsGenericDescriptor(Desc) is true, no further validation is required.

7. Else if IsDataDescriptor(current) and IsDataDescriptor(Desc) have different results, then
   a. Return false, if the [[Configurable]] field of current is false.
   b. If IsDataDescriptor(current) is true, then
      i. If O is not undefined, convert the property named P of object O from a data property to an accessor property.
         Preserve the existing values of the converted property’s [[Configurable]] and [[Enumerable]] attributes and set the rest of the property’s attributes to their default values.
   c. Else,
      i. If O is not undefined, convert the property named P of object O from an accessor property to a data property.
         Preserve the existing values of the converted property’s [[Configurable]] and [[Enumerable]] attributes and set the rest of the property’s attributes to their default values.

8. Else if IsDataDescriptor(current) and IsDataDescriptor(Desc) are both true, then
   a. If the [[Configurable]] field of current is false, then
      i. Return false, if the [[Writable]] field of current is false and the [[Writable]] field of Desc is true.
      ii. If the [[Writable]] field of current is false, then
          1. Return false, if the [[Value]] field of Desc is present and SameValue(Desc.[[Value]], current.[[Value]]) is false.
   b. Else the [[Configurable]] field of current is true, so any change is acceptable.

9. Else IsAccessorDescriptor(current) and IsAccessorDescriptor(Desc) are both true,
   a. If the [[Configurable]] field of current is false, then
      i. Return false, if the [[Set]] field of Desc is present and SameValue(Desc.[[Set]], current.[[Set]]) is false.
      ii. Return false, if the [[Get]] field of Desc is present and SameValue(Desc.[[Get]], current.[[Get]]) is false.

10. If O is not undefined, then
    a. For each 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 2 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:


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 ? O.[[GetOwnProperty]](P).
   3. If hasOwn is not undefined, return true.
   4. Let parent be ? O.[[GetPrototypeOf]].
   5. If parent is not null, then
   6. 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:


9.1.8.1 OrdinaryGet (O, P, Receiver)

When the abstract operation OrdinaryGet is called with Object O, property key P, and ECMAScript language value Receiver, the following steps are taken:

1. Assert: IsPropertyKey(P) is true.
2. Let desc be ? O.[[GetOwnProperty]](P).
3. If desc is undefined, then
   a. Let parent be ? O.[[GetPrototypeOf]]().
   b. If parent is null, return undefined.
4. If IsDataDescriptor(desc) is true, return desc.[[Value]].
5. Assert: IsAccessorDescriptor(desc) is true.
6. Let getter be desc.[[Get]].
7. If getter is undefined, return undefined.

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:


9.1.9.1 OrdinarySet (O, P, V, Receiver)

When the abstract operation OrdinarySet is called with Object O, property key P, value V, and ECMAScript language value Receiver, the following steps are taken:

1. Assert: IsPropertyKey(P) is true.
3. If ownDesc is undefined, then
   a. Let parent be ? O.[[GetPrototypeOf]]().
   b. If parent is not null, then
   c. Else,
      i. Let ownDesc be the PropertyDescriptor{[[Value]]: undefined, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
4. If IsDataDescriptor(ownDesc) is true, then
   a. If ownDesc.[[Writable]] is false, return false.
   b. If Type(Receiver) is not Object, return false.
   c. Let existingDescriptor be ? Receiver.[[GetOwnProperty]](P).
5. If existingDescriptor is not undefined, then
   i. If IsAccessorDescriptor(existingDescriptor) is true, return false.
   ii. If existingDescriptor.[[Writable]] is false, return false.
   iii. Let valueDesc be the PropertyDescriptor{[[Value]]: V}.
6. Else Receiver does not currently have a property P,
   i. Return ? CreateDataProperty(Receiver, P, V).
5. Assert: IsAccessorDescriptor(ownDesc) is true.
6. Let \( setter \) be \( ownDesc \) \([\text{Set}]\).
7. If \( setter \) is \text{undefined}, return \text{false}.
8. Perform \( ? \text{Call}(setter, \text{Receiver}, \text{« } V \text{ »}) \).
9. Return \text{true}.

9.1.10 \([\text{Delete}] \) \((P)\)

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

1. Return \( ? \text{OrdinaryDelete}(O, P) \).

9.1.10.1 \text{OrdinaryDelete} \((O, P)\)

When the abstract operation \text{OrdinaryDelete} is called with Object \( O \) and property key \( P \), the following steps are taken:

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

9.1.11 \([\text{OwnPropertyKeys}]\) \((\)\)

When the \([\text{OwnPropertyKeys}]\) internal method of \( O \) is called, the following steps are taken:

1. Return \( ! \text{OrdinaryOwnPropertyKeys}(O) \).

9.1.11.1 \text{OrdinaryOwnPropertyKeys} \((O)\)

When the abstract operation \text{OrdinaryOwnPropertyKeys} is called with Object \( O \), the following steps are taken:

1. Let \( keys \) be a new empty \text{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 ascending chronological order of property creation
   a. Add \( P \) as the last element of \( keys \).
4. For each own property key \( P \) of \( O \) that is a Symbol, in ascending chronological order of property creation
   a. Add \( P \) as the last element of \( keys \).
5. Return \( keys \).

9.1.12 \text{ObjectCreate} \((proto \ [\ , \ \text{internalSlotsList}] \))

The abstract operation \text{ObjectCreate} with argument \( proto \) (an object or null) is used to specify the runtime creation of new ordinary objects. The optional argument \text{internalSlotsList} is a \text{List} of the names of additional internal slots that must be defined as part of the object. If the list is not provided, a new empty \text{List} is used. This abstract operation performs the following steps:

1. If \text{internalSlotsList} was not provided, let \text{internalSlotsList} be a new empty \text{List}.
2. Let \( obj \) be a newly created object with an internal slot for each name in \text{internalSlotsList}.
3. Set \( obj \)'s essential internal methods to the default ordinary object definitions specified in 9.1.
4. Set the \([\text{Prototype}]\) internal slot of \( obj \) to \( proto \).
5. Set the \([\text{Extensible}]\) internal slot of \( obj \) to \text{true}.
6. Return \( obj \).

9.1.13 \text{OrdinaryCreateFromConstructor} \((constructor, \text{intrinsicDefaultProto} \ [\ , \ \text{internalSlotsList}] \))
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, a new 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. Return `ObjectCreate(proto, internalSlotsList)`.

9.14 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: `IsCallable(constructor)` is `true`.
3. Let `proto` be `? Get(constructor, "prototype")`.
4. If `Type(proto)` is not Object, then
   a. Let `realm` be `? GetFunctionRealm(constructor)`.
   b. Let `proto` be `realm`'s intrinsic object named `intrinsicDefaultProto`.
5. Return `proto`.

NOTE If `constructor` does not supply a `[[Prototype]]` value, the default value that is used is obtained from the 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 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. An ECMAScript function object whose code is strict mode code is called a strict function. One whose code is not strict mode code is called a non-strict function.

ECMAScript function objects have the additional internal slots listed in `Table 27`.
Table 27: 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 text 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 text 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 realm in which the function was created and which provides any intrinsic objects that are accessed when evaluating the function.</td>
</tr>
<tr>
<td>[[ScriptOrModule]]</td>
<td>Script Record or Module Record</td>
<td>The script or module in which the function was created.</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>[[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.

### 9.2.1 [[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 calleeContext be the running execution context.
4. Let calleeContext be PrepareForOrdinaryCall($F$, undefined).
5. Assert: calleeContext is now the running execution context.
6. Perform OrdinaryCallBindThis($F$, calleeContext, thisArgument).
7. Let result be OrdinaryCallEvaluateBody($F$, argumentsList).
8. Remove calleeContext from the execution context stack and restore calleeContext as the running execution context.
9. If result.([[Type]]) is return, return NormalCompletion(result.([[Value]])).
10. ReturnIfAbrupt(result).
11. 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.

### 9.2.1.1 PrepareForOrdinaryCall (F, newTarget)

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.
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. Let `calleeContext` be a new ECMAScript code 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. Set the ScriptOrModule of `calleeContext` to the value of `F`'s `[[ScriptOrModule]]` internal slot.
8. Let `localEnv` be `NewFunctionEnvironment(F, newTarget)`.
9. Set the LexicalEnvironment of `calleeContext` to `localEnv`.
10. Set the VariableEnvironment of `calleeContext` to `localEnv`.
11. If `callerContext` is not already suspended, suspend `callerContext`.
12. Push `calleeContext` onto the execution context stack; `calleeContext` is now the running execution context.
13. NOTE Any exception objects produced after this point are associated with `calleeRealm`.

### 9.2.1.2 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 `globalEnv` be `calleeRealm`,`[[GlobalEnv]]`.
      ii. Let `globalEnvRec` be `globalEnv`'s `EnvironmentRecord`.
      iii. Let `thisValue` be `globalEnvRec`,`[[GlobalThisValue]]`.
   b. Else,
      i. Let `thisValue` be `ToObject(thisArgument)`.
      ii. NOTE `ToObject` produces wrapper objects using `calleeRealm`.
7. Let `envRec` be `localEnv`,`EnvironmentRecord`.
8. Assert: The next step never returns an abrupt completion because `envRec`'s `[[ThisBindingStatus]]` is not "initialized".
9. Return `envRec`.BindThisValue(`thisValue`).

### 9.2.1.3 OrdinaryCallEvaluateBody (F, argumentsList)

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

1. Perform ? `FunctionDeclarationInstantiation(F, argumentsList)`.
2. Return the result of `EvaluateBody` of the parsed code that is the value of `F`'s `[[ECMAScriptCode]]` internal slot passing `F` as the argument.

### 9.2.2 [[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 `callerContext` be the running execution context.
4. Let \( \text{kind} \) be \( F \)'s [[ConstructorKind]] internal slot.
5. If \( \text{kind} \) is "base", then
   a. Let \( \text{thisArgument} \) be \( \text{ OrdinaryCreateFromConstructor(newTarget, "%ObjectPrototype%")} \).
6. Let \( \text{calleeContext} \) be \( \text{ PrepareForOrdinaryCall}(F, \text{newTarget}) \).
7. Assert: \( \text{calleeContext} \) is now the running execution context.
8. If \( \text{kind} \) is "base", perform \( \text{ OrdinaryCallBindThis}(F, \text{calleeContext, thisArgument}) \).
9. Let \( \text{constructorEnv} \) be the LexicalEnvironment of \( \text{calleeContext} \).
10. Let \( \text{envRec} \) be \( \text{constructorEnv}'s \) EnvironmentRecord.
11. Let \( \text{result} \) be \( \text{ OrdinaryCallEvaluateBody}(F, \text{argumentsList}) \).
12. Remove \( \text{calleeContext} \) from the execution context stack and restore \( \text{calleeContext} \) as the running execution context.
13. If \( \text{result}[[\text{Type}]] \) is return, then
    a. If \( \text{Type(result[[Value]])} \) is Object, return \( \text{ NormalCompletion(result[[Value]])} \).
    b. If \( \text{kind} \) is "base", return \( \text{NormalCompletion(thisArgument)} \).
    c. If \( \text{result}[[\text{Value}]] \) is not \text{undefined}, throw a \text{TypeError} exception.
14. Else, \( \text{ReturnIfAbrupt(result)} \).
15. Return \( ?\text{envRec.GetThisBinding}() \).

### 9.2.3 FunctionAllocate \((\text{functionPrototype, strict, functionKind})\)

The abstract operation FunctionAllocate requires the three arguments \( \text{functionPrototype, strict and functionKind}. \) FunctionAllocate performs the following steps:

1. Assert: \( \text{Type(functionPrototype)} \) is Object.
2. Assert: \( \text{functionKind} \) is either "normal", "non-constructor" or "generator".
3. If \( \text{functionKind} \) is "normal", let \( \text{needsConstruct} \) be \text{true}.
4. Else, let \( \text{needsConstruct} \) be \text{false}.
5. If \( \text{functionKind} \) is "non-constructor", let \( \text{functionKind} \) be "normal".
6. Let \( F \) be a newly created ECMAScript function object with the internal slots listed in Table 27. All of these internal slots are initialized to \text{undefined}.
7. Set \( F \)'s essential internal methods to the default ordinary object definitions specified in 9.1.
8. Set \( F \)'s [[Call]] internal method to the definition specified in 9.2.1.
9. If \( \text{needsConstruct} \) is \text{true}, then
   a. Set \( F \)'s [[Construct]] internal method to the definition specified in 9.2.2.
   b. Set the [[ConstructorKind]] internal slot of \( F \) to "base".
10. Set the [[Strict]] internal slot of \( F \) to \( \text{strict} \).
11. Set the [[FunctionKind]] internal slot of \( F \) to \( \text{functionKind} \).
12. Set the [[Prototype]] internal slot of \( F \) to \( \text{functionPrototype} \).
13. Set the [[Extensible]] internal slot of \( F \) to \text{true}.
14. Set the [[Realm]] internal slot of \( F \) to the current Realm Record.
15. Return \( F \).

### 9.2.4 FunctionInitialize \((F, \text{kind}, \text{ParameterList}, \text{Body}, \text{Scope})\)

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

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

### 9.2.5 FunctionCreate (kind, ParameterList, Body, Scope, Strict [, prototype ])

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 `prototype`. `FunctionCreate` performs the following steps:

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

### 9.2.6 GeneratorFunctionCreate (kind, ParameterList, Body, Scope, Strict)

The abstract operation `GeneratorFunctionCreate` 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`, 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, ParameterList, Body, Scope)`.

### 9.2.7 AddRestrictedFunctionProperties (F, realm)

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

1. Assert: `realm`.([[Intrinsics]]) [[%ThrowTypeError%]] exists and has been initialized.
2. Let `thrower` be `realm`.([[Intrinsics]]) [[%ThrowTypeError%]].

### 9.2.7.1 %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 }`.  

### 9.2.8 MakeConstructor (F [, writablePrototype, prototype ])

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 ECMAScript function object.
2. Assert: \( F \) has a \([\text{Construct}]\) internal method.
3. Assert: \( F \) is an extensible object that does not have a \texttt{prototype} own property.
4. If the \texttt{writablePrototype} argument was not provided, let \texttt{writablePrototype} be \texttt{true}.
5. If the \texttt{prototype} argument was not provided, then
   a. Let \texttt{prototype} be \texttt{ObjectCreate}(%ObjectPrototype%).
   b. Perform \!\!DefinePropertyOrThrow(\texttt{prototype}, "\texttt{constructor}"), PropertyDescriptor([\[Value\]: \( F \), \[\text{Writable}\]: \texttt{writablePrototype}, \[\text{Enumerable}\]: \texttt{false}, \[\text{Configurable}\]: \texttt{true})).
6. Perform \!\!DefinePropertyOrThrow(\( F \), "\texttt{prototype}"), PropertyDescriptor([\[Value\]: \texttt{prototype}, \[\text{Writable}\]: \texttt{false}, \[\text{Enumerable}\]: \texttt{false}, \[\text{Configurable}\]: \texttt{false})).
7. Return \texttt{NormalCompletion(\texttt{undefined})}.

\section*{9.2.9 MakeClassConstructor ( \( F \))}

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

1. Assert: \( F \) is an ECMAScript function object.
2. Assert: \( F \)'s \([\text{FunctionKind}]\) internal slot is "normal".
3. Set \( F \)'s \([\text{FunctionKind}]\) internal slot to "\texttt{classConstructor}".
4. Return \texttt{NormalCompletion(\texttt{undefined})}.

\section*{9.2.10 MakeMethod ( \( F, \texttt{homeObject} \))}

The abstract operation MakeMethod with arguments \( F \) and \texttt{homeObject} configures \( F \) as a method by performing the following steps:

1. Assert: \( F \) is an ECMAScript function object.
2. Assert: \texttt{Type(homeObject)} is Object.
3. Set the \([\text{HomeObject}]\) internal slot of \( F \) to \texttt{homeObject}.
4. Return \texttt{NormalCompletion(\texttt{undefined})}.

\section*{9.2.11 SetFunctionName ( \( F, \texttt{name} [ , \texttt{prefix} ] \))}

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

1. Assert: \( F \) is an extensible object that does not have a \texttt{name} own property.
2. Assert: \texttt{Type(name)} is either Symbol or String.
3. Assert: If \texttt{prefix} was passed, then \texttt{Type(prefix)} is String.
4. If \texttt{Type(name)} is Symbol, then
   a. Let \texttt{description} be \texttt{name}'s \([\text{Description}]\) value.
   b. If \texttt{description} is \texttt{undefined}, let \texttt{name} be the empty String.
   c. Else, let \texttt{name} be the concatenation of "[", \texttt{description}, and "]".
5. If \texttt{prefix} was passed, then
   a. Let \texttt{name} be the concatenation of \texttt{prefix}, code unit \texttt{0x0020} (SPACE), and \texttt{name}.
6. Return \!\!DefinePropertyOrThrow(\( F \), "\texttt{name}"), PropertyDescriptor([\[Value\]: \texttt{name}, \[\text{Writable}\]: \texttt{false}, \[\text{Enumerable}\]: \texttt{false}, \[\text{Configurable}\]: \texttt{true})).

\section*{9.2.12 FunctionDeclarationInstantiation ( \( \texttt{func}, \texttt{argumentsList} \))}

\section*{NOTE 1} 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
FunctionDeclarationInstantiation is performed as follows using arguments `func` and `argumentsList`. `func` is the function object for which the execution context is being established.

1. Let `calleeContext` be the running execution context.
2. Let `env` be the LexicalEnvironment of `calleeContext`.
3. Let `envRec` be `env`'s EnvironmentRecord.
4. Let `code` be the value of the [[ECMAScriptCode]] internal slot of `func`.
5. Let `strict` be the value of the [[Strict]] internal slot of `func`.
6. Let `formals` be the value of the [[FormalParameters]] internal slot of `func`.
7. Let `parameterNames` be the BoundNames of `formals`.
8. If `parameterNames` has any duplicate entries, let `hasDuplicates` be `true`. Otherwise, let `hasDuplicates` be `false`.
9. Let `simpleParameterList` be `isSimpleParameterList` of `formals`.
10. Let `hasParameterExpressions` be `ContainsExpression` of `formals`.
11. Let `varNames` be the VarDeclaredNames of `code`.
12. Let `varDeclarations` be the VarScopedDeclarations of `code`.
13. Let `lexicalNames` be the LexicallyDeclaredNames of `code`.
14. Let `functionNames` be a new empty List.
15. Let `functionsToInitialize` be a new empty List.
16. 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 `FunctionDeclaration`s or `GeneratorDeclaration`s for the same name, the last declaration is used.
          3. Insert `d` as the first element of `functionsToInitialize`.
17. Let `argumentsObjectNeeded` be `true`.
18. If the value of the [[ThisMode]] internal slot of `func` is lexical, then
   a. NOTE Arrow functions never have an arguments objects.
   b. Let `argumentsObjectNeeded` be `false`.
19. Else if "`arguments"" is an element of `parameterNames`, then
   a. Let `argumentsObjectNeeded` be `false`.
20. 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`.
21. For each String `paramName` in `parameterNames`, do
   a. Let `alreadyDeclared` be `envRec.HasBinding(paramName)`.
   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. Perform `envRec.CreateMutableBinding(paramName, false)`.
      ii. If `hasDuplicates` is `true`, then
         1. Perform `envRec.InitializeBinding(paramName, undefined)`.
22. If `argumentsObjectNeeded` is `true`, then
   a. If `strict` is `true` or if `simpleParameterList` is `false`, then
      i. Let `ao` be `CreateUnmappedArgumentsObject(argumentsList)`.
   b. Else, 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.
      i. Let `ao` be `CreateMappedArgumentsObject(func, formals, argumentsList, envRec)`.
For each element
Let Set the LexicalEnvironment of
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Else,
i. If IsConstantDeclaration of \( d \) is true, then
   1. Perform \( ! \text{lexEnvRec}.CreateImmutableBinding(\( dn \), true). \)

ii. Else,
   1. Perform \( ! \text{lexEnvRec}.CreateMutableBinding(\( dn \), false). \)

35. For each parsed grammar phrase \( f \) 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 \( \text{lexEnv}. \)
   c. Perform \( ! \text{varEnvRec}.SetMutableBinding(fn, fo, false). \)

36. Return \NormalCompletion(\emptyset). \)

NOTE 2  B.3.3 provides an extension to the above algorithm that is necessary for backwards compatibility with web browser implementations of ECMAScript that predate ECMAScript 2015.

NOTE 3  Parameter \Initializer\ may contain direct eval expressions. Any top level declarations of such evals are only visible to the eval code (10.2). The creation of the environment for such declarations is described in 14.1.19.

### 9.3 Built-in Function Objects

The built-in function objects defined in this specification may be implemented as either ECMAScript function objects (9.2) 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. All such exotic function objects also have [[Prototype]], [[Extensible]], [[Realm]], and [[ScriptOrModule]] internal slots.

Unless otherwise specified every built-in function object has the %FunctionPrototype% object 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]] invocations of the function. However, [[Construct]] invocation is not supported by all built-in functions. 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 conform 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 ECMAScript code 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. Set the ScriptOrModule of `calleeContext` to the value of `F`'s `[[ScriptOrModule]]` internal slot.
8. Perform any necessary implementation defined initialization of `calleeContext`.
9. Push `calleeContext` onto the execution context stack; `calleeContext` is now the running execution context.
10. 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.
11. Remove `calleeContext` from the execution context stack and restore `callerContext` as the running execution context.
12. Return `result`.

NOTE 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 are the same as `[[Call]]` (see 9.3.1) except that step 10 is replaced by:

10. 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 ])

The abstract operation CreateBuiltinFunction takes arguments `realm`, `prototype`, and `steps`. 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, a new 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 function's 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. Set the `[[Extensible]]` internal slot of `func` to true.
7. Set the `[[ScriptOrModule]]` internal slot of `func` to null.
8. Return `func`.

Each built-in function defined in this specification is created as if by calling the CreateBuiltinFunction abstract operation, unless otherwise specified.

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 27. Instead they have the internal slots defined in Table 28.

<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>

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.
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. Assert: Type(targetFunction) is Object.
2. Let proto be ? targetFunction.([[GetPrototypeOf]])).
3. Let obj be a newly created object.
4. Set obj’s essential internal methods to the default ordinary object definitions specified in 9.1.
5. Set the [[Call]] internal method of obj as described in 9.4.1.1.
6. If targetFunction has a [[Construct]] internal method, then
   a. Set the [[Construct]] internal method of obj as described in 9.4.1.2.
7. Set the [[Prototype]] internal slot of obj to proto.
8. Set the [[Extensible]] internal slot of obj to true.
9. Set the [[BoundTargetFunction]] internal slot of \( \text{obj} \) to \( \text{targetFunction} \).
10. Set the [[BoundThis]] internal slot of \( \text{obj} \) to the value of \( \text{boundThis} \).
11. Set the [[BoundArguments]] internal slot of \( \text{obj} \) to \( \text{boundArgs} \).
12. Return \( \text{obj} \).

### 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]] ( \( P, \text{Desc} \) )

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: IsPropertyKey\((P)\) is true.
2. If \( P \) is "length", then
   a. Return ? ArraySetLength\((A, \text{Desc})\).
3. Else if \( P \) is an array index, then
   a. Let \( \text{oldLenDesc} \) be OrdinaryGetProperty\((A, \text{"length"})\).
   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 oldLenDesc.\([\text{Value}]\).
   d. Let \( \text{index} \) be \( \text{! ToUint32}(P) \).
   e. If \( \text{index} \geq \text{oldLen} \) and oldLenDesc.\([\text{Writable}]\) is false, return false.
   f. Let succeeded be \( \text{! OrdinaryDefineOwnProperty}(A, P, \text{Desc}) \).
   g. If succeeded is false, return false.
   h. If \( \text{index} \geq \text{oldLen} \), then
      i. Set oldLenDesc.\([\text{Value}]\) to \( \text{index} + 1 \).
      ii. Let succeeded be \( \text{! OrdinaryDefineOwnProperty}(A, \text{"length"}, \text{oldLenDesc}) \).
      iii. Assert: succeedes is true.
   i. Return true.
4. Return OrdinaryDefineOwnProperty\((A, P, \text{Desc})\).

#### 9.4.2.2 ArrayCreate (\( \text{length} [, \text{proto} ] \))

The abstract operation ArrayCreate with argument \( \text{length} \) (either 0 or 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 \( \text{length} \geq 2^{32} - 1 \), throw a **RangeError** exception.
4. If the \( \text{proto} \) argument was not passed, let \( \text{proto} \) 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 \( \text{proto} \).
9. Set the [[Extensible]] internal slot of \( A \) to true.
10. Perform \! OrdinaryDefineOwnProperty(\( A \), "length", PropertyDescriptor([[Value]]: \( \text{length} \), [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false)).
11. Return \( A \).

### 9.4.2.3 ArraySpeciesCreate (originalArray, length)

The abstract operation ArraySpeciesCreate with arguments \( \text{originalArray} \) and \( \text{length} \) is used to specify the creation of a new Array object using a constructor function that is derived from \( \text{originalArray} \). 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. Let \( C \) be undefined.
4. Let \( \text{isArray} \) be ? IsArray(\( \text{originalArray} \)).
5. If \( \text{isArray} \) is true, then
   a. Let \( C \) be ? Get(\( \text{originalArray} \), "constructor").
   b. If IsConstructor(\( C \)) is true, then
      i. Let \( \text{thisRealm} \) be the current Realm Record.
      ii. Let \( \text{realmC} \) be ? GetFunctionRealm(\( C \)).
      iii. If \( \text{thisRealm} \) and \( \text{realmC} \) are not the same Realm Record, then
         1. If SameValue(\( C \), \%realmC\%[Intrinsics].[[%Array%]]) is true, let \( C \) be undefined.
   c. If Type(\( C \)) is Object, then
      i. Let \( C \) be ? Get(\( C \), @@species).
      ii. If \( C \) is null, let \( C \) be undefined.
6. If \( C \) is undefined, return ? ArrayCreate(\( \text{length} \)).
7. If IsConstructor(\( C \)) is false, throw a **TypeError** exception.
8. Return ? Construct(\( C \), « \( \text{length} \) »).

**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)

When the abstract operation ArraySetLength is called with an Array exotic object \( A \), and Property Descriptor \( \text{Desc} \), the following steps are taken:

1. If the [[Value]] field of \( \text{Desc} \) is absent, then
   a. Return OrdinaryDefineOwnProperty(\( A \), "length", \( \text{Desc} \)).
2. Let newLenDesc be a copy of \( \text{Desc} \).
3. Let newLen be ? ToUint32(\( \text{Desc} \).[[Value]])
4. Let numberLen be ? ToNumber(\( \text{Desc} \).[[Value]])
5. If newLen ≠ numberLen, throw a **RangeError** exception.
7. Let oldLenDesc be OrdinaryGetOwnProperty(\( A \), "length").
8. 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.
9. Let oldLen be oldLenDesc.[[Value]].
10. If `newLen ≥ oldLen`, then
   a. Return `OrdinaryDefineOwnProperty(A, "length", newLenDesc)`.  
11. If `oldLenDesc.[[Writable]]` is `false`, return `false`.
12. If `newLenDesc.[[Writable]]` is absent or has the value `true`, let `newWritable` be `true`.
13. 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`.
14. Let `succeeded` be `! OrdinaryDefineOwnProperty(A, "length", newLenDesc)`.
15. If `succeeded` is `false`, return `false`.
16. While `newLen < oldLen` repeat,
   a. Set `oldLen` to `oldLen - 1`.
   b. Let `deleteSucceeded` be `! A.[[Delete]]([ToString(oldLen)])`.
   c. 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)`.
      iv. Return `false`.
17. If `newWritable` is `false`, then
   a. Return `OrdinaryDefineOwnProperty(A, "length", PropertyDescriptor({[[Writable]]: false})`). This call will always return `true`.
18. 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 `[[GetOwnProperty]] ( P )`

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

1. Assert: `IsPropertyKey(P)` is `true`.
2. Let `desc` be `OrdinaryGetOwnProperty(S, P)`.
3. If `desc` is not `undefined`, return `desc`.
4. If `Type(P)` is not `String`, return `undefined`.
5. Let `index` be `! CanonicalNumericIndexString(P)`.
6. If `index` is `undefined`, return `undefined`.
7. If `IsInteger(index)` is `false`, return `undefined`.
8. If `index = -0`, return `undefined`.
9. Let `str` be the String value of the `[[StringData]]` internal slot of `S`.
10. Let `len` be the number of elements in `str`.
11. If `index < 0` or `len ≤ index`, return `undefined`.
12. Let `resultStr` be a String value of length 1, containing one code unit from `str`, specifically the code unit at index `index`.
13. Return a PropertyDescriptor({[[Value]]: `resultStr`, [[Writable]]: `false`, [[Enumerable]]: `true`, [[Configurable]]: `false`}).
### 9.4.3.2 [[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 ascending chronological order of property creation,
   a. Add $P$ as the last element of $keys$.
7. For each own property key $P$ of $O$ such that $Type(P)$ is Symbol, in ascending chronological order of property creation,
   a. Add $P$ as the last element of $keys$.
8. Return $keys$.

### 9.4.3.3 StringCreate ( value, prototype )

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. Assert: $Type(value)$ is String.
2. Let $S$ be a newly created String exotic object.
3. Set the [[StringData]] internal slot of $S$ to $value$.
4. Set $S$'s essential internal methods to the default ordinary object definitions specified in 9.1.
5. Set the [[OwnProperty]] internal method of $S$ as specified in 9.4.3.1.
6. Set the [[OwnPropertyKeys]] internal method of $S$ as specified in 9.4.3.2.
7. Set the [[Prototype]] internal slot of $S$ to $prototype$.
8. Set the [[Extensible]] internal slot of $S$ to true.
9. Let $length$ be the number of code unit elements in $value$.
10. Perform !DefinePropertyOrThrow($S$, "$length", PropertyDescriptor{[[Value]]: length, [[Writable]]: false,
                     [[Enumerable]]: false, [[Configurable]]: false }).
11. Return $S$.

### 9.4.4 Arguments Exotic Objects

Most ECMAScript functions make an arguments object available to their code. Depending upon the characteristics of the function definition, its arguments 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 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 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 key `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. If the value of `isMapped` is `true`, then
   a. Set `desc.[[Value]]` to `Get(map, P)`.
7. If `IsDataDescriptor(desc)` is `true` and `P` is "caller" and `desc.[[Value]]` is a strict mode Function object, throw a `TypeError` exception.
8. Return `desc`.

If an implementation does not provide a built-in `caller` property for argument exotic objects then step 7 of this algorithm must be skipped.

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

The `[[DefineOwnProperty]]` internal method of an arguments exotic object when called with a property key `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 `newArgDesc` be `Desc`.
5. If `isMapped` is `true` and `IsDataDescriptor(Desc)` is `true`, then
   a. If `Desc.[[Value]]` is not present and `Desc.[[Writable]]` is present and its value is `false`, then
   i. Let `newArgDesc` be a copy of `Desc`.
   ii. Set `newArgDesc.[[Value]]` to `Get(map, P)`.
7. If `allowed` is `false`, return `false`.
8. If the value of `isMapped` is `true`, then
   a. If `IsAccessorDescriptor(Desc)` is `true`, then
   i. Call `map.[[Delete]](P)`.
   b. Else,
   i. If `Desc.[[Value]]` is present, then
      1. Let `setStatus` be `Set(map, P, Desc.[[Value]], false)`.
      2. Assert: `setStatus` 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 `map.[[Delete]](P)`.  

9. Return `true`.

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

The `[[Get]]` internal method of an arguments exotic object when called with a property key `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. If the value of `isMapped` is `false`, then
5. Else `map` contains a formal parameter mapping for `P`,
   a. Return `Get(map, P)`.

### 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 `false`.
3. Else,
   a. Let `map` be the value of the `[[ParameterMap]]` internal slot of the arguments object.
   b. Let `isMapped` be `! HasOwnProperty(map, P)`.
4. If `isMapped` is `true`, then
   a. Let `setStatus` be `Set(map, P, V, false)`.
   b. Assert: `setStatus` is `true` because formal parameters mapped by argument objects are always writable.

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

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

1. Let `args` be the arguments object.
2. If `P` is "`caller`", then
   a. Let `desc` be `! OrdinaryGetOwnProperty(args, P)`.
   b. If `IsDataDescriptor(desc)` is `true`, return `true`.

If an implementation does not provide a built-in caller property for argument exotic objects then step 2 of this algorithm must be skipped.

### 9.4.4.6 `[[Delete]] (P)`

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

1. Let `args` be the arguments object.
2. Let `map` be the value of the `[[ParameterMap]]` internal slot of `args`.
3. Let `isMapped` be `! HasOwnProperty(map, P)`.
4. Let `result` be `? OrdinaryDelete(args, P)`.
5. If `result` is `true` and the value of `isMapped` is `true`, then
   a. Call `map.[[Delete]](P)`.
6. Return `result`.
9.4.4.7 CreateUnmappedArgumentsObject (argumentsList)

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 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, "caller", PropertyDescriptor {[[Get]]: %ThrowTypeError%, [[Set]]: %ThrowTypeError%, [[Enumerable]]: false, [[Configurable]]: false}).
10. Return obj.

9.4.4.8 CreateMappedArgumentsObject (func, formals, argumentsList, env)

The abstract operation CreateMappedArgumentsObject is called with object func, parsed grammar phrase 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 [[HasProperty]] internal method of obj as specified in 9.4.4.5.
9. Set the [[Delete]] internal method of obj as specified in 9.4.4.6.
10. Set the remainder of obj’s essential internal methods to the default ordinary object definitions specified in 9.1.
11. Set the [[Prototype]] internal slot of obj to %ObjectPrototype%.
12. Set the [[Extensible]] internal slot of obj to true.
13. Let map be ObjectCreate(null).
14. Set the [[ParameterMap]] internal slot of obj to map.
15. Let parameterNames be the BoundNames of formals.
16. Let numberOfParameters be the number of elements in parameterNames.
17. Let index be 0.
18. Repeat while index < len,
   a. Let val be argumentsList[index].
   b. Perform CreateDataProperty(obj, !ToString(index), val).
   c. Let index be index + 1.
19. Perform DefinePropertyOrThrow(obj, "length", PropertyDescriptor{[[Value]]: len, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}).
20. Let mappedNames be a new empty List.
21. Let index be numberOfParameters - 1.
22. Repeat while index ≥ 0,
Let `name` be `parameterNames[index]`.

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. Perform `map.([DefineOwnProperty]()! ToString(index), PropertyDescriptor({[Set]: p, [Get]: g, [Enumerable]: false, [Configurable]: true}))`.

Let `index` be `index - 1`.

23. Perform `DefinePropertyOrThrow(obj, @@iterator, PropertyDescriptor({[Value]: %ArrayProto_values%, [Writable]: true, [Enumerable]: false, [Configurable]: true}))`.


25. Return `obj`.

9.4.4.8.1 MakeArgGetter (name, env)

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 Record.
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.

NOTE ArgGetter functions are never directly accessible to ECMAScript code.

9.4.4.8.2 MakeArgSetter (name, env)

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 Record.
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 `env.SetMutableBinding(name, value, 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 and 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 ! CanonicalNumericalIndexString\((P)\).
   b. If numericIndex is not undefined, then
      i. Let value be ? IntegerIndexedElementGet\((O, numericIndex)\).
      ii. If value is undefined, return undefined.
   iii. Return a PropertyDescriptor\([[[Value]]: value, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: false]\).
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 ! CanonicalNumericalIndexString\((P)\).
   b. 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\((numericIndex)\) is false, return false.
      iv. If numericIndex = -0, return false.
      v. If numericIndex < 0, return false.
   vi. If numericIndex ≥ the value of \(O\)'s [[ArrayLength]] internal slot, return false.
   vii. 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 ! CanonicalNumericalIndexString\((P)\).
   b. 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 \( \text{length} \) be the value of \( O \)'s [[ArrayLength]] internal slot.
vi. If \( \text{intIndex} \neq \text{length} \), return \( \text{false} \).

vii. If IsAccessorDescriptor\((\text{Desc})\) is \( \text{true} \), return \( \text{false} \).

viii. If \( \text{Desc} \) has a [[Configurable]] field and if \( \text{Desc}.[[\text{Configurable}]] \) is \( \text{true} \), return \( \text{false} \).

ix. If \( \text{Desc} \) has an [[Enumerable]] field and if \( \text{Desc}.[[\text{Enumerable}]] \) is \( \text{false} \), return \( \text{false} \).

x. If \( \text{Desc} \) has a [[Writable]] field and if \( \text{Desc}.[[\text{Writable}]] \) is \( \text{false} \), return \( \text{false} \).

xi. If \( \text{Desc} \) has a [[Value]] field, then
   1. Let \( \text{value} \) be \( \text{Desc}.[[\text{Value}]] \).
   2. Return ? IntegerIndexedElementSet\((O, \text{intIndex}, \text{value})\).

xii. Return \( \text{true} \).

4. Return OrdinaryDefineOwnProperty\((O, P, \text{Desc})\).

9.4.5.4 [[Get]] \((P, \text{Receiver})\)

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

1. Assert: IsPropertyKey\((P)\) is \( \text{true} \).
2. If Type\((P)\) is String, then
   a. Let \( \text{numericIndex} \) be ! CanonicalNumericIndexString\((P)\).
   b. If \( \text{numericIndex} \) is not \( \text{undefined} \), then
      i. Return ? IntegerIndexedElementGet\((O, \text{numericIndex})\).
3. Return ? OrdinaryGet\((O, P, \text{Receiver})\).

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

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

1. Assert: IsPropertyKey\((P)\) is \( \text{true} \).
2. If Type\((P)\) is String, then
   a. Let \( \text{numericIndex} \) be ! CanonicalNumericIndexString\((P)\).
   b. If \( \text{numericIndex} \) is not \( \text{undefined} \), then
      i. Return ? IntegerIndexedElementSet\((O, \text{numericIndex}, V)\).

9.4.5.6 [[OwnPropertyKeys]]()

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

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

9.4.5.7 IntegerIndexedObjectCreate \((\text{prototype}, \text{internalSlotsList})\)

The abstract operation IntegerIndexedObjectCreate with arguments \( \text{prototype} \) and \( \text{internalSlotsList} \) is used to specify the creation of new Integer Indexed exotic objects. The argument \( \text{internalSlotsList} \) 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. Assert: $\text{internalSlotsList}$ contains the names $\text{[[ViewedArrayBuffer]]}$, $\text{[[ArrayLength]]}$, $\text{[[ByteOffset]]}$, and $\text{[[TypedArrayName]]}$.
2. Let $A$ be a newly created object with an internal slot for each name in $\text{internalSlotsList}$.
3. Set $A$'s essential internal methods to the default ordinary object definitions specified in 9.1.
4. Set the $\text{[[GetOwnProperty]]}$ internal method of $A$ as specified in 9.4.5.1.
5. Set the $\text{[[HasProperty]]}$ internal method of $A$ as specified in 9.4.5.2.
6. Set the $\text{[[DefineOwnProperty]]}$ internal method of $A$ as specified in 9.4.5.3.
7. Set the $\text{[[Get]]}$ internal method of $A$ as specified in 9.4.5.4.
8. Set the $\text{[[Set]]}$ internal method of $A$ as specified in 9.4.5.5.
9. Set the $\text{[[OwnPropertyKeys]]}$ internal method of $A$ as specified in 9.4.5.6.
10. Set the $\text{[[Prototype]]}$ internal slot of $A$ to $\text{prototype}$.
11. Set the $\text{[[Extensible]]}$ internal slot of $A$ to $\text{true}$.
12. Return $A$.

9.4.5.8 IntegerIndexedElementGet ( $O$, $index$ )

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

1. Assert: $\text{Type}(\text{index})$ is Number.
2. Assert: $O$ is an Object that has $\text{[[ViewedArrayBuffer]]}$, $\text{[[ArrayLength]]}$, $\text{[[ByteOffset]]}$, and $\text{[[TypedArrayName]]}$ internal slots.
3. Let $buffer$ be the value of $O$'s $\text{[[ViewedArrayBuffer]]}$ internal slot.
4. If $\text{IsDetachedBuffer}(buffer)$ is $\text{true}$, throw a $\text{TypeError}$ exception.
5. If $\text{IsInteger}(index)$ is $\text{false}$, return $\text{undefined}$.
6. If $index = -0$, return $\text{undefined}$.
7. Let $length$ be the value of $O$'s $\text{[[ArrayLength]]}$ internal slot.
8. If $\text{index} < 0$ or $\text{index} \geq length$, return $\text{undefined}$.
9. Let $offset$ be the value of $O$'s $\text{[[ByteOffset]]}$ internal slot.
10. Let $arrayTypeName$ be the String value of $O$'s $\text{[[TypedArrayName]]}$ internal slot.
11. Let $elementSize$ be the Number value of the Element Size value specified in Table 50 for $arrayTypeName$.
12. Let $indexedPosition$ be $(\text{index} \times \text{elementSize}) + \text{offset}$.
13. Let $elementType$ be the String value of the Element Type value in Table 50 for $arrayTypeName$.
14. Return $\text{GetValueFromBuffer}(buffer, indexedPosition, elementType)$.

9.4.5.9 IntegerIndexedElementSet ( $O$, $index$, $value$ )

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

1. Assert: $\text{Type}(\text{index})$ is Number.
2. Assert: $O$ is an Object that has $\text{[[ViewedArrayBuffer]]}$, $\text{[[ArrayLength]]}$, $\text{[[ByteOffset]]}$, and $\text{[[TypedArrayName]]}$ internal slots.
3. Let $numValue$ be $\text{? ToNumber}(value)$.
4. Let $buffer$ be the value of $O$'s $\text{[[ViewedArrayBuffer]]}$ internal slot.
5. If $\text{IsDetachedBuffer}(buffer)$ is $\text{true}$, throw a $\text{TypeError}$ exception.
6. If $\text{IsInteger}(index)$ is $\text{false}$, return $\text{false}$.
7. If $index = -0$, return $\text{false}$.
8. Let $length$ be the value of $O$'s $\text{[[ArrayLength]]}$ internal slot.
9. If $\text{index} < 0$ or $\text{index} \geq length$, return $\text{false}$.
10. Let $offset$ be the value of $O$'s $\text{[[ByteOffset]]}$ internal slot.
11. Let $arrayTypeName$ be the String value of $O$'s $\text{[[TypedArrayName]]}$ internal slot.
12. Let $elementSize$ be the Number value of the Element Size value specified in Table 50 for $arrayTypeName$.
13. Let $indexedPosition$ be $(\text{index} \times \text{elementSize}) + \text{offset}$.
14. Let $elementType$ be the String value of the Element Type value in Table 50 for $arrayTypeName$.
15. Perform $\text{SetValueInBuffer}(buffer, indexedPosition, elementType, numValue)$.
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 { [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: false }. Module namespace objects are not extensible.

Module namespace objects have the internal slots defined in Table 29.

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Module]]</td>
<td>Module Record</td>
<td>The Module Record whose exports this namespace exposes.</td>
</tr>
<tr>
<td>[[Exports]]</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 <code>SortCompare</code> 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. Let exports be the value of O’s [[Exports]] internal slot.
3. If P is not an element of exports, return undefined.
5. Return PropertyDescriptor{[[Value]]: value, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: false).

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
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.
7. Assert: binding is neither null nor "ambiguous".
8. Let targetModule be binding.[[Module]].
9. Assert: targetModule is not undefined.
10. Let targetEnv be targetModule.[[Environment]].
11. If targetEnv is undefined, throw a ReferenceError exception.
12. Let targetEnvRec be targetEnv’s EnvironmentRecord.

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

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

1. Let \( exports \) be a copy of the value of \( O \)'s \([\text{Exports}]\) internal slot.
2. Let \( symbolKeys \) be ! OrdinaryOwnPropertyKeys(\( O \)).
3. Append all the entries of \( symbolKeys \) to the end of \( exports \).
4. Return \( exports \).

9.4.6.12 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.
2. Assert: \( module.[[Namespace]] \) is undefined.
3. Assert: \( exports \) is a List of String values.
4. Let \( M \) be a newly created object.
5. Set \( M \)'s essential internal methods to the definitions specified in 9.4.6.
6. Set \( M \)'s \([\text{Module}]\) internal slot to \( module \).
7. Set \( M \)'s \([\text{Exports}]\) internal slot to \( exports \).
8. Create own properties of \( M \) corresponding to the definitions in 26.3.
9. Set \( module.[[Namespace]] \) to \( M \).
10. Return \( M \).

9.4.7 Immutable Prototype Exotic Objects

An immutable prototype exotic object is an exotic object that has an immutable \([\text{Prototype}]\) internal slot.

9.4.7.1 \([\text{SetPrototypeOf}] (\ V)\)

When the \([\text{SetPrototypeOf}]\) internal method of an immutable prototype exotic object \( O \) is called with argument \( V \), the following steps are taken:

1. Assert: Either \( \text{Type}(V) \) is Object or \( \text{Type}(V) \) is Null.
2. Let \( current \) be the value of the \([\text{Prototype}]\) internal slot of \( O \).
3. If \( \text{SameValue}(V, current) \) is true, return true.
4. Return false.

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 objects has an internal slot called \([\text{ProxyHandler}]\). The value of \([\text{ProxyHandler}]\) is an object, called the proxy's handler object, or null. Methods (see Table 30) 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 \([\text{ProxyTarget}]\) whose value is either an object or the null value. This object is called the proxy's target object.
Table 30: Proxy Handler Methods

<table>
<thead>
<tr>
<th>Internal Method</th>
<th>Handler Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[GetPrototypeOf]]</td>
<td>getPrototypeOf</td>
</tr>
<tr>
<td>[[SetPrototypeOf]]</td>
<td>setPrototypeOf</td>
</tr>
<tr>
<td>[[IsExtensible]]</td>
<td>isExtensible</td>
</tr>
<tr>
<td>[[PreventExtensions]]</td>
<td>preventExtensions</td>
</tr>
<tr>
<td>[[GetOwnProperty]]</td>
<td>getOwnPropertyDescriptor</td>
</tr>
<tr>
<td>[[HasProperty]]</td>
<td>has</td>
</tr>
<tr>
<td>[[Get]]</td>
<td>get</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>set</td>
</tr>
<tr>
<td>[[Delete]]</td>
<td>deleteProperty</td>
</tr>
<tr>
<td>[[DefineOwnProperty]]</td>
<td>defineProperty</td>
</tr>
<tr>
<td>[[OwnPropertyKeys]]</td>
<td>ownKeys</td>
</tr>
<tr>
<td>[[Call]]</td>
<td>apply</td>
</tr>
<tr>
<td>[[Construct]]</td>
<td>construct</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 a Proxy exotic 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. If trap is undefined, then
   a. Return ? target.[[GetPrototypeOf]]().
7. Let $\text{handlerProto}$ be $\text{Call}(\text{trap, handler, "target"})$.
8. If $\text{Type(handlerProto)}$ is neither Object nor Null, throw a $\text{TypeError}$ exception.
9. Let $\text{extensibleTarget}$ be $\text{IsExtensible(target)}$.
10. If $\text{extensibleTarget}$ is $\text{true}$, return $\text{handlerProto}$.
11. Let $\text{targetProto}$ be $\text{Call}(\text{trap, handler, "targetProto"})$.
12. If $\text{SameValue(handlerProto, targetProto)}$ is $\text{false}$, throw a $\text{TypeError}$ exception.
13. Return $\text{handlerProto}$.

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

- The result of $\text{[[GetPrototypeOf]]}$ must be either an Object or null.
- If the target object is not extensible, $\text{[[GetPrototypeOf]]}$ applied to the proxy object must return the same value as $\text{[[GetPrototypeOf]]}$ applied to the proxy object’s target object.

### 9.5.2 $\text{[[SetPrototypeOf]]} (V)$

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

1. Assert: Either $\text{Type(V)}$ is Object or $\text{Type(V)}$ is Null.
2. Let $\text{handler}$ be the value of the $\text{[[ProxyHandler]]}$ internal slot of $O$.
3. If $\text{handler}$ is $\text{null}$, throw a $\text{TypeError}$ exception.
4. Assert: $\text{Type(handler)}$ is Object.
5. Let $\text{target}$ be the value of the $\text{[[ProxyTarget]]}$ internal slot of $O$.
6. Let $\text{trap}$ be $\text{GetMethod(handler, "setPrototypeOf")}$.
7. If $\text{trap}$ is $\text{undefined}$, then
   a. Return $\text{Call}(\text{trap, handler, "target", V})$.
8. Let $\text{booleanTrapResult}$ be $\text{ToBoolean(Call(trap, handler, "target", V))}$.
9. If $\text{booleanTrapResult}$ is $\text{false}$, return $\text{false}$.
10. Let $\text{extensibleTarget}$ be $\text{IsExtensible(target)}$.
11. If $\text{extensibleTarget}$ is $\text{true}$, return $\text{true}$.
12. Let $\text{targetProto}$ be $\text{Call}(\text{trap, handler, "targetProto"})$.
13. If $\text{SameValue(V, targetProto)}$ is $\text{false}$, throw a $\text{TypeError}$ exception.
14. Return $\text{true}$.

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

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

### 9.5.3 $\text{[[IsExtensible]]}$

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

1. Let $\text{handler}$ be the value of the $\text{[[ProxyHandler]]}$ internal slot of $O$.
2. If $\text{handler}$ is $\text{null}$, throw a $\text{TypeError}$ exception.
3. Assert: $\text{Type(handler)}$ is Object.
4. Let $\text{target}$ be the value of the $\text{[[ProxyTarget]]}$ internal slot of $O$.
5. Let $\text{trap}$ be $\text{GetMethod(handler, "isExtensible")}$.
6. If $\text{trap}$ is $\text{undefined}$, then
   a. Return $\text{Call}(\text{trap, handler, "target"})$.
7. Let $\text{booleanTrapResult}$ be $\text{ToBoolean(Call(trap, handler, "target"))}$.
8. Let $\text{targetResult}$ be $\text{Call}(\text{trap, handler, "target"})$.
9. If $\text{SameValue(booleanTrapResult, targetResult)}$ is $\text{false}$, throw a $\text{TypeError}$ exception.
10. Return $\text{booleanTrapResult}$.
NOTE

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

- The result of [[IsExtensible]] is a Boolean value.
- [[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 a Proxy exotic 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. If `trap` is `undefined`, then
7. Let `booleanTrapResult` be `ToBoolean(? Call(trap, handler, « target »))`.
8. If `booleanTrapResult` is `true`, then
   b. If `targetIsExtensible` is `true`, throw a `TypeError` exception.
9. Return `booleanTrapResult`.

NOTE

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

- The result of [[PreventExtensions]] is a Boolean value.
- [[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 a Proxy exotic 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. If `trap` is `undefined`, then
   a. Return `? target.[[GetOwnProperty]](P)`.
8. Let `trapResultObj` be `? Call(trap, handler, « target, P »)`.
9. If `Type(trapResultObj)` is neither Object nor Undefined, throw a `TypeError` exception.
10. Let `targetDesc` be `? target.[[GetOwnProperty]](P)`.
11. 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. Assert: `Type(extensibleTarget)` is Boolean.
   e. If `extensibleTarget` is `false`, throw a `TypeError` exception.
   f. Return `undefined`.
12. Let `extensibleTarget` be `? IsExtensible(target)`.
13. Let `resultDesc` be `? ToPropertyDescriptor(trapResultObj)`.
14. Call `CompletePropertyDescriptor(resultDesc)`.
15. Let `valid` be `IsCompatiblePropertyDescriptor(extensibleTarget, resultDesc, targetDesc)`. 
16. If `valid` is `false`, throw a `TypeError` exception.
17. If `resultDesc.[[Configurable]]` is `false`, then
   a. If `targetDesc` is `undefined` or `targetDesc.[[Configurable]]` is `true`, then
      i. Throw a `TypeError` exception.
18. 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.

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

When the [[DefineOwnProperty]] internal method of a Proxy 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. 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. If `trap` is `undefined`, then
8. Let `descObj` be `FromPropertyDescriptor(Desc)`.
9. Let `booleanTrapResult` be `ToBoolean(? Call(trap, handler, « target, P, descObj »))`.
10. If `booleanTrapResult` is `false`, return `false`.
11. Let `targetDesc` be `? target.[[GetOwnProperty]](P)`.
12. Let `extensibleTarget` be `? IsExtensible(target)`.
13. If `Desc` has a `[[Configurable]]` field and if `Desc.[[Configurable]]` is `false`, then
    a. Let `settingConfigFalse` be `true`.
14. Else let `settingConfigFalse` be `false`.
15. If `targetDesc` is `undefined`, then
    a. If `extensibleTarget` is `false`, throw a `TypeError` exception.
    b. If `settingConfigFalse` is `true`, throw a `TypeError` exception.
16. 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.
17. Return `true`.

NOTE  [[DefineOwnProperty]] for proxy objects enforces the following invariants:
   - The result of [[DefineOwnProperty]] is a Boolean value.
   - A property cannot be added, if the target object is not extensible.
   - A property cannot be non-configurable, unless there exists a corresponding non-configurable own property of the target object.
   - If a property has a corresponding target object property then applying the `Property Descriptor` of the property to the target object using [[DefineOwnProperty]] will not throw an exception.
When the `[[HasProperty]]` internal method of a Proxy exotic 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. If `trap` is `undefined`, then
   a. Return `target.[[HasProperty]](P)`.
8. Let `booleanTrapResult` be `ToBoolean(Call(trap, handler, « target, P »))`.
9. If `booleanTrapResult` is `false`, then
   a. Let `targetDesc` be `target.[[GetOwnProperty]](P)`.
   b. If `targetDesc` is not `undefined`, then
      i. If `targetDesc.[[Configurable]]` is `false`, throw a `TypeError` exception.
      ii. Let `extensibleTarget` be `IsExtensible(target)`.
      iii. If `extensibleTarget` is `false`, throw a `TypeError` exception.
10. Return `booleanTrapResult`.

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

- The result of `[[HasProperty]]` is a Boolean value.
- 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.

When the `[[Get]]` internal method of a Proxy 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. 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. If `trap` is `undefined`, then
8. Let `trapResult` be `Call(trap, handler, « target, P, Receiver »)`.
9. Let `targetDesc` be `target.[[GetOwnProperty]](P)`.
10. If `targetDesc` is not `undefined`, then
    a. If `IsDataDescriptor(targetDesc)` is `true` 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)` is `true` and `targetDesc.[[Configurable]]` is `false` and `targetDesc.[[Get]]` is `undefined`, then
         i. If `trapResult` is not `undefined`, throw a `TypeError` exception.
11. Return `trapResult`.

NOTE `[[Get]]` for proxy objects enforces the following invariants:
• The value reported for a property must be the same as the value of the corresponding target object property if the target object property is a non-writable, non-configurable own data property.
• The value reported for a property must be undefined if the corresponding target object property is a non-configurable own accessor property that has undefined as its [[Get]] attribute.

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

When the [[Set]] internal method of a Proxy exotic 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.
7. If trap is undefined, then
8. Let booleanTrapResult be ToBoolean(? Call(trap, handler, « target, P, V, Receiver »)).
9. If booleanTrapResult is false, return false.
11. If targetDesc is not undefined, then
    a. If IsDataDescriptor(targetDesc) is true 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) is true and targetDesc.[[Configurable]] is false, then
          i. If targetDesc.[[Set]] is undefined, throw a TypeError exception.
12. Return true.

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

• The result of [[Set]] is a Boolean value.
• 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 own data property.
• Cannot set the value of a property if the corresponding target object property is a non-configurable own accessor property that has undefined as its [[Set]] attribute.

9.5.10 [[Delete]] (P)

When the [[Delete]] internal method of a Proxy exotic 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, "deleteProperty").
7. If trap is undefined, then
8. Let booleanTrapResult be ToBoolean(? Call(trap, handler, « target, P »)).
9. If booleanTrapResult is false, return false.
11. If targetDesc is undefined, return true.
12. If targetDesc.[[Configurable]] is false, throw a TypeError exception.
13. Return true.
NOTE [[Delete]] for proxy objects enforces the following invariant:

- The result of [[Delete]] is a Boolean value.
- A property cannot be reported as deleted, if it exists as a non-configurable own property of the target object.

9.5.11 [[OwnPropertyKeys]] ()

When the [[OwnPropertyKeys]] internal method of a Proxy exotic 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, "OwnPropertyKeys").
6. If trap is undefined, then
   a. Return ? target.[[OwnPropertyKeys]]().
7. Let trapResultArray be ? Call (trap, handler, « target »).
8. Let trapResult be ? CreateListFromArrayLike (trapResultArray, « String, Symbol »).
10. Let targetKeys be ? target.[[OwnPropertyKeys]]().
11. Assert: targetKeys is a List containing only String and Symbol values.
12. Let targetConfigurableKeys be a new empty List.
13. Let targetNonconfigurableKeys be a new empty List.
14. Repeat, for each element key of targetKeys,
   a. Let desc be ? target.[[GetOwnProperty]] (key).
   b. If desc is not undefined and desc.[[Configurable]] is false, then
      i. Append key as an element of targetNonconfigurableKeys.
   c. Else,
      i. Append key as an element of targetConfigurableKeys.
15. If extensibleTarget is true and targetNonconfigurableKeys is empty, then
   a. Return trapResult.
16. Let uncheckedResultKeys be a new List which is a copy of trapResult.
17. 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.
18. If extensibleTarget is true, return trapResult.
19. 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.
20. If uncheckedResultKeys is not empty, throw a TypeError exception.

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.

9.5.12 [[Call]] (thisArgument, argumentsList)

The [[Call]] internal method of a Proxy exotic 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: $\text{Type}(handler)$ is Object.
4. Let $target$ be the value of the $[[ProxyTarget]]$ internal slot of $O$.
5. Let $trap$ be ? $\text{GetMethod}(handler, \"apply\")$.
6. If $trap$ is undefined, then
   a. Return ? $\text{Call}(target, thisArgument, argumentsList)$.
7. Let $argArray$ be $\text{CreateArrayFromList}(argumentsList)$.
8. Return ? $\text{Call}(trap, handler, \langle target, thisArgument, argArray \rangle)$.

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.

9.5.13 $\text{[[Construct]] (argumentsList, newTarget)}$

The $\text{[[Construct]]}$ internal method of a Proxy exotic 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: $\text{Type}(handler)$ is Object.
4. Let $target$ be the value of the $[[ProxyTarget]]$ internal slot of $O$.
5. Let $trap$ be ? $\text{GetMethod}(handler, \"construct\")$.
6. If $trap$ is undefined, then
   a. Assert: $target$ has a $[[Construct]]$ internal method.
   b. Return ? $\text{Construct}(target, argumentsList, newTarget)$.
7. Let $argArray$ be $\text{CreateArrayFromList}(argumentsList)$.
8. Let $newObj$ be ? $\text{Call}(trap, handler, \langle target, thisArgument, argArray, newTarget \rangle)$.
9. If $\text{Type}(newObj)$ is not Object, throw a TypeError exception.
10. 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 $\text{[[Construct]]}$ for proxy objects enforces the following invariants:

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

9.5.14 ProxyCreate ($target, handler$)

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

1. If $\text{Type}(target)$ is not Object, throw a TypeError exception.
2. If $target$ is a Proxy exotic object and the value of the $[[ProxyHandler]]$ internal slot of $target$ is null, throw a TypeError exception.
3. If $\text{Type}(handler)$ is not Object, throw a TypeError exception.
4. If $handler$ is a Proxy exotic object and the value of the $[[ProxyHandler]]$ internal slot of $handler$ is null, throw a TypeError exception.
5. Let $P$ be a newly created object.
6. Set $P$'s essential internal methods (except for $[[Call]]$ and $[[Construct]]$) to the definitions specified in 9.5.
7. If $\text{Callable}(target)$ is true, then
   a. Set the $[[Call]]$ internal method of $P$ as specified in 9.5.12.
   b. If $target$ has a $[[Construct]]$ internal method, then
      i. Set the $[[Construct]]$ internal method of $P$ as specified in 9.5.13.
8. Set the $[[ProxyTarget]]$ internal slot of $P$ to $target$.
9. Set the $[[ProxyHandler]]$ internal slot of $P$ to $handler$. 


10 ECMAScript Language: Source Code

10.1 Source Text

Syntax

SourceCharacter ::
 any Unicode code point

ECMAScript code is expressed using Unicode, version 8.0.0 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 source text, or behave as though they were performing normalization of source 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: UTF16Encoding ( cp )

The UTF16Encoding 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) × 1024 + (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]]` and `[[FormalParameters]]` internal slots (see 9.2) of an ECMAScript function object. The function code of a particular ECMAScript function 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 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 arguments 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. Code is interpreted as *strict mode code* in the following situations:

- Global code is strict mode code if it begins with a *Directive Prologue* that contains a *Use Strict Directive*.
- Module code is always strict mode code.
- All parts of a *ClassDeclaration* or a *ClassExpression* are strict mode code.
- Eval code is strict mode code if it begins with a *Directive Prologue* that contains a *Use Strict Directive* or if the call to `eval` is a direct `eval` that is contained in strict mode code.
- Function code is strict mode code if the associated *FunctionDeclaration*, *FunctionExpression*, *GeneratorDeclaration*, *GeneratorExpression*, *MethodDefinition*, or *ArrowFunction* is contained in strict mode code or if the code that produces the value of the function’s `[[ECMAScriptCode]]` internal slot begins with a *Directive Prologue* that contains a *Use Strict Directive*.
- Function code that is supplied as the arguments to the built-in `Function` and `Generator` constructors is strict mode code if the last argument is a String that when processed is a *FunctionBody* that begins with a *Directive Prologue* that contains a *Use Strict Directive*.

ECMAScript code that is not strict mode code is called *non-strict code*.

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 points 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 `InputElementRegExpOrTemplateTail` goal is used in syntactic grammar contexts where a `RegularExpressionLiteral`, a `TemplateMiddle`, or a `TemplateTail` is permitted. The `InputElementRegExp` goal symbol is used in all syntactic grammar contexts where a `RegularExpressionLiteral` is permitted but neither a `TemplateMiddle`, nor a `TemplateTail` is permitted. The `InputElementTemplateTail` goal is used in all syntactic grammar contexts where a `TemplateMiddle` or a `TemplateTail` is permitted but a `RegularExpressionLiteral` is not permitted. In all other contexts, `InputElementDiv` is used as the lexical goal symbol.

NOTE The use of multiple lexical goals ensures that there are no lexical ambiguities that would affect automatic semicolon insertion. For example, 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:

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

where the first non-whitespace, non-comment code point after a `LineTerminator` is U+002F (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:

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

**Syntax**

```
InputElementDiv  ::=  
  WhiteSpace  LineTerminator  Comment  CommonToken  DivPunctuator  RightBracePunctuator

InputElementRegExp  ::=  
  WhiteSpace  LineTerminator  Comment  CommonToken  DivPunctuator  RightBracePunctuator  RegularExpressionLiteral

InputElementRegExpOrTemplateTail  ::=  
  WhiteSpace  LineTerminator  Comment  CommonToken  RegularExpressionLiteral  TemplateSubstitutionTail

InputElementTemplateTail  ::=  
  WhiteSpace  LineTerminator  Comment  CommonToken  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 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 31.

<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 32.

<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 \textit{WhiteSpace} code points listed in the "Separator, space" (Zs) category.

\begin{footnotesize}
\begin{itemize}
\item Other than for the code points listed in \textbf{Table 32}, ECMAScript \textit{WhiteSpace} intentionally excludes all code points that have the Unicode “White_Space” property but which are not classified in category “Zs”.
\end{itemize}
\end{footnotesize}

\section*{Syntax}

\textit{WhiteSpace} ::
\begin{itemize}
\item \texttt{<TAB>}
\item \texttt{<VT>}
\item \texttt{<FF>}
\item \texttt{<SP>}
\item \texttt{<NBSP>}
\item \texttt{<ZWNBSP>}
\item \texttt{<USP>}
\end{itemize}

\subsection*{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 \textit{StringLiteral}, \textit{Template}, or \textit{TemplateSubstitutionTail}. Line terminators may only occur within a \textit{StringLiteral} token as part of a \textit{LineContinuation}.

A line terminator can occur within a \textit{MultiLineComment} but cannot occur within a \textit{SingleLineComment}.

Line terminators are included in the set of white space code points that are matched by the \texttt{\s} class in regular expressions.

The ECMAScript line terminator code points are listed in \textbf{Table 33}.

\begin{table}[h]
\centering
\caption{Line Terminator Code Points}
\begin{tabular}{|c|c|c|}
\hline
Code Point & Unicode Name & Abbreviation \\
\hline
U+000A & LINE FEED (LF) & \texttt{<LF>} \\
U+000D & CARRIAGE RETURN (CR) & \texttt{<CR>} \\
U+2028 & LINE SEPARATOR & \texttt{<LS>} \\
U+2029 & PARAGRAPH SEPARATOR & \texttt{<PS>} \\
\hline
\end{tabular}
\end{table}

Only the Unicode code points in \textbf{Table 33} 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 \textbf{Table 32}. The sequence \texttt{<CR><LF>} is commonly used as a line terminator. It should be considered a single \textit{SourceCharacter} for the purpose of reporting line numbers.

\section*{Syntax}

\textit{Line Terminator} ::
\begin{itemize}
\item \texttt{<LF>}
\item \texttt{<CR>}
\item \texttt{<LS>}
\item \texttt{<PS>}
\end{itemize}

\textit{Line Terminator Sequence} ::
\begin{itemize}
\item \texttt{<LF>}
\end{itemize}
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

```
CommonToken  ::
  IdentifierName
```
NOTE 1

The `DivPunctuator`, `RegularExpressionLiteral`, `RightBracePunctuator`, and `TemplateSubstitutionTail` productions derive additional tokens that are not included in the `CommonToken` 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`. The Unicode identifier grammar is based on character properties specified by the Unicode Standard. The Unicode code points in the specified categories in version 8.0.0 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: U+0024 (DOLLAR SIGN) and U+005F (LOW LINE) are permitted anywhere in an `IdentifierName`, and the code points U+200C (ZERO WIDTH NON-JOINER) and U+200D (ZERO WIDTH JOINER) are permitted anywhere after the first code point 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, after replacement of each `UnicodeEscapeSequence`, they are represented by the exact same sequence of code points.

#### Syntax

```
IdentifierName  ::
  IdentifierStart
  IdentifierName IdentifierPart

IdentifierStart  ::
  UnicodeIDStart
  $
  _
  \ UnicodeEscapeSequence

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

UnicodeIDStart  ::
  any Unicode code point with the Unicode property “ID_Start”
```
**NOTE** 2  The sets of code points with Unicode properties "ID_Start" and "ID_Continue" include, respectively, the code points with Unicode properties "Other_ID_Start" and "Other_ID_Continue".

### 11.6.1 Identifier Names

#### 11.6.1.1 Static Semantics: Early Errors

**IdentifierStart** :: \ UnicodeEscapeSequence

- It is a Syntax Error if SV(UnicodeEscapeSequence) is none of "$", or "_", or the UTF16Encoding of a code point matched by the UnicodeIDStart lexical grammar production.

**IdentifierPart** :: \ UnicodeEscapeSequence

- It is a Syntax Error if SV(UnicodeEscapeSequence) is none of "$", or "_", or the UTF16Encoding of either <ZWNJ> or <ZWJ>, or the UTF16Encoding of a Unicode code point that would be matched by the UnicodeIDContinue lexical grammar production.

#### 11.6.1.2 Static Semantics: StringValue

**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 UTF16Encoding 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
doin 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
In some contexts `yield` is given the semantics of an `Identifier`. See 12.1. In `strict mode code`, `let` and `static` are treated as reserved keywords through static semantic restrictions (see 12.1, 13.3.1.1, 13.7.5.1, and 14.5.1) rather than the lexical grammar.

11.6.2.2 Future Reserved Words

The following tokens are reserved for used 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` 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
  { ( ) [ ] . . . ; , < <= >= == != == + - * % ++ -- << >> >>> & | ^ ! ~ & & | | ? : = += -= *= %= <<= >>= >>>= &= | |= => ** *=

DivPunctuator ::
  /
  /=

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

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
11.8.3.1 Static Semantics: MV

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** :: **DecimalLiteral**. **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** :: **DecimalLiteral**. **ExponentPart** is the MV of **DecimalIntegerLiteral** × 10\(^{e}\), where \(e\) is the MV of **ExponentPart**.
- The MV of **DecimalLiteral** :: **DecimalLiteral**. **DecimalDigits** **ExponentPart** is (the MV of **DecimalIntegerLiteral** plus (the MV of **DecimalDigits** × 10\(^{-n}\))) × 10\(^{e}\), 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 **DecimalDigit** × 10\(^{-n}\), where \(n\) is the number of code points in **DecimalDigits**.
- The MV of **DecimalLiteral** :: **DecimalIntegerLiteral** **ExponentPart** is the MV of **DecimalIntegerLiteral** × 10\(^{e}\), where \(e\) is the MV of **ExponentPart**.
- The MV of **DecimalIntegerLiteral** :: **0** is 0.
- The MV of **DecimalIntegerLiteral** :: **NonZeroDigit** is the MV of **NonZeroDigit**.
- The MV of **DecimalIntegerLiteral** :: **NonZeroDigit** **DecimalDigits** is (the MV of **NonZeroDigit** × 10\(^{n}\)) plus the MV of **DecimalDigits**, where \(n\) is the number of code points in **DecimalDigits**.
- The MV of **DecimalDigits** :: **DecimalDigit** is the MV of **DecimalDigit**.
- The MV of **DecimalDigits** :: **DecimalDigits** **DecimalDigit** is (the MV of **DecimalDigits** × 10) plus the MV of **DecimalDigit**.
- The MV of **ExponentPart** :: **ExponentIndicator** **SignedInteger** is the MV of **SignedInteger**.
- The MV of **SignedInteger** :: **DecimalDigits** is the MV of **DecimalDigits**.
- The MV of **SignedInteger** :: + **DecimalDigits** is the MV of **DecimalDigits**.
- The MV of **SignedInteger** :: - **DecimalDigits** is the negative of the MV of **DecimalDigits**.
- The MV of **DecimalDigit** :: **0** or of **HexDigit** :: **0** or of **OctalDigit** :: **0** or of **BinaryDigit** :: **0** is 0.
• The MV of `DecimalDigit` :: 1 or of `NonZeroDigit` :: 1 or of `HexDigit` :: 1 or of `OctalDigit` :: 1 or of `BinaryDigit` :: 1 is 1.
• 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.

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 1** 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, U+005C (REVERSE SOLIDUS), U+000D (CARRIAGE RETURN), U+000A (LINE SEPARATOR), U+2029 (PARAGRAPH SEPARATOR), and U+000A (LINE FEED). 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 the 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**

```plaintext
StringLiteral ::
   " DoubleStringCharacters opt "
```
SingleStringCharacters\_opt\:

DoubleStringCharacters ::
  DoubleStringCharacter\ DoubleStringCharacters\_opt

SingleStringCharacters ::
  SingleStringCharacter\ SingleStringCharacters\_opt

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

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

LineContinuation ::
  \ LineTerminatorSequence

EscapeSequence ::
  CharacterEscapeSequence
  Θ [lookahead ∈ DecimalDigit]
  HexEscapeSequence
  UnicodeEscapeSequence

A conforming implementation, when processing strict mode code, 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 }

Hex4Digits ::
  HexDigit HexDigit HexDigit HexDigit

The definition of the nonterminal HexDigit is given in 11.8.3. SourceCharacter is defined in 10.1.
NOTE 2 A line terminator code point cannot appear in a string literal, except as part of a 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 \n or \u000A.

11.8.4.1 Static Semantics: Early Errors

UnicodeEscapeSequence :: u{ HexDigits }

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

11.8.4.2 Static Semantics: StringValue

StringLiteral ::
  " DoubleStringCharacters opt "
  ' SingleStringCharacters opt '

1. Return the String value whose elements are the SV of this StringLiteral.

11.8.4.3 Static Semantics: SV

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 StringLiteral :: " " is the empty code unit sequence.
- The SV of StringLiteral :: ' ' is the empty code unit sequence.
- The SV of StringLiteral :: " DoubleStringCharacters " is the SV of DoubleStringCharacters.
- The SV of StringLiteral :: ' SingleStringCharacters ' is the SV of SingleStringCharacters.
- The SV of DoubleStringCharacters :: DoubleStringCharacter is a sequence of one or two code units that is the SV of DoubleStringCharacter.
- The SV of DoubleStringCharacters :: DoubleStringCharacter DoubleStringCharacters is a sequence of one or two code units that is the SV of DoubleStringCharacter followed by all the code units in the SV of DoubleStringCharacters in order.
- The SV of SingleStringCharacters :: SingleStringCharacter is a sequence of one or two code units that is the SV of SingleStringCharacter.
- The SV of SingleStringCharacters :: SingleStringCharacter SingleStringCharacters is a sequence of one or two code units that is the SV of SingleStringCharacter followed by all the code units in the SV of SingleStringCharacters in order.
- The SV of DoubleStringCharacter :: SourceCharacter but not one of " or \ or LineTerminator is the UTF16Encoding of the code point value of SourceCharacter.
- The SV of DoubleStringCharacter :: \ EscapeSequence is the SV of the EscapeSequence.
- The SV of DoubleStringCharacter :: LineContinuation is the empty code unit sequence.
- The SV of SingleStringCharacter :: SourceCharacter but not one of ' or \ or LineTerminator is the UTF16Encoding 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 34.
Table 34: String Single Character Escape Sequences

<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 UTF16Encoding of the code point value of SourceCharacter.
- The SV of HexEscapeSequence :: x HexDigit HexDigit is the code unit value that is (16 times the MV of the first HexDigit) plus the MV of the second HexDigit.
- The 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 UTF16Encoding of the MV of HexDigits.

### 11.8.5 Regular Expression Literals

Note 1 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 or calling the RegExp constructor as a function (see 21.2.3).

The productions below describe the syntax for a regular expression literal and are used by the input element scanner to find the end of the regular expression literal. The source text comprising the RegularExpressionBody and the RegularExpressionFlags are subsequently parsed again 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]
NOTE 2 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 text that was recognized as RegularExpressionBody.

11.8.5.3 Static Semantics: FlagText

RegularExpressionLiteral :: / RegularExpressionBody / RegularExpressionFlags

1. Return the source text that was recognized as RegularExpressionFlags.

11.8.6 Template Literal Lexical Components

Syntax

Template ::

   NoSubstitutionTemplate
   TemplateHead
NoSubstitutionTemplate ::
  ' TemplateCharacters_opt '

TemplateHead ::
  ' TemplateCharacters_opt $ { 

TemplateSubstitutionTail ::
  TemplateMiddle
  TemplateTail

TemplateMiddle ::
  } TemplateCharacters_opt $ { 

TemplateTail ::
  } TemplateCharacters_opt ' 

TemplateCharacters ::
  TemplateCharacter TemplateCharacters_opt

TemplateCharacter ::
  $ [lookahead ≠ { ]
  \ EscapeSequence
  LineContinuation
  LineTerminatorSequence
  SourceCharacter but not one of ` or \ 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 and TRV

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 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 UTF16Encoding of the code point value of SourceCharacter.
- The TV of TemplateCharacter :: $ is the code unit value 0x0024.
- The TV of TemplateCharacter :: \ EscapeSequence is the SV of EscapeSequence.
- The TV of TemplateCharacter :: LineContinuation is the TV of LineContinuation.
The TV of TemplateCharacter :: LineTerminatorSequence is the TRV of LineTerminatorSequence.
The TV of LineContinuation :: \ LineTerminatorSequence is the empty code unit sequence.
The TRV of NoSubstitutionTemplate :: ` TemplateCharacters ` is the TRV of TemplateCharacters.
The TRV of TemplateHead :: ` TemplateCharacters ${ is the TRV of TemplateCharacters.
The TRV of TemplateMiddle :: } TemplateCharacters ${ is the TRV of TemplateCharacters.
The TRV of TemplateTail :: } TemplateCharacters ` is the TRV of TemplateCharacters.
The TRV 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 UTF16Encoding of the code point value of SourceCharacter.
The TRV of TemplateCharacter :: $ is the code unit value 0x0024.
The TRV of TemplateCharacter :: \ EscapeSequence is the sequence consisting of the code unit value 0x005C followed by the code units of TRV of EscapeSequence.
The TRV of TemplateCharacter :: LineContinuation is the TRV of LineContinuation.
The TRV of TemplateCharacter :: LineTerminatorSequence is the TRV of LineTerminatorSequence.
The TRV of EscapeSequence :: CharacterEscapeSequence is the TRV of the CharacterEscapeSequence.
The TRV of EscapeSequence :: \ is the code unit value 0x0030 (DIGIT ZERO).
The TRV of EscapeSequence :: HexEscapeSequence is the TRV of the HexEscapeSequence.
The TRV of EscapeSequence :: UnicodeEscapeSequence is the TRV of the UnicodeEscapeSequence.
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 0x007B 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 a 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 0x005C 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 0x2028.
The TRV of LineTerminatorSequence :: <PS> is the code unit value 0x2029.
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> LineTerminatorSequences 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

Most ECMAScript statements and declarations must be terminated with a semicolon. 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

In the following rules, "token" means the actual recognized lexical token determined using the current lexical goal symbol as described in clause 11.

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 }.
   - The previous token is ) and the inserted semicolon would then be parsed as the terminating semicolon of a do-while statement (13.7.2).

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 13.7.4).

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

\[
\begin{align*}
UpdateExpression[Yield] & : \\
& \quad LeftHandSideExpression[Yield] \quad [no LineTerminator here] ++ \\
& \quad LeftHandSideExpression[Yield] \quad [no LineTerminator here] -- \\
ContinueStatement[Yield] & : \\
& \quad continue ; \\
& \quad continue [no LineTerminator here] LabelIdentifier[Yield] ; \\
BreakStatement[Yield] & : \\
& \quad break ; \\
& \quad break [no LineTerminator here] LabelIdentifier[Yield] ; \\
ReturnStatement[Yield] & : \\
& \quad return ; \\
& \quad return [no LineTerminator here] Expression[In, ?Yield] ; \\
ThrowStatement[Yield] & : \\
& \quad throw [no LineTerminator here] Expression[In, ?Yield] ; \\
ArrowFunction[In, Yield] & : \\
& \quad ArrowParameters[Yield] \quad [no LineTerminator here] \Rightarrow ConciseBody[?In] \\
YieldExpression[In] & : \\
& \quad yield [no LineTerminator here] * AssignmentExpression[In, Yield] \\
& \quad yield [no LineTerminator here] AssignmentExpression[In, Yield]
\end{align*}
\]
The practical effect of these restricted productions is as follows:

- When a `++` or `--` token is encountered where the parser would treat it as a postfix operator, and at least one `LineTerminator` occurred between the preceding token and the `++` or `--` token, then a semicolon is automatically inserted before the `++` or `--` token.
- When a `continue`, `break`, `return`, `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.
- A `LabelIdentifier` 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 1 The expression `a + b` is not treated as a value to be returned by the `return` statement, because a `LineTerminator` separates it from the token `return`.

The source

```javascript
```


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

is transformed by automatic semicolon insertion into the following:

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

NOTE 2 The token `++` is not treated as a postfix operator applying to the variable `b`, because a `LineTerminator` occurs between `b` and `++`.

The source

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

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

The source

```plaintext
a = b + c
(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:

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

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

## 12 ECMAScript Language: Expressions

### 12.1 Identifiers

**Syntax**

```plaintext
IdentifierReference[Yield] : Identifier [←Yield] yield


LabelIdentifier[Yield] : Identifier [←Yield] yield

Identifier : IdentifierName but not ReservedWord
```

### 12.1.1 Static Semantics: Early Errors

```plaintext
BindingIdentifier : Identifier
```
• It is a Syntax Error if the code matched by this production is contained in **strict mode code** and the StringValue of **Identifier** is "arguments" or "eval".

**IdentifierReference** : `yield`

**BindingIdentifier** : `yield`

**LabelIdentifier** : `yield`

• It is a Syntax Error if the code matched by this production is contained in **strict mode code**.

**IdentifierReference** : Identifier

**BindingIdentifier** : Identifier

**LabelIdentifier** : 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 mode 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

**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 mode 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

**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
NOTE 1  **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 9.2.12). 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 `EnvironmentRecord` component of *environment*.
   b. Perform *env*.InitializeBinding(name, value).
   c. Return NormalCompletion(**undefined**).
3. Else,
   a. Let *lhs* be **ResolveBinding**(name).

### 12.1.6 Runtime Semantics: Evaluation

**IdentifierReference** : 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 13.3.1 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[Yield]
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral[Yield]
```
Supplemental Syntax

When processing the production

\[ \text{PrimaryExpression} : \text{CoverParenthesizedExpressionAndArrowParameterList} \]

the interpretation of \text{CoverParenthesizedExpressionAndArrowParameterList} is refined using the following grammar:

\[ \text{ParenthesizedExpression}[\text{Yield}] : ( \text{Expression}[\text{In}, \text{?Yield}] ) \]

12.2.1 Semantics

12.2.1.1 Static Semantics: CoveredParenthesizedExpression

\[ \text{CoverParenthesizedExpressionAndArrowParameterList} : ( \text{Expression} ) \]

1. Return the result of parsing the lexical token stream matched by \text{CoverParenthesizedExpressionAndArrowParameterList}[\text{Yield}] using either \text{ParenthesizedExpression} or \text{ParenthesizedExpression}[\text{Yield}] as the goal symbol depending upon whether the \text{Yield} grammar parameter was present when \text{CoverParenthesizedExpressionAndArrowParameterList} was matched.

12.2.1.2 Static Semantics: HasName

\[ \text{PrimaryExpression} : \text{CoverParenthesizedExpressionAndArrowParameterList} \]

1. Let \( expr \) be CoveredParenthesizedExpression of \text{CoverParenthesizedExpressionAndArrowParameterList}.
2. If \text{IsFunctionDefinition} of \( expr \) is \text{false}, return \text{false}.
3. Return HasName of \( expr \).

12.2.1.3 Static Semantics: IsFunctionDefinition

\[ \text{PrimaryExpression} : \]

\[ \text{this} \]

\[ \text{IdentifierReference} \]

\[ \text{Literal} \]

\[ \text{ArrayLiteral} \]

\[ \text{ObjectLiteral} \]

\[ \text{RegularExpressionLiteral} \]

\[ \text{TemplateLiteral} \]

1. Return \text{false}.

\[ \text{PrimaryExpression} : \text{CoverParenthesizedExpressionAndArrowParameterList} \]

1. Let \( expr \) be CoveredParenthesizedExpression of \text{CoverParenthesizedExpressionAndArrowParameterList}.
2. Return \text{IsFunctionDefinition} of \( expr \).

12.2.1.4 Static Semantics: IsIdentifierRef
PrimaryExpression : IdentifierReference

1. Return true.

PrimaryExpression :

    this
    Literal
    ArrayLiteral
    ObjectLiteral
    FunctionExpression
    ClassExpression
    GeneratorExpression
    RegularExpressionLiteral
    TemplateLiteral
    CoverParenthesizedExpressionAndArrowParameterList

1. Return false.

12.2.1.5 Static Semantics: IsValidSimpleAssignmentTarget

PrimaryExpression :

    this
    Literal
    ArrayLiteral
    ObjectLiteral
    FunctionExpression
    ClassExpression
    GeneratorExpression
    RegularExpressionLiteral
    TemplateLiteral

1. Return false.

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoveredParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return IsValidSimpleAssignmentTarget of expr.

12.2.2 The this Keyword

12.2.2.1 Runtime Semantics: Evaluation

PrimaryExpression : this

1. Return ? ResolveThisBinding().

12.2.3 Identifier Reference

See 12.1 for IdentifierReference.

12.2.4 Literals

Syntax

Literal :

    NullLiteral
    BooleanLiteral
    NumericLiteral
    StringLiteral
12.2.4.1 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.

12.2.5 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[Yield] :
  [ Elisionopt ]
  [ ElementList[?Yield] ]
  [ ElementList[?Yield] , Elisionopt ]

ElementList[Yield] :
  Elisionopt AssignmentExpression[In, ?Yield]
  Elisionopt SpreadElement[?Yield]
  ElementList[?Yield] , Elisionopt AssignmentExpression[In, ?Yield]
  ElementList[?Yield] , Elisionopt SpreadElement[?Yield]

Elision :
  ,
  Elision ,

SpreadElement[Yield] :
  ... AssignmentExpression[In, ?Yield]

12.2.5.1 Static Semantics: ElisionWidth

Elision :
  1. Return the numeric value 1.

Elision : Elision ,
  1. Let preceding be the ElisionWidth of Elision.
2. Return \( \text{preceding}+1 \).

### 12.2.5.2 Runtime Semantics: ArrayAccumulation

With parameters \( \text{array} \) and \( \text{nextIndex} \).

**ElementList : Elision AssignmentExpression**

1. Let \( \text{padding} \) be the \( \text{ElisionWidth} \) of \( \text{Elision} \); if \( \text{Elision} \) is not present, use the numeric value zero.
2. Let \( \text{initResult} \) be the result of evaluating \( \text{AssignmentExpression} \).
3. Let \( \text{initValue} \) be \( ? \ \text{GetValue}(\text{initResult}) \).
4. Let \( \text{created} \) be \( \text{CreateDataProperty}(\text{array}, \text{ToString}(\text{ToUint32}(\text{nextIndex}+\text{padding})), \text{initValue}) \).
5. Assert: \( \text{created} \) is \text{true}.
6. Return \( \text{nextIndex}+\text{padding}+1 \).

**ElementList : Elision SpreadElement**

1. Let \( \text{padding} \) be the \( \text{ElisionWidth} \) of \( \text{Elision} \); if \( \text{Elision} \) is not present, use the numeric value zero.
2. Return the result of performing ArrayAccumulation for \( \text{SpreadElement} \) with arguments \( \text{array} \) and \( \text{nextIndex}+\text{padding} \).

**ElementList : ElementList , Elision AssignmentExpression**

1. Let \( \text{postIndex} \) be the result of performing ArrayAccumulation for \( \text{ElementList} \) with arguments \( \text{array} \) and \( \text{nextIndex} \).
2. ReturnIfAbrupt(\( \text{postIndex} \)).
3. Let \( \text{padding} \) be the \( \text{ElisionWidth} \) of \( \text{Elision} \); if \( \text{Elision} \) is not present, use the numeric value zero.
4. Let \( \text{initResult} \) be the result of evaluating \( \text{AssignmentExpression} \).
5. Let \( \text{initValue} \) be \( ? \ \text{GetValue}(\text{initResult}) \).
6. Let \( \text{created} \) be \( \text{CreateDataProperty}(\text{array}, \text{ToString}(\text{ToUint32}(\text{postIndex}+\text{padding})), \text{initValue}) \).
7. Assert: \( \text{created} \) is \text{true}.
8. Return \( \text{postIndex}+\text{padding}+1 \).

**ElementList : ElementList , Elision SpreadElement**

1. Let \( \text{postIndex} \) be the result of performing ArrayAccumulation for \( \text{ElementList} \) with arguments \( \text{array} \) and \( \text{nextIndex} \).
2. ReturnIfAbrupt(\( \text{postIndex} \)).
3. Let \( \text{padding} \) be the \( \text{ElisionWidth} \) of \( \text{Elision} \); if \( \text{Elision} \) is not present, use the numeric value zero.
4. Return the result of performing ArrayAccumulation for \( \text{SpreadElement} \) with arguments \( \text{array} \) and \( \text{postIndex}+\text{padding} \).

**SpreadElement : ... AssignmentExpression**

1. Let \( \text{spreadRef} \) be the result of evaluating \( \text{AssignmentExpression} \).
2. Let \( \text{spreadObj} \) be \( ? \ \text{GetValue}(\text{spreadRef}) \).
3. Let \( \text{iterator} \) be \( ? \ \text{GetIterator}(\text{spreadObj}) \).
4. Repeat
   a. Let \( \text{next} \) be \( ? \ \text{IteratorStep}(\text{iterator}) \).
   b. If \( \text{next} \) is \text{false}, return \( \text{nextIndex} \).
   c. Let \( \text{nextValue} \) be \( ? \ \text{IteratorValue}(\text{next}) \).
   d. Let \( \text{status} \) be \( \text{CreateDataProperty}(\text{array}, \text{ToString}(\text{ToUint32}(\text{nextIndex})), \text{nextValue}) \).
   e. Assert: \( \text{status} \) is \text{true}.
   f. Let \( \text{nextIndex} \) be \( \text{nextIndex}+1 \).

**NOTE** \( \text{CreateDataProperty} \) 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 \( [[\text{Set}]] \).

### 12.2.5.3 Runtime Semantics: Evaluation

**ArrayLiteral : [ Elision ]**
1. Let `array` be `ArrayCreate(0)`.
2. Let `pad` be the ElisionWidth of `Elision`; if `Elision` is not present, use the numeric value zero.
3. Perform `Set(array, "length", ToUint32(pad), false)`.
4. NOTE: The above Set 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`).
4. Perform `Set(array, "length", ToUint32(len), false)`.
5. NOTE: The above Set cannot fail because of the nature of the object returned by `ArrayCreate`.
6. Return `array`.

`ArrayLiteral` : [ ElementList, Elision ]

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 `Set(array, "length", ToUint32(padding+len), false)`.
6. NOTE: The above Set cannot fail because of the nature of the object returned by `ArrayCreate`.
7. Return `array`.

### 12.2.6 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 keys 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]` :

```
{ }   # `ObjectLiteral` with no yield
{ PropertyDefinitionList[Yield] }  # `ObjectLiteral` with yield
{ PropertyDefinitionList[Yield], }  # `ObjectLiteral` with yield
```

`PropertyDefinitionList[Yield]` :

```
PropertyDefinition[?Yield]
PropertyDefinitionList[?Yield], PropertyDefinition[?Yield]
```

`PropertyDefinition[Yield]` :

```
IdentifierReference[?Yield]
CoverInitializedName[?Yield]
PropertyName[?Yield] : AssignmentExpression[In, ?Yield]
MethodDefinition[?Yield]
```

`PropertyName[Yield]` :

```
LiteralPropertyName
ComputedPropertyName[?Yield]
```

`LiteralPropertyName` :

```
IdentifierName
StringLiteral
NumericLiteral
```
**ComputedPropertyName[Yield]** :  
  [ AssignmentExpression[In, ?Yield] ]

**CoverInitializedName[Yield]** :  
  IdentifierReference[?Yield] Initializer[In, ?Yield]

**Initializer[In, yield]** :  
  = AssignmentExpression[?In, ?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.

### 12.2.6.1 Static Semantics: Early Errors

*PropertyDefinition : MethodDefinition*

- It is a Syntax Error if HasDirectSuper of *MethodDefinition* is true.

In addition to describing an actual object initializer the *ObjectLiteral* productions are also used as a cover grammar for *ObjectAssignmentPattern*. 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 code matches this production.

NOTE  This production exists so that *ObjectLiteral* can serve as a cover grammar for *ObjectAssignmentPattern*. It cannot occur in an actual object initializer.

### 12.2.6.2 Static Semantics: ComputedPropertyNameContains

With parameter *symbol*.

*PropertyName : LiteralPropertyName*

1. Return false.

*PropertyName : ComputedPropertyName*

1. Return the result of *ComputedPropertyNameContains* *symbol*.

### 12.2.6.3 Static Semantics: Contains

With parameter *symbol*.

*PropertyDefinition : MethodDefinition*

1. If *symbol* is *MethodDefinition*, return true.
2. Return the result of ComputedPropertyNameContains 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.
12.2.6.4 Static Semantics: HasComputedPropertyKey

\[\text{PropertyDefinitionList} : \text{PropertyDefinitionList} \; , \; \text{PropertyDefinition}\]

1. If HasComputedPropertyKey of PropertyDefinitionList is true, return true.
2. Return HasComputedPropertyKey of PropertyDefinition.

\[\text{PropertyDefinition} : \text{IdentifierReference}\]

1. Return false.

\[\text{PropertyDefinition} : \text{PropertyName} \; : \text{AssignmentExpression}\]

1. Return IsComputedPropertyKey of PropertyName.

12.2.6.5 Static Semantics: IsComputedPropertyKey

\[\text{PropertyName} : \text{LiteralPropertyName}\]

1. Return false.

\[\text{PropertyName} : \text{ComputedPropertyName}\]

1. Return true.

12.2.6.6 Static Semantics: PropName

\[\text{PropertyDefinition} : \text{IdentifierReference}\]

1. Return StringValue of IdentifierReference.

\[\text{PropertyDefinition} : \text{PropertyName} \; : \text{AssignmentExpression}\]

1. Return PropName of PropertyName.

\[\text{LiteralPropertyName} : \text{IdentifierName}\]

1. Return StringValue of IdentifierName.

\[\text{LiteralPropertyName} : \text{StringLiteral}\]

1. Return a String value whose code units are the SV of the StringLiteral.

\[\text{LiteralPropertyName} : \text{NumericLiteral}\]

1. Let \(nbr\) be the result of forming the value of the NumericLiteral.
2. Return \(!\text{ToString}(nbr)\).

\[\text{ComputedPropertyName} : [ \text{AssignmentExpression} ]\]

1. Return empty.

12.2.6.7 Static Semantics: PropertyNameList

\[\text{PropertyDefinitionList} : \text{PropertyDefinition}\]

1. If PropName of PropertyDefinition is empty, return a new empty List.
2. Return a new List containing PropName of PropertyDefinition.

\[\text{PropertyDefinitionList} : \text{PropertyDefinitionList} \; , \; \text{PropertyDefinition}\]

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.

12.2.6.8 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. Return ?ToPropertyKey(propName).

12.2.6.9 Runtime Semantics: PropertyDefinitionEvaluation

With parameters object and enumerable.

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. Let propValue be ?GetValue(exprValue).
4. Assert: enumerable is true.
5. 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. If $IsAnonymousFunctionDefinition(AssignmentExpression)$ is $true$, then
   a. Let $hasNameProperty$ be $HasOwnProperty(propValue, "name")$.
   b. If $hasNameProperty$ is $false$, perform $SetFunctionName(propValue, propKey)$.
6. Assert: $enumerable$ is $true$.
7. Return $CreateDataPropertyOrThrow(object, propKey, propValue)$.

NOTE An alternative semantics for this production is given in B.3.1.

12.2.7 Function Defining Expressions

See 14.1 for PrimaryExpression : FunctionExpression .

See 14.4 for PrimaryExpression : GeneratorExpression .

See 14.5 for PrimaryExpression : ClassExpression .

12.2.8 Regular Expression Literals

Syntax

See 11.8.5.

12.2.8.1 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 ECMA Script 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.

12.2.8.2 Runtime Semantics: Evaluation

PrimaryExpression : RegularExpressionLiteral

1. Let $pattern$ be the String value consisting of the $UTF16Encoding$ of each code point of BodyText of $RegularExpressionLiteral$.
2. Let $flags$ be the String value consisting of the $UTF16Encoding$ of each code point of FlagText of $RegularExpressionLiteral$.
3. Return $RegExpCreate(pattern, flags)$.

12.2.9 Template Literals

Syntax

TemplateLiteral[Yield] :
   NoSubstitutionTemplate
   TemplateHead Expression[In, ?Yield] TemplateSpans[?Yield]

TemplateSpans[Yield] :
   TemplateTail
   TemplateMiddleList[?Yield] TemplateTail

TemplateMiddleList[Yield] :
   TemplateMiddle Expression[In, ?Yield]
   TemplateMiddleList[?Yield] TemplateMiddle Expression[In, ?Yield]

12.2.9.1 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 elements, 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`.

**12.2.9.2 Runtime Semantics: ArgumentListEvaluation**

**TemplateLiteral : NoSubstitutionTemplate**

1. Let `templateLiteral` be this `TemplateLiteral`. 
2. Let \( \text{siteObj} \) be GetTemplateObject(\( \text{templateLiteral} \)).
3. Return a List containing the one element which is \( \text{siteObj} \).

**TemplateLiteral** : **TemplateHead** Expression **TemplateSpans**

1. Let \( \text{templateLiteral} \) be this TemplateLiteral.
2. Let \( \text{siteObj} \) be GetTemplateObject(\( \text{templateLiteral} \)).
3. Let \( \text{firstSub} \) be the result of evaluating Expression.
4. ReturnIfAbrupt(\( \text{firstSub} \)).
5. Let \( \text{restSub} \) be SubstitutionEvaluation of TemplateSpans.
6. ReturnIfAbrupt(\( \text{restSub} \)).
7. Assert: \( \text{restSub} \) is a List.
8. Return a List whose first element is \( \text{siteObj} \), whose second elements is \( \text{firstSub} \), and whose subsequent elements are the elements of \( \text{restSub} \), in order. \( \text{restSub} \) may contain no elements.

### 12.2.9.3 Runtime Semantics: GetTemplateObject ( \( \text{templateLiteral} \) )

The abstract operation GetTemplateObject is called with a grammar production, TemplateLiteral, as an argument. It performs the following steps:

1. Let \( \text{rawStrings} \) be TemplateStrings of \( \text{templateLiteral} \) with argument true.
2. Let \( \text{realm} \) be the current Realm Record.
3. Let \( \text{templateRegistry} \) be \( \text{realm}[[\text{TemplateMap}]] \).
4. For each element \( e \) of \( \text{templateRegistry} \), do
   a. Return \( e[[\text{Array}]] \).
5. Let \( \text{cookedStrings} \) be TemplateStrings of \( \text{templateLiteral} \) with argument false.
6. Let \( \text{count} \) be the number of elements in the List \( \text{cookedStrings} \).
7. Let \( \text{template} \) be ArrayCreate(\( \text{count} \)).
8. Let \( \text{rawObj} \) be ArrayCreate(\( \text{count} \)).
9. Let \( \text{index} \) be 0.
10. Repeat while \( \text{index} \lt \text{count} \)
   a. Let \( \text{prop} \) be ! ToString(\( \text{index} \)).
   b. Let \( \text{cookedValue} \) be the String value \( \text{cookedStrings}[\text{index}] \).
   c. Call \( \text{template}[[\text{DefineOwnProperty}]](\text{prop}, \text{PropertyDescriptor}[[\text{Value}]: \text{cookedValue}, [[\text{Writable}]: \text{false}, [[\text{Enumerable}]: \text{true}, [[\text{Conferigurable}]: \text{false}}]).
   d. Let \( \text{rawValue} \) be the String value \( \text{rawStrings}[\text{index}] \).
   e. Call \( \text{rawObj}[[\text{DefineOwnProperty}]](\text{prop}, \text{PropertyDescriptor}[[\text{Value}]: \text{rawValue}, [[\text{Writable}]: \text{false}, [[\text{Enumerable}]: \text{true}, [[\text{Conferigurable}]: \text{false}}]).
   f. Let \( \text{index} \) be \( \text{index} \)+1.
11. Perform SetIntegrityLevel(\( \text{rawObj}, \text{"frozen"} \)).
12. Call \( \text{template}[[\text{DefineOwnProperty}]](\text{"raw"}, \text{PropertyDescriptor}[[\text{Value}]: \text{rawObj}, [[\text{Writable}]: \text{false}, [[\text{Enumerable}]: \text{false}, [[\text{Conferigurable}]: \text{false}}]).
13. Perform SetIntegrityLevel(\( \text{template}, \text{"frozen"} \)).
14. Append the Record([[Strings]: \( \text{rawStrings} \), [[Array]: \( \text{template} \) to \( \text{templateRegistry} \).
15. Return \( \text{template} \).

**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 (12.2.9.5). 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.
12.2.9.4 Runtime Semantics: SubstitutionEvaluation

TemplateSpans : TemplateTail

1. Return a new 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.

12.2.9.5 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. ReturnIfAbrupt(sub).
4. Let middle be ?ToString(sub).
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 1 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. ReturnIfAbrupt(sub).
4. Let middle be ?ToString(sub).
5. Return the sequence of code units consisting of the code units of head followed by the elements of middle.

NOTE 2  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. ReturnIfAbrupt(sub).
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 3  The string conversion semantics applied to the Expression value are like `String.prototype.concat` rather than the + operator.

12.2.10 The Grouping Operator

12.2.10.1 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 CoveredParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.

12.2.10.2 Static Semantics: IsFunctionDefinition

ParenthesizedExpression : ( Expression )

1. Return IsFunctionDefinition of Expression.

12.2.10.3 Static Semantics: IsValidSimpleAssignmentTarget

ParenthesizedExpression : ( Expression )

1. Return IsValidSimpleAssignmentTarget of Expression.

12.2.10.4 Runtime Semantics: Evaluation

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList

1. Let expr be CoveredParenthesizedExpression 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] :`

- `PrimaryExpression[Yield]
- `MemberExpression[Yield] [ Expression[In, ?Yield] ]`
- `MemberExpression[Yield] . IdentifierName`
- `MemberExpression[Yield] TemplateLiteral[?Yield]
- `SuperProperty[?Yield]
- `MetaProperty`
  - `new MemberExpression[?Yield] Arguments[?Yield]

`SuperProperty[?Yield] :`

- `super [ Expression[In, ?Yield] ]`
- `super . IdentifierName`

`MetaProperty :`

- `NewTarget`

`NewTarget :`

- `new . target`

`NewExpression[Yield] :`

- `MemberExpression[?Yield]
- `new NewExpression[?Yield]

`CallExpression[Yield] :`

- `MemberExpression[?Yield] Arguments[?Yield]
- `SuperCall[?Yield]
- `CallExpression[?Yield] Arguments[?Yield]
- `CallExpression[?Yield] [ Expression[In, ?Yield] ]`
- `CallExpression[?Yield] . IdentifierName`
- `CallExpression[?Yield] TemplateLiteral[?Yield]

`SuperCall[?Yield] :`

- `super Arguments[?Yield]

`Arguments[?Yield] :`

- `( )
- `( ArgumentList[?Yield] )

`ArgumentList[?Yield] :`

- `AssignmentExpression[In, ?Yield]
- `... AssignmentExpression[In, ?Yield]
- `ArgumentList[?Yield] , AssignmentExpression[In, ?Yield]
- `ArgumentList[?Yield] , ... AssignmentExpression[In, ?Yield]

`LeftHandSideExpression[Yield] :`

- `NewExpression[?Yield]
- `CallExpression[?Yield]

12.3.1 Static Semantics

12.3.1.1 Static Semantics: Contains
With parameter `symbol`.

**MemberExpression** : `MemberExpression . IdentifierName`

1. If `MemberExpression` Contains `symbol` is `true`, return `true`.
2. If `symbol` is a `ReservedWord`, return `false`.
3. If `symbol` is an `Identifier` and `StringValue` of `symbol` is the same value as the `StringValue` of `IdentifierName`, return `true`.
4. Return `false`.

**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

**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

**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

CallExpression :
MemberExpression Arguments
SuperCall
CallExpression Arguments
CallExpression [ Expression ]
CallExpression . IdentifierName
CallExpression TemplateLiteral

1. Return false.

12.3.1.4 Static Semantics: IsIdentifierRef

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

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

MemberExpression :
MemberExpression TemplateLiteral
new MemberExpression Arguments

NewTarget :

new . target

1. Return false.

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. Let propertyNameReference be the result of evaluating Expression.
4. Let propertyNameValue be ? GetValue(propertyNameReference).
5. Let bv be ? RequireObjectCoercible(baseValue).
6. Let propertyKey be ? ToPropertyKey(propertyNameValue).
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, 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).
4. Let propertyNameString be StringValue of IdentifierName.
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 a value of type Reference whose base value is bv, 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


MemberExpression : new MemberExpression Arguments

1. Return ? EvaluateNew(MemberExpression, Arguments).

12.3.3.1.1 Runtime Semantics: EvaluateNew(constructProduction, arguments)

The abstract operation EvaluateNew with arguments constructProduction, and arguments performs the following steps:

1. Assert: constructProduction is either a NewExpression or a MemberExpression.
2. Assert: arguments is either empty or an Arguments production.
3. Let ref be the result of evaluating constructProduction.
4. Let constructor be ? GetValue(ref).
5. If arguments is empty, let argList be a new empty List.
6. Else,
   b. ReturnIfAbrupt(argList).
7. If IsConstructor(constructor) is false, throw a TypeError exception.

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. If Type(ref) is Reference and IsPropertyReference(ref) is false and GetReferencedName(ref) is "eval", then
   a. If SameValue(func, %eval%) is true, then
      ii. If argList has no elements, return undefined.
      iii. Let evalText be the first element of argList.
      iv. If the source code matching this CallExpression is strict code, let strictCaller be true. Otherwise let strictCaller be false.
      v. Let evalRealm be the current Realm Record.
4. If Type(ref) is Reference, then
   a. If IsPropertyReference(ref) is true, then
i. Let \( \text{thisValue} \) be \( \text{GetThisValue}(\text{ref}) \).

b. Else, the base of \( \text{ref} \) is an Environment Record
   i. Let \( \text{refEnv} \) be \( \text{GetBase}() \).
   ii. Let \( \text{thisValue} \) be \( \text{refEnv}.\text{WithBaseObject}() \).

5. Else \( \text{Type}(\text{ref}) \) is not Reference,
   a. Let \( \text{thisValue} \) be \( \text{undefined} \).

6. Let \( \text{thisCall} \) be this \( \text{CallExpression} \).
7. Let \( \text{tailCall} \) be \( \text{IsInTailPosition}(\text{thisCall}) \).
8. Return ? \( \text{EvaluateDirectCall}(\text{func}, \text{thisValue}, \text{Arguments}, \text{tailCall}) \).

A \( \text{CallExpression} \) evaluation that executes step 3.a.vi is a direct eval.

\[ \text{CallExpression} : \text{CallExpression} \text{ Arguments} \]

1. Let \( \text{ref} \) be the result of evaluating \( \text{CallExpression} \).
2. Let \( \text{thisCall} \) be this \( \text{CallExpression} \).
3. Let \( \text{tailCall} \) be \( \text{IsInTailPosition}(\text{thisCall}) \).
4. Return ? \( \text{EvaluateCall}(\text{ref}, \text{Arguments}, \text{tailCall}) \).

12.3.4.2 Runtime Semantics: \( \text{EvaluateCall}(\text{ref}, \text{arguments}, \text{tailPosition}) \)

The abstract operation \( \text{EvaluateCall} \) takes as arguments a value \( \text{ref} \), a syntactic grammar production \( \text{arguments} \), and a Boolean argument \( \text{tailPosition} \). It performs the following steps:

1. Let \( \text{func} \) be ? \( \text{GetValue}(\text{ref}) \).
2. If \( \text{Type}() \) is Reference, then
   a. If \( \text{IsPropertyReference}(\text{ref}) \) is \( \text{true} \), then
      i. Let \( \text{thisValue} \) be \( \text{GetThisValue}(\text{ref}) \).
   b. Else, the base of \( \text{ref} \) is an Environment Record
      i. Let \( \text{refEnv} \) be \( \text{GetBase}(\text{ref}) \).
      ii. Let \( \text{thisValue} \) be \( \text{refEnv}.\text{WithBaseObject}() \).
3. Else \( \text{Type}(\text{ref}) \) is not Reference,
   a. Let \( \text{thisValue} \) be \( \text{undefined} \).
4. Return ? \( \text{EvaluateDirectCall}(\text{func}, \text{thisValue}, \text{Arguments}, \text{tailPosition}) \).

12.3.4.3 Runtime Semantics: \( \text{EvaluateDirectCall}(\text{func}, \text{thisValue}, \text{arguments}, \text{tailPosition}) \)

The abstract operation \( \text{EvaluateDirectCall} \) takes as arguments a value \( \text{func} \), a value \( \text{thisValue} \), a syntactic grammar production \( \text{arguments} \), and a Boolean argument \( \text{tailPosition} \). It performs the following steps:

1. Let \( \text{argList} \) be ? \( \text{ArgumentListEvaluation}(\text{arguments}) \).
2. If \( \text{Type}(\text{func}) \) is not Object, throw a \( \text{TypeError} \) exception.
3. If \( \text{IsCallable}(\text{func}) \) is \( \text{false} \), throw a \( \text{TypeError} \) exception.
4. If \( \text{tailPosition} \) is \( \text{true} \), perform \( \text{PrepareForTailCall}() \).
5. Let \( \text{result} \) be \( \text{Call}(\text{func}, \text{thisValue}, \text{argList}) \).
6. Assert: If \( \text{tailPosition} \) is \( \text{true} \), the above call will not return here, but instead evaluation will continue as if the following return has already occurred.
7. Assert: If \( \text{result} \) is not an abrupt completion, then \( \text{Type}(\text{result}) \) is an ECMAScript language type.
8. Return \( \text{result} \).

12.3.5 The super Keyword

12.3.5.1 Runtime Semantics: Evaluation

\[ \text{SuperProperty} : \text{super} [\ \text{Expression} \ ] \]

1. Let \( \text{propertyNameReference} \) be the result of evaluating \( \text{Expression} \).
2. Let \( \text{propertyNameValue} \) be \( \text{GetValue}(\text{propertyNameReference}) \).
3. Let `propertyKey` be `? ToPropertyKey(propertyNameValue)`.
4. If the code matched by the syntactic production that is being evaluated is strict mode code, let `strict` be `true`, else let `strict` be `false`.
5. Return `? 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`.

**SuperCall**: `super Arguments`

1. Let `newTarget` be `GetNewTarget()`.
2. If `newTarget` is `undefined`, throw a `ReferenceError` exception.
5. ReturnIfAbrupt(`argList`).
6. Let `result` be `? Construct(func, argList, newTarget)`.
7. Let `thisER` be `GetThisEnvironment()`.
8. Return `? thisER.BindThisValue(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]]`.
5. If `IsConstructor(superConstructor)` is `false`, throw a `TypeError` exception.
6. 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 `env.HasSuperBinding()` is `false`, throw a `ReferenceError` exception.
3. Let `actualThis` be `? env.GetThisBinding()`.
5. Let `bv` be `? RequireObjectCoercible(baseValue)`.
6. 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.

12.3.6.1 Runtime Semantics: `ArgumentListEvaluation`

**Arguments**: `()`

1. Return a new empty `List`.

**ArgumentList**: `AssignmentExpression`

1. Let `ref` be the result of evaluating `AssignmentExpression`. 
2. Let \( \text{arg} \) be \( ? \text{GetValue}(\text{ref}) \).
3. Return a \textbf{List} whose sole item is \( \text{arg} \).

\textbf{ArgumentList : ... AssignmentExpression}

1. Let \( \text{list} \) be a new empty \textbf{List}.
2. Let \( \text{spreadRef} \) be the result of evaluating \textbf{AssignmentExpression}.
3. Let \( \text{spreadObj} \) be \( ? \text{GetValue}(\text{spreadRef}) \).
4. Let \( \text{iterator} \) be \( ? \text{GetIterator}(\text{spreadObj}) \).
5. Repeat
   a. Let \( \text{next} \) be \( ? \text{IteratorStep}(\text{iterator}) \).
   b. If \( \text{next} \) is \( \text{false} \), return \( \text{list} \).
   c. Let \( \text{nextArg} \) be \( ? \text{IteratorValue}(\text{next}) \).
   d. Append \( \text{nextArg} \) as the last element of \( \text{list} \).

\textbf{ArgumentList : ArgumentList , AssignmentExpression}

1. Let \( \text{precedingArgs} \) be the result of evaluating \textbf{ArgumentList}.
2. \textbf{ReturnIfAbrupt}(\( \text{precedingArgs} \)).
3. Let \( \text{ref} \) be the result of evaluating \textbf{AssignmentExpression}.
4. Let \( \text{arg} \) be \( ? \text{GetValue}(\text{ref}) \).
5. Append \( \text{arg} \) to the end of \( \text{precedingArgs} \).
6. Return \( \text{precedingArgs} \).

\textbf{ArgumentList : ArgumentList , ... AssignmentExpression}

1. Let \( \text{precedingArgs} \) be the result of evaluating \textbf{ArgumentList}.
2. Let \( \text{spreadRef} \) be the result of evaluating \textbf{AssignmentExpression}.
3. Let \( \text{iterator} \) be \( ? \text{GetIterator}(\text{GetValue}(\text{spreadRef})) \).
4. Repeat
   a. Let \( \text{next} \) be \( ? \text{IteratorStep}(\text{iterator}) \).
   b. If \( \text{next} \) is \( \text{false} \), return \( \text{precedingArgs} \).
   c. Let \( \text{nextArg} \) be \( ? \text{IteratorValue}(\text{next}) \).
   d. Append \( \text{nextArg} \) as the last element of \( \text{precedingArgs} \).

\textbf{12.3.7 Tagged Templates}

\textbf{NOTE} A tagged template is a function call where the arguments of the call are derived from a TemplateLiteral (12.2.9). The actual arguments include a template object (12.2.9.3) and the values produced by evaluating the expressions embedded within the TemplateLiteral.

\textbf{12.3.7.1 Runtime Semantics: Evaluation}

\textbf{MemberExpression : MemberExpression TemplateLiteral}

1. Let \( \text{tagRef} \) be the result of evaluating \textbf{MemberExpression}.
2. Let \( \text{thisCall} \) be this \textbf{MemberExpression}.
3. Let \( \text{tailCall} \) be \( \text{IsInTailPosition}(\text{thisCall}) \).
4. Return \( ? \text{EvaluateCall}(\text{tagRef}, \text{TemplateLiteral}, \text{tailCall}) \).

\textbf{CallExpression : CallExpression TemplateLiteral}

1. Let \( \text{tagRef} \) be the result of evaluating \textbf{CallExpression}.
2. Let \( \text{thisCall} \) be this \textbf{CallExpression}.
3. Let \( \text{tailCall} \) be \( \text{IsInTailPosition}(\text{thisCall}) \).
4. Return \( ? \text{EvaluateCall}(\text{tagRef}, \text{TemplateLiteral}, \text{tailCall}) \).

\textbf{12.3.8 Meta Properties}
12.3.8.1 Runtime Semantics: Evaluation

\textit{NewTarget} : \texttt{new . target}

1. Return \texttt{GetNewTarget()}. 

12.4 Update Expressions

Syntax

\[ \text{UpdateExpression}_{[Yield]} : \]
\[ \text{LeftHandSideExpression}_{[Yield]} \]
\[ \text{LeftHandSideExpression}_{[Yield]} \text{ [no LineTerminator here]} \quad \text{++} \]
\[ \text{LeftHandSideExpression}_{[Yield]} \text{ [no LineTerminator here]} \quad \text{--} \]
\[ \text{++ UnaryExpression}_{[Yield]} \]
\[ \text{-- UnaryExpression}_{[Yield]} \]

12.4.1 Static Semantics: Early Errors

\[ \text{UpdateExpression} : \]
\[ \text{LeftHandSideExpression} \quad \text{++} \]
\[ \text{LeftHandSideExpression} \quad \text{--} \]

- It is an early \texttt{Reference Error} if \texttt{IsValidSimpleAssignmentTarget} of \texttt{LeftHandSideExpression} is \texttt{false}.

\[ \text{UpdateExpression} : \]
\[ \text{++ UnaryExpression} \]
\[ \text{-- UnaryExpression} \]

- It is an early \texttt{Reference Error} if \texttt{IsValidSimpleAssignmentTarget} of \texttt{UnaryExpression} is \texttt{false}.

12.4.2 Static Semantics: IsFunctionDefinition

\[ \text{UpdateExpression} : \]
\[ \text{LeftHandSideExpression} \quad \text{++} \]
\[ \text{LeftHandSideExpression} \quad \text{--} \]
\[ \text{++ UnaryExpression} \]
\[ \text{-- UnaryExpression} \]

1. Return \texttt{false}.

12.4.3 Static Semantics: IsValidSimpleAssignmentTarget

\[ \text{UpdateExpression} : \]
\[ \text{LeftHandSideExpression} \quad \text{++} \]
\[ \text{LeftHandSideExpression} \quad \text{--} \]
\[ \text{++ UnaryExpression} \]
\[ \text{-- UnaryExpression} \]

1. Return \texttt{false}.

12.4.4 Postfix Increment Operator

12.4.4.1 Runtime Semantics: Evaluation

\[ \text{UpdateExpression} : \text{LeftHandSideExpression} \quad \text{++} \]

1. Let \texttt{ihs} be the result of evaluating \texttt{LeftHandSideExpression}. 
2. Let `oldValue` be `?ToNumber(?GetValue(lhs))`.
3. Let `newValue` be the result of adding the value `1` to `oldValue`, using the same rules as for the `+` operator (see 12.8.5).
5. Return `oldValue`.

12.4.5 Postfix Decrement Operator

12.4.5.1 Runtime Semantics: Evaluation

\[ \text{UpdateExpression : LeftHandSideExpression } -- \]

1. Let `lhs` be the result of evaluating `LeftHandSideExpression`.
2. Let `oldValue` be `?ToNumber(?GetValue(lhs))`.
3. Let `newValue` be the result of subtracting the value `1` from `oldValue`, using the same rules as for the `-` operator (see 12.8.5).
5. Return `oldValue`.

12.4.6 Prefix Increment Operator

12.4.6.1 Runtime Semantics: Evaluation

\[ \text{UpdateExpression : ++ UnaryExpression} \]

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Let `oldValue` be `?ToNumber(?GetValue(expr))`.
3. Let `newValue` be the result of adding the value `1` to `oldValue`, using the same rules as for the `+` operator (see 12.8.5).
5. Return `newValue`.

12.4.7 Prefix Decrement Operator

12.4.7.1 Runtime Semantics: Evaluation

\[ \text{UpdateExpression : -- UnaryExpression} \]

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Let `oldValue` be `?ToNumber(?GetValue(expr))`.
3. Let `newValue` be the result of subtracting the value `1` from `oldValue`, using the same rules as for the `-` operator (see 12.8.5).
5. Return `newValue`.

12.5 Unary Operators

Syntax

\[ \text{UnaryExpression[Yield]} : \]

\[ \text{UpdateExpression[Yield]} \]

\[ \text{delete UnaryExpression[Yield]} \]

\[ \text{void UnaryExpression[Yield]} \]

\[ \text{typeof UnaryExpression[Yield]} \]

\[ + \text{ UnaryExpression[Yield]} \]

\[ - \text{ UnaryExpression[Yield]} \]

\[ ~ \text{ UnaryExpression[Yield]} \]

\[ ! \text{ UnaryExpression[Yield]} \]
12.5.1 Static Semantics: IsFunctionDefinition

UnaryExpression : UpdateExpression
    delete UnaryExpression
    void UnaryExpression
    typeof UnaryExpression
    + UnaryExpression
    - UnaryExpression
    ~ UnaryExpression
    ! UnaryExpression

1. Return false.

12.5.2 Static Semantics: IsValidSimpleAssignmentTarget

UnaryExpression : UpdateExpression
    delete UnaryExpression
    void UnaryExpression
    typeof UnaryExpression
    + UnaryExpression
    - UnaryExpression
    ~ UnaryExpression
    ! UnaryExpression

1. Return false.

12.5.3 The delete Operator

12.5.3.1 Static Semantics: Early Errors

UnaryExpression : delete UnaryExpression

- It is a Syntax Error if the UnaryExpression is contained in strict mode 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.

12.5.3.2 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) is true, throw a ReferenceError exception. 
   b. Let baseObj be !ToObject(GetBase(ref)).
c. Let `deleteStatus` be `baseObj.[[Delete]](GetReferencedName(ref))`.

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 `? bindings.DeleteBinding(GetReferencedName(ref))`.

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.

12.5.4 The `void` Operator

12.5.4.1 Runtime Semantics: Evaluation

`UnaryExpression : void UnaryExpression`

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Perform `? GetValue(expr)`.
3. Return `undefined`.

NOTE `GetValue` must be called even though its value is not used because it may have observable side-effects.

12.5.5 The `typeof` Operator

12.5.5.1 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 `? GetValue(val)`.
4. Return a String according to Table 35.

<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 [[Call]])</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Object (standard exotic and does not implement [[Call]])</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Object (implements [[Call]])</td>
<td>&quot;function&quot;</td>
</tr>
<tr>
<td>Object (non-standard exotic and does not implement [[Call]])</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.

12.5.6 Unary + Operator

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

12.5.6.1 Runtime Semantics: Evaluation

\[ UnaryExpression \; : \; + \; UnaryExpression \]

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Return `?ToNumber(?GetValue(expr))`.

12.5.7 Unary - Operator

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

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. If `oldValue` is `NaN`, return `NaN`.
4. Return the result of negating `oldValue`; that is, compute a Number with the same magnitude but opposite sign.

12.5.8 Bitwise NOT Operator ( ~ )

12.5.8.1 Runtime Semantics: Evaluation

\[ UnaryExpression \; : \; \sim \; UnaryExpression \]

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Let `oldValue` be `?ToInt32(?GetValue(expr))`.
3. Return the result of applying bitwise complement to `oldValue`. The result is a signed 32-bit integer.

12.5.9 Logical NOT Operator ( ! )

12.5.9.1 Runtime Semantics: Evaluation

\[ UnaryExpression \; : \; \! \; UnaryExpression \]

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Let `oldValue` be `ToBoolean(?GetValue(expr))`.
3. If `oldValue` is `true`, return `false`.
4. Return `true`.

12.6 Exponentiation Operator

Syntax


12.6.1 Static Semantics: IsFunctionDefinition

\[ ExponentiationExpression \; : \]
UpdateExpression ** ExponentiationExpression

1. Return false.

12.6.2 Static Semantics: IsValidSimpleAssignmentTarget

ExponentiationExpression :
UpdateExpression ** ExponentiationExpression

1. Return false.

12.6.3 Runtime Semantics: Evaluation

ExponentiationExpression : UpdateExpression ** ExponentiationExpression

1. Let left be the result of evaluating UpdateExpression.
2. Let leftValue be GetValue(left).
3. Let right be the result of evaluating ExponentiationExpression.
4. Let rightValue be GetValue(right).
5. Let base be ToNumber(leftValue).
6. Let exponent be ToNumber(rightValue).
7. Return the result of applying the ** operator with base and exponent as specified in 12.7.3.4.

12.7 Multiplicative Operators

Syntax

MultiplicativeExpression[Yield] :
ExponentiationExpression[Yield]
MultiplicativeExpression[Yield] MultiplicativeOperator ExponentiationExpression[Yield]

MultiplicativeOperator : one of
* / %

12.7.1 Static Semantics: IsFunctionDefinition

MultiplicativeExpression : MultiplicativeExpression MultiplicativeOperator ExponentiationExpression

1. Return false.

12.7.2 Static Semantics: IsValidSimpleAssignmentTarget

MultiplicativeExpression : MultiplicativeExpression MultiplicativeOperator ExponentiationExpression

1. Return false.

12.7.3 Runtime Semantics: Evaluation

MultiplicativeExpression : MultiplicativeExpression MultiplicativeOperator ExponentiationExpression

1. Let left be the result of evaluating MultiplicativeExpression.
2. Let leftValue be GetValue(left).
3. Let right be the result of evaluating ExponentiationExpression.
4. Let rightValue be GetValue(right).
5. Let lnun be ToNumber(leftValue).
6. Let rnum be ToNumber(rightValue).
7. Return the result of applying the MultiplicativeOperator (*, /, or %) to lnun and rnum as specified in 12.7.3.1, 12.7.3.2, or 12.7.3.3.
### 12.7.3.1 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 754-2008 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 754-2008 round to nearest, ties to even 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 754-2008.

### 12.7.3.2 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 754-2008 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 754-2008 round to nearest, ties to even 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 754-2008.

### 12.7.3.3 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 754-2008. The IEEE 754-2008 “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:
12.7.3.4 Applying the ** Operator

Returns an implementation-dependent approximation of the result of raising base to the power exponent.

- If exponent is NaN, the result is NaN.
- If exponent is +0, the result is 1, even if base is NaN.
- If exponent is -0, the result is 1, even if base is NaN.
- If base is NaN and exponent is nonzero, the result is NaN.
- If abs(base) > 1 and exponent is +∞, the result is +∞.
- If abs(base) > 1 and exponent is -∞, the result is +0.
- If abs(base) is 1 and exponent is +∞, the result is NaN.
- If abs(base) is 1 and exponent is -∞, the result is NaN.
- If abs(base) < 1 and exponent is +∞, the result is +0.
- If abs(base) < 1 and exponent is -∞, the result is +0.
- If base is +∞ and exponent > 0, the result is +∞.
- If base is +∞ and exponent < 0, the result is +0.
- If base is -∞ and exponent > 0 and exponent is an odd integer, the result is -∞.
- If base is -∞ and exponent > 0 and exponent is not an odd integer, the result is +∞.
- If base is -∞ and exponent < 0 and exponent is an odd integer, the result is -0.
- If base is -∞ and exponent < 0 and exponent is not an odd integer, the result is +0.
- If base is +0 and exponent > 0, the result is +0.
- If base is +0 and exponent < 0, the result is +∞.
- If base is -0 and exponent > 0 and exponent is an odd integer, the result is -0.
- If base is -0 and exponent > 0 and exponent is not an odd integer, the result is +0.
- If base is -0 and exponent < 0 and exponent is an odd integer, the result is -∞.
- If base is -0 and exponent < 0 and exponent is not an odd integer, the result is +∞.
- If base < 0 and base is finite and exponent is finite and exponent is not an integer, the result is NaN.

**NOTE** The result of base ** exponent when base is 1 or -1 and exponent is +Infinity or -Infinity differs from IEEE 754-2008. The first edition of ECMAScript specified a result of NaN for this operation, whereas later versions of IEEE 754-2008 specified 1. The historical ECMAScript behaviour is preserved for compatibility reasons.

12.8 Additive Operators

Syntax

```
AdditiveExpression[Yield] :  
    MultiplicativeExpression[Yield]
    AdditiveExpression[Yield] + MultiplicativeExpression[Yield]
    AdditiveExpression[Yield] - MultiplicativeExpression[Yield]
```

12.8.1 Static Semantics: IsFunctionDefinition

```
AdditiveExpression :
```
### 12.8.2 Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

### 12.8.3 The Addition Operator (+)

**NOTE**  
The addition operator either performs string concatenation or numeric addition.

**12.8.3.1 Runtime Semantics: Evaluation**

**AdditiveExpression** : AdditiveExpression + MultiplicativeExpression

1. Let lref be the result of evaluating AdditiveExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating MultiplicativeExpression.
4. Let rval be GetValue(rref).
5. Let lprim be ToPrimitive(lval).
6. Let rprim be ToPrimitive(rval).
7. If Type(lprim) is String or Type(rprim) is String, then
   a. Let lstr be ToString(lprim).
   b. Let rstr be ToString(rprim).
   c. Return the String that is the result of concatenating lstr and rstr.
8. Let lnum be ToNumber(lprim).
9. Let rnum be ToNumber(rprim).
10. Return the result of applying the addition operation to lnum and rnum. See the Note below 12.8.5.

**NOTE 1**  
No hint is provided in the calls to ToPrimitive in steps 5 and 6. 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 7 differs from step 5 of the Abstract Relational Comparison algorithm, by using the logical-or operation instead of the logical-and operation.

### 12.8.4 The Subtraction Operator (-)

**12.8.4.1 Runtime Semantics: Evaluation**

**AdditiveExpression** : AdditiveExpression - MultiplicativeExpression

1. Let lref be the result of evaluating AdditiveExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating MultiplicativeExpression.
4. Let rval be GetValue(rref).
5. Let lnum be ToNumber(lval).
6. Let rnum be ToNumber(rval).
7. Return the result of applying the subtraction operation to lnum and rnum. See the note below 12.8.5.

### 12.8.5 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 754-2008 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 754-2008 round to nearest, ties to even 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 754-2008.

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).

12.9 Bitwise Shift Operators

Syntax

ShiftExpression[Yield] :
  AdditiveExpression[Yield]
  ShiftExpression[Yield] << AdditiveExpression[Yield]
  ShiftExpression[Yield] >> AdditiveExpression[Yield]
  ShiftExpression[Yield] >>> AdditiveExpression[Yield]

12.9.1 Static Semantics: IsFunctionDefinition

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

1. Return false.

12.9.2 Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

12.9.3 The Left Shift Operator ( << )

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

12.9.3.1 Runtime Semantics: Evaluation
**ShiftExpression** : ShiftExpression << AdditiveExpression

1. Let lref be the result of evaluating ShiftExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating AdditiveExpression.
4. Let rval be GetValue(rref).
5. Let lnum be ToInt32(lval).
6. Let rnum be ToUint32(rval).
7. Let shiftCount be the result of masking out all but the least significant 5 bits of rnum, that is, compute rnum & 0x1F.
8. Return the result of left shifting lnum by shiftCount bits. The result is a signed 32-bit integer.

### 12.9.4 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.

#### 12.9.4.1 Runtime Semantics: Evaluation

**ShiftExpression** : ShiftExpression >> AdditiveExpression

1. Let lref be the result of evaluating ShiftExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating AdditiveExpression.
4. Let rval be GetValue(rref).
5. Let lnum be ToInt32(lval).
6. Let rnum be ToUint32(rval).
7. Let shiftCount be the result of masking out all but the least significant 5 bits of rnum, that is, compute rnum & 0x1F.
8. 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.

### 12.9.5 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.

#### 12.9.5.1 Runtime Semantics: Evaluation

**ShiftExpression** : ShiftExpression >>> AdditiveExpression

1. Let lref be the result of evaluating ShiftExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating AdditiveExpression.
4. Let rval be GetValue(rref).
5. Let lnum be ToInt32(lval).
6. Let rnum be ToUint32(rval).
7. Let shiftCount be the result of masking out all but the least significant 5 bits of rnum, that is, compute rnum & 0x1F.
8. 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.

### 12.10 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.

**Syntax**

*RelationalExpression*[In, Yield] :
NOTE 2 The [In] grammar parameter is needed to avoid confusing the in operator in a relational expression with the in operator in a for statement.

12.10.1 Static Semantics: IsFunctionDefinition

RelationalExpression :
  RelationalExpression < ShiftExpression
  RelationalExpression > ShiftExpression
  RelationalExpression <= ShiftExpression
  RelationalExpression >= ShiftExpression
  RelationalExpression instanceof ShiftExpression
  RelationalExpression in ShiftExpression

1. Return false.

12.10.2 Static Semantics: IsValidSimpleAssignmentTarget

RelationalExpression :
  RelationalExpression < ShiftExpression
  RelationalExpression > ShiftExpression
  RelationalExpression <= ShiftExpression
  RelationalExpression >= ShiftExpression
  RelationalExpression instanceof ShiftExpression
  RelationalExpression in ShiftExpression

1. Return false.

12.10.3 Runtime Semantics: Evaluation

RelationalExpression : RelationalExpression < ShiftExpression

1. Let lref be the result of evaluating RelationalExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating ShiftExpression.
4. Let rval be GetValue(rref).
5. Let r be the result of performing Abstract Relational Comparison lval < rval.
6. ReturnIfAbrupt(r).
7. 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. Let rref be the result of evaluating ShiftExpression.
4. Let rval be GetValue(rref).
5. Let r be the result of performing Abstract Relational Comparison rval < lval with LeftFirst equal to false.
6. ReturnIfAbrupt(r).
7. 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. Let \( rref \) be the result of evaluating ShiftExpression.
4. Let \( rval \) be ? GetValue(\( rref \)).
5. Let \( r \) be the result of performing Abstract Relational Comparison \( rval < lval \) with \( \text{LeftFirst} \) equal to false.
6. ReturnIfAbrupt(\( r \)).
7. 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. Let \( rref \) be the result of evaluating ShiftExpression.
4. Let \( rval \) be ? GetValue(\( rref \)).
5. Let \( r \) be the result of performing Abstract Relational Comparison \( lval < rval \).
6. ReturnIfAbrupt(\( r \)).
7. 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. Let \( rref \) be the result of evaluating ShiftExpression.
4. Let \( rval \) be ? GetValue(\( rref \)).
5. Return ? InstanceofOperator(\( lval, rval \)).

**RelationalExpression** : RelationalExpression in ShiftExpression

1. Let \( lref \) be the result of evaluating RelationalExpression.
2. Let \( lval \) be ? GetValue(\( lref \)).
3. Let \( rref \) be the result of evaluating ShiftExpression.
4. Let \( rval \) be ? GetValue(\( rref \)).
5. If \( \text{Type}(rval) \) is not Object, throw a TypeError exception.
6. Return ? HasProperty(\( rval, \text{ToPropertyKey}(lval) \)).

### 12.10.4 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 \( \text{Type}(C) \) is not Object, throw a TypeError exception.
2. Let \( instOfHandler \) be ? GetMethod(\( C, @@hasInstance \)).
3. If \( instOfHandler \) is not undefined, then
   a. Return ToBoolean(? Call(\( \text{instOfHandler}, C, \times O \))).
4. If \( \text{IsCallable}(C) \) is false, throw a TypeError exception.
5. 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.

### 12.11 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]
  EqualityExpression[?In, ?Yield] == RelationalExpression[?In, ?Yield]
  EqualityExpression[?In, ?Yield] != RelationalExpression[?In, ?Yield]
  EqualityExpression[?In, ?Yield] === RelationalExpression[?In, ?Yield]
  EqualityExpression[?In, ?Yield] !== RelationalExpression[?In, ?Yield]

12.11.1 Static Semantics: IsFunctionDefinition

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

1. Return false.

12.11.2 Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

12.11.3 Runtime Semantics: Evaluation

EqualityExpression : EqualityExpression == RelationalExpression

1. Let lref be the result of evaluating EqualityExpression.
2. Let lval be ? GetValue(lref).
3. Let rref be the result of evaluating RelationalExpression.
4. Let rval be ? GetValue(rref).
5. 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. Let rref be the result of evaluating RelationalExpression.
4. Let rval be ? GetValue(rref).
5. Let r be the result of performing Abstract Equality Comparison rval == lval.
6. 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. Let rref be the result of evaluating RelationalExpression.
4. Let rval be ? GetValue(rref).
5. 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. Let \( rref \) be the result of evaluating \( RelationalExpression \).
4. Let \( rval \) be \( ?GetValue(rref) \).
5. Let \( r \) be the result of performing Strict Equality Comparison \( rval === lval \).
6. If \( r \) is \text{true}, return \text{false}. Otherwise, return \text{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: 
  
  \( !a == !b \).

**NOTE 2**

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

**NOTE 3**

The equality operator is not always transitive. For example, there might be two distinct String objects, each representing the same String value; each String object would be considered equal to the String value by the \( == \) operator, but the two String objects would not be equal to each other. For example:
- \( \text{new String("a")} == \text{"a"} \) and \( \text{"a"} == \text{new String("a")} \) are both \text{true}.
- \( \text{new String("a")} == \text{new String("a")} \) is \text{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.

### 12.12 Binary Bitwise Operators

**Syntax**

\[
\text{BitwiseANDExpression}[[\text{In}, \text{Yield}]] = \begin{align*}
\text{EqualityExpression}[[?, ?\text{Yield}]] & \text{ BitwiseANDExpression}[[?\text{In}, ?\text{Yield}]] \& \text{ EqualityExpression}[[?\text{In}, ?\text{Yield}]] \\
\text{BitwiseXORExpression}[[?\text{In}, ?\text{Yield}]] & \text{ BitwiseANDExpression}[[?\text{In}, ?\text{Yield}]] \^ \text{ BitwiseANDExpression}[[?\text{In}, ?\text{Yield}]] \\
\text{BitwiseORExpression}[[\text{In}, \text{Yield}]] & \begin{align*}
\text{BitwiseXORExpression}[[?\text{In}, ?\text{Yield}]] & \mid \text{ BitwiseXORExpression}[[?\text{In}, ?\text{Yield}]] \\
\end{align*}
\]

#### 12.12.1 Static Semantics: IsFunctionDefinition

\[
\text{BitwiseANDExpression} : \text{BitwiseANDExpression} \& \text{EqualityExpression} \\
\text{BitwiseXORExpression} : \text{BitwiseXORExpression} \^ \text{BitwiseANDExpression} \\
\text{BitwiseORExpression} : \text{BitwiseORExpression} \mid \text{BitwiseXORExpression}
\]

1. Return \text{false}.

#### 12.12.2 Static Semantics: IsValidSimpleAssignmentTarget
BitwiseANDExpression : BitwiseANDExpression & EqualityExpression
BitwiseXORExpression : BitwiseXORExpression ^ BitwiseANDExpression
BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

1. Return false.

12.12.3 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 $GetValue(lref)$.
3. Let $rref$ be the result of evaluating $B$.
4. Let $rval$ be $GetValue(rref)$.
5. Let $lnum$ be $ToInt32(lval)$.
6. Let $rnum$ be $ToInt32(rval)$.
7. Return the result of applying the bitwise operator @ to $lnum$ and $rnum$. The result is a signed 32 bit integer.

12.13 Binary Logical Operators

Syntax

LogicalANDExpression[In, Yield] :
    BitwiseORExpression[?In, ?Yield]
    LogicalANDExpression[?In, ?Yield] && BitwiseORExpression[?In, ?Yield]

LogicalORExpression[In, Yield] :
    LogicalANDExpression[?In, ?Yield]
    LogicalORExpression[?In, ?Yield] || LogicalANDExpression[?In, ?Yield]

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

12.13.1 Static Semantics: IsFunctionDefinition

LogicalANDExpression : LogicalANDExpression && BitwiseORExpression
LogicalORExpression : LogicalORExpression || LogicalANDExpression

1. Return false.

12.13.2 Static Semantics: IsValidSimpleAssignmentTarget

LogicalANDExpression : LogicalANDExpression && BitwiseORExpression
LogicalORExpression : LogicalORExpression || LogicalANDExpression

1. Return false.

12.13.3 Runtime Semantics: Evaluation

LogicalANDExpression : LogicalANDExpression && BitwiseORExpression

1. Let $lref$ be the result of evaluating LogicalANDExpression.
2. Let $lval$ be $GetValue(lref)$.
3. Let $lbool$ be $ToBoolean(lval)$.
4. If $lbool$ is false, return $lval$.
5. Let $rref$ be the result of evaluating BitwiseORExpression.
6. Return $GetValue(rref)$.
1. Let \( lref \) be the result of evaluating \( \text{LogicalORExpression} \).
2. Let \( lval \) be \( ? \, \text{GetValue}(lref) \).
3. Let \( lbool \) be \( \text{ToBoolean}(lval) \).
4. If \( lbool \) is \( \text{true} \), return \( lval \).
5. Let \( rref \) be the result of evaluating \( \text{LogicalANDExpression} \).
6. Return \( ? \, \text{GetValue}(rref) \).

### 12.14 Conditional Operator ( ? : )

**Syntax**

\[
\text{ConditionalExpression} \ [\text{In}, \text{Yield}] : \begin{cases} 
\text{LogicalORExpression} \ [\text{?In}, \text{?Yield}] \ \\
\text{LogicalORExpression} \ [\text{?In}, \text{?Yield}] \ ? \text{AssignmentExpression} \ [\text{?In}, \text{?Yield}] 
\end{cases}
\]

NOTE: The grammar for a \( \text{ConditionalExpression} \) in ECMAScript is slightly different from that in C and Java, which each allow the second subexpression to be an \( \text{Expression} \) but restrict the third expression to be a \( \text{ConditionalExpression} \). 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.

#### 12.14.1 Static Semantics: IsFunctionDefinition

\[
\text{ConditionalExpression} : \text{LogicalORExpression} ? \text{AssignmentExpression} : \text{AssignmentExpression}
\]

1. Return \( \text{false} \).

#### 12.14.2 Static Semantics: IsValidSimpleAssignmentTarget

\[
\text{ConditionalExpression} : \text{LogicalORExpression} ? \text{AssignmentExpression} : \text{AssignmentExpression}
\]

1. Return \( \text{false} \).

#### 12.14.3 Runtime Semantics: Evaluation

\[
\text{ConditionalExpression} : \text{LogicalORExpression} ? \text{AssignmentExpression} : \text{AssignmentExpression}
\]

1. Let \( lref \) be the result of evaluating \( \text{LogicalORExpression} \).
2. Let \( lval \) be \( \text{ToBoolean}(? \, \text{GetValue}(lref)) \).
3. If \( lval \) is \( \text{true} \), then
   a. Let \( \text{trueRef} \) be the result of evaluating the first \( \text{AssignmentExpression} \).
   b. Return \( ? \, \text{GetValue}(\text{trueRef}) \).
4. Else,
   a. Let \( \text{falseRef} \) be the result of evaluating the second \( \text{AssignmentExpression} \).
   b. Return \( ? \, \text{GetValue}(\text{falseRef}) \).

### 12.15 Assignment Operators

**Syntax**

\[
\text{AssignmentExpression} \ [\text{In}, \text{Yield}] : \\
\text{ConditionalExpression} \ [\text{?In}, \text{?Yield}] \\
[?\text{Yield}] \text{YieldExpression} \ [\text{?In}] \\
\text{ArrowFunction} \ [\text{?In}, \text{?Yield}]
\]
\[
\text{LeftHandSideExpression}[?Yield] = \text{AssignmentExpression}[?In, ?Yield]
\]
\[
\text{LeftHandSideExpression}[?Yield] \text{ AssignmentOperator AssignmentExpression}[?In, ?Yield]
\]

AssignmentOperator: one of

* = /= %= += -= <<= >>= >>>= &= ^= |= **=

12.15.1 Static Semantics: Early Errors

\[\text{AssignmentExpression} : \text{LeftHandSideExpression} = \text{AssignmentExpression}\]

- It is a Syntax Error if \text{LeftHandSideExpression} is either an \text{ObjectLiteral} or an \text{ArrayLiteral} and the lexical token sequence matched by \text{LeftHandSideExpression} cannot be parsed with no tokens left over using \text{AssignmentPattern} as the goal symbol.
- It is an early Reference Error if \text{LeftHandSideExpression} is neither an \text{ObjectLiteral} nor an \text{ArrayLiteral} and \text{IsValidSimpleAssignmentTarget} of \text{LeftHandSideExpression} is \text{false}.

\[\text{AssignmentExpression} : \text{LeftHandSideExpression AssignmentOperator AssignmentExpression}\]

- It is an early Reference Error if \text{IsValidSimpleAssignmentTarget} of \text{LeftHandSideExpression} is \text{false}.

12.15.2 Static Semantics: IsFunctionDefinition

\[\text{AssignmentExpression} : \text{ArrowFunction}\]

1. Return \text{true}.

\[\text{AssignmentExpression} : \]

\[
\text{YieldExpression}
\]
\[
\text{LeftHandSideExpression} = \text{AssignmentExpression}
\]
\[
\text{LeftHandSideExpression AssignmentOperator AssignmentExpression}
\]

1. Return \text{false}.

12.15.3 Static Semantics: IsValidSimpleAssignmentTarget

\[\text{AssignmentExpression} : \]

\[
\text{YieldExpression}
\]
\[
\text{ArrowFunction}
\]
\[
\text{LeftHandSideExpression} = \text{AssignmentExpression}
\]
\[
\text{LeftHandSideExpression AssignmentOperator AssignmentExpression}
\]

1. Return \text{false}.

12.15.4 Runtime Semantics: Evaluation

\[\text{AssignmentExpression} : \text{LeftHandSideExpression} = \text{AssignmentExpression}\]

1. If \text{LeftHandSideExpression} is neither an \text{ObjectLiteral} nor an \text{ArrayLiteral}, then
   a. Let \text{lref} be the result of evaluating \text{LeftHandSideExpression}.
   b. ReturnIfAbrupt(\text{lref}).
   c. Let \text{rref} be the result of evaluating \text{AssignmentExpression}.
   d. Let \text{ rval} be \text{GetValue}(\text{rref}).
   e. If \text{IsAnonymousFunctionDefinition}(\text{AssignmentExpression}) and \text{IsIdentifierRef} of \text{LeftHandSideExpression} are both \text{true}, then
      i. Let \text{hasOwnProperty} be \text{HasOwnProperty}(\text{ rval}, "name").
      ii. If \text{hasOwnProperty} is \text{false}, perform \text{SetFunctionName} (\text{ rval}, GetReferencedName(\text{lref})).
   f. Perform \text{PutValue}(\text{lref}, \text{ rval}).
   g. Return \text{ rval}.
2. Let assignmentPattern be the parse of the source text 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. Let status be the result of performing DestructuringAssignmentEvaluation of assignmentPattern using rval as the argument.
6. ReturnIfAbrupt(status).
7. Return rval.

AssignmentExpression : LeftHandSideExpression AssignmentOperator AssignmentExpression

1. Let lref be the result of evaluating LeftHandSideExpression.
2. Let lval be GetValue(lref).
3. Let rref be the result of evaluating AssignmentExpression.
4. Let rval be GetValue(rref).
5. Let op be the @ where AssignmentOperator is @=.
6. Let r be the result of applying op to lval and rval as if evaluating the expression lval op rval.
8. Return r.

NOTE When an assignment occurs within strict mode code, it is a runtime error if lref in step 1 of the first algorithm or step 7 of the second algorithm it is an unresolvable reference. If it is, a ReferenceError exception is thrown. The LeftHandSideExpression also may not be a reference to a data property with the attribute value {[[Writable]]: false}, to an accessor property with the attribute value {[[Set]]: undefined}, nor to a non-existent property of an object for which the IsExtensible predicate returns the value false. In these cases a TypeError exception is thrown.

12.15.5 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[?Yield] opt ]
  [ AssignmentElementList[?Yield] ]

AssignmentPropertyList[?Yield] :
  AssignmentProperty[?Yield]
  AssignmentPropertyList[?Yield] , AssignmentProperty[?Yield]

AssignmentElementList[?Yield] :
  AssignmentElisionElement[?Yield]
  AssignmentElementList[?Yield] , AssignmentElisionElement[?Yield]
AssignmentElisionElement[Yield] :  
  Elision.opt AssignmentElement[?Yield]

AssignmentProperty[Yield] :
  IdentifierReference[?Yield] Initializer[In, ?Yield] opt
  PropertyName[?Yield] : AssignmentElement[?Yield]

AssignmentElement[Yield] :
  DestructuringAssignmentTarget[?Yield] Initializer[In, ?Yield] opt

AssignmentRestElement[Yield] :
  ... DestructuringAssignmentTarget[?Yield]

DestructuringAssignmentTarget[Yield] :
  LeftHandSideExpression[?Yield]

12.15.5.1 Static Semantics: Early Errors

AssignmentProperty : IdentifierReference Initializer

- It is a Syntax Error if IsValidSimpleAssignmentTarget 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.

12.15.5.2 Runtime Semantics: DestructuringAssignmentEvaluation

with parameter value

ObjectAssignmentPattern : { }

2. Return NormalCompletion(empty).

ObjectAssignmentPattern :
  { AssignmentPropertyList }
  { AssignmentPropertyList , }

2. Return the result of performing DestructuringAssignmentEvaluation for AssignmentPropertyList using value as the argument.

ArrayAssignmentPattern : [ ]

1. Let iterator be ? GetIterator(value).
2. Return ? IteratorClose(iterator, NormalCompletion(empty)).

ArrayAssignmentPattern : [ Elision ]

1. Let iterator be ? GetIterator(value).
2. Let iteratorRecord be Record {[[Iterator]]: iterator, [[Done]]: false}.
3. Let result be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iteratorRecord as the argument.
4. If iteratorRecord.[[Done]] is false, return ? IteratorClose(iterator, result).
5. Return `result`.

`ArrayAssignmentPattern : [ Elision AssignmentRestElement ]`

1. Let `iterator` be `? GetIterator(value)`.
2. Let `iteratorRecord` be `Record` `{{[Iterator]}: iterator, [[Done]]: false}`.
3. If `Elision` is present, then
   a. Let `status` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `Elision` with `iteratorRecord` as the argument.
   b. If `status` is an abrupt completion, then
      i. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, status).
      ii. Return `Completion(status)`.
4. Let `result` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `AssignmentRestElement` with `iteratorRecord` as the argument.
5. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, result).
6. Return `result`.

`ArrayAssignmentPattern : [ AssignmentElementList ]`

1. Let `iterator` be `? GetIterator(value)`.
2. Let `iteratorRecord` be `Record` `{{[Iterator]}: iterator, [[Done]]: false}`.
3. Let `result` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `AssignmentElementList` using `iteratorRecord` as the argument.
4. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, result).
5. Return `result`.

`ArrayAssignmentPattern : [ AssignmentElementList , Elision AssignmentRestElement ]`

1. Let `iterator` be `? GetIterator(value)`.
2. Let `iteratorRecord` be `Record` `{{[Iterator]}: iterator, [[Done]]: false}`.
3. Let `status` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `AssignmentElementList` using `iteratorRecord` as the argument.
4. If `status` is an abrupt completion, then
   a. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, status).
   b. Return `Completion(status)`.
5. If `Elision` is present, then
   a. Let `status` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `Elision` with `iteratorRecord` as the argument.
   b. If `status` is an abrupt completion, then
      i. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, status).
      ii. Return `Completion(status)`.
6. If `AssignmentRestElement` is present, then
   a. Let `status` be the result of performing `IteratorDestructuringAssignmentEvaluation` of `AssignmentRestElement` with `iteratorRecord` as the argument.
7. If `iteratorRecord.{{[Done]}: false, return ? IteratorClose(iterator, status).
8. Return `Completion(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 Initializer`
1. Let \( P \) be stringValue of \( \text{IdentifierReference} \).
2. Let \( \text{lref} \) be \( \text{ResolveBinding}(P) \).
3. Let \( \text{v} \) be \( \text{GetV}(\text{value}, P) \).
4. If \( \text{Initializer}_{\text{opt}} \) is present and \( \text{v} \) is \text{undefined}, then
   a. Let \( \text{defaultValue} \) be the result of evaluating \( \text{Initializer} \).
   b. Let \( \text{v} \) be \( \text{GetValue}(\text{defaultValue}) \).
   c. If \( \text{IsAnonymousFunctionDeclaration}(\text{Initializer}) \) is \text{true}, then
      i. Let \( \text{hasNameProperty} \) be \( \text{HasOwnProperty}(\text{v}, \text{"name"}) \).
      ii. If \( \text{hasNameProperty} \) is \text{false}, perform \( \text{SetFunctionName}(\text{v}, P) \).
5. Return \( \text{PutValue}(\text{lref}, \text{v}) \).

**AssignmentProperty : PropertyName : AssignmentElement**

1. Let \( \text{name} \) be the result of evaluating \( \text{PropertyName} \).
2. \( \text{ReturnIfAbrupt}(\text{name}) \).
3. Return the result of performing KeyedDestructuringAssignmentEvaluation of \( \text{AssignmentElement} \) with \( \text{value} \) and \( \text{name} \) as the arguments.

12.15.5.3 **Runtime Semantics: IteratorDestructuringAssignmentEvaluation**

with parameters \( \text{iteratorRecord} \)

**AssignmentElementList : AssignmentElisionElement**

1. Return the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{AssignmentElisionElement} \) using \( \text{iteratorRecord} \) as the argument.

**AssignmentElementList : AssignmentElementList , AssignmentElisionElement**

1. Let \( \text{status} \) be the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{AssignmentElementList} \) using \( \text{iteratorRecord} \) as the argument.
2. \( \text{ReturnIfAbrupt}(\text{status}) \).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{AssignmentElisionElement} \) using \( \text{iteratorRecord} \) as the argument.

**AssignmentElisionElement : AssignmentElement**

1. Return the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{AssignmentElement} \) with \( \text{iteratorRecord} \) as the argument.

**AssignmentElisionElement : Elision AssignmentElement**

1. Let \( \text{status} \) be the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{Elision} \) with \( \text{iteratorRecord} \) as the argument.
2. \( \text{ReturnIfAbrupt}(\text{status}) \).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of \( \text{AssignmentElement} \) with \( \text{iteratorRecord} \) as the argument.

**Elision : ,**

1. If \( \text{iteratorRecord}[[\text{Done}]] \) is \text{false}, then
   a. Let \( \text{next} \) be \( \text{IteratorStep}(\text{iteratorRecord}[[\text{Iterator}]]) \).
   b. If \( \text{next} \) is an abrupt completion, set \( \text{iteratorRecord}[[\text{Done}]] \) to \text{true}.
   c. \( \text{ReturnIfAbrupt}(\text{next}) \).
   d. If \( \text{next} \) is \text{false}, set \( \text{iteratorRecord}[[\text{Done}]] \) to \text{true}.
2. Return \( \text{NormalCompletion} \) (empty).

**Elision : Elision ,**
1. Let \( \text{status} \) be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with \( \text{iteratorRecord} \) as the argument.
2. ReturnIfAbrupt(\( \text{status} \)).
3. If \( \text{iteratorRecord}.[[\text{Done}]] \) is \textit{false}, then
   a. Let \( \text{next} \) be \( \text{IteratorStep}(\text{iteratorRecord}.[[\text{Iterator}]]). \)
   b. If \( \text{next} \) is an abrupt completion, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
   c. ReturnIfAbrupt(\( \text{next} \)).
   d. If \( \text{next} \) is \textit{false}, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
4. Return NormalCompletion(empty).

**AssignmentElement : DestructuringAssignmentTarget Initializer**

1. If \( \text{DestructuringAssignmentTarget} \) is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Let \( \text{lref} \) be the result of evaluating \( \text{DestructuringAssignmentTarget} \).
   b. ReturnIfAbrupt(\( \text{lref} \)).
2. If \( \text{iteratorRecord}.[[\text{Done}]] \) is \textit{false}, then
   a. Let \( \text{next} \) be \( \text{IteratorStep}(\text{iteratorRecord}.[[\text{Iterator}]]). \)
   b. If \( \text{next} \) is an abrupt completion, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
   c. ReturnIfAbrupt(\( \text{next} \)).
   d. If \( \text{next} \) is \textit{false}, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
   e. Else,
      i. Let \( \text{value} \) be \( \text{IteratorValue}(\text{next}) \).
      ii. If \( \text{value} \) is an abrupt completion, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
      iii. ReturnIfAbrupt(\( \text{value} \)).
3. If \( \text{iteratorRecord}.[[\text{Done}]] \) is \textit{true}, let \( \text{value} \) be \textit{undefined}.
4. If \( \text{Initializer} \) is present and \( \text{value} \) is \textit{undefined}, then
   a. Let \( \text{defaultValue} \) be the result of evaluating \( \text{Initializer} \).
   b. Let \( \text{v} \) be \( \text{GetValue}(\text{defaultValue}) \).
5. Else, let \( \text{v} \) be \textit{value}.
6. If \( \text{DestructuringAssignmentTarget} \) is an ObjectLiteral or an ArrayLiteral, then
   a. Let \( \text{nestedAssignmentPattern} \) be the parse of the source text corresponding to \( \text{DestructuringAssignmentTarget} \) using either \( \text{AssignmentPattern} \) or \( \text{AssignmentPattern}[[\text{Yield}]] \) as the goal symbol depending upon whether this \( \text{AssignmentElement} \) has the \text{[Yield]} parameter.
   b. Return the result of performing DestructuringAssignmentEvaluation of \( \text{nestedAssignmentPattern} \) with \( \text{v} \) as the argument.
7. If \( \text{Initializer} \) is present and \( \text{value} \) is \textit{undefined} and IsAnonymousFunctionDefinition(\( \text{Initializer} \)) and IsIdentifierRef of \( \text{DestructuringAssignmentTarget} \) are both \textit{true}, then
   a. Let \( \text{hasNameProperty} \) be \( \text{? HasOwnProperty}(\text{v}, "\text{name}"")).
   b. If \( \text{hasNameProperty} \) is \textit{false}, perform SetFunctionName(\( \text{v}, \text{GetReferencedName}(\text{lref}) \).
8. Return \( \text{? PutValue}(\text{lref}, \text{v}) \).

**NOTE** Left to right evaluation order is maintained by evaluating a \( \text{DestructuringAssignmentTarget} \) that is not a destructuring pattern prior to accessing the iterator or evaluating the \( \text{Initializer} \).

**AssignmentRestElement : \ldots \text{DestructuringAssignmentTarget}**

1. If \( \text{DestructuringAssignmentTarget} \) is neither an ObjectLiteral nor an ArrayLiteral, then
   a. Let \( \text{lref} \) be the result of evaluating \( \text{DestructuringAssignmentTarget} \).
   b. ReturnIfAbrupt(\( \text{lref} \)).
2. Let \( \text{A} \) be \( \text{ArrayCreate}(0) \).
3. Let \( \text{n} \) be \( 0 \).
4. Repeat while \( \text{iteratorRecord}.[[\text{Done}]] \) is \textit{false},
   a. Let \( \text{next} \) be \( \text{IteratorStep}(\text{iteratorRecord}.[[\text{Iterator}]]). \)
   b. If \( \text{next} \) is an abrupt completion, set \( \text{iteratorRecord}.[[\text{Done}]] \) to \textit{true}.
   c. ReturnIfAbrupt(\( \text{next} \)).
d. If \texttt{next} is \texttt{false}, set \texttt{iteratorRecord.[[Done]]} to \texttt{true}.

e. Else,
   i. Let \texttt{nextValue} be \texttt{IteratorValue(next)}.
   ii. If \texttt{nextValue} is an abrupt completion, set \texttt{iteratorRecord.[[Done]]} to \texttt{true}.
   iii. \texttt{ReturnIfAbrupt(nextValue)}.
   iv. Let \texttt{status} be \texttt{CreateDataProperty(A, \texttt{!ToString(n)}, nextValue)}.
   v. Assert: \texttt{status} is \texttt{true}.
   vi. Increment \texttt{n} by 1.

5. If \texttt{DestructuringAssignmentTarget} is neither an \texttt{ObjectLiteral} nor an \texttt{ArrayLiteral}, then
   a. Return \texttt{?PutValue(lref, A)}.

6. Let \texttt{nestedAssignmentPattern} be the parse of the source text corresponding to \texttt{DestructuringAssignmentTarget} using either \texttt{AssignmentPattern} or \texttt{AssignmentPattern[Yield]} as the goal symbol depending upon whether this \texttt{AssignmentElement} has the \texttt{[Yield]} parameter.
7. Return the result of performing DestructuringAssignmentEvaluation of \texttt{nestedAssignmentPattern} with \texttt{A} as the argument.

\subsection*{12.15.5.4 Runtime Semantics: KeyedDestructuringAssignmentEvaluation}

\texttt{AssignmentElement} : \texttt{DestructuringAssignmentTarget} \texttt{Initializer}

1. If \texttt{DestructuringAssignmentTarget} is neither an \texttt{ObjectLiteral} nor an \texttt{ArrayLiteral}, then
   a. Let \texttt{lref} be the result of evaluating \texttt{DestructuringAssignmentTarget}.
   b. \texttt{ReturnIfAbrupt(lref)}.
2. Let \texttt{v} be \texttt{?GetV(value, propertyName)}.
3. If \texttt{Initializer} is present and \texttt{v} is \texttt{undefined}, then
   a. Let \texttt{defaultValue} be the result of evaluating \texttt{Initializer}.
   b. Let \texttt{rhsValue} be \texttt{?GetValue(defaultValue)}.
4. Else, let \texttt{rhsValue} be \texttt{v}.
5. If \texttt{DestructuringAssignmentTarget} is an \texttt{ObjectLiteral} or an \texttt{ArrayLiteral}, then
   a. Let \texttt{assignmentPattern} be the parse of the source text corresponding to \texttt{DestructuringAssignmentTarget} using either \texttt{AssignmentPattern} or \texttt{AssignmentPattern[Yield]} as the goal symbol depending upon whether this \texttt{AssignmentElement} has the \texttt{[Yield]} parameter.
   b. Return the result of performing DestructuringAssignmentEvaluation of \texttt{assignmentPattern} with \texttt{rhsValue} as the argument.
6. If \texttt{Initializer} is present and \texttt{v} is \texttt{undefined} and \texttt{IsAnonymousFunctionDefinition(Initializer)} and \texttt{IsIdentifierRef of DestructuringAssignmentTarget} are both \texttt{true}, then
   a. Let \texttt{hasNameProperty} be \texttt{?HasOwnProperty(rhsValue, "name")}.
   b. If \texttt{hasNameProperty} is \texttt{false}, perform \texttt{SetFunctionName(rhsValue, GetReferencedName(lref))}.
7. Return \texttt{?PutValue(lref, rhsValue)}.

\subsection*{12.16 Comma Operator ( , )}

\textbf{Syntax}

\texttt{Expression[In, Yield]} :

\begin{align*}
\text{AssignmentExpression[?In, ?Yield]} & \quad \text{Expression[?In, ?Yield] }, \text{AssignmentExpression[?In, ?Yield]} \\
\end{align*}

\subsection*{12.16.1 Static Semantics: IsFunctionDefinition}

\texttt{Expression} : \texttt{Expression , AssignmentExpression}

1. Return \texttt{false}.
12.16.2 Static Semantics: IsValidSimpleAssignmentTarget

Expression : Expression , AssignmentExpression

1. Return false.

12.16.3 Runtime Semantics: Evaluation

Expression : Expression , AssignmentExpression

1. Let lref be the result of evaluating Expression.
2. Perform 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]

13.1 Statement Semantics

13.1.1 Static Semantics: ContainsDuplicateLabels
With argument `labelSet`.

Statement:
- VariableStatement
- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- ThrowStatement
- DebuggerStatement

1. Return `false`.

### 13.1.2 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.

Statement:
- VariableStatement
- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- ThrowStatement
- DebuggerStatement

1. Return `false`.

### 13.1.3 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 `IterationStatement` with arguments `newIterationSet` and « ».

### 13.1.4 Static Semantics: DeclarationPart

**HoistableDeclaration**: `FunctionDeclaration`

1. Return `FunctionDeclaration`.

**HoistableDeclaration**: `GeneratorDeclaration`

1. Return `GeneratorDeclaration`.
Declaration : ClassDeclaration

1. Return ClassDeclaration.

Declaration : LexicalDeclaration

1. Return LexicalDeclaration.

### 13.1.5 Static Semantics: VarDeclaredNames

**Statement** :
- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- ThrowStatement
- DebuggerStatement

1. Return a new empty List.

### 13.1.6 Static Semantics: VarScopedDeclarations

**Statement** :
- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ReturnStatement
- ThrowStatement
- DebuggerStatement

1. Return a new empty List.

### 13.1.7 Runtime Semantics: LabelledEvaluation

With argument `labelSet`.

**BreakableStatement : IterationStatement**

1. Let `stmtResult` be the result of performing LabelledEvaluation of `IterationStatement` with argument `labelSet`.
2. If `stmtResult`.[[Type]] is break, then
   a. If `stmtResult`.[[Target]] is empty, then
      i. If `stmtResult`.[[Value]] is empty, let `stmtResult` be `NormalCompletion(undefined)`.
      ii. Else, let `stmtResult` be `NormalCompletion(stmtResult.[[Value]])`.
3. Return `Completion(stmtResult)`.

**BreakableStatement : SwitchStatement**

1. Let `stmtResult` be the result of evaluating `SwitchStatement`.
2. If `stmtResult`.[[Type]] is break, then
   a. If `stmtResult`.[[Target]] is empty, then
      i. If `stmtResult`.[[Value]] is empty, let `stmtResult` be `NormalCompletion(undefined)`.
      ii. Else, let `stmtResult` be `NormalCompletion(stmtResult.[[Value]])`.
3. Return `Completion(stmtResult)`.

**NOTE**

A **BreakableStatement** is one that can be exited via an unlabelled **BreakStatement**.
13.1.8 Runtime Semantics: Evaluation

HoistableDeclaration :
  GeneratorDeclaration
  1. Return NormalCompletion(empty).

HoistableDeclaration :
  FunctionDeclaration
  1. Return the result of evaluating FunctionDeclaration.

BreakableStatement :
  IterationStatement SwitchStatement
  1. Let newLabelSet be a new empty List.
     2. Return the result of performing LabelledEvaluation of this BreakableStatement with argument newLabelSet.

13.2 Block

Syntax

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]

13.2.1 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.

13.2.2 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.
13.2.3 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.

13.2.4 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.

13.2.5 Static Semantics: LexicallyDeclaredNames

\[ Block : \{ \} \]

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 LabelledStatement.
2. Return a new empty List.

StatementListItem : Declaration

1. Return the BoundNames of Declaration.

13.2.6 Static Semantics: LexicallyScopedDeclarations
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 LabelledStatement.
2. Return a new empty List.

StatementListItem : Declaration

1. Return a new List containing DeclarationPart of Declaration.

13.2.7 Static Semantics: TopLevelLexicallyDeclaredNames

StatementList : StatementList StatementListItem

1. Let names be TopLevelLexicallyDeclaredNames of StatementList.
2. Append to names the elements of the TopLevelLexicallyDeclaredNames of StatementListItem.
3. Return names.

StatementListItem : Statement

1. Return a new empty List.

StatementListItem : Declaration

1. If Declaration is Declaration : HoistableDeclaration , then a. Return « ».
2. Return the BoundNames of Declaration.

NOTE At the top level of a function, or script, function declarations are treated like var declarations rather than like lexical declarations.

13.2.8 Static Semantics: TopLevelLexicallyScopedDeclarations

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 : HoistableDeclaration , then a. Return « ».
2. Return a new List containing Declaration.

13.2.9 Static Semantics: TopLevelVarDeclaredNames

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 : HoistableDeclaration`, then
   a. Return the `BoundNames` of `HoistableDeclaration`
2. Return a new empty `List`.

`StatementList : 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.

### 13.2.10 Static Semantics: `TopLevelVarScopedDeclarations`

`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 : HoistableDeclaration`, then
   a. Let `declaration` be `DeclarationPart` of `HoistableDeclaration`
   b. Return « `declaration` »
2. Return a new empty `List`.

### 13.2.11 Static Semantics: `VarDeclaredNames`

`Block : { }`

1. Return a new empty `List`.

`StatementList : StatementList StatementListItem`

1. Let `names` be `VarDeclaredNames` of `StatementList`
2. Append to `names` the elements of the `VarDeclaredNames` of `StatementListItem`
3. Return `names`.

`StatementListItem : Declaration`

1. Return a new empty `List`.
### 13.2.12 Static Semantics: VarScopedDeclarations

#### Block

1. Return a new empty List.

#### StatementList

1. Let declarations be VarScopedDeclarations of StatementList.
2. Append to declarations the elements of the VarScopedDeclarations of StatementListItem.
3. Return declarations.

#### StatementListItem

1. Return a new empty List.

### 13.2.13 Runtime Semantics: Evaluation

#### Block

1. Return NormalCompletion(empty).

#### Block

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. Return blockValue.

NOTE 1 No matter how control leaves the Block the LexicalEnvironment is always restored to its former state.

#### StatementList

1. Let $s$ be the result of evaluating StatementList.
2. ReturnIfAbrupt($s$).
3. Let $s$ be the result of evaluating StatementListItem.
4. Return Completion(UpdateEmpty($s$, $sl$)).

NOTE 2 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;")
```

### 13.2.14 Runtime Semantics: BlockDeclarationInstantiation( code, env )

NOTE When a Block or CaseBlock production is evaluated a new declarative EnvironmentRecord is created and bindings for each block scoped variable, constant, function, generator function, or class declared in the block are instantiated in the EnvironmentRecord.

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 LexicalEnvironment in which bindings are to be created.

1. Let envRec be $env$’s EnvironmentRecord.
2. Assert: envRec is a declarative EnvironmentRecord.
3. Let declarations be the LexicallyScopedDeclarations of code.
4. 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. Perform $\text{envRec}.\text{CreateImmutableBinding}(dn, \text{true})$.
      ii. Else,
         1. Perform $\text{envRec}.\text{CreateMutableBinding}(dn, \text{false})$.
   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 $\text{env}$.
      iii. Perform $\text{envRec}.\text{InitializeBinding}(fn, fo)$.

13.3 Declarations and the Variable Statement

13.3.1 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[In, Yield] :
  LetOrConst BindingList[?In, ?Yield] ;

LetOrConst :
  let
  const

BindingList[In, Yield] :
  LexicalBinding[?In, ?Yield]
  BindingList[?In, ?Yield] , LexicalBinding[?In, ?Yield]

LexicalBinding[In, Yield] :
  BindingIdentifier[?Yield] Initializer[?In, ?Yield] opt
  BindingPattern[?Yield] Initializer[?In, ?Yield]
```

13.3.1.1 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 Initializer
```

- It is a Syntax Error if Initializer is not present and IsConstantDeclaration of the LexicalDeclaration containing this production is true.

13.3.1.2 Static Semantics: BoundNames

```
LexicalDeclaration : LetOrConst BindingList ;
```

1. Return the BoundNames of BindingList.

```
BindingList : BindingList , LexicalBinding
```
1. Let names be the BoundNames of BindingList.
2. Append to names the elements of the BoundNames of LexicalBinding.
3. Return names.

LexicalBinding : BindingIdentifier Initializer

1. Return the BoundNames of BindingIdentifier.

LexicalBinding : BindingPattern Initializer

1. Return the BoundNames of BindingPattern.

13.3.1.3 Static Semantics: IsConstantDeclaration

LexicalDeclaration : LetOrConst BindingList ;

1. Return IsConstantDeclaration of LetOrConst.

LetOrConst : let

1. Return false.

LetOrConst : const

1. Return true.

13.3.1.4 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. If IsAnonymousFunctionDefinition(Initializer) is true, then
   a. Let hasNameProperty be ? HasOwnProperty(value, "name").
   b. If hasNameProperty is false, perform SetFunctionName(value, bindingId).
6. Return InitializeReferencedBinding(lhs, value).

LexicalBinding : BindingPattern Initializer

1. Let rhs be the result of evaluating Initializer.
2. Let $value$ be $\text{GetValue}(\text{rhs})$.
3. Let $env$ be the running execution context’s LexicalEnvironment.
4. Return the result of performing BindingInitialization for $BindingPattern$ using $value$ and $env$ as the arguments.

### 13.3.2 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

$\text{VariableStatement}[\text{Yield}] :$

```
var VariableDeclarationList[\text{In}, \text{?Yield}] ;
```

$\text{VariableDeclarationList}[\text{In}, \text{Yield}] :$

```
VariableDeclaration[\text{?In}, \text{?Yield}]
VariableDeclarationList[\text{?In}, \text{?Yield}] , VariableDeclaration[\text{?In}, \text{?Yield}]
```

$\text{VariableDeclaration}[\text{In}, \text{Yield}] :$

```
$BindingIdentifier[\text{?Yield}] \text{Initializer[\text{?In}, \text{?Yield}]} \text{opt}$
$BindingPattern[\text{?Yield}] \text{Initializer[\text{?In}, \text{?Yield}]}$
```

#### 13.3.2.1 Static Semantics: BoundNames

$\text{VariableDeclarationList} : \text{VariableDeclarationList} , \text{VariableDeclaration}$

1. Let $names$ be BoundNames of $\text{VariableDeclarationList}$.
2. Append to $names$ the elements of BoundNames of $\text{VariableDeclaration}$.
3. Return $names$.

$\text{VariableDeclaration} : \text{BindingIdentifier} \text{Initializer}$

1. Return the BoundNames of $\text{BindingIdentifier}$.

$\text{VariableDeclaration} : \text{BindingPattern} \text{Initializer}$

1. Return the BoundNames of $\text{BindingPattern}$.

#### 13.3.2.2 Static Semantics: VarDeclaredNames

$\text{VariableStatement} : \text{var} \text{ VariableDeclarationList} ;$

1. Return BoundNames of $\text{VariableDeclarationList}$.

#### 13.3.2.3 Static Semantics: VarScopedDeclarations

$\text{VariableDeclarationList} : \text{VariableDeclaration}$

1. Return a new $\text{List}$ containing $\text{VariableDeclaration}$.

$\text{VariableDeclarationList} : \text{VariableDeclarationList} , \text{VariableDeclaration}$

1. Let $declarations$ be VarScopedDeclarations of $\text{VariableDeclarationList}$.
2. Append $\text{VariableDeclaration}$ to $declarations$.
3. Return $declarations$.
13.3.2.4 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. Let `rhs` be the result of evaluating `Initializer`.
4. Let `value` be `? GetValue(rhs)`.
5. If `IsAnonymousFunctionDefinition(Initializer)` is `true`, then
   a. Let `hasNameProperty` be `? HasOwnProperty(value, "name")`.
   b. If `hasNameProperty` is `false`, perform `SetFunctionName(value, bindingId)`.

**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 `EnvironmentRecord`, then step 6 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. Return the result of performing `BindingInitialization` for `BindingPattern` passing `rval` and `undefined` as arguments.

13.3.3 Destructuring Binding Patterns

**Syntax**

`BindingPattern[Yield]` :

- `ObjectBindingPattern[Yield]`
- `ArrayBindingPattern[Yield]`

**ObjectBindingPattern[Yield]** :

- `{ }` `{ BindingPropertyList[Yield] }` `{ BindingPropertyList[Yield], }`

**ArrayBindingPattern[Yield]** :

- `[ Elision opt BindingRestElement[Yield] opt ]` `[ BindingElementList[Yield] ]` `[ BindingElementList[Yield], Elision opt BindingRestElement[Yield] opt ]`
BindingPropertyList[?Yield] :
  BindingProperty[?Yield]
  BindingPropertyList[?Yield] , BindingProperty[?Yield]

BindingElementList[?Yield] :
  BindingElisionElement[?Yield]
  BindingElementList[?Yield] , BindingElisionElement[?Yield]

BindingElisionElement[?Yield] :
  Elisionopt BindingElement[?Yield]

BindingProperty[?Yield] :
  SimpleNameBinding[?Yield]
  PropertyName[?Yield] : BindingElement[?Yield]

BindingElement[?Yield] :
  SimpleNameBinding[?Yield]
  BindingPattern[?Yield]_initializer[?In, ?Yield]opt

SimpleNameBinding[?Yield] :
  BindingIdentifier[?Yield]_initializer[?In, ?Yield]opt

BindingRestElement[?Yield] :
  ... BindingIdentifier[?Yield]
  ... BindingPattern[?Yield]

13.3.3.1 Static Semantics: BoundNames

ObjectBindingPattern : { }

1. Return a new empty List.

ArrayBindingPattern : [ Elision ]

1. Return a new empty List.

ArrayBindingPattern : [ Elision BindingRestElement ]

1. Return the BoundNames of BindingRestElement.

ArrayBindingPattern : [ BindingElementList , Elision ]

1. Return the BoundNames of BindingElementList.

ArrayBindingPattern : [ BindingElementList , Elision 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 BindingElement

1. Return BoundNames of BindingElement.

BindingProperty : PropertyName : BindingElement

1. Return the BoundNames of BindingElement.

PropertyName

SingleNameBinding : BindingIdentifier Initializer

1. Return the BoundNames of BindingIdentifier.

BindingElement : BindingPattern Initializer

1. Return the BoundNames of BindingPattern.

### 13.3.3.2 Static Semantics: ContainsExpression

ObjectBindingPattern : { }

1. Return false.

ArrayBindingPattern : [ Elision ]

1. Return false.

ArrayBindingPattern : [ Elision BindingRestElement ]

1. Return ContainsExpression of BindingRestElement.

ArrayBindingPattern : [ BindingElementList, Elision ]

1. Return ContainsExpression of BindingElementList.

ArrayBindingPattern : [ BindingElementList, Elision BindingRestElement ]

1. Let has be ContainsExpression of BindingElementList.
2. If has is true, return true.
3. Return ContainsExpression of BindingRestElement.

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 : Elision 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 ContainsExpression of BindingElement.

BindingElement : BindingPattern Initializer

1. Return true.

SingleNameBinding : BindingIdentifier

1. Return false.

SingleNameBinding : BindingIdentifier Initializer

1. Return true.

BindingRestElement : ... BindingIdentifier

1. Return false.

BindingRestElement : ... BindingPattern

1. Return ContainsExpression of BindingPattern.

13.3.3.3 Static Semantics: HasInitializer

BindingElement : BindingPattern

1. Return false.

BindingElement : BindingPattern Initializer

1. Return true.

SingleNameBinding : BindingIdentifier

1. Return false.

SingleNameBinding : BindingIdentifier Initializer

1. Return true.

13.3.3.4 Static Semantics: IsSimpleParameterList

BindingElement : BindingPattern

1. Return false.

BindingElement : BindingPattern Initializer

1. Return false.

SingleNameBinding : BindingIdentifier

1. Return true.

SingleNameBinding : BindingIdentifier Initializer

1. Return false.

13.3.3.5 Runtime Semantics: BindingInitialization

With parameters value 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.

**BindingPattern**: ObjectBindingPattern

2. Return the result of performing BindingInitialization for ObjectBindingPattern using value and environment as arguments.

**BindingPattern**: ArrayBindingPattern

1. Let iterator be ? GetIterator(value).
2. Let iteratorRecord be Record {[[Iterator]]: iterator, [[Done]]: false}.
3. Let result be IteratorBindingInitialization for ArrayBindingPattern using iteratorRecord and environment as arguments.
4. If iteratorRecord.[[Done]] is false, return ? IteratorClose(iterator, result).
5. Return 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.

13.3.3.6 Runtime Semantics: IteratorBindingInitialization

With parameters iteratorRecord, 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.

**ArrayBindingPattern**: [

1. Return NormalCompletion(empty).

**ArrayBindingPattern**: [ Elision ]

1. Return the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iteratorRecord as the argument.

**ArrayBindingPattern**: [ Elision BindingRestElement ]
1. If Elision is present, then
   a. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iteratorRecord as the argument.
   b. ReturnIfAbrupt(status).
2. Return the result of performing IteratorBindingInitialization for BindingRestElement with iteratorRecord and environment as arguments.

ArrayBindingPattern : [ BindingElementList ]

1. Return the result of performing IteratorBindingInitialization for BindingElementList with iteratorRecord and environment as arguments.

ArrayBindingPattern : [ BindingElementList, ]

1. Return the result of performing IteratorBindingInitialization for BindingElementList with iteratorRecord and environment as arguments.

ArrayBindingPattern : [ BindingElementList, Elision ]

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList with iteratorRecord and environment as arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iteratorRecord as the argument.

ArrayBindingPattern : [ BindingElementList, Elision BindingRestElement ]

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList with iteratorRecord 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 iteratorRecord as the argument.
   b. ReturnIfAbrupt(status).
4. Return the result of performing IteratorBindingInitialization for BindingRestElement with iteratorRecord and environment as arguments.

BindingElementList : BindingElisionElement

1. Return the result of performing IteratorBindingInitialization for BindingElisionElement with iteratorRecord and environment as arguments.

BindingElementList : BindingElementList, BindingElisionElement

1. Let status be the result of performing IteratorBindingInitialization for BindingElementList with iteratorRecord and environment as arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing IteratorBindingInitialization for BindingElisionElement using iteratorRecord and environment as arguments.

BindingElisionElement : BindingElement

1. Return the result of performing IteratorBindingInitialization of BindingElement with iteratorRecord and environment as the arguments.

BindingElisionElement : Elision BindingElement

1. Let status be the result of performing IteratorDestructuringAssignmentEvaluation of Elision with iteratorRecord as the argument.
2. `ReturnIfAbrupt(status)`.
3. Return the result of performing `IteratorBindingInitialization` of `BindingElement` with `iteratorRecord` and `environment` as the arguments.

**BindingElement**: `SimpleNameBinding`

1. Return the result of performing `IteratorBindingInitialization` for `SimpleNameBinding` with `iteratorRecord` and `environment` as the arguments.

**SimpleNameBinding**: `BindingIdentifier` `Initializer`

1. Let `bindingId` be `StringValue` of `BindingIdentifier`.
2. Let `lhs` be ? `ResolveBinding(bindingId, environment)`.
3. If `iteratorRecord`[[Done]] is `false`, then
   a. Let `next` be `IteratorStep(iteratorRecord.([Iterator]))`.
   b. If `next` is an abrupt completion, set `iteratorRecord`[[Done]] to `true`.
   c. `ReturnIfAbrupt(next)`.
   d. If `next` is `false`, set `iteratorRecord`[[Done]] to `true`.
   e. Else,
      i. Let `v` be `IteratorValue(next)`.
      ii. If `v` is an abrupt completion, set `iteratorRecord`[[Done]] to `true`.
      iii. `ReturnIfAbrupt(v)`.
4. If `iteratorRecord`[[Done]] is `true`, let `v` be `undefined`.
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. If `IsAnonymousFunctionDefinition(Initializer)` is `true`, then
      i. Let `hasNameProperty` be ? `HasOwnProperty(v, "name")`.
      ii. If `hasNameProperty` is `false`, perform `SetFunctionName(v, bindingId)`.
6. If `environment` is `undefined`, return ? `PutValue(lhs, v)`.
7. Return `InitializeReferencedBinding(lhs, v)`.

**BindingElement**: `BindingPattern` `Initializer`

1. If `iteratorRecord`[[Done]] is `false`, then
   a. Let `next` be `IteratorStep(iteratorRecord.([Iterator]))`.
   b. If `next` is an abrupt completion, set `iteratorRecord`[[Done]] to `true`.
   c. `ReturnIfAbrupt(next)`.
   d. If `next` is `false`, set `iteratorRecord`[[Done]] to `true`.
   e. Else,
      i. Let `v` be `IteratorValue(next)`.
      ii. If `v` is an abrupt completion, set `iteratorRecord`[[Done]] to `true`.
5. If `environment` is `undefined`, return ? `PutValue(lhs, v)`.

**BindingRestElement**: `...` `BindingIdentifier`

1. Let `lhs` be ? `ResolveBinding(StringValue of BindingIdentifier, environment)`.
2. Let `A` be `ArrayCreate(0)`.
3. Let `n` be `0`.
4. Repeat,
   a. If `iteratorRecord`[[Done]] is `false`, then
i. Let next be IteratorStep(iteratorRecord.[[Iterator]]).
ii. If next is an abrupt completion, set iteratorRecord.[[Done]] to true.
iii. ReturnIfAbrupt(next).
iv. If next is false, set iteratorRecord.[[Done]] to true.

b. If iteratorRecord.[[Done]] is true, then
   i. If environment is undefined, return ? PutValue(lhs, A).
   ii. Return InitializeReferencedBinding(lhs, A).

c. Let nextValue be IteratorValue(next).
d. If nextValue is an abrupt completion, set iteratorRecord.[[Done]] to true.
e. ReturnIfAbrupt(nextValue).
f. Let status be CreateDataProperty(A, ! ToString(n), nextValue).
g. Assert: status is true.
h. Increment n by 1.

**BindingRestElement : ... BindingPattern**

1. Let A be ArrayCreate(0).
2. Let n be 0.
3. Repeat,
   a. If iteratorRecord.[[Done]] is false, then
      i. Let next be IteratorStep(iteratorRecord.[[Iterator]]).
      ii. If next is an abrupt completion, set iteratorRecord.[[Done]] to true.
      iii. ReturnIfAbrupt(next).
      iv. If next is false, set iteratorRecord.[[Done]] to true.
   b. If iteratorRecord.[[Done]] is true, then
      i. Return the result of performing BindingInitialization of BindingPattern with A and environment as the arguments.
   c. Let nextValue be IteratorValue(next).
   d. If nextValue is an abrupt completion, set iteratorRecord.[[Done]] to true.
   e. ReturnIfAbrupt(nextValue).
   f. Let status be CreateDataProperty(A, ! ToString(n), nextValue).
   g. Assert: status is true.
   h. Increment n by 1.

**13.3.3.7 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 Initializer**

1. Let v be ? GetV(value, propertyName).
2. If Initializer is present and v is undefined, then
   a. Let defaultValue be the result of evaluating Initializer.
   b. Let v be ? GetValue(defaultValue).
3. Return the result of performing BindingInitialization for BindingPattern passing v and environment as arguments.

**SingleNameBinding : BindingIdentifier Initializer**

1. Let bindingId be StringValue of BindingIdentifier.
2. Let lhs be ? ResolveBinding(bindingId, environment).
3. Let v be ? GetV(value, propertyName).
4. 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. If `IsAnonymousFunctionDefinition(Initializer)` is `true`, then
   i. Let `hasNameProperty` be `HasOwnProperty(v, "name")`.
   ii. If `hasNameProperty` is `false`, perform `SetFunctionName(v, bindingId)`.
5. If `environment` is `undefined`, return `PutValue(lhs, v)`.
6. Return `InitializeReferencedBinding(lhs, v)`.

13.4 Empty Statement

Syntax

EmptyStatement : ;

13.4.1 Runtime Semantics: Evaluation

EmptyStatement : ;

1. Return `NormalCompletion(empty)`.

13.5 Expression Statement

Syntax

ExpressionStatement[Yield] :

[lookahead ∈ { { , function , class , let } ] Expression[In, ?Yield] ;

NOTE An `ExpressionStatement` cannot start with a U+007B (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`.

13.5.1 Runtime Semantics: Evaluation

ExpressionStatement : Expression ;

1. Let `exprRef` be the result of evaluating `Expression`.
2. Return `GetValue(exprRef)`.

13.6 The if Statement

Syntax

IfStatement[Yield, Return] :

if ( Expression[In, ?Yield] ) Statement[?Yield, ?Return]

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`.

13.6.1 Static Semantics: Early Errors

IfStatement :

if ( Expression ) Statement else Statement
\[ \text{If ( Expression ) Statement} \]

- It is a Syntax Error if \text{IsLabelledFunction(Statement)} is true.

NOTE: It is only necessary to apply this rule if the extension specified in B.3.2 is implemented.

### 13.6.2 Static Semantics: ContainsDuplicateLabels

With argument labelSet.

\text{IfStatement : if ( Expression ) Statement else Statement}

1. Let hasDuplicate be ContainsDuplicateLabels of the first Statement with argument labelSet.
2. If hasDuplicate is true, return true.
3. Return ContainsDuplicateLabels of the second Statement with argument labelSet.

\text{IfStatement : if ( Expression ) Statement}

1. Return ContainsDuplicateLabels of Statement with argument labelSet.

### 13.6.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.

\text{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.

\text{IfStatement : if ( Expression ) Statement}

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

### 13.6.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

\text{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 « ».

\text{IfStatement : if ( Expression ) Statement}

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

### 13.6.5 Static Semantics: VarDeclaredNames

\text{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.

\text{IfStatement : if ( Expression ) Statement}

1. Return the VarDeclaredNames of Statement.

### 13.6.6 Static Semantics: VarScopedDeclarations
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 VarScopedDeclarations of Statement.

13.6.7 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. If *exprValue* is true, then
   a. Let *stmtCompletion* be the result of evaluating the first Statement.
4. Else,
   a. Let *stmtCompletion* be the result of evaluating the second Statement.
5. Return Completion(UpdateEmpty(*stmtCompletion*, undefined)).

IfStatement : if ( Expression ) Statement

1. Let *exprRef* be the result of evaluating *Expression*.
2. Let *exprValue* be ToBoolean(? GetValue(*exprRef*)).
3. If *exprValue* is false, then
   a. Return NormalCompletion(undefined).
4. Else,
   a. Let *stmtCompletion* be the result of evaluating *Statement*.
   b. Return Completion(UpdateEmpty(*stmtCompletion*, undefined)).

13.7 Iteration Statements

Syntax

```
IterationStatement[Yield, Return] :
    do Statement[?Yield, ?Return] while ( Expression[In, ?Yield] ) ;
    while ( Expression[In, ?Yield] ) Statement[?Yield, ?Return]
    for ( [lookahead ∉ { let [ ]}] Expression[?Yield] opt ; Expression[In, ?Yield] opt ;
        Expression[In, ?Yield] opt ) Statement[?Yield, ?Return]
    for ( var VariableDeclarationList[?Yield] ; Expression[In, ?Yield] opt ; Expression[In, ?Yield] opt )
        Statement[?Yield, ?Return]
    for ( LexicalDeclaration[?Yield] Expression[In, ?Yield] opt ; Expression[In, ?Yield] opt )
        Statement[?Yield, ?Return]
    for ( [lookahead ∉ { let [ ]}] LeftHandSideExpression[?Yield] in Expression[In, ?Yield] )
        Statement[?Yield, ?Return]
    for ( ForDeclaration[?Yield] in Expression[In, ?Yield] ) Statement[?Yield, ?Return]
    for ( [lookahead ≠ let] LeftHandSideExpression[?Yield] of AssignmentExpression[In, ?Yield] )
        Statement[?Yield, ?Return]
    for ( ForDeclaration[?Yield] of AssignmentExpression[In, ?Yield] ) Statement[?Yield, ?Return]
```

ForDeclaration[Yield] :
13.7.1 Semantics

13.7.1.1 Static Semantics: Early Errors

### IterationStatement:

```plaintext
do Statement while ( Expression )
while ( Expression ) Statement
for ( Expressionopt ; Expressionopt ; Expressionopt ) Statement
for ( var VariableDeclarationList ; Expressionopt ; Expressionopt ) Statement
for ( LexicalDeclaration Expressionopt ; Expressionopt ) Statement
for ( LeftHandSideExpression in Expression ) Statement
for ( var ForBinding in Expression ) Statement
for ( var ForBinding of AssignmentExpression ) Statement
for ( ForDeclaration of AssignmentExpression ) Statement
```

- It is a Syntax Error if IsLabelledFunction(Statement) is `true`.

**NOTE** It is only necessary to apply this rule if the extension specified in B.3.2 is implemented.

13.7.1.2 Runtime Semantics: LoopContinues(`completion`, `labelSet`)

The abstract operation LoopContinues with arguments `completion` and `labelSet` is defined by the following steps:

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.

13.7.2 The do-while Statement

13.7.2.1 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.

```plaintext
IterationStatement : do Statement while ( Expression )
```

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

13.7.2.2 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.

```plaintext
IterationStatement : do Statement while ( Expression )
```

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

13.7.2.3 Static Semantics: ContainsUndefinedContinueTarget
With arguments iterationSet and labelSet.

IterationStatement : do Statement while ( Expression ) ;

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.7.2.4 Static Semantics: VarDeclaredNames

IterationStatement : do Statement while ( Expression ) ;

1. Return the VarDeclaredNames of Statement.

13.7.2.5 Static Semantics: VarScopedDeclarations

IterationStatement : do Statement while ( Expression ) ;

1. Return the VarScopedDeclarations of Statement.

13.7.2.6 Runtime Semantics: LabelledEvaluation

With argument labelSet.

IterationStatement : do Statement while ( Expression ) ;

1. Let V be undefined.
2. Repeat
   a. Let stmt be the result of evaluating Statement.
   b. If LoopContinues(stmt, labelSet) is false, return Completion(UpdateEmpty(stmt, V)).
   c. If stmt.[[Value]] is not empty, let V be stmt.[[Value]].
   d. Let exprRef be the result of evaluating Expression.
   e. Let exprValue be GetValue(exprRef).
   f. If ToBoolean(exprValue) is false, return NormalCompletion(V).

13.7.3 The while Statement

13.7.3.1 Static Semantics: ContainsDuplicateLabels

With argument labelSet.

IterationStatement : while ( Expression ) Statement

1. Return ContainsDuplicateLabels of Statement with argument labelSet.

13.7.3.2 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.

IterationStatement : while ( Expression ) Statement

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

13.7.3.3 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

IterationStatement : while ( Expression ) Statement

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.7.3.4 Static Semantics: VarDeclaredNames

IterationStatement : while ( Expression ) Statement
1. Return the VarDeclaredNames of Statement.

### 13.7.3.5 Static Semantics: VarScopedDeclarations

**IterationStatement**: while ( Expression ) Statement

1. Return the VarScopedDeclarations of Statement.

### 13.7.3.6 Runtime Semantics: LabelledEvaluation

With argument `labelSet`.

**IterationStatement**: while ( Expression ) Statement

1. Let `V` be `undefined`.
2. Repeat
   a. Let `exprRef` be the result of evaluating `Expression`.
   b. Let `exprValue` be `GetValue(exprRef)`.
   c. If `ToBoolean(exprValue)` is `false`, return `NormalCompletion(V)`.
   d. Let `stmt` be the result of evaluating `Statement`.
   e. If `LoopContinues(stmt, labelSet)` is `false`, return `Completion(UpdateEmpty(stmt, V))`.
   f. If `stmt.[[Value]]` is not empty, let `V` be `stmt.[[Value]]`.

### 13.7.4 The for Statement

#### 13.7.4.1 Static Semantics: Early Errors

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

- It is a Syntax Error if any element of the BoundNames of `LexicalDeclaration` also occurs in the VarDeclaredNames of `Statement`.

#### 13.7.4.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.

**IterationStatement**:

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

#### 13.7.4.3 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.

**IterationStatement**:

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

#### 13.7.4.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.

**IterationStatement**:

1. Return `ContainsUndefinedContinueTarget` of `Statement` with argument `labelSet`.

---

*Static Semantics: VarScopedDeclarations*

*13.7.3.5*

*Runtime Semantics: LabelledEvaluation*

*13.7.3.6*

*The for Statement*

*13.7.4*

*Static Semantics: Early Errors*

*13.7.4.1*

*Static Semantics: ContainsDuplicateLabels*

*With argument labelSet.*

*IterationStatement*:

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

*Static Semantics: ContainsUndefinedBreakTarget*

*With argument labelSet.*

*IterationStatement*:

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

*Static Semantics: ContainsUndefinedContinueTarget*

*With arguments iterationSet and labelSet.*

*IterationStatement*:

1. Return `ContainsUndefinedContinueTarget` of `Statement` with argument `labelSet`.

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*Static Semantics: VarScopedDeclarations*

*13.7.3.5*

*Runtime Semantics: LabelledEvaluation*

*13.7.3.6*

*The for Statement*

*13.7.4*

*Static Semantics: Early Errors*

*13.7.4.1*

*Static Semantics: ContainsDuplicateLabels*

*With argument labelSet.*

*IterationStatement*:

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

*Static Semantics: ContainsUndefinedBreakTarget*

*With argument labelSet.*

*IterationStatement*:

1. Return `ContainsUndefinedBreakTarget` of `Statement` with argument `labelSet`.

*Static Semantics: ContainsUndefinedContinueTarget*

*With arguments iterationSet and labelSet.*

*IterationStatement*:
for ( var VariableDeclarationList; Expressionopt; Expressionopt ) Statement

for ( LexicalDeclaration Expressionopt; Expressionopt ) Statement

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.7.4.5 Static Semantics: VarDeclaredNames

IterationStatement : for ( Expression; Expression; Expression ) Statement

1. Return the VarDeclaredNames of Statement.

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

1. Return the VarDeclaredNames of Statement.

13.7.4.6 Static Semantics: VarScopedDeclarations

IterationStatement : for ( Expression; Expression; Expression ) Statement

1. Return the VarScopedDeclarations of Statement.

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

1. Return the VarScopedDeclarations of Statement.

13.7.4.7 Runtime Semantics: LabelledEvaluation

With argument labelSet.

IterationStatement : for ( Expression; Expression; Expression ) Statement

1. If the first Expression is present, then
   a. Let exprRef be the result of evaluating the first Expression.
   b. Perform GetValue(exprRef).
2. Return ? ForBodyEvaluation (the second Expression, the third Expression, Statement, « », labelSet).

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

1. Let varDcl be the result of evaluating VariableDeclarationList.
2. ReturnIfAbrupt(varDcl).
3. Return ? ForBodyEvaluation (the first Expression, the second Expression, Statement, « », labelSet).

IterationStatement : for ( LexicalDeclaration Expression; Expression ) Statement

1. Let oldEnv be the running execution context's LexicalEnvironment.
2. Let loopEnv be NewDeclarativeEnvironment(oldEnv).
3. Let loopEnvRec be loopEnv's EnvironmentRecord.
4. Let isConst be the result of performing IsConstantDeclaration of LexicalDeclaration.
5. Let boundNames be the BoundNames of LexicalDeclaration.
6. For each element \( dn \) of \( boundNames \) do
   a. If \( isConst \) is \( true \), then
      i. Perform \( \text{loopEnvRec}.\text{CreateImmutableBinding}(dn, \text{true}) \).
   b. Else,
      i. Perform \( \text{loopEnvRec}.\text{CreateMutableBinding}(dn, \text{false}) \).
7. Set the running execution context’s LexicalEnvironment to \( \text{loopEnv} \).
8. Let \( forDcl \) be the result of evaluating LexicalDeclaration.
9. If \( forDcl \) is an abrupt completion, then
   a. Set the running execution context’s LexicalEnvironment to \( oldEnv \).
   b. Return Completion\((forDcl)\).
10. If \( isConst \) is \( false \), let \( perIterationLets \) be \( boundNames \); otherwise let \( perIterationLets \) be « ».
11. Let \( bodyResult \) be ForBodyEvaluation\((\text{the first Expression, the second Expression, Statement, perIterationLets, labelSet})\).
12. Set the running execution context’s LexicalEnvironment to \( oldEnv \).
13. Return Completion\((bodyResult)\).

### 13.7.4.9 Runtime Semantics: CreatePerIterationEnvironment\(( perIterationBindings ) \)

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 \( lastIterationEnvRec \) be \( lastIterationEnv \)'s EnvironmentRecord.
   c. Let \( outer \) be \( lastIterationEnv \)'s outer environment reference.
   d. Assert: \( outer \) is not \( null \).
   e. Let \( thisIterationEnv \) be NewDeclarativeEnvironment\((outer)\).
   f. Let \( thisIterationEnvRec \) be \( thisIterationEnv \)'s EnvironmentRecord.
   g. For each element \( bn \) of \( perIterationBindings \) do,
      i. Perform \( \text{thisIterationEnvRec}.\text{CreateMutableBinding}(bn, \text{false}) \).
      ii. Let \( lastValue \) be \( \text{lastIterationEnvRec}.\text{GetBindingValue}(bn, \text{true}) \).
      iii. Perform \( \text{thisIterationEnvRec}.\text{InitializeBinding}(bn, lastValue) \).
   h. Set the running execution context’s LexicalEnvironment to \( thisIterationEnv \).
2. Return \( undefined \).

### 13.7.5 The for-in and for-of Statements

#### 13.7.5.1 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 `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.

13.7.5.2 Static Semantics: `BoundNames`  

`ForDeclaration : LetOrConst ForBinding`  

1. Return the `BoundNames` of `ForBinding`.

13.7.5.3 Static Semantics: `ContainsDuplicateLabels`  

With argument `labelSet`.

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

1. Return `ContainsDuplicateLabels` of `Statement` with argument `labelSet`.

13.7.5.4 Static Semantics: `ContainsUndefinedBreakTarget`  

With argument `labelSet`.

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

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

### 13.7.5.5 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

**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

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ». 

### 13.7.5.6 Static Semantics: IsDestructuring

**ForDeclaration**: LetOrConst ForBinding

1. Return IsDestructuring of ForBinding.

**ForBinding**: BindingIdentifier

1. Return false.

**ForBinding**: BindingPattern

1. Return true.

### 13.7.5.7 Static Semantics: VarDeclaredNames

**IterationStatement**: for ( LeftHandSideExpression in Expression ) Statement

1. Return the VarDeclaredNames of Statement.

**IterationStatement**: for ( var ForBinding in Expression ) Statement

1. Let names be the BoundNames of ForBinding.
2. Append to names the elements of the VarDeclaredNames of Statement.
3. Return names.

**IterationStatement**: for ( ForDeclaration in Expression ) Statement

1. Return the VarDeclaredNames of Statement.

**IterationStatement**: for ( LeftHandSideExpression of AssignmentExpression ) Statement

1. Return the VarDeclaredNames of Statement.

**IterationStatement**: for ( var ForBinding of AssignmentExpression ) Statement

1. Let names be the BoundNames of ForBinding.
2. Append to names the elements of the VarDeclaredNames of Statement.
3. Return names.

**IterationStatement**: for ( ForDeclaration of AssignmentExpression ) Statement

1. Return the VarDeclaredNames of Statement.
13.7.5.8 Static Semantics: VarScopedDeclarations

*IterationStatement*: \( \text{for ( } \text{LeftHandSideExpression in Expression } \text{ ) Statement} \)

1. Return the VarScopedDeclarations of Statement.

*IterationStatement*: \( \text{for ( var ForBinding in Expression } \text{ ) Statement} \)

1. Let \( \text{declarations} \) be a List containing \( \text{ForBinding} \).
2. Append to \( \text{declarations} \) the elements of the VarScopedDeclarations of Statement.
3. Return \( \text{declarations} \).

*IterationStatement*: \( \text{for ( } \text{ForDeclaration in Expression } \text{ ) Statement} \)

1. Return the VarScopedDeclarations of Statement.

*IterationStatement*: \( \text{for ( } \text{LeftHandSideExpression of AssignmentExpression } \text{ ) Statement} \)

1. Return the VarScopedDeclarations of Statement.

*IterationStatement*: \( \text{for ( var ForBinding of AssignmentExpression } \text{ ) Statement} \)

1. Let \( \text{declarations} \) be a List containing \( \text{ForBinding} \).
2. Append to \( \text{declarations} \) the elements of the VarScopedDeclarations of Statement.
3. Return \( \text{declarations} \).

*IterationStatement*: \( \text{for ( } \text{ForDeclaration of AssignmentExpression } \text{ ) Statement} \)

1. Return the VarScopedDeclarations of Statement.

13.7.5.9 Runtime Semantics: BindingInitialization

With arguments \( \text{value} \) and \( \text{environment} \).

NOTE  \text{undefined} is passed for \( \text{environment} \) to indicate that a \text{PutValue} operation should be used to assign the initialization value. This is the case for \text{var} statements and the formal parameter lists of some non-strict functions (see 9.2.12). In those cases a lexical binding is hoisted and preinitialized prior to evaluation of its initializer.

*ForDeclaration*: \( \text{LetOrConst ForBinding} \)

1. Return the result of performing BindingInitialization for \( \text{ForBinding} \) passing \( \text{value} \) and \( \text{environment} \) as the arguments.

13.7.5.10 Runtime Semantics: BindingInstantiation

With argument \( \text{environment} \).

*ForDeclaration*: \( \text{LetOrConst ForBinding} \)

1. Let \( \text{envRec} \) be \( \text{environment's EnvironmentRecord} \).
2. Assert: \( \text{envRec} \) is a declarative \text{Environment Record}.
3. For each element \( \text{name} \) of the BoundNames of \( \text{ForBinding} \) do
   a. If IsConstantDeclaration of \( \text{LetOrConst} \) is \text{true}, then
      i. Perform ! \( \text{envRec}.\text{CreateImmutableBinding(name, true)} \).
   b. Else,
      i. Perform ! \( \text{envRec}.\text{CreateMutableBinding(name, false)} \).

13.7.5.11 Runtime Semantics: LabelledEvaluation

With argument \( \text{labelSet} \).
IterationStatement: \( \text{for} \ ( \text{LeftHandSideExpression in Expression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be \( \text{ForIn/OfHeadEvaluation} \) \((« », \text{Expression}, \text{enumerate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{LeftHandSideExpression, Statement, keyResult, assignment, labelSet})\).

IterationStatement: \( \text{for} \ ( \text{var ForBinding in Expression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be \( \text{ForIn/OfHeadEvaluation} \) \((« », \text{Expression}, \text{enumerate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{ForBinding, Statement, keyResult, varBinding, labelSet})\).

IterationStatement: \( \text{for} \ ( \text{ForDeclaration in Expression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be the result of performing \( \text{ForIn/OfHeadEvaluation} \) \((\text{BoundNames of ForDeclaration, Expression, enumerate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{ForDeclaration, Statement, keyResult, lexicalBinding, labelSet})\).

IterationStatement: \( \text{for} \ ( \text{LeftHandSideExpression of AssignmentExpression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be the result of performing \( \text{ForIn/OfHeadEvaluation} \) \((« », \text{AssignmentExpression, iterate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{LeftHandSideExpression, Statement, keyResult, assignment, labelSet})\).

IterationStatement: \( \text{for} \ ( \text{var ForBinding of AssignmentExpression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be the result of performing \( \text{ForIn/OfHeadEvaluation} \) \((« », \text{AssignmentExpression, iterate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{ForBinding, Statement, keyResult, varBinding, labelSet})\).

IterationStatement: \( \text{for} \ ( \text{ForDeclaration of AssignmentExpression} ) \text{ Statement} \)

1. Let \( \text{keyResult} \) be the result of performing \( \text{ForIn/OfHeadEvaluation} \) \((\text{BoundNames of ForDeclaration, AssignmentExpression, iterate})\).
2. Return \( \text{ForIn/OfBodyEvaluation} \) \((\text{ForDeclaration, Statement, keyResult, lexicalBinding, labelSet})\).

13.7.5.12 Runtime Semantics: ForIn/OfHeadEvaluation (TDZnames, expr, iterationKind)

The abstract operation ForIn/OfHeadEvaluation is called with arguments \( \text{TDZnames, expr, and iterationKind} \). The value of \( \text{iterationKind} \) is either \text{enumerate} or \text{iterate}.

1. Let \( \text{oldEnv} \) be the running execution context’s LexicalEnvironment.
2. If \( \text{TDZnames} \) is not an empty List, then
   a. Assert: \( \text{TDZnames} \) has no duplicate entries.
   b. Let \( \text{TDZ} \) be \( \text{NewDeclarativeEnvironment(oldEnv)} \).
   c. Let \( \text{TDZEnvRec} \) be \( \text{TDZ} \)’s EnvironmentRecord.
   d. For each string \( \text{name} \) in \( \text{TDZnames} \), do
      i. Perform \( \text{TDZEnvRec.CreateMutableBinding(name, false)} \).
   e. Set the running execution context’s LexicalEnvironment to \( \text{TDZ} \).
3. Let \( \text{exprRef} \) be the result of evaluating \( \text{expr} \).
4. Set the running execution context’s LexicalEnvironment to \( \text{oldEnv} \).
5. Let \( \text{exprValue} \) be \( \text{GetValue(exprRef)} \).
6. If \( \text{iterationKind} \) is \text{enumerate}, then
   a. If \( \text{exprValue} \) is \text{null} or undefined, then
      i. Return Completion([\{Type\}: break, [\{Value\}: empty, [\{Target\}: empty])
   b. Let \( \text{obj} \) be \( \text{ToObject(exprValue)} \).
   c. Return \( \text{EnumerateObjectProperties(obj)} \).
7. Else,
   a. Assert: \( \text{iterationKind} \) is \text{iterate}.
   b. Return \( \text{GetIterator(exprValue)} \).

13.7.5.13 Runtime Semantics: ForIn/OfBodyEvaluation (lhs, stmt, iterator, lhsKind, labelSet)
The abstract operation ForIn/OfBodyEvaluation is called with arguments \( \textit{lhs}, \textit{stmt}, \textit{iterator}, \textit{lhsKind}, \) and \( \textit{labelSet} \). The value of \( \textit{lhsKind} \) is either assignment, varBinding or lexicalBinding.

1. Let \( \textit{oldEnv} \) be the running execution context’s LexicalEnvironment.
2. Let \( \textit{V} \) be undefined.
3. Let \( \textit{destructuring} \) be IsDestructuring of \( \textit{lhs} \).
4. If \( \textit{destructuring} \) is true and if \( \textit{lhsKind} \) is assignment, then
   a. Assert: \( \textit{lhs} \) is a LeftHandSideExpression.
   b. Let \( \textit{assignmentPattern} \) be the parse of the source text corresponding to \( \textit{lhs} \) using AssignmentPattern as the goal symbol.
5. Repeat
   a. Let \( \textit{nextResult} \) be ? IteratorStep(\( \textit{iterator} \)).
   b. If \( \textit{nextResult} \) is false, return NormalCompletion(\( \textit{V} \)).
   c. Let \( \textit{nextValue} \) be ? IteratorValue(\( \textit{nextResult} \)).
   d. If \( \textit{lhsKind} \) is either assignment or varBinding, then
      i. If \( \textit{destructuring} \) is false, then
         1. Let \( \textit{lhsRef} \) be the result of evaluating \( \textit{lhs} \). (It may be evaluated repeatedly.)
      e. Else,
         i. Assert: \( \textit{lhsKind} \) is lexicalBinding.
         ii. Assert: \( \textit{lhs} \) is a ForDeclaration.
         iii. Let \( \textit{iterationEnv} \) be NewDeclarativeEnvironment(\( \textit{oldEnv} \)).
         iv. Perform BindingInstantiation for \( \textit{lhs} \) passing \( \textit{iterationEnv} \) as the argument.
         v. Set the running execution context’s LexicalEnvironment to \( \textit{iterationEnv} \).
      vi. If \( \textit{destructuring} \) is false, then
         1. Assert: \( \textit{lhs} \) binds a single name.
         2. Let \( \textit{lhsName} \) be the sole element of BoundNames of \( \textit{lhs} \).
         3. Let \( \textit{lhsRef} \) be ! ResolveBinding(\( \textit{lhsName} \)).
    f. If \( \textit{destructuring} \) is false, then
       i. If \( \textit{lhsRef} \) is an abrupt completion, then
          1. Let \( \textit{status} \) be \( \textit{lhsRef} \).
       ii. Else if \( \textit{lhsKind} \) is lexicalBinding, then
          1. Let \( \textit{status} \) be InitializeReferencedBinding(\( \textit{lhsRef}, \textit{nextValue} \)).
       iii. Else,
          1. Let \( \textit{status} \) be PutValue(\( \textit{lhsRef}, \textit{nextValue} \)).
    g. Else,
       i. If \( \textit{lhsKind} \) is assignment, then
          1. Let \( \textit{status} \) be the result of performing DestructuringAssignmentEvaluation of \( \textit{assignmentPattern} \) using \( \textit{nextValue} \) as the argument.
       ii. Else if \( \textit{lhsKind} \) is varBinding, then
          1. Assert: \( \textit{lhs} \) is a ForBinding.
          2. Let \( \textit{status} \) be the result of performing BindingInitialization for \( \textit{lhs} \) passing \( \textit{nextValue} \) and undefined as the arguments.
       iii. Else,
          1. Assert: \( \textit{lhsKind} \) is lexicalBinding.
          2. Assert: \( \textit{lhs} \) is a ForDeclaration.
          3. Let \( \textit{status} \) be the result of performing BindingInitialization for \( \textit{lhs} \) passing \( \textit{nextValue} \) and \( \textit{iterationEnv} \) as arguments.
    h. If \( \textit{status} \) is an abrupt completion, then
       i. Set the running execution context’s LexicalEnvironment to \( \textit{oldEnv} \).
       ii. Return ? IteratorClose(\( \textit{iterator}, \textit{status} \)).
    i. Let \( \textit{result} \) be the result of evaluating \( \textit{stmt} \).
    j. Set the running execution context’s LexicalEnvironment to \( \textit{oldEnv} \).
    k. If \( \textit{LoopContinues}(\textit{result}, \textit{labelSet}) \) is false, return ? IteratorClose(\( \textit{iterator}, \textit{UpdateEmpty}(\textit{result}, \textit{V}) \)).
    l. If \( \textit{result}[[\text{Value}]] \) is not empty, let \( \textit{V} \) be \( \textit{result}[[\text{Value}]] \).
13.7.5.14 Runtime Semantics: Evaluation

ForBinding : BindingIdentifier

1. Let bindingId be StringValue of BindingIdentifier.
2. Return ? ResolveBinding(bindingId).

13.7.5.15 EnumerateObjectProperties (O)

When the abstract operation EnumerateObjectProperties is called with argument O, the following steps are taken:

1. Assert: Type(O) is Object.
2. 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 is never directly accessible to ECMAScript code. The mechanics and order of enumerating the properties is not specified but must conform to the rules specified below.

The iterator’s throw and return methods are null and are never invoked. The iterator’s next method processes object properties to determine whether the property key should be returned as an iterator value. Returned property keys do not include keys that are Symbols. Properties of the target object 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 target object 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 the target object includes enumerating properties of its prototype, and the prototype of the prototype, and so on, recursively; but a property of a prototype is not 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 enumerable property names of prototype objects must be obtained by invoking EnumerateObjectProperties passing the prototype object as the argument. EnumerateObjectProperties must obtain the own property keys of the target object by calling its [[OwnPropertyKeys]] internal method. Property attributes of the target object must be obtained by calling its [[GetOwnProperty]] internal method.

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

```javascript
function* EnumerateObjectProperties(obj) {
    let visited = new Set;
    for (let key of Reflect.ownKeys(obj)) {
        if (typeof key === "string") {
            let desc = Reflect.getOwnPropertyDescriptor(obj, key);
            if (desc && !visited.has(key)) {
                visited.add(key);
                if (desc.enumerable) yield key;
            }
        }
    }
    let proto = Reflect.getPrototypeOf(obj);
    if (proto === null) return;
    for (let protoName of EnumerateObjectProperties(proto)) {
        if (!visited.has(protoName)) yield protoName;
    }
}
```

13.8 The continue Statement

Syntax

```
ContinueStatement[Yield] :
    continue ;
```
13.8.1 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`.

13.8.2 Static Semantics: ContainsUndefinedContinueTarget

With arguments `iterationSet` and `labelSet`.

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`.

13.8.3 Runtime Semantics: Evaluation

ContinueStatement : `continue` ;


ContinueStatement : `continue LabelIdentifier` ;

1. Let `label` be the `StringValue` of `LabelIdentifier`.

13.9 The break Statement

Syntax

`BreakStatement[Yield]` :

`break` ;
`break` [no LineTerminator here] `LabelIdentifier[Yield]` ;

13.9.1 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`.

13.9.2 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.

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`.

13.9.3 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`).

### 13.10 The return Statement

**Syntax**

`ReturnStatement[Yield]` :

- `return` ;

**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`.

13.10.1 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. Return `Completion`([[Type]]: `return`, [[Value]]: `exprValue`, [[Target]]: `empty`).

### 13.11 The with Statement

**Syntax**

`WithStatement[Yield, Return]` :

- `with` ( `Expression[In, ?Yield]` ) `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.

13.11.1 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.

13.11.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`. 
WithStatement : with ( Expression ) Statement

1. Return ContainsDuplicateLabels of Statement with argument labelSet.

13.11.3 Static Semantics: ContainsUndefinedBreakTarget

With argument labelSet.

WithStatement : with ( Expression ) Statement

1. Return ContainsUndefinedBreakTarget of Statement with argument labelSet.

13.11.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

WithStatement : with ( Expression ) Statement

1. Return ContainsUndefinedContinueTarget of Statement with arguments iterationSet and « ».

13.11.5 Static Semantics: VarDeclaredNames

WithStatement : with ( Expression ) Statement

1. Return the VarDeclaredNames of Statement.

13.11.6 Static Semantics: VarScopedDeclarations

WithStatement : with ( Expression ) Statement

1. Return the VarScopedDeclarations of Statement.

13.11.7 Runtime Semantics: Evaluation

WithStatement : with ( Expression ) Statement

1. Let val be the result of evaluating Expression.
2. Let obj be ?ToObject(?GetValue(val)).
3. Let oldEnv be the running execution context's LexicalEnvironment.
4. Let newEnv beNewObjectEnvironment(obj, oldEnv).
5. Set the withEnvironment flag of newEnv's EnvironmentRecord to true.
6. Set the running execution context's LexicalEnvironment to newEnv.
7. Let C be the result of evaluating Statement.
8. Set the running execution context's LexicalEnvironment to oldEnv.
9. Return Completion(UpdateEmpty(C, undefined)).

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.

13.12 The switch Statement

Syntax


CaseBlock[Yield, Return] :
CaseClauses : [Yield, Return] :
   CaseClause : [Yield, ?Return]

CaseClause : [Yield, Return] :

DefaultClause : [Yield, Return] :

13.12.1 Static Semantics: Early Errors

SwitchStatement : `switch ( Expression ) CaseBlock`

- It is a Syntax Error if the LexicallyDeclaredNames of CaseBlock contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of CaseBlock also occurs in the VarDeclaredNames of CaseBlock.

13.12.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.

SwitchStatement : `switch ( Expression ) CaseBlock`

1. Return ContainsDuplicateLabels of CaseBlock with argument `labelSet`.

CaseBlock : { }

1. Return `false`.

CaseBlock : { CaseClauses DefaultClause CaseClauses }

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 : StatementList

1. If the StatementList is present, return ContainsDuplicateLabels of StatementList with argument `labelSet`.
2. Else return `false`.

DefaultClause : default : StatementList

1. If the StatementList is present, return ContainsDuplicateLabels of StatementList with argument `labelSet`.
2. Else return `false`.

13.12.3 Static Semantics: ContainsUndefinedBreakTarget

With argument `labelSet`.
SwitchStatement : \textbf{switch} ( Expression ) CaseBlock

1. Return ContainsUndefinedBreakTarget of CaseBlock with argument labelSet.

CaseBlock : \{ \}

1. Return false.

CaseBlock : \{ CaseClauses DefaultClause CaseClauses \}

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 : StatementList

1. If the StatementList is present, return ContainsUndefinedBreakTarget of StatementList with argument labelSet.
2. Else return false.

DefaultClause : default : StatementList

1. If the StatementList is present, return ContainsUndefinedBreakTarget of StatementList with argument labelSet.
2. Else return false.

13.12.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

SwitchStatement : \textbf{switch} ( Expression ) CaseBlock

1. Return ContainsUndefinedContinueTarget of CaseBlock with arguments iterationSet and « ».

CaseBlock : \{ \}

1. Return false.

CaseBlock : \{ CaseClauses DefaultClause CaseClauses \}

1. If the first CaseClauses is present, then
   a. Let hasUndefinedLabels be ContainsUndefinedContinueTarget of the first CaseClauses with arguments iterationSet and « ».
   b. If hasUndefinedLabels is true, return true.
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 : StatementList`

1. If the `StatementList` is present, return `ContainsUndefinedContinueTarget` of `StatementList` with arguments `iterationSet` and « ».
2. Else return `false`.

`DefaultClause : default : StatementList`

1. If the `StatementList` is present, return `ContainsUndefinedContinueTarget` of `StatementList` with arguments `iterationSet` and « ».
2. Else return `false`.

### 13.12.5 Static Semantics: LexicallyDeclaredNames

`CaseBlock : { }`

1. Return a new empty `List`.

`CaseBlock : { CaseClauses DefaultClause CaseClauses }`

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 : StatementList`

1. If the `StatementList` is present, return the LexicallyDeclaredNames of `StatementList`.
2. Else return a new empty `List`.

`DefaultClause : default : StatementList`

1. If the `StatementList` is present, return the LexicallyDeclaredNames of `StatementList`.
2. Else return a new empty `List`.

### 13.12.6 Static Semantics: LexicallyScopedDeclarations

`CaseBlock : { }`

1. Return a new empty `List`.

`CaseBlock : { CaseClauses DefaultClause CaseClauses }`

1. If the first `CaseClauses` is present, let `declarations` be the LexicallyScopedDeclarations of the first `CaseClauses`.
2. Else let `declarations` be a new empty `List`.
3. Append to `declarations` the elements of the LexicallyScopedDeclarations 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 LexicallyScopedDeclarations of the second `CaseClauses`. 
CaseClauses : CaseClauses CaseClause

1. Let declarations be LexicallyScopedDeclarations of CaseClauses.
2. Append to declarations the elements of the LexicallyScopedDeclarations of CaseClause.
3. Return declarations.

CaseClause : case Expression : StatementList

1. If the StatementList is present, return the LexicallyScopedDeclarations of StatementList.
2. Else return a new empty List.

DefaultClause : default : StatementList

1. If the StatementList is present, return the LexicallyScopedDeclarations of StatementList.
2. Else return a new empty List.

13.12.7 Static Semantics: VarDeclaredNames

SwitchStatement : switch ( Expression ) CaseBlock

1. Return the VarDeclaredNames of CaseBlock.

CaseBlock : { }

1. Return a new empty List.

CaseBlock : { CaseClauses DefaultClause CaseClauses }

1. If the first CaseClauses is present, let names be the VarDeclaredNames of the first CaseClauses.
2. Else let names be a new empty List.
3. Append to names the elements of the VarDeclaredNames of the DefaultClause.
4. If the second CaseClauses is not present, return names.
5. Else return the result of appending to names the elements of the VarDeclaredNames of the second CaseClauses.

CaseClauses : CaseClauses CaseClause

1. Let names be VarDeclaredNames of CaseClauses.
2. Append to names the elements of the VarDeclaredNames of CaseClause.
3. Return names.

CaseClause : case Expression : StatementList

1. If the StatementList is present, return the VarDeclaredNames of StatementList.
2. Else return a new empty List.

DefaultClause : default : StatementList

1. If the StatementList is present, return the VarDeclaredNames of StatementList.
2. Else return a new empty List.

13.12.8 Static Semantics: VarScopedDeclarations

SwitchStatement : switch ( Expression ) CaseBlock

1. Return the VarScopedDeclarations of CaseBlock.

CaseBlock : { }

1. Return a new empty List.

CaseBlock : { CaseClauses DefaultClause CaseClauses }
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`.

`CaseClauses` : `CaseClauses` `CaseClause`

1. Let `declarations` be VarScopedDeclarations of `CaseClauses`.
2. Append to `declarations` the elements of the VarScopedDeclarations of `CaseClause`.
3. Return `declarations`.

`CaseClause` : `case` `Expression` : `StatementList`

1. If the `StatementList` is present, return the VarScopedDeclarations of `StatementList`.
2. Else return a new empty `List`.

`DefaultClause` : `default` : `StatementList`

1. If the `StatementList` is present, return the VarScopedDeclarations of `StatementList`.
2. Else return a new empty `List`.

13.12.9 Runtime Semantics: CaseBlockEvaluation

With argument `input`.

`CaseBlock` : `{ }`

1. Return `NormalCompletion(undefined)`.

`CaseBlock` : `{ CaseClauses `}

1. Let `V` be `undefined`.
2. Let `A` be the `List` of `CaseClause` items in `CaseClauses`, in source text order.
3. Let `found` be `false`.
4. Repeat for each `CaseClause` `C` in `A`,
   a. If `found` is `false`, then
      i. Let `clauseSelector` be the result of CaseSelectorEvaluation of `C`.
      ii. ReturnIfAbrupt(`clauseSelector`).
      iii. Let `found` be the result of performing Strict Equality Comparison `input === clauseSelector.[[Value]]`.
   b. If `found` is `true`, then
      i. Let `R` be the result of evaluating `C`.
      ii. If `R.[[Value]]` is not empty, let `V` be `R.[[Value]]`.
      iii. If `R` is an abrupt completion, return `Completion(UpdateEmpty(R, V))`.
5. Return `NormalCompletion(V)`.

`CaseBlock` : `{ CaseClauses DefaultClause CaseClauses `}

1. Let `V` be `undefined`.
2. Let `A` be the `List` of `CaseClause` items in the first `CaseClauses`, in source text order. If the first `CaseClauses` is not present, `A` is « ».
3. Let `found` be `false`.
4. Repeat for each `CaseClause` `C` in `A`,
   a. If `found` is `false`, then
      i. Let `clauseSelector` be the result of CaseSelectorEvaluation of `C`.
      ii. ReturnIfAbrupt(`clauseSelector`).
      iii. Let `found` be the result of performing Strict Equality Comparison `input === clauseSelector.[[Value]]`. 
b. If \textit{found} is true, then
   i. Let \( R \) be the result of evaluating \( C \).
   ii. If \( R.\\text{[Value]} \) is not empty, let \( V \) be \( R.\\text{[Value]} \).
   iii. If \( R \) is an abrupt completion, return \texttt{Completion(UpdateEmpty(R, V))}.

5. Let \( \text{foundInB} \) be false.
6. Let \( B \) be the List containing the \textit{CaseClause} items in the second \textit{CaseClauses}, in source text order. If the second \textit{CaseClauses} is not present, \( B \) is « ». 
7. If \( \text{found} \) is false, then
   a. Repeat for each \textit{CaseClause} \( C \) in \( B \)
      i. If \( \text{foundInB} \) is false, then
         1. Let \( \text{clauseSelector} \) be the result of CaseSelectorEvaluation of \( C \).
         2. Return\texttt{IfAbrupt(\text{clauseSelector})}.
         3. Let \( \text{foundInB} \) be the result of performing \texttt{Strict Equality Comparison} \( input \equiv \text{clauseSelector.}[\text{Value}] \).
      ii. If \( \text{foundInB} \) is true, then
         1. Let \( R \) be the result of evaluating \textit{CaseClause} \( C \).
         2. If \( R.\\text{[Value]} \) is not empty, let \( V \) be \( R.\\text{[Value]} \).
         3. If \( R \) is an abrupt completion, return \texttt{Completion(UpdateEmpty(R, V))}.
   8. If \( \text{foundInB} \) is true, return \texttt{NormalCompletion(V)}.
9. Let \( R \) be the result of evaluating \texttt{DefaultClause}.
10. If \( R.\\text{[Value]} \) is not empty, let \( V \) be \( R.\\text{[Value]} \).
11. If \( R \) is an abrupt completion, return \texttt{Completion(UpdateEmpty(R, V))}.
12. Repeat for each \textit{CaseClause} \( C \) in \( B \) (NOTE this is another complete iteration of the second \textit{CaseClauses})
   a. Let \( R \) be the result of evaluating \textit{CaseClause} \( C \).
   b. If \( R.\\text{[Value]} \) is not empty, let \( V \) be \( R.\\text{[Value]} \).
   c. If \( R \) is an abrupt completion, return \texttt{Completion(UpdateEmpty(R, V))}.
13. Return \texttt{NormalCompletion(V)}.

\section*{13.12.10 Runtime Semantics: CaseSelectorEvaluation}

\texttt{CaseClause} : \texttt{case} \texttt{Expression} : \texttt{StatementList}

1. Let \( \text{exprRef} \) be the result of evaluating \texttt{Expression}.
2. Return ? \texttt{GetValue(\text{exprRef})}.

\texttt{NOTE} CaseSelectorEvaluation does not execute the associated \texttt{StatementList}. It simply evaluates the \texttt{Expression} and returns the value, which the \texttt{CaseBlock} algorithm uses to determine which \texttt{StatementList} to start executing.

\section*{13.12.11 Runtime Semantics: Evaluation}

\texttt{SwitchStatement} : \texttt{switch ( Expression ) CaseBlock}

1. Let \( \text{exprRef} \) be the result of evaluating \texttt{Expression}.
2. Let \( \text{switchValue} \) be ? \texttt{GetValue(\text{exprRef})}.
3. Let \( \text{oldEnv} \) be the running execution context’s LexicalEnvironment.
4. Let \( \text{blockEnv} \) be \texttt{NewDeclarativeEnvironment(\text{oldEnv})}.
5. Perform \texttt{BlockDeclarationInstantiation(\text{CaseBlock}, \text{blockEnv})}.
6. Set the running execution context’s LexicalEnvironment to \( \text{blockEnv} \).
7. Let \( R \) be the result of performing CaseBlockEvaluation of \texttt{CaseBlock} with argument \( \text{switchValue} \).
8. Set the running execution context’s LexicalEnvironment to \( \text{oldEnv} \).
9. Return \( R \).

\texttt{NOTE} No matter how control leaves the \texttt{SwitchStatement} the LexicalEnvironment is always restored to its former state.

\texttt{CaseClause} : \texttt{case} \texttt{Expression} :

1. Return \texttt{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.

13.13 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.

13.13.1 Static Semantics: Early Errors

LabelledItem : FunctionDeclaration

- It is a Syntax Error if any source text matches this rule.

NOTE An alternative deﬁnition for this rule is provided in B.3.2.

13.13.2 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.

13.13.3 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.
1. Return \texttt{false}.

### 13.13.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments \texttt{iterationSet} and \texttt{labelSet}.

\[\text{LabelledStatement} : \text{LabelIdentiﬁer} : \text{LabelledItem}\]

1. Let \texttt{label} be the StringValue of \texttt{LabelIdentiﬁer}.
2. Let \texttt{newLabelSet} be a copy of \texttt{labelSet} with \texttt{label} appended.
3. Return \texttt{ContainsUndefinedContinueTarget} of \texttt{LabelledItem} with arguments \texttt{iterationSet} and \texttt{newLabelSet}.

\[\text{LabelledItem} : \text{FunctionDeclaration}\]

1. Return \texttt{false}.

### 13.13.5 Static Semantics: IsLabelledFunction ( \texttt{stmt} )

The abstract operation \texttt{IsLabelledFunction} with argument \texttt{stmt} performs the following steps:

1. If \texttt{stmt} is not a \texttt{LabelledStatement}, return \texttt{false}.
2. Let \texttt{item} be the \texttt{LabelledItem} component of \texttt{stmt}.
3. If \texttt{item} is \texttt{LabelledItem : FunctionDeclaration}, return \texttt{true}.
4. Let \texttt{subStmt} be the \texttt{Statement} component of \texttt{item}.
5. Return \texttt{IsLabelledFunction}(\texttt{subStmt}).

### 13.13.6 Static Semantics: LexicallyDeclaredNames

\[\text{LabelledStatement} : \text{LabelIdentiﬁer} : \text{LabelledItem}\]

1. Return the LexicallyDeclaredNames of \texttt{LabelledItem}.

\[\text{LabelledItem} : \text{Statement}\]

1. Return a new empty \texttt{List}.

\[\text{LabelledItem} : \text{FunctionDeclaration}\]

1. Return BoundNames of \texttt{FunctionDeclaration}.

### 13.13.7 Static Semantics: LexicallyScopedDeclarations

\[\text{LabelledStatement} : \text{LabelIdentiﬁer} : \text{LabelledItem}\]

1. Return the LexicallyScopedDeclarations of \texttt{LabelledItem}.

\[\text{LabelledItem} : \text{Statement}\]

1. Return a new empty \texttt{List}.

\[\text{LabelledItem} : \text{FunctionDeclaration}\]

1. Return a new \texttt{List} containing \texttt{FunctionDeclaration}.

### 13.13.8 Static Semantics: TopLevelLexicallyDeclaredNames

\[\text{LabelledStatement} : \text{LabelIdentiﬁer} : \text{LabelledItem}\]

1. Return a new empty \texttt{List}. 
13.13.9 **Static Semantics: TopLevelLexicallyScopedDeclarations**

\[
\text{LabelledStatement} : \text{LabelledItem} : \text{LabelledItem}
\]

1. Return a new empty List.

13.13.10 **Static Semantics: TopLevelVarDeclaredNames**

\[
\text{LabelledStatement} : \text{LabelIdentifer} : \text{LabelledItem}
\]

1. Return the TopLevelVarDeclaredNames of LabelledItem.

\[
\text{LabelledItem} : \text{Statement}
\]

1. If Statement is Statement : LabelledStatement, return TopLevelVarDeclaredNames of Statement.

2. Return VarDeclaredNames of Statement.

\[
\text{LabelledItem} : \text{FunctionDeclaration}
\]

1. Return BoundNames of FunctionDeclaration.

13.13.11 **Static Semantics: TopLevelVarScopedDeclarations**

\[
\text{LabelledStatement} : \text{LabelIdentifer} : \text{LabelledItem}
\]

1. Return the TopLevelVarScopedDeclarations of LabelledItem.

\[
\text{LabelledItem} : \text{Statement}
\]

1. If Statement is Statement : LabelledStatement, return TopLevelVarScopedDeclarations of Statement.

2. Return VarScopedDeclarations of Statement.

\[
\text{LabelledItem} : \text{FunctionDeclaration}
\]

1. Return a new List containing FunctionDeclaration.

13.13.12 **Static Semantics: VarDeclaredNames**

\[
\text{LabelledStatement} : \text{LabelIdentifer} : \text{LabelledItem}
\]

1. Return the VarDeclaredNames of LabelledItem.

\[
\text{LabelledItem} : \text{FunctionDeclaration}
\]

1. Return a new empty List.

13.13.13 **Static Semantics: VarScopedDeclarations**

\[
\text{LabelledStatement} : \text{LabelIdentifer} : \text{LabelledItem}
\]

1. Return the VarScopedDeclarations of LabelledItem.

\[
\text{LabelledItem} : \text{FunctionDeclaration}
\]

1. Return a new empty List.

13.13.14 **Runtime Semantics: LabelledEvaluation**

With argument labelSet.

\[
\text{LabelledStatement} : \text{LabelIdentifer} : \text{LabelledItem}
\]

1. Let label be the StringValue of LabelIdentifer.
2. Append \textit{label} as an element of \textit{labelSet}.
3. Let \textit{stmtResult} be LabelledEvaluation of \textit{LabelledItem} with argument \textit{labelSet}.
4. If \textit{stmtResult}[[\text{Type}]] is break and SameValue(strmResult[[\text{Target}]], \textit{label}) is \textbf{true}, then
   a. Let \textit{stmtResult} be \textbf{NormalCompletion}(stmtResult[[\text{Value}])}.
5. Return \textbf{Completion}(stmtResult).

\textit{LabelledItem} : \textit{Statement}

1. If \textit{Statement} is either a \textit{LabelledStatement} or a \textit{BreakableStatement}, then
   a. Return LabelledEvaluation of \textit{Statement} with argument \textit{labelSet}.
2. Else, 
   a. Return the result of evaluating \textit{Statement}.

\textit{LabelledItem} : \textit{FunctionDeclaration}

1. Return the result of evaluating \textit{FunctionDeclaration}.

\textbf{13.13.15 Runtime Semantics: Evaluation}

\textit{LabelledStatement} : \textit{LabelIdentrinsic} : \textit{LabelledItem}

1. Let \textit{newLabelSet} be a new empty List.
2. Return LabelledEvaluation of this \textit{LabelledStatement} with argument \textit{newLabelSet}.

\textbf{13.14 The throw Statement}

\textbf{Syntax}

\textit{ThrowStatement}_{	extbf{ Yield}} : \\
\hspace{1em} \textbf{throw} [\text{no LineTerminator here}] \textit{Expression}_{\textbf{ In, } \textbf{Yield} } ;

\textbf{13.14.1 Runtime Semantics: Evaluation}

\textit{ThrowStatement} : \textbf{throw} \textit{Expression} ;

1. Let \textit{exprRef} be the result of evaluating \textit{Expression}.
2. Let \textit{exprValue} be \textbf{GetValue}(exprRef).
3. Return \textbf{Completion}([[\text{Type}]: \text{throw}, [[\text{Value}]: \textit{exprValue}, [[\text{Target}]: \text{empty}].

\textbf{13.15 The try Statement}

\textbf{Syntax}

\textit{TryStatement}_{	extbf{ Yield, Return}} : \\
\hspace{1em} \textbf{try} \textit{Block}_{\textbf{Yield, ?Return}} \textit{Catch}_{\textbf{Yield, ?Return}} \textit{Finally}_{\textbf{Yield, ?Return}} \\
\hspace{1em} \textbf{try} \textit{Block}_{\textbf{Yield, ?Return}} \textit{Catch}_{\textbf{Yield, ?Return}} \textit{Finally}_{\textbf{Yield, ?Return}} \\
\hspace{1em} \textbf{try} \textit{Block}_{\textbf{Yield, ?Return}} \textit{Catch}_{\textbf{Yield, ?Return}} \textit{Finally}_{\textbf{Yield, ?Return}}

\textit{Catch}_{	extbf{Yield, Return}} : \\
\hspace{1em} \textbf{catch} ( \textit{CatchParameter}_{\textbf{Yield}} ) \textit{Block}_{\textbf{Yield, ?Return}}

\textit{Finally}_{	extbf{Yield, Return}} : \\
\hspace{1em} \textbf{finally} \textit{Block}_{\textbf{Yield, ?Return}}

\textit{CatchParameter}_{	extbf{Yield}} : \\
\hspace{1em} \textit{BindingIdentrinsic}_{\textbf{Yield}} \textit{BindingPattern}_{\textbf{Yield}}
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.

13.15.1 Static Semantics: Early Errors

```
Catch : catch ( CatchParameter ) Block
```

- It is a Syntax Error if `BoundNames` of `CatchParameter` contains any duplicate elements.
- 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.

13.15.2 Static Semantics: ContainsDuplicateLabels

With argument `labelSet`.

```
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`.

13.15.3 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. Return `ContainsUndefinedBreakTarget` of `Finally` with argument `labelSet`.
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.

13.15.4 Static Semantics: ContainsUndefinedContinueTarget

With arguments iterationSet and labelSet.

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 « ».

13.15.5 Static Semantics: VarDeclaredNames

TryStatement : try Block Catch

1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Catch.
3. Return names.

TryStatement : try Block Finally

1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Finally.
3. Return names.

TryStatement : try Block Catch Finally

1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Catch.
3. Append to names the elements of the VarDeclaredNames of Finally.
4. Return names.

Catch : catch ( CatchParameter ) Block
1. Return the VarDeclaredNames of Block.

13.15.6 Static Semantics: VarScopedDeclarations

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.

13.15.7 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. Let catchEnvRec be catchEnv’s EnvironmentRecord.
4. For each element argName of the BoundNames of CatchParameter, do
   a. Perform !catchEnvRec.CreateMutableBinding(argName, false).
5. Set the running execution context’s LexicalEnvironment to catchEnv.
6. Let status be the result of performing BindingInitialization for CatchParameter passing thrownValue and catchEnv as arguments.
7. If status is an abrupt completion, then
   a. Set the running execution context’s LexicalEnvironment to oldEnv.
   b. Return Completion(status).
8. Let B be the result of evaluating Block.
9. Set the running execution context’s LexicalEnvironment to oldEnv.
10. Return Completion(B).

NOTE No matter how control leaves the Block the LexicalEnvironment is always restored to its former state.

13.15.8 Runtime Semantics: Evaluation

TryStatement : try Block Catch

1. Let B be the result of evaluating Block.
2. If B[[Type]] is throw, let C be CatchClauseEvaluation of Catch with parameter B[[Value]].
3. Else, let C be B.
4. Return Completion(UpdateEmpty(C, undefined)).
### 13.16 The debugger Statement

**Syntax**

```
DebuggerStatement :
  debugger ;
```

#### 13.16.1 Runtime Semantics: Evaluation

**NOTE** Evaluating the `DebuggerStatement` production may allow an implementation to cause a breakpoint when run under a debugger. If a debugger is not present or active this statement has no observable effect.

```
DebuggerStatement : debugger ;
```

1. If an implementation defined debugging facility is available and enabled, then
   a. Perform an implementation defined debugging action.
   b. Let `result` be an implementation defined `Completion` value.
2. Else,
   a. Let `result` be `NormalCompletion`(`empty`).
3. Return `result`.

### 14 ECMAScript Language: Functions and Classes

**NOTE** Various ECMAScript language elements cause the creation of ECMAScript function objects (9.2). Evaluation of such functions starts with the execution of their `[[Call]]` internal method (9.2.1).

#### 14.1 Function Definitions

**Syntax**

```
FunctionDeclaration[Yield, Default] :
  function BindingIdentifier[Yield] ( FormalParameters ) { FunctionBody }
[+Default] function ( FormalParameters ) { FunctionBody }

FunctionExpression :
  function BindingIdentifier [opt] ( FormalParameters ) { FunctionBody }
```

```
StrictFormalParameters[Yield] :
  FormalParameters[Yield]
```

A Directive Prologue is the longest sequence of ExpressionStatement productions occurring as the initial StatementListItem or ModuleItem productions of a FunctionBody, a ScriptBody, or a ModuleBody 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
- It is a Syntax Error if `ContainsUseStrict` of `FunctionBody` is `true` and `IsSimpleParameterList` of `FormalParameters` is `false`.
- 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 SuperProperty` is `true`.
- It is a Syntax Error if `FunctionBody` `Contains SuperProperty` is `true`.
- It is a Syntax Error if `FormalParameters` `Contains SuperCall` is `true`.
- It is a Syntax Error if `FunctionBody` `Contains SuperCall` is `true`.

**NOTE 1**

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 2**

Multiple occurrences of the same `BindingIdentifier` in a `FormalParameterList` is only allowed for functions and generator functions which have simple parameter lists and which are not defined in strict mode code.

**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

**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 a new empty `List`.

**FormalParameterList : FormalsList , FunctionRestParameter**

1. Let `names` be `BoundNames` of `FormalsList`.
2. Append to `names` the `BoundNames` of `FunctionRestParameter`.
3. Return `names`.

**FormalsList : FormalsList , FormalParameter**

1. Let `names` be `BoundNames` of `FormalsList`.
2. Append to `names` the elements of `BoundNames` of `FormalParameter`. 
3. Return names.

### 14.1.4 Static Semantics: Contains

With parameter symbol.

\[
\text{FunctionDeclaration} : \text{function } \text{BindingIdentifier} ( \text{FormalParameters} ) \{ \text{FunctionBody} \}
\]

\[
\text{FunctionDeclaration} : \text{function} ( \text{FormalParameters} ) \{ \text{FunctionBody} \}
\]

\[
\text{FunctionExpression} : \text{function } \text{BindingIdentifier} ( \text{FormalParameters} ) \{ \text{FunctionBody} \}
\]

1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

### 14.1.5 Static Semantics: ContainsExpression

\[
\text{FormalParameters} : [\text{empty}]
\]

1. Return false.

\[
\text{FormalParameterList} : \text{FunctionRestParameter}
\]

1. Return ContainsExpression of FunctionRestParameter.

\[
\text{FormalParameterList} : \text{FormalsList}, \text{FunctionRestParameter}
\]

1. If ContainsExpression of FormalsList is true, return true.
2. Return ContainsExpression of FunctionRestParameter.

\[
\text{FormalsList} : \text{FormalsList}, \text{FormalParameter}
\]

1. If ContainsExpression of FormalsList is true, return true.
2. Return ContainsExpression of FormalParameter.

### 14.1.6 Static Semantics: ContainsUseStrict

\[
\text{FunctionBody} : \text{FunctionStatementList}
\]

1. If the Directive Prologue of FunctionStatementList contains a Use Strict Directive, return true; otherwise, return false.

### 14.1.7 Static Semantics: ExpectedArgumentCount

\[
\text{FormalParameters} : [\text{empty}]
\]

1. Return 0.

\[
\text{FormalParameterList} : \text{FunctionRestParameter}
\]

1. Return 0.

\[
\text{FormalParameterList} : \text{FormalsList}, \text{FunctionRestParameter}
\]

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.

\[
\text{FormalsList} : \text{FormalParameter}
\]

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.

14.1.8 Static Semantics: HasInitializer

FormalsList : FormalsList , FormalParameter

1. If HasInitializer of FormalsList is true, return true.
2. Return HasInitializer of FormalParameter.

14.1.9 Static Semantics: HasName

FunctionExpression : function ( FormalParameters ) { FunctionBody }

1. Return false.

FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return true.

14.1.10 Static Semantics: IsAnonymousFunctionDefinition ( production )

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 orInitializer. 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

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return false.

FunctionDeclaration : function ( FormalParameters ) { FunctionBody }

1. Return false.

14.1.12 Static Semantics: IsFunctionDefinition

FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return true.

14.1.13 Static Semantics: IsSimpleParameterList

FormalParameters : [empty]

1. Return true.

FormalParameterList : FunctionRestParameter

1. Return false.

FormalParameterList : FormalsList , FunctionRestParameter
1. Return false.

FormalsList : FormalsList , FormalParameter

1. If IsSimpleParameterList of FormalsList is false, return false.

FormalParameter : BindingElement

1. Return IsSimpleParameterList of BindingElement.

14.1.14 Static Semantics: LexicallyDeclaredNames

FunctionStatementList : [empty]

1. Return a new empty List.

FunctionStatementList : StatementList

1. Return TopLevelLexicallyDeclaredNames of StatementList.

14.1.15 Static Semantics: LexicallyScopedDeclarations

FunctionStatementList : [empty]

1. Return a new empty List.

FunctionStatementList : StatementList

1. Return the TopLevelLexicallyScopedDeclarations of StatementList.

14.1.16 Static Semantics: VarDeclaredNames

FunctionStatementList : [empty]

1. Return a new empty List.

FunctionStatementList : StatementList

1. Return TopLevelVarDeclaredNames of StatementList.

14.1.17 Static Semantics: VarScopedDeclarations

FunctionStatementList : [empty]

1. Return a new empty List.

FunctionStatementList : StatementList

1. Return the TopLevelVarScopedDeclarations of StatementList.

14.1.18 Runtime Semantics: EvaluateBody

With parameter functionObject.

FunctionBody : FunctionStatementList

1. Return the result of evaluating FunctionStatementList.

14.1.19 Runtime Semantics: IteratorBindingInitialization

With parameters iteratorRecord and environment.
NOTE 1 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 `iteratorRecord` and `environment` as the arguments.
2. ReturnIfAbrupt(`restIndex`).
3. Return the result of performing `IteratorBindingInitialization` for `FunctionRestParameter` using `iteratorRecord` and `environment` as the arguments.

FormalsList : FormalsList, FormalParameter

1. Let `status` be the result of performing `IteratorBindingInitialization` for `FormalsList` using `iteratorRecord` and `environment` as the arguments.
2. ReturnIfAbrupt(`status`).
3. Return the result of performing `IteratorBindingInitialization` for `FormalParameter` using `iteratorRecord` and `environment` as the arguments.

FormalParameter : BindingElement

1. If `ContainsExpression` of `BindingElement` is `false`, return the result of performing `IteratorBindingInitialization` for `BindingElement` using `iteratorRecord` and `environment` as the arguments.
2. Let `currentContext` be the running execution context.
3. Let `originalEnv` be the VariableEnvironment of `currentContext`.
4. Assert: The VariableEnvironment and LexicalEnvironment of `currentContext` are the same.
5. Assert: `environment` and `originalEnv` are the same.
6. Let `paramVarEnv` be `NewDeclarativeEnvironment`(`originalEnv`).
7. Set the VariableEnvironment of `currentContext` to `paramVarEnv`.
8. Set the LexicalEnvironment of `currentContext` to `paramVarEnv`.
9. Let `result` be the result of performing `IteratorBindingInitialization` for `BindingElement` using `iteratorRecord` and `environment` as the arguments.
10. Set the VariableEnvironment of `currentContext` to `originalEnv`.
11. Set the LexicalEnvironment of `currentContext` to `originalEnv`.
12. Return `result`.

NOTE 2 The new `Environment Record` created in step 6 is only used if the `BindingElement` contains a direct `eval`.

FunctionRestParameter : BindingRestElement

1. If `ContainsExpression` of `BindingRestElement` is `false`, return the result of performing `IteratorBindingInitialization` for `BindingRestElement` using `iteratorRecord` and `environment` as the arguments.
2. Let `currentContext` be the running execution context.
3. Let `originalEnv` be the VariableEnvironment of `currentContext`.
4. Assert: The VariableEnvironment and LexicalEnvironment of `currentContext` are the same.
5. Assert: `environment` and `originalEnv` are the same.
6. Let `paramVarEnv` be `NewDeclarativeEnvironment`(`originalEnv`).
7. Set the VariableEnvironment of `currentContext` to `paramVarEnv`.
8. Set the LexicalEnvironment of `currentContext` to `paramVarEnv`.
9. Let `result` be the result of performing `IteratorBindingInitialization` for `BindingRestElement` using `iteratorRecord` and `environment` as the arguments.
10. Set the VariableEnvironment of currentContext to originalEnv.
11. Set the LexicalEnvironment of currentContext to originalEnv.
12. Return result.

NOTE 3    The new Environment Record created in step 6 is only used if the BindingRestElement contains a direct eval.

### 14.1.20 Runtime Semantics: InstantiateFunctionObject

With parameter scope.

**FunctionDeclaration**: \( \text{function} \ \text{BindingIdentifier}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. If the function code for FunctionDeclaration is strict mode code, let strict be true. Otherwise let strict be false.
2. Let name be StringValue of BindingIdentifier.
4. Perform MakeConstructor(F).
5. Perform SetFunctionName(F, name).
6. Return F.

**FunctionDeclaration**: \( \text{function}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. If the function code for FunctionDeclaration is strict mode code, let strict be true. Otherwise let strict be false.
2. Let F be FunctionCreate(Normal, FormalParameters, FunctionBody, scope, strict).
3. Perform MakeConstructor(F).
4. Perform SetFunctionName(F, "default").
5. Return F.

NOTE    An anonymous FunctionDeclaration can only occur as part of an export default declaration.

### 14.1.21 Runtime Semantics: Evaluation

**FunctionDeclaration**: \( \text{function} \ \text{BindingIdentifier}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. Return NormalCompletion(empty).

NOTE 1    An alternative semantics is provided in B.3.3.

**FunctionDeclaration**: \( \text{function}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. Return NormalCompletion(empty).

**FunctionExpression**: \( \text{function}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. If the function code for FunctionExpression is strict mode code, let strict be true. Otherwise let strict be false.
2. Let scope be the LexicalEnvironment of the running execution context.
4. Perform MakeConstructor(closure).
5. Return closure.

**FunctionExpression**: \( \text{function} \ \text{BindingIdentifier}(\ \text{FormalParameters}) \ \{ \ \text{FunctionBody} \} \)

1. If the function code for FunctionExpression is strict mode code, let strict be true. Otherwise let strict be false.
2. Let scope be the running execution context's LexicalEnvironment.
3. Let funcEnv be NewDeclarativeEnvironment(scope).
4. Let envRec be funcEnv's EnvironmentRecord.
5. Let name be StringValue of BindingIdentifier.
7. Let closure be FunctionCreate(Normal, FormalParameters, FunctionBody, funcEnv, strict).
8. Perform MakeConstructor(closure).
9. Perform `SetFunctionName(closure, name)`.

**NOTE 2**  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 3**  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**

```plaintext
ArrowFunction[In, Yield] :
    ArrowParameters[Yield] [no LineTerminator here] => ConciseBody[?In]

ArrowParameters[Yield] :
    BindingIdentifier[Yield]
    CoverParenthesizedExpressionAndArrowParameterList[Yield]

ConciseBody[In] :
    [lookahead ≠ {] AssignmentExpression[?In]
    { FunctionBody }
```

**Supplemental Syntax**

When the production `ArrowParameters : CoverParenthesizedExpressionAndArrowParameterList` is recognized the following grammar is used to refine the interpretation of `CoverParenthesizedExpressionAndArrowParameterList`:

```plaintext
ArrowFormalParameters[Yield] :
    ( StrictFormalParameters[Yield] )
```

### 14.2.1 Static Semantics: Early Errors

**ArrowFunction : ArrowParameters => ConciseBody**

- It is a Syntax Error if ArrowParameters Contains YieldExpression is true.
- It is a Syntax Error if ContainsUseStrict of ConciseBody is true and IsSimpleParameterList of ArrowParameters is false.
- It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the LexicallyDeclaredNames of ConciseBody.

**ArrowParameters : CoverParenthesizedExpressionAndArrowParameterList**

- 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] 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].

### 14.2.2 Static Semantics: BoundNames

\[
\text{ArrowParameters} : \text{CoverParenthesizedExpressionAndArrowParameterList}
\]

1. Let \( \text{formals} \) be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList.
2. Return the BoundNames of \( \text{formals} \).

### 14.2.3 Static Semantics: Contains

With parameter \( \text{symbol} \).

\[
\text{ArrowFunction} : \text{ArrowParameters} \Rightarrow \text{ConciseBody}
\]

1. If \( \text{symbol} \) is not one of NewTarget, SuperProperty, SuperCall, super or this, return false.
2. If ArrowParameters Contains \( \text{symbol} \) is true, return true.
3. Return ConciseBody Contains \( \text{symbol} \).

**NOTE** Normally, Contains does not look inside most function forms. However, Contains is used to detect new.target, this, and super usage within an ArrowFunction.

### 14.2.4 Static Semantics: ContainsExpression

\[
\text{ArrowParameters} : \text{BindingIdentifier}
\]

1. Return false.

### 14.2.5 Static Semantics: ContainsUseStrict

\[
\text{ConciseBody} : \text{AssignmentExpression}
\]

1. Return false.

### 14.2.6 Static Semantics: ExpectedArgumentCount

\[
\text{ArrowParameters} : \text{BindingIdentifier}
\]

1. Return 1.

### 14.2.7 Static Semantics: HasName

\[
\text{ArrowFunction} : \text{ArrowParameters} \Rightarrow \text{ConciseBody}
\]

1. Return false.

### 14.2.8 Static Semantics: IsSimpleParameterList

\[
\text{ArrowParameters} : \text{BindingIdentifier}
\]

1. Return true.

\[
\text{ArrowParameters} : \text{CoverParenthesizedExpressionAndArrowParameterList}
\]

1. Let \( \text{formals} \) be CoveredFormalsList of CoverParenthesizedExpressionAndArrowParameterList.
14.2.9 Static Semantics: CoveredFormalsList

ArrowParameters : BindingIdentifier

1. Return this ArrowParameters.

CoverParenthesizedExpressionAndArrowParameterList[Yield] :

( Expression )
( )
( ... BindingIdentifier )
( ... BindingPattern )
( Expression , ... BindingIdentifier )
( Expression , ... BindingPattern )

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] 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.

14.2.10 Static Semantics: LexicallyDeclaredNames

ConciseBody : AssignmentExpression

1. Return a new empty List.

14.2.11 Static Semantics: LexicallyScopedDeclarations

ConciseBody : AssignmentExpression

1. Return a new empty List.

14.2.12 Static Semantics: VarDeclaredNames

ConciseBody : AssignmentExpression

1. Return a new empty List.

14.2.13 Static Semantics: VarScopedDeclarations

ConciseBody : AssignmentExpression

1. Return a new empty List.

14.2.14 Runtime Semantics: IteratorBindingInitialization

With parameters iteratorRecord 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.

ArrowParameters : BindingIdentifier

1. Assert: iteratorRecord[[Done]] is false.
2. Let next be IteratorStep(iteratorRecord[[Iterator]]).
3. If `next` is an abrupt completion, set `iteratorRecord.[[Done]]` to `true`.
4. `ReturnIfAbrupt(next)`.
5. If `next` is `false`, set `iteratorRecord.[[Done]]` to `true`.
6. Else,
   a. Let `v` be `IteratorValue(next)`.
   b. If `v` is an abrupt completion, set `iteratorRecord.[[Done]]` to `true`.
   c. `ReturnIfAbrupt(v)`.
7. If `iteratorRecord.[[Done]]` is `true`, let `v` be `undefined`.
8. Return the result of performing `BindingInitialization` for `BindingIdentifier` using `v` and `environment` as the arguments.

### 14.2.15 Runtime Semantics: EvaluateBody

With parameter `functionObject`.

`ConciseBody` : `AssignmentExpression`

1. Let `exprRef` be the result of evaluating `AssignmentExpression`.
2. Let `exprValue` be `GetValue(exprRef)`.
3. Return `Completion{[[Type]]: `return`, [[Value]]: `exprValue`, [[Target]]: `empty`}`.

### 14.2.16 Runtime Semantics: Evaluation

`ArrowFunction` : `ArrowParameters` => `ConciseBody`

1. If the function code for this `ArrowFunction` is strict mode code, 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`.
4. Let `closure` be `FunctionCreate(Arrow, parameters, ConciseBody, scope, strict)`.
5. Return `closure`.

**NOTE**  An `ArrowFunction` does not define local bindings for `arguments`, `super`, `this`, or `new.target`. Any reference to `arguments`, `super`, `this`, or `new.target` 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 `ContainsUseStrict` of `FunctionBody` is `true` and `IsSimpleParameterList` of `StrictFormalParameters` is `false`. 
- 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 `ContainsUseStrict` of `FunctionBody` is `true` and `IsSimpleParameterList` of `PropertySetParameterList` is `false`.
- 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`.

**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

**PropertySetParameterList**: `FormalParameter`

1. If `HasInitializer` of `FormalParameter` is `true`, return 0.
2. Return 1.

### 14.3.4 Static Semantics: HasComputedPropertyKey

**MethodDefinition**:

```
PropertyName ( StrictFormalParameters ) { FunctionBody }
get PropertyName ( ) { FunctionBody }
set PropertyName ( PropertySetParameterList ) { FunctionBody }
```

1. Return `IsComputedPropertyKey` of `PropertyName`.

### 14.3.5 Static Semantics: HasDirectSuper

**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

**MethodDefinition**:

```
PropertyName ( StrictFormalParameters ) { FunctionBody }
get PropertyName ( ) { FunctionBody }
```
set PropertyName ( PropertySetParameterList ) { FunctionBody }

1. Return PropName of PropertyName.

14.3.7 Static Semantics: SpecialMethod

MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }

1. Return false.

MethodDefinition :

  GeneratorMethod
  get PropertyName ( ) { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }

1. Return true.

14.3.8 Runtime Semantics: DefineMethod

With parameters object and optional parameter functionPrototype.

MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }

1. Let propName be the result of evaluating PropertyName.
2. ReturnIfAbrupt(propName).
3. If the function code for this MethodDefinition is strict mode code, let strict be true. Otherwise let strict be false.
4. Let scope be the running execution context’s LexicalEnvironment.
5. If functionPrototype was passed as a parameter; let kind be Normal; otherwise let kind be Method.
6. Let closure be FunctionCreate(kind, StrictFormalParameters, FunctionBody, scope, strict). If functionPrototype was passed as a parameter, then pass its value as the prototype optional argument of FunctionCreate.
7. Perform MakeMethod(closure, object).
8. Return the Record{[Key]: propName, [Closure]: closure}.

14.3.9 Runtime Semantics: PropertyDefinitionEvaluation

With parameters object and enumerable.

MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }

1. Let methodDef be DefineMethod of MethodDefinition with argument object.
2. ReturnIfAbrupt(methodDef).
3. Perform SetFunctionName(methodDef[[Closure]], methodDef[[Key]]).
4. Let desc be the PropertyDescriptor{[[Value]]: methodDef[[Closure]], [[Writable]]: true, [[Enumerable]]: enumerable, [[Configurable]]: true}.
5. Return ? DefinePropertyOrThrow(object, methodDef[[Key]], desc).

MethodDefinition : GeneratorMethod

See 14.4.

MethodDefinition : get PropertyName ( ) { FunctionBody }

1. Let propName be the result of evaluating PropertyName.
2. ReturnIfAbrupt(propName).
3. If the function code for this MethodDefinition is strict mode code, let strict be true. Otherwise let strict be false.
4. Let scope be the running execution context’s LexicalEnvironment.
5. Let formalParameterList be the production FormalParameters : [empty] .
7. Perform MakeMethod(closure, object).
8. Perform `SetFunctionName(closure, propKey, "get")`.
9. Let `desc` be the `PropertyDescriptor`{[[Get]]: closure, [[Enumerable]]: enumerable, [[Configurable]]: true}.
10. Return `DefinePropertyOrThrow(object, propKey, desc)`.

### MethodDefinition: `set` `PropertyName` ( `PropertySetParameterList` ) { `FunctionBody` }

1. Let `propKey` be the result of evaluating `PropertyName`.
2. ReturnIfAbrupt(`propKey`).
3. If the function code for this `MethodDefinition` is strict mode code, let `strict` be true. Otherwise let `strict` be false.
4. Let `scope` be the running execution context's LexicalEnvironment.
5. Let `closure` be `FunctionCreate(Method, PropertySetParameterList, FunctionBody, scope, strict)`.
6. 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[Yield]** :

* `PropertyName`[?Yield] ( `StrictFormalParameters`[Yield] ) { `GeneratorBody` }

**GeneratorDeclaration[Yield, Default]** :

* `function` * `BindingIdentifier`[?Yield] ( `FormalParameters`[Yield] ) { `GeneratorBody` }

[+Default] * `function` * ( `FormalParameters`[Yield] ) { `GeneratorBody` }

**GeneratorExpression** :

* `function` * `BindingIdentifier`[Yield] opt ( `FormalParameters`[Yield] ) { `GeneratorBody` }

`GeneratorBody` :

* `FunctionBody`[Yield]

**YieldExpression[In]** :

* `yield` [no `LineTerminator` here] `AssignmentExpression`[?In, Yield]
* `yield` [no `LineTerminator` here] * `AssignmentExpression`[?In, Yield]

**NOTE 1**  
The syntactic context immediately following `yield` requires use of the `InputElementRegExpOrTemplateTail` lexical goal.

**NOTE 2**  
`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 3**  
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` of `GeneratorMethod` is true.
- It is a Syntax Error if `StrictFormalParameters` Contains `YieldExpression` is true.
- It is a Syntax Error if `ContainsUseStrict` of `GeneratorBody` is true and `IsSimpleParameterList` of `StrictFormalParameters` is false.
- It is a Syntax Error if any element of the `BoundNames` of `StrictFormalParameters` also occurs in the `LexicallyDeclaredNames` of `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 `ContainsUseStrict of GeneratorBody` is `true` and `IsSimpleParameterList of FormalParameters` is `false`.

It is a Syntax Error if any element of the `BoundNames of FormalParameters` also occurs in the `LexicallyDeclaredNames of GeneratorBody`.

It is a Syntax Error if `FormalParameters Contains YieldExpression` is `true`.

It is a Syntax Error if `FormalParameters Contains SuperProperty` is `true`.

It is a Syntax Error if `GeneratorBody Contains SuperProperty` is `true`.

It is a Syntax Error if `FormalParameters Contains SuperCall` is `true`.

It is a Syntax Error if `GeneratorBody Contains SuperCall` is `true`.

14.4.2 Static Semantics: BoundNames

```
GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
GeneraorDeclaration : function * ( FormalParameters ) { GeneratorBody }
GeneratorExpression : 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`.

```
GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
```

1. Return the result of `ComputedPropertyContains for PropertyName with argument symbol`.

14.4.4 Static Semantics: Contains

With parameter `symbol`.

```
GeneratorDeclaration : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
GeneratorDeclaration : function * ( FormalParameters ) { GeneratorBody }
GeneratorExpression : function * BindingIdentifier ( 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

```
GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
```

1. Return `IsComputedPropertyKey of PropertyName`.

14.4.6 Static Semantics: HasDirectSuper

```
GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
```
1. If `StrictFormalParameters Contains SuperCall` is `true`, return `true`.
2. Return `GeneratorBody Contains SuperCall`.

### 14.4.7 Static Semantics: HasName

- **GeneratorExpression** : `function * ( FormalParameters ) { GeneratorBody }

  1. Return `false`.

### 14.4.8 Static Semantics: IsConstantDeclaration

- **GeneratorDeclaration** : `function * BindingIdentifier ( FormalParameters ) { GeneratorBody }

  1. Return `false`.

### 14.4.9 Static Semantics: IsFunctionDefinition

- **GeneratorExpression** : `function * BindingIdentifier ( FormalParameters ) { GeneratorBody }

  1. Return `true`.

### 14.4.10 Static Semantics: PropName

- **GeneratorMethod** : `* PropertyName ( StrictFormalParameters ) { GeneratorBody }

  1. Return PropName of `PropertyName`.

### 14.4.11 Runtime Semantics: EvaluateBody

With parameter `functionObject`.

- **GeneratorBody** : `FunctionBody`

  1. Let `G` be `? OrdinaryCreateFromConstructor(functionObject, "%GeneratorPrototype", "\[[GeneratorState]\], [GeneratorContext]]")`.
  2. Perform `GeneratorStart(G, FunctionBody)`.
  3. Return `Completion([[[Type]]]: return, [[Value]]: G, [[Target]]: empty)`.

### 14.4.12 Runtime Semantics: InstantiateFunctionObject

With parameter `scope`.

- **GeneratorDeclaration** : `function * BindingIdentifier ( FormalParameters ) { GeneratorBody }

  1. If the function code for `GeneratorDeclaration` is `strict mode 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. Let `prototype` be `ObjectCreate(%GeneratorPrototype%)`.
  5. Perform `DefineOwnPropertyOrThrow(F, "prototype", PropertyDescriptor{[[Value]]: prototype, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false})`.
  6. Perform `SetFunctionName(F, name)`.
  7. Return `F`.

- **GeneratorDeclaration** : `function * ( FormalParameters ) { GeneratorBody }`
1. If the function code for `GeneratorDeclaration` is strict mode code, let `strict` be `true`. Otherwise let `strict` be `false`.
2. Let `F` be `GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, scope, strict)`. 
3. Let `prototype` be `ObjectCreate(%GeneratorPrototype%)`. 
4. Perform `DefinePropertyOrThrow(F, "prototype", PropertyDescriptor{[[Value]]: prototype, [[Writable]]: true, 
   [[Enumerable]]: false, [[Configurable]]: false}).` 
5. Perform `SetFunctionName(F, "default")`. 

NOTE An anonymous `GeneratorDeclaration` can only occur as part of an `export default` declaration.

### 14.4.13 Runtime Semantics: PropertyDefinitionEvaluation

With parameter `object` and `enumerable`.

```javascript
GeneratorMethod : * PropertyName ( StrictFormalParameters ) { GeneratorBody }
```

1. Let `propKey` be the result of evaluating `PropertyName`. 
2. `ReturnIfAbrupt(propKey)`. 
3. If the function code for this `GeneratorMethod` is strict mode code, let `strict` be `true`. Otherwise let `strict` be `false`. 
4. Let `scope` be the running execution context’s LexicalEnvironment. 
5. Let `closure` be `GeneratorFunctionCreate(Method, StrictFormalParameters, GeneratorBody, scope, strict)`. 
6. Perform `MakeMethod(closure, object)`. 
7. Let `prototype` be `ObjectCreate(%GeneratorPrototype%)`. 
8. Perform `DefinePropertyOrThrow(closure, "prototype", PropertyDescriptor{[[Value]]: prototype, [[Writable]]: true, 
   [[Enumerable]]: false, [[Configurable]]: false}).` 
9. Perform `SetFunctionName(closure, propKey)`. 
10. Let `desc` be the PropertyDescriptor{[[Value]]: closure, [[Writable]]: true, [[Enumerable]]: enumerable, [[Configurable]]: true}. 
11. Return `DefinePropertyOrThrow(object, propKey, desc)`.

### 14.4.14 Runtime Semantics: Evaluation

```javascript
GeneratorExpression : function * ( FormalParameters ) { GeneratorBody }
```

1. If the function code for this `GeneratorExpression` is strict mode code, let `strict` be `true`. Otherwise let `strict` be `false`. 
2. Let `scope` be the LexicalEnvironment of the running execution context. 
3. Let `closure` be `GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, scope, strict)`. 
4. Let `prototype` be `ObjectCreate(%GeneratorPrototype%)`. 
5. Perform `DefinePropertyOrThrow(closure, "prototype", PropertyDescriptor{[[Value]]: prototype, [[Writable]]: true, 
   [[Enumerable]]: false, [[Configurable]]: false}).` 

```javascript
GeneratorExpression : function * BindingIdentifier ( FormalParameters ) { GeneratorBody }
```

1. If the function code for this `GeneratorExpression` is strict mode code, let `strict` be `true`. Otherwise let `strict` be `false`. 
2. Let `scope` be the running execution context’s LexicalEnvironment. 
3. Let `funcEnv` be `NewDeclarativeEnvironment(scope)`. 
4. Let `envRec` be `funcEnv`’s EnvironmentRecord. 
5. Let `name` be StringValue of `BindingIdentifier`. 
6. Perform `envRec.CreateImmutableBinding(name, false)`. 
7. Let `closure` be `GeneratorFunctionCreate(Normal, FormalParameters, GeneratorBody, funcEnv, strict)`. 
8. Let `prototype` be `ObjectCreate(%GeneratorPrototype%)`. 
9. Perform `DefinePropertyOrThrow(closure, "prototype", PropertyDescriptor{[[Value]]: prototype, [[Writable]]: true, 
   [[Enumerable]]: false, [[Configurable]]: false}).` 
10. Perform `SetFunctionName(closure, name)`. 
11. Perform `envRec.InitializeBinding(name, closure)`.
12. Return `closure`.

NOTE 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. Return `GeneratorYield(CreateIterResultObject(value, false))`.

**YieldExpression** : `yield` `*` `AssignmentExpression`

1. Let `exprRef` be the result of evaluating `AssignmentExpression`.
2. Let `value` be `GetValue(exprRef)`.
3. Let `iterator` be `GetIterator(value)`.
4. Let `received` be `NormalCompletion(undefined)`.
5. Repeat
   a. If `received.[[Type]]` is normal, then
      i. Let `innerResult` be `IteratorNext(iterator, received.[[Value]])`.
      ii. Let `done` be `IteratorComplete(innerResult)`.
      iii. If `done` is `true`, then
          1. Return `GeneratorYield(innerResult)`.
     iv. Let `received` be `GeneratorYield(innerResult)`.
   b. Else if `received.[[Type]]` is throw, then
      i. Let `throw` be `GetMethod(iterator, "throw")`.
      ii. If `throw` is not `undefined`, then
         1. Let `innerResult` be `Call(throw, iterator, « received.[[Value]] »)`.
         2. NOTE: Exceptions from the inner iterator `throw` method are propagated. Normal completions from an inner `throw` method are processed similarly to an inner `next`.
         3. If `Type(innerResult)` is not `Object`, throw a `TypeError` exception.
         4. Let `done` be `IteratorComplete(innerResult)`.
         5. If `done` is `true`, then
            a. Return `GeneratorYield(innerResult)`.
         6. Let `received` be `GeneratorYield(innerResult)`.
   c. 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. Perform `IteratorClose(iterator, Completion({[[Type]]: normal, [[Value]]: empty, [[Target]]: empty})`.
      3. NOTE: The next step throws a `TypeError` to indicate that there was a `yield*` protocol violation: `iterator` does not have a `throw` method.
      4. Throw a `TypeError` exception.
   d. Else,
      i. Assert: `received.[[Type]]` is return.
      ii. Let `return` be `GetMethod(iterator, "return")`.
      iii. If `return` is `undefined`, return `Completion(received)`.
      iv. Let `innerReturnResult` be `Call(return, iterator, « received.[[Value]] »)`.
      v. If `Type(innerReturnResult)` is not `Object`, throw a `TypeError` exception.
      vi. Let `done` be `IteratorComplete(innerReturnResult)`.
      vii. If `done` is `true`, then
1. Let \( \text{value} \) be \(? \text{IteratorValue}(\text{innerReturnResult})\).
2. Return Completion\{[[Type]]: return, [[Value]]: value, [[Target]]: empty\}.

viii. Let \( \text{received} \) be GeneratorYield(\text{innerReturnResult})

### 14.5 Class Definitions

**Syntax**

\[
\text{ClassDeclaration}[\text{Yield, Default}] : \text{class} \ \text{BindingIdentifier}[^{\text{Yield}}] \ \text{ClassTail}[^{\text{Yield}}] \\
\text{[+Default] class} \ \text{ClassTail}[^{\text{Yield}}]
\]

\[
\text{ClassExpression}[\text{Yield}] : \text{class} \ \text{BindingIdentifier}[^{\text{Yield}}] \ \text{opt} \ \text{ClassTail}[^{\text{Yield}}]
\]

\[
\text{ClassTail}[\text{Yield}] : \text{ClassHeritage}[^{\text{Yield}}] \ \text{opt} \ \{ \ \text{ClassBody}[^{\text{Yield}}] \ \text{opt} \ \}
\]

\[
\text{ClassHeritage}[\text{Yield}] : \text{extends} \ \text{LeftHandSideExpression}[^{\text{Yield}}]
\]

\[
\text{ClassBody}[\text{Yield}] : \text{ClassElementList}[^{\text{Yield}}]
\]

\[
\text{ClassElementList}[\text{Yield}] : \text{ClassElement}[^{\text{Yield}}] \ \text{ClassElementList}[^{\text{Yield}}] \ \text{ClassElement}[^{\text{Yield}}]
\]

\[
\text{ClassElement}[\text{Yield}] : \text{MethodDefinition}[^{\text{Yield}}] \\
\text{static} \ \text{MethodDefinition}[^{\text{Yield}}] \\
;
\]

**NOTE** A class definition is always strict code.

### 14.5.1 Static Semantics: Early Errors

\[
\text{ClassTail} : \text{ClassHeritage} \ \{ \ \text{ClassBody} \ \}
\]

- It is a Syntax Error if \text{ClassHeritage} is not present and the following algorithm evaluates to \text{true}:
  
  1. Let \( \text{constructor} \) be ConstructorMethod of \text{ClassBody}.
  2. If \( \text{constructor} \) is empty, return \text{false}.
  3. Return HasDirectSuper of \( \text{constructor} \).

\[
\text{ClassBody} : \text{ClassElementList}
\]

- It is a Syntax Error if PrototypePropertyNameList of \text{ClassElementList} contains more than one occurrence of "constructor".

\[
\text{ClassElement} : \text{MethodDefinition}
\]

- It is a Syntax Error if PropName of \text{MethodDefinition} is not "constructor" and HasDirectSuper of \text{MethodDefinition} is true.
- It is a Syntax Error if PropName of \text{MethodDefinition} is "constructor" and SpecialMethod of \text{MethodDefinition} is true.

\[
\text{ClassElement} : \text{static} \ \text{MethodDefinition}
\]
- It is a Syntax Error if HasDirectSuper of MethodDefinition is true.
- It is a Syntax Error if PropName of MethodDefinition is "prototype".

14.5.2 Static Semantics: BoundNames

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.

ClassTail : ClassHeritage { 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.

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.
**14.5.6 Static Semantics: HasName**

*ClassExpression : class ClassTail*

1. Return false.

*ClassExpression : class BindingIdentifier ClassTail*

1. Return true.

**14.5.7 Static Semantics: IsConstantDeclaration**

*ClassDeclaration : class BindingIdentifier ClassTail*

1. Return false.

*ClassDeclaration : class ClassTail*

1. Return false.

**14.5.8 Static Semantics: IsFunctionDefinition**

*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 ; ; , 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

`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 : ClassHeritage { ClassBody }`

1. Let `lex` be the LexicalEnvironment of the running execution context.
2. Let `classScope` be NewDeclarativeEnvironment(`lex`).
3. Let `classScopeEnvRec` be `classScope`’s EnvironmentRecord.
4. If `className` is not `undefined`, then
   a. Perform `classScopeEnvRec.CreateImmutableBinding(className, true)`.
5. If `ClassHeritage` 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`.

Static Semantics: PrototypePropertyNameList

Static Semantics: PropName

Static Semantics: StaticPropertyNameList

Runtime Semantics: ClassDefinitionEvaluation
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. Let protoParent be ? Get(superclass, "prototype").
   ii. If Type(protoParent) is neither Object nor Null, throw a TypeError exception.
   iii. Let constructorParent be superclass.

7. Let proto be ObjectCreate(protoParent).
8. If ClassBodyopt is not present, let constructor be empty.
9. Else, let constructor be ConstructorMethod of ClassBody.
10. If constructor is empty, then
    a. If ClassHeritageopt is present, then
       i. Let constructor be the result of parsing the source text
          
          constructor(... args){ super (...args);}

          using the syntactic grammar with the goal symbol MethodDefinition.
    b. Else,
       i. Let constructor be the result of parsing the source text
          
          constructor( ){ }

          using the syntactic grammar with the goal symbol MethodDefinition.
11. Set the running execution context’s LexicalEnvironment to classScope.
12. Let constructorInfo be the result of performing DefineMethod for constructor with arguments proto and constructorParent as the optional functionPrototype argument.
13. Assert: constructorInfo is not an abrupt completion.
14. Let F be constructorInfo.[[Closure]].
15. If ClassHeritageopt is present, set F’s [[ConstructorKind]] internal slot to "derived".
16. Perform MakeConstructor(F, false, proto).
17. Perform MakeClassConstructor(F).
19. If ClassBodyopt is not present, let methods be a new empty List.
20. Else, let methods be NonConstructorMethodDefinitions of ClassBody.
21. 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,
       i. Let status be the result of performing PropertyDefinitionEvaluation for m with arguments F and false.
       c. If status is an abrupt completion, then
          i. Set the running execution context’s LexicalEnvironment to lex.
          ii. Return Completion(status).
22. Set the running execution context’s LexicalEnvironment to lex.
23. If className is not undefined, then
    a. Perform classScopeEnvRec.InitializeBinding(className, F).
24. Return F.

14.5.15 Runtime Semantics: BindingClassDeclarationEvaluation

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. If hasNameProperty is false, perform SetFunctionName(value, className).
6. Let env be the running execution context’s LexicalEnvironment.
7. Perform ? InitializeBoundName(className, value, env).
8. Return value.

ClassDeclaration : class ClassTail

1. Return the result of ClassDefinitionEvaluation of ClassTail with argument undefined.

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 15.2.3.11.

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 1 ClassDeclaration : class ClassTail only occurs as part of an ExportDeclaration and is never directly evaluated.

ClassExpression : class BindingIdentifier ClassTail

1. If BindingIdentifier_opt is not present, let className be undefined.
2. Else, let className be StringValue of BindingIdentifier.
3. Let value be the result of ClassDefinitionEvaluation of ClassTail with argument className.
4. ReturnIfAbrupt(value).
5. If className is not undefined, then
   a. Let hasNameProperty be ? HasOwnProperty(value, "name").
   b. If hasNameProperty is false, then
      i. Perform SetFunctionName(value, className).
6. Return NormalCompletion(value).

NOTE 2 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)

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 GeneratorBody, 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 9.2.7) that enables observation of the chain of caller contexts.

14.6.2 Static Semantics: HasProductionInTailPosition
NOTE nonterminal is a parsed grammar production that represents a specific range of source text. When the following algorithms compare nonterminal to other grammar symbols they are testing whether the same source text 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]

**StatementListItem** : Declaration

**Statement** :

- VariableStatement
- EmptyStatement
- ExpressionStatement
- ContinueStatement
- BreakStatement
- ThrowStatement
- DebuggerStatement

**Block** : { }

**ReturnStatement** : return ;

**LabelledItem** : FunctionDeclaration

**IterationStatement** :

```plaintext
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 HasProductionInTailPosition of the first Statement with argument nonterminal.
2. If has is true, return true.
3. Return HasProductionInTailPosition of the second Statement with argument nonterminal.

**IfStatement** : if ( Expression ) Statement

**IterationStatement** :

```plaintext
do Statement while ( Expression )
while ( Expression ) Statement
for ( ExpressionOpt ; ExpressionOpt ; ExpressionOpt ) Statement
for ( var VariableDeclarationList ; ExpressionOpt ; ExpressionOpt ) Statement
```
for ( LexicalDeclaration Expression\_opt ; Expression\_opt ) Statement

WithStatement : with ( Expression ) Statement

1. Return HasProductionInTailPosition of Statement with argument nonterminal.

LabelledStatement :
   LabelIdentiﬁer : LabelledItem

1. Return HasProductionInTailPosition of LabelledItem with argument nonterminal.

ReturnStatement : return Expression ;

1. Return HasProductionInTailPosition of Expression with argument nonterminal.

SwitchStatement : switch ( Expression ) CaseBlock

1. Return HasProductionInTailPosition of CaseBlock with argument nonterminal.

CaseBlock : { CaseClauses DefaultClause CaseClauses }

1. Let has be false.
2. If the ﬁrst CaseClauses is present, let has be HasProductionInTailPosition of the ﬁrst CaseClauses with argument nonterminal.
3. If has is true, return true.
4. Let has be HasProductionInTailPosition of the DefaultClause with argument nonterminal.
5. If has is true, return true.
6. If the second CaseClauses is present, let has be HasProductionInTailPosition 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 : StatementList

DefaultClause : default : StatementList

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 ExponentiationExpression

ExponentiationExpression:
  UpdateExpression ** ExponentiationExpression

UpdateExpression:
  LeftHandSideExpression ++
  LeftHandSideExpression --
  ++ UnaryExpression
  -- UnaryExpression

UnaryExpression:
  delete UnaryExpression
  void UnaryExpression
typeof UnaryExpression
  + UnaryExpression
  - UnaryExpression
  ~ UnaryExpression
  ! UnaryExpression

CallExpression:
  SuperCall
**CallExpression** [ **Expression** ]

**CallExpression** . IdentifierName

**NewExpression** : `new` **NewExpression**

**MemberExpression** :

  **MemberExpression** [ **Expression** ]
  **MemberExpression** . IdentifierName
  SuperProperty
  MetaProperty
  `new` **MemberExpression** Arguments

**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
  **CallExpression** Arguments
  **CallExpression** TemplateLiteral

1. If this **CallExpression** is `nonterminal`, return `true`.
2. Return `false`.

**MemberExpression** :

  **MemberExpression** TemplateLiteral

1. If this **MemberExpression** 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 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_opt

ScriptBody : StatementList

15.1.1 Static Semantics: Early Errors

Script : ScriptBody

- It is a Syntax Error if the LexicallyDeclaredNames of ScriptBody contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of ScriptBody also occurs in the VarDeclaredNames of ScriptBody.

ScriptBody : 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 that is not the function code of an ArrowFunction.
- 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 that is not the function code of an ArrowFunction.
- 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

**ScriptBody** : `StatementList`

1. If the Directive Prologue of `StatementList` contains a Use Strict Directive, return `true`; otherwise, return `false`.

### 15.1.3 Static Semantics: LexicallyDeclaredNames

**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

**ScriptBody** : `StatementList`

1. Return `TopLevelLexicallyScopedDeclarations` of `StatementList`.

### 15.1.5 Static Semantics: VarDeclaredNames

**ScriptBody** : `StatementList`

1. Return `TopLevelVarDeclaredNames` of `StatementList`.

### 15.1.6 Static Semantics: VarScopedDeclarations

**ScriptBody** : `StatementList`

1. Return `TopLevelVarScopedDeclarations` of `StatementList`.

### 15.1.7 Runtime Semantics: Evaluation

**Script** : [empty]

1. Return `NormalCompletion(undefined)`.

### 15.1.8 Script Records

A `Script Record` encapsulates information about a script being evaluated. Each script record contains the fields listed in Table 36.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Realm]]</code></td>
<td>`Realm Record</td>
<td>undefined`</td>
</tr>
<tr>
<td><code>[[Environment]]</code></td>
<td>`Lexical Environment</td>
<td>undefined`</td>
</tr>
<tr>
<td><code>[[ECMAScriptCode]]</code></td>
<td>a parse result</td>
<td>The result of parsing the source text of this module using <code>Script</code> as the goal symbol.</td>
</tr>
<tr>
<td><code>[[HostDefined]]</code></td>
<td>Any, default value is <code>undefined</code></td>
<td>Field reserved for use by host environments that need to associate additional information with a script.</td>
</tr>
</tbody>
</table>

### 15.1.9 ParseScript ( `sourceText`, `realm`, `hostDefined` )
The abstract operation ParseScript with arguments `sourceText`, `realm`, and `hostDefined` creates a `Script Record` based upon the result of parsing `sourceText` as a `Script`. ParseScript performs the following steps:

1. Assert: `sourceText` is an ECMAScript source text (see clause 10).
2. Parse `sourceText` 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 `body` be the resulting parse tree. Otherwise, let `body` be a `List` of one or more `SyntaxError` or `ReferenceError` objects representing the parsing errors and/or early errors. Parsing and early error detection may be interleaved in an implementation dependent manner. If more than one parsing error or early error is present, the number and ordering of error objects in the list is implementation dependent, but at least one must be present.
3. If `body` is a `List` of errors, then return `body`.

**NOTE** An implementation may parse script source text and analyze it for Early Error conditions prior to evaluation of ParseScript for that script source text. However, the reporting of any errors must be deferred until the point where this specification actually performs ParseScript upon that source text.

### 15.1.10 ScriptEvaluation (scriptRecord)

1. Let `globalEnv` be `scriptRecord` `[[Realm]], [[GlobalEnv]]`.
2. Let `scriptCxt` be a new ECMAScript code `execution context`.
3. Set the Function of `scriptCxt` to `null`.
4. Set the `Realm` of `scriptCxt` to `scriptRecord` `[[Realm]]`.
5. Set the `ScriptOrModule` of `scriptCxt` to `scriptRecord`.
6. Set the `VariableEnvironment` of `scriptCxt` to `globalEnv`.
7. Set the `LexicalEnvironment` of `scriptCxt` to `globalEnv`.
8. Suspend the currently `running execution context`.
9. Push `scriptCxt` on to the `execution context stack`; `scriptCxt` is now the `running execution context`.
10. Let `result` be `GlobalDeclarationInstantiation`(`ScriptBody`, `globalEnv`).
11. If `result` `[[Type]]` is normal, then
    a. Let `result` be the result of evaluating `ScriptBody`.
12. If `result` `[[Type]]` is normal and `result` `[[Value]]` is empty, then
    a. Let `result` be `NormalCompletion`(`undefined`).
13. Suspend `scriptCxt` and remove it from the `execution context stack`.
14. Assert: the `execution context stack` is not empty.
15. Resume the context that is now on top of the `execution context stack` as the `running execution context`.
16. Return `Completion`(`result`).

### 15.1.11 Runtime Semantics: GlobalDeclarationInstantiation (script, env)

**NOTE 1** 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 `EnvironmentRecord`.
2. Assert: `envRec` is a global `Environment Record`.
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 `envRec.HasVarDeclaration(`name`)` is `true`, throw a `SyntaxError` exception.
   b. If `envRec.HasLexicalDeclaration(`name`)` is `true`, throw a `SyntaxError` exception.
   c. Let `hasRestrictedGlobal` be `? envRec.HasRestrictedGlobalProperty(`name`)`.
   d. If `hasRestrictedGlobal` is `true`, throw a `SyntaxError` exception.
6. For each name in varNames, do
   a. If envRec.HasLexicalDeclaration(name) is true, throw a SyntaxError exception.
7. Let varDeclarations be the VarScopedDeclarations of script.
8. Let functionsToInitialize be a new empty List.
9. Let declaredFunctionNames be a new empty List.
10. 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.
    b. If fn is not an element of declaredFunctionNames, then
       2. If fnDefinable is false, throw a TypeError exception.
       3. Append fn to declaredFunctionNames.
    c. Insert d as the first element of functionsToInitialize.
11. Let declaredVarNames be a new 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
             b. If vnDefinable is false, throw a 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. NOTE: Annex B.3.3.2 adds additional steps at this point.
15. Let lexDeclarations be the LexicallyScopedDeclarations of script.
16. For each element d in lexDeclarations do
    a. NOTE: Lexically declared names are only instantiated here but not initialized.
       b. For each element dn of the BoundNames of d do
          i. If IsConstantDeclaration of d is true, then
          ii. Else,
17. 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.
18. For each String vn in declaredVarNames, in list order do
19. Return NormalCompletion(empty).

NOTE 2 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.
The job `ScriptEvaluationJob` with parameters `sourceText` and `hostDefined` parses, validates, and evaluates `sourceText` as a `Script`.

1. Assert: `sourceText` is an ECMAScript source text (see clause 10).
2. Let `realm` be the current Realm Record.
3. Let `s` be `ParseScript(sourceText, realm, hostDefined)`.
4. If `s` is a List of errors, then
   a. Perform `HostReportErrors(s)`.
   b. `NextJob NormalCompletion(undefined)`.
5. Let `status` be `ScriptEvaluation(s)`.
6. `NextJob Completion(status)`.

### 15.2 Modules

**Syntax**

```
Module  :
  ModuleBodyopt

ModuleBody :
  ModuleItemList

ModuleItemList :
  ModuleItem
  ModuleItemList ModuleItem

ModuleItem :
  ImportDeclaration
  ExportDeclaration
  StatementListItem
```

### 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` does not also occur in either the VarDeclaredNames of `ModuleItemList`, or the LexicallyDeclaredNames of `ModuleItemList`.
- It is a Syntax Error if `ModuleItemList` contains `super`.
- It is a Syntax Error if `ModuleItemList` contains `NewTarget`.
- It is a Syntax Error if `ContainsDuplicateLabels` of `ModuleItemList` with argument « » is `true`.
- It is a Syntax Error if `ContainsUndefinedBreakTarget` of `ModuleItemList` with argument « » is `true`.
- It is a Syntax Error if `ContainsUndefinedContinueTarget` of `ModuleItemList` with arguments « » and « » is `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.
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

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

NOTE  ExportedNames are the externally visible names that a Module explicitly maps to one of its local name bindings.

\[ \text{ModuleItemList} : \text{ModuleItemList} \text{ ModuleItem} \]

1. Let names be ExportedNames of ModuleItemList.
2. Append to names the elements of the ExportedNames of ModuleItem.
3. Return names.

\[ \text{ModuleItem} : \text{ExportDeclaration} \]

1. Return the ExportedNames of ExportDeclaration.

\[ \text{ModuleItem} : \text{ImportDeclaration} \]

\[ \text{StatementListItem} \]

1. Return a new empty List.

15.2.1.7 Static Semantics: ExportEntries

Module : [empty]

1. Return a new empty List.

\[ \text{ModuleItemList} : \text{ModuleItemList} \text{ ModuleItem} \]

1. Let entries be ExportEntries of ModuleItemList.
2. Append to entries the elements of the ExportEntries of ModuleItem.
3. Return entries.

\[ \text{ModuleItem} : \text{ImportDeclaration} \]

\[ \text{StatementListItem} \]

1. Return a new empty List.

15.2.1.8 Static Semantics: ImportEntries

Module : [empty]

1. Return a new empty List.

\[ \text{ModuleItemList} : \text{ModuleItemList} \text{ ModuleItem} \]

1. Let entries be ImportEntries of ModuleItemList.
2. Append to entries the elements of the ImportEntries of ModuleItem.
3. Return entries.

\[ \text{ModuleItem} : \text{ExportDeclaration} \]

\[ \text{StatementListItem} \]

1. Return a new empty List.

15.2.1.9 Static Semantics: ImportedLocalNames (importEntries)

The abstract operation ImportedLocalNames with argument importEntries creates a List of all of the local name bindings defined by a List of ImportEntry Records (see Table 40). ImportedLocalNames performs the following steps:
1. Let `localNames` be a new empty `List`.
2. For each `ImportEntry Record i` in `importEntries`, do
   a. Append `i[[LocalName]]` to `localNames`.
3. Return `localNames`.

### 15.2.1.10 Static Semantics: ModuleRequests

```plaintext
Module : [empty]
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 LexicallyDeclaredNames of `StatementListItem`.
```

### 15.2.1.11 Static Semantics: LexicallyDeclaredNames

**NOTE 1** The LexicallyDeclaredNames of a `Module` includes the names of all of its imported bindings.

```plaintext
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 2** 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

```plaintext
Module : [empty]
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

Module : [empty]

1. Return a new empty `List`.

ModuleItemList : 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 a new 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

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 Abstract Module Records

A `Module Record` encapsulates structural information about the imports and exports of a single module. This information is used to link the imports and exports of sets of connected modules. A `Module Record` includes four fields that are only used when evaluating a module.

For specification purposes `Module Record` values are values of the `Record` specification type and can be thought of as existing in a simple object-oriented hierarchy where `Module Record` is an abstract class with concrete subclasses. This specification only defines a single `Module Record` concrete subclass named `Source Text Module Record`. Other specifications and implementations may define additional `Module Record` subclasses corresponding to alternative module definition facilities that they defined.

`Module Record` defines the fields listed in Table 37. All `Module Definition` subclasses include at least those fields. `Module Record` also defines the abstract method list in Table 38. All `Module definition` subclasses must provide concrete
implementations of these abstract methods.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Realm]]</td>
<td>Realm Record</td>
<td>The Realm within which this module was created. <code>undefined</code> if not yet assigned.</td>
</tr>
<tr>
<td>[[Environment]]</td>
<td>Lexical Environment</td>
<td>The Lexical Environment containing the top level bindings for this module. This field is set when the module is instantiated.</td>
</tr>
<tr>
<td>[[Namespace]]</td>
<td>Object</td>
<td>The Module Namespace Object (26.3) if one has been created for this module. Otherwise <code>undefined</code>.</td>
</tr>
<tr>
<td>[[Evaluated]]</td>
<td>Boolean</td>
<td>Initially <code>false</code>, <code>true</code> if evaluation of this module has started. Remains <code>true</code> when evaluation completes, even if it is an abrupt completion.</td>
</tr>
<tr>
<td>[[HostDefined]]</td>
<td>Any, default value is <code>undefined.</code></td>
<td>Field reserved for use by host environments that need to associate additional information with a module.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetExportedNames(exportStarSet)</td>
<td>Return a list of all names that are either directly or indirectly exported from this module.</td>
</tr>
<tr>
<td>ResolveExport(exportName, resolveSet, exportStarSet)</td>
<td>Return the binding of a name exported by this module. Bindings are represented by a Record of the form <code>{{[Module]}: Module Record, [[BindingName]]: String}</code></td>
</tr>
<tr>
<td>ModuleDeclarationInstantiation()</td>
<td>Transitively resolve all module dependencies and create a module Environment Record for the module.</td>
</tr>
<tr>
<td>ModuleEvaluation()</td>
<td>Do nothing if this module has already been evaluated. Otherwise, transitively evaluate all module dependences of this module and then evaluate this module. ModuleDeclarationInstantiation must be completed prior to invoking this method.</td>
</tr>
</tbody>
</table>

15.2.1.16 Source Text Module Records

A Source Text Module Record is used to represent information about a module that was defined from ECMAScript source text (10) that was parsed using the goal symbol `Module`. Its fields contain digested information about the names that are imported by the module and its concrete methods use this digest to link, instantiate, and evaluate the module.

In addition to the fields, defined in Table 37, Source Text Module Records have the additional fields listed in Table 39. Each of these fields initially has the value `undefined`. 
Table 39: Additional Fields of Source Text Module Records

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[ECMAScriptCode]]</td>
<td>a parse result</td>
<td>The result of parsing the source text of this module using Module as the goal symbol.</td>
</tr>
<tr>
<td>[[RequestedModules]]</td>
<td>List of String</td>
<td>A List of all the ModuleSpecifier strings used by the module represented by this record to request the importation of a module. The List is source code occurrence ordered.</td>
</tr>
<tr>
<td>[[ImportEntries]]</td>
<td>List of ImportEntry Records</td>
<td>A List of ImportEntry records derived from the code of this module.</td>
</tr>
<tr>
<td>[[LocalExportEntries]]</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.</td>
</tr>
<tr>
<td>[[IndirectExportEntries]]</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.</td>
</tr>
<tr>
<td>[[StarExportEntries]]</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.</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 40:

Table 40: 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>String value of the ModuleSpecifier of the ImportDeclaration.</td>
</tr>
<tr>
<td>[[ImportName]]</td>
<td>String</td>
<td>The name under which the desired binding is exported by the module identified by [[ModuleRequest]]. 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 1  Table 41 gives examples of ImportEntry records fields used to represent the syntactic import forms:

Table 41 (Informative): Import Forms Mappings to ImportEntry Records

<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>&quot;x&quot;</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 &quot;mod&quot;;</td>
<td></td>
<td>An ImportEntry Record is not created.</td>
<td></td>
</tr>
</tbody>
</table>
An ExportEntry Record is a Record that digests information about a single declarative export. Each ExportEntry Record has the fields defined in Table 42:

<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 used to export this binding by this module.</td>
</tr>
<tr>
<td>[[[ModuleRequest]]]</td>
<td>String</td>
<td>null if the ExportDeclaration does not have a ModuleSpecifier.</td>
</tr>
<tr>
<td>[[[ImportName]]]</td>
<td>String</td>
<td>null if the ExportDeclaration does not have a ModuleSpecifier.</td>
</tr>
<tr>
<td>[[[LocalName]]]</td>
<td>String</td>
<td>null if the exported value is not locally accessible from within the module.</td>
</tr>
</tbody>
</table>

Table 43 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>[[[ImportName]]]</th>
<th>[[[LocalName]]]</th>
</tr>
</thead>
<tbody>
<tr>
<td>export var v;</td>
<td>&quot;v&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;v&quot;</td>
</tr>
<tr>
<td>export default function f(){</td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;f&quot;</td>
</tr>
<tr>
<td>export default function(){}</td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;*default&quot;</td>
</tr>
<tr>
<td>export default 42;</td>
<td>&quot;default&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;*default&quot;</td>
</tr>
<tr>
<td>export {x};</td>
<td>&quot;x&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;x&quot;</td>
</tr>
<tr>
<td>export {v as x};</td>
<td>&quot;v&quot;</td>
<td>null</td>
<td>null</td>
<td>&quot;v&quot;</td>
</tr>
<tr>
<td>export {x} from &quot;mod&quot;;</td>
<td>&quot;x&quot;</td>
<td>&quot;mod&quot;</td>
<td>&quot;x&quot;</td>
<td>null</td>
</tr>
<tr>
<td>export {v as x} from &quot;mod&quot;;</td>
<td>&quot;x&quot;</td>
<td>&quot;mod&quot;</td>
<td>&quot;v&quot;</td>
<td>null</td>
</tr>
<tr>
<td>export * from &quot;mod&quot;;</td>
<td>null</td>
<td>&quot;mod&quot;</td>
<td>&quot;*&quot;</td>
<td>null</td>
</tr>
</tbody>
</table>

The following definitions specify the required concrete methods and other abstract operations for Source Text Module Records

15.2.16.1 ParseModule (sourceText, realm, hostDefined)

The abstract operation ParseModule with arguments sourceText, realm, and hostDefined creates a Source Text Module Record based upon the result of parsing sourceText as a Module. ParseModule performs the following steps:

1. Assert: sourceText is an ECMAScript source text (see clause 10).
2. Parse sourceText 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 body be a List of one or more SyntaxError or ReferenceError objects representing the parsing errors and/or early errors. Parsing and early error detection may be interweaved in an implementation dependent manner. If more than one parsing error or early error is present, the number and ordering of error objects in the list is implementation dependent, but at least one must be present.
3. If body is a List of errors, then return body.
4. Let requestedModules be the ModuleRequests of body.
5. Let importEntries be ImportEntries of body.
6. Let importedBoundNames be ImportedLocalNames(importEntries).
7. Let indirectExportEntries be a new empty List.
8. Let localExportEntries be a new empty List.
9. Let starExportEntries be a new empty List.
10. Let exportEntries be ExportEntries of body.
11. For each record ee in exportEntries, do
    a. If ee.[[ModuleRequest]] is null, then
       i. If ee.[[LocalName]] is not an element of importedBoundNames, then
          1. Append ee to localExportEntries.
       ii. Else,
           1. Let ie be the element of importEntries whose [[LocalName]] is the same as ee.[[LocalName]].
           2. If ie.[[ModuleName]] is "**", then
              a. Assert: this is a re-export of an imported module namespace object.
              b. Append ee to localExportEntries.
           3. Else, this is a re-export of a single name
              a. Append to indirectExportEntries the Record [[[ModuleRequest]]: ie.[[ModuleRequest]],
                 [[ModuleName]]: ie.[[ModuleName]], [[LocalName]]: null, [[ExportName]]: ee.[[ExportName]]}.
       b. Else, if ee.[[ModuleName]] is "*", then
          i. Append ee to starExportEntries.
    c. Else,
       i. Append ee to indirectExportEntries.
12. Return Source Text Module Record [[[Realm]]: realm, [[Environment]]: undefined, [[HostDefined]]: hostDefined,
    [[Namespace]]: undefined, [[Evaluated]]: false, [[ECMAScriptCode]]: body, [[RequestedModules]]: requestedModules,
    [[ImportEntries]]: importEntries, [[LocalExportEntries]]: localExportEntries, [[StarExportEntries]]: starExportEntries,
    [[IndirectExportEntries]]: indirectExportEntries).

NOTE An implementation may parse module source text and analyze it for Early Error conditions prior to the evaluation of ParseModule for that module source text. However, the reporting of any errors must be deferred until the point where this specification actually performs ParseModule upon that source text.

15.2.1.16.2 GetExportedNames( exportStarSet ) Concrete Method

The GetExportedNames concrete method of a Source Text Module Record with argument exportStarSet performs the following steps:

1. Let module be this Source Text Module Record.
2. If exportStarSet 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 exportStarSet.
4. Let exportedNames be a new empty List.
5. For each ExportEntry Record e in module.[[LocalExportEntries]], do
   a. Assert: module provides the direct 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 requestedModule be ? HostResolveImportedModule(module, e.[[ModuleRequest]])
   b. Let starNames be ? requestedModule.GetExportedNames(exportStarSet).
   c. For each element n of starNames, do
      i. If SameValue(n, "default") is false, then
         1. If n is not an element of exportedNames, then
8. Return \textit{exportedNames}.

\textbf{NOTE} \hspace{1em} GetExportedNames does not filter out or throw an exception for names that have ambiguous star export bindings.

\subsection*{15.2.1.16.3 ResolveExport( \textit{exportName}, \textit{resolveSet}, \textit{exportStarSet} ) Concrete Method}

The ResolveExport concrete method of a Source Text Module Record with arguments \textit{exportName}, \textit{resolveSet}, and \textit{exportStarSet} performs the following steps:

1. Let \textit{module} be this Source Text Module Record.
2. For each \texttt{Record} \(([[\text{Module}]], [[\text{Name}]])\) \texttt{r} in \textit{resolveSet}, do:
   a. If \textit{module} and \texttt{r.\([[[\text{Module}]]]\)} are the same Module Record and \texttt{SameValue(exportName, r.\([[[\text{Name}]]]\))} is \texttt{true}, then
      i. Assert: this is a circular import request.
      ii. Return \texttt{null}.
3. Append the \texttt{Record} \(([[\text{Module}]]: \textit{module}, [[\text{Name}]]: \textit{exportName})\) to \textit{resolveSet}.
4. For each ExportEntry \texttt{Record} \texttt{e} in \textit{module}.\([[[\text{ExportEntries}}]]\), do
   a. If \texttt{SameValue(exportName, e.\([[[\text{Name}}])\))} is \texttt{true}, then
      i. Assert: \textit{module} provides the direct binding for this export.
      ii. Return \texttt{Record} \(([[\text{Module}]]: \textit{module}, [[\text{BindingName}]]: e.\([[[\text{Name}}])\))
6. If \texttt{SameValue(exportName, "default")} is \texttt{true}, then
   a. Assert: A \texttt{default} export was not explicitly defined by this module.
   b. Throw a SyntaxError exception.
   c. NOTE A \texttt{default} export cannot be provided by an \texttt{export *}.
7. If \textit{exportStarSet} contains \textit{module}, return \texttt{null}.
8. Append \textit{module} to \textit{exportStarSet}.
9. Let \textit{starResolution} be \texttt{null}.
10. For each ExportEntry \texttt{Record} \texttt{e} in \textit{module}.\([[[\text{ExportEntries}}]]\), do
    a. Let \texttt{importedModule} be \texttt{HostResolveImportedModule} (\textit{module}, \texttt{e.\([[[\text{ModuleRequest}}])\)).
    b. Let \texttt{resolution} be \texttt{HostResolveExport} (\texttt{exportName}, \textit{resolveSet}, \textit{exportStarSet}).
    c. If \texttt{resolution} is "ambiguous", return "ambiguous".
    d. If \texttt{resolution} is \texttt{null}, then
        i. If \texttt{starResolution} is \texttt{null}, let \texttt{starResolution} be \texttt{resolution}.
        ii. Else,
           1. Assert: there is more than one * import that includes the requested name.
           2. If \texttt{resolution.\([[[\text{Module}}]) and starResolution.\([[[\text{Module}}]) are not the same Module Record or \texttt{SameValue(resolution.\([[[\text{BindingName}}], starResolution.\([[[\text{BindingName}}])\))} is \texttt{false}, return "ambiguous".
11. Return \textit{starResolution}.

\textbf{NOTE} \hspace{1em} ResolveExport attempts to resolve an imported binding to the actual defining module and local binding name. The defining module may be the module represented by the Module Record\ this method was invoked on or some other module that is imported by that module. The parameter resolveSet 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 resolveSet, an import circularity has been encountered. Before recursively calling ResolveExport, a pair consisting of module and exportName is added to resolveSet.

If a defining module is found a \texttt{Record} \(([[\text{Module}]], [[\text{BindingName}}])\) is returned. This record identifies the resolved binding of the originally requested export. If no definition was found or the request is found to be
15.2.1.16.4 ModuleDeclarationInstantiation() Concrete Method

The ModuleDeclarationInstantiation concrete method of a Source Text Module Record performs the following steps:

1. Let module be this Source Text Module Record.
2. Let realm be module.[[Realm]].
3. Assert: realm is not undefined.
4. Let code be module.[[ECMAScriptCode]].
5. If module.[[Environment]] is not undefined, return NormalCompletion(empty).
6. Let env be NewModuleEnvironment(realm,[[GlobalEnv]]).
7. Set module.[[Environment]] to env.
8. For each String required that is an element of module.[[RequestedModules]] do,
   a. NOTE: Before instantiating a module, all of the modules it requested must be available. An implementation may perform this test at any time prior to this point.
   b. Let requiredModule be ? HostResolveImportedModule(module, required).
   c. Perform ? requiredModule.ModuleDeclarationInstantiation().
9. For each ExportEntry Record e in module.[[IndirectExportEntries]], do
   a. Let resolution be ? module.ResolveExport(e.[[ModuleName]], « », « »).
   b. If resolution is null or resolution is "ambiguous", throw a SyntaxError exception.
10. Assert: all named exports from module are resolvable.
11. Let envRec be env's EnvironmentRecord.
12. For each ImportEntry Record in in module.[[ImportEntries]], do
    a. Let importedModule be ? HostResolveImportedModule(module, in.[[ModuleRequest]]).
    b. If in.[[ModuleName]] is "*", then
       i. Let namespace be ? GetModuleNameSpace(importedModule).
       ii. Perform ! envRec.CreateImmutableBinding(in.[[ModuleName]], true).
       iii. Call envRec.InitializeBinding(in.[[ModuleName]], namespace).
    c. Else,
       i. Let resolution be ? importedModule.ResolveExport(in.[[ModuleName]], « », « »).
       ii. If resolution is null or resolution is "ambiguous", throw a SyntaxError exception.
       iii. Call envRec.CreateImmutableBinding(in.[[ModuleName]], resolution.[[Module]], resolution.[[BindingName]]).
13. Let varDeclarations be the VarScopedDeclarations of code.
14. Let declaredVarNames be a new empty List.
15. For each element d in varDeclarations do
    a. For each element dn of the BoundNames of d do
       i. If dn is not an element of declaredVarNames, then
          2. Call envRec.InitializeBinding(dn, undefined).
          3. Append dn to declaredVarNames.
16. Let lexDeclarations be the LexicallyScopedDeclarations of code.
17. 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
       ii. Else,
       iii. 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.InitializeBinding(dn, fo).
18. Return NormalCompletion(empty).

15.2.1.16.5 ModuleEvaluation() Concrete Method
The ModuleEvaluation concrete method of a Source Text Module Record performs the following steps:

1. Let module be this Source Text Module Record.
2. Assert: ModuleDeclarationInstantiation has already been invoked on module and successfully completed.
3. Assert: module.[[Realm]] is not undefined.
4. If module.[[Evaluated]] is true, return undefined.
5. Set module.[[Evaluated]] to true.
6. For each String required that is an element of module.[[RequestedModules]] do,
   a. Let requiredModule be ? HostResolveImportedModule(module, required).
   b. Perform ? requiredModule.ModuleEvaluation().
7. Let moduleCxt be a new ECMAScript code execution context.
8. Set the Function of moduleCxt to null.
9. Set the Realm of moduleCxt to module.[[Realm]].
10. Set the ScriptOrModule of moduleCxt to module.
11. Assert: module has been linked and declarations in its module environment have been instantiated.
12. Set the VariableEnvironment of moduleCxt to module.[[Environment]].
13. Set the LexicalEnvironment of moduleCxt to module.[[Environment]].
14. Suspend the currently running execution context.
15. Push moduleCxt on to the execution context stack; moduleCxt is now the running execution context.
16. Let result be the result of evaluating module.[[ECMAScriptCode]].
17. Suspend moduleCxt and remove it from the execution context stack.
18. Resume the context that is now on the top of the execution context stack as the running execution context.
19. Return Completion(result).

15.2.1.17 Runtime Semantics: HostResolveImportedModule (referencingModule, specifier)

HostResolveImportedModule is an implementation defined abstract operation that provides the concrete Module Record subclass instance that corresponds to the ModuleSpecifier String, specifier, occurring within the context of the module represented by the Module Record referencingModule.

The implementation of HostResolveImportedModule must conform to the following requirements:

- The normal return value must be an instance of a concrete subclass of Module Record.
- If a Module Record corresponding to the pair referencingModule, specifier does not exist or cannot be created, an exception must be thrown.
- This operation must be idempotent if it completes normally. Each time it is called with a specific referencingModule, specifier pair as arguments it must return the same Module Record instance.

Multiple different referencingModule, specifier pairs may map to the same Module Record instance. The actual mapping semantic is implementation defined but typically a normalization process is applied to specifier as part of the mapping process. A typical normalization process would include actions such as alphabetic case folding and expansion of relative and abbreviated path specifiers.

15.2.1.18 Runtime Semantics: GetModuleNamespace (module)

The abstract operation GetModuleNamespace called with argument module performs the following steps:

1. Assert: module is an instance of a concrete subclass of Module Record.
2. Let namespace be module.[[Namespace]].
3. If namespace is undefined, then
   a. Let exportedNames be ? module.GetExportedNames(" ").
   b. Let unambiguousNames be a new empty List.
   c. For each name that is an element of exportedNames,
      i. Let resolution be ? module.ResolveExport(name, " ", " ").
      ii. If resolution is null, throw a SyntaxError exception.
      iii. If resolution is not "ambiguous", append name to unambiguousNames.
   d. Let namespace be ModuleNamespaceCreate(module, unambiguousNames).
4. Return `namespace`.

### 15.2.1.19 Runtime Semantics: `TopLevelModuleEvaluationJob (sourceText, hostDefined)`

A `TopLevelModuleEvaluationJob` with parameters `sourceText` and `hostDefined` is a job that parses, validates, and evaluates `sourceText` as a `Module`.

1. Assert: `sourceText` is an ECMAScript source text (see clause 10).
2. Let `realm` be the current Realm Record.
3. Let `m` be `ParseModule(sourceText, realm, hostDefined)`.
4. If `m` is a `List` of errors, then
   a. Perform `HostReportErrors(m)`.
   b. `NextJob NormalCompletion(undefined)`.
5. Let `status` be `m.ModuleDeclarationInstantiation()`.
6. If `status` is not an abrupt completion, then
   a. Assert: all dependencies of `m` have been transitively resolved and `m` is ready for evaluation.
   b. Let `status` be `m.ModuleEvaluation()`.
7. `NextJob Completion(status)`.

**NOTE** An implementation may parse a `sourceText` as a `Module`, analyze it for Early Error conditions, and instantiate it prior to the execution of the `TopLevelModuleEvaluationJob` for that `sourceText`. An implementation may also resolve, pre-parse and pre-analyze, and pre-instantiate module dependencies of `sourceText`. However, the reporting of any errors detected by these actions must be deferred until the `TopLevelModuleEvaluationJob` is actually executed.

### 15.2.1.20 Runtime Semantics: Evaluation

#### Module: [empty]

1. Return `NormalCompletion(undefined)`.

#### ModuleBody: ModuleItemList

1. Let `result` be the result of evaluating `ModuleItemList`.
2. If `result`.[[Type]] is normal and `result`.[[Value]] is empty, then
   a. Return `NormalCompletion(undefined)`.
3. Return `Completion(result)`.

#### 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. Return `Completion(UpdateEmpty(s, sl.[[Value]])).

**NOTE** 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`:

```javascript
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

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

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 \( \textit{specs} \) be the ImportEntriesForModule of ImportsList with argument \( \textit{module} \).
2. Append to \( \textit{specs} \) the elements of the ImportEntriesForModule of ImportSpecifier with argument \( \textit{module} \).
3. Return \( \textit{specs} \).

**ImportSpecifier** : \( \texttt{ImportedBinding} \)

1. Let \( \textit{localName} \) be the sole element of BoundNames of ImportedBinding.
2. Let \( \textit{entry} \) be the Record {[[ModuleRequest]]: \( \textit{module} \), [[ImportName]]: \( \textit{localName} \), [[LocalName]]: \( \textit{localName} \) }.
3. Return a new List containing \( \textit{entry} \).

**ImportSpecifier** : \( \texttt{IdentifierName as ImportedBinding} \)

1. Let \( \textit{importName} \) be the stringValue of IdentifierName.
2. Let \( \textit{localName} \) be the stringValue of ImportedBinding.
3. Let \( \textit{entry} \) be the Record {[[ModuleRequest]]: \( \textit{module} \), [[ImportName]]: \( \textit{importName} \), [[LocalName]]: \( \textit{localName} \) }.
4. Return a new List containing \( \textit{entry} \).

**15.2.2.5 Static Semantics: ModuleRequests**

**ImportDeclaration** : \( \texttt{import ImportClause FromClause } \);  

1. Return ModuleRequests of FromClause.

**ModuleSpecifier** : \( \texttt{StringLiteral} \)

1. Return a List containing the stringValue of StringLiteral.

**15.2.3 Exports**

**Syntax**

**ExportDeclaration** :  
\( \texttt{export \ast \ FromClause } \);  
\( \texttt{export ExportClause FromClause } \);  
\( \texttt{export ExportClause } \);  
\( \texttt{export VariableStatement} \);  
\( \texttt{export Declaration} \);  
\( \texttt{export default HoistableDeclaration[Default]} \);  
\( \texttt{export default ClassDeclaration[Default]} \);  
\( \texttt{export default [lookahead \notin \{\texttt{function, class}\}} ] \texttt{AssignmentExpression[In]} \);  

**ExportClause** :  
\{ \}  
\{ ExportsList \}  
\{ ExportsList , \}  

**ExportsList** :  
ExportSpecifier  
ExportsList , ExportSpecifier  

**ExportSpecifier** :  
IdentifierName  
IdentifierName as IdentifierName

**15.2.3.1 Static Semantics: Early Errors**

**ExportDeclaration** : \( \texttt{export ExportClause } \);
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", or "static".

The above rule means that each ReferencedBindings of ExportClause is treated as an IdentifierReference.

15.2.3.2 Static Semantics: BoundNames

ExportDeclaration :
  export * FromClause ;
  export ExportClause FromClause ;
  export ExportClause ;

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

ExportDeclaration :
  export ExportClause FromClause ;
  export * FromClause ;

1. Return a new empty List.

ExportDeclaration : export ExportClause ;

1. Return the ExportedBindings 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

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`.
ExportSpecifer : IdentifierName as IdentifierName

1. Return a List containing the StringValue of the second IdentifierName.

15.2.3.5 Static Semantics: ExportEntries

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
}. 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

`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

`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

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. If hasNameProperty is false, perform SetFunctionName(value, "default").
   c. Let env be the running execution context’s LexicalEnvironment.
   d. Perform ? 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. If IsAnonymousFunctionDefinition(AssignmentExpression) is true, then
   a. Let hasNameProperty be ? HasOwnProperty(value, "name").
   b. If hasNameProperty is false, perform SetFunctionName(value, "default").
4. Let env be the running execution context’s LexicalEnvironment.
5. Perform ? InitializeBoundName("*default*", value, env).
6. 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 parsing that Script in ParseScript. 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 16.2, 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 16.2, 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 HostReportErrors (errorList)

HostReportErrors is an implementation-defined abstract operation that allows host environments to report parsing errors, early errors, and runtime errors.

An implementation of HostReportErrors must complete normally in all cases. The default implementation of HostReportErrors is to do nothing.

NOTE `errorList` will be a List of ECMAScript language values. If the errors are parsing errors or early errors, these will always be SyntaxError or ReferenceError objects. Runtime errors, however, can be any ECMAScript value.

### 16.2 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 mode code must not be created with own properties named "caller" or "arguments" other than those that are created by applying the AddRestrictedFunctionProperties abstract operation to the function. Such own properties also must not be created for function objects defined using an ArrowFunction, MethodDefinition, GeneratorDeclaration, GeneratorExpression, ClassDeclaration, or ClassExpression regardless of whether the definition is contained in strict mode code. 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 or built-in function objects with an own property named "caller" the value of that property, as observed using [[Get]] or [[GetOwnProperty]], must not be a strict function object. If it is an accessor property, the function that is the value of the property's [[Get]] attribute must never return a strict function when called.
- 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`, `Array.prototype.toLocaleDateString`, `Date.prototype.toLocaleDateString`, `Date.prototype.toLocaleTimeString`, `Date.prototype.toLocaleTimeString`, `String.prototype.localeCompare`, `%TypedArray%.prototype.toLocaleString`
- 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 text that matches the BindingIdentifier nonterminal symbol.
- When processing strict mode code, the syntax of NumericLiteral must not be extended to include LegacyOctalIntegerLiteral and the syntax of DecimalIntegerLiteral must not be extended to include NonOctalDecimalIntegerLiteral as described in B.1.1.
- The SyntaxCharacter must not be extended to include LegacyOctalEscapeSequence as defined in B.1.2.
- When processing strict mode code, the extensions defined in 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 Realm Record of the 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 the properties of that 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 1: 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 this specification 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. Optional parameters (which are indicated with brackets: [ ]) or rest parameters (which are shown using the form «...name») are not included in the default argument count.

Note 2: For example, the function object that is the initial value of the map property of the Array prototype object is described under the subclause heading «Array.prototype.map (callbackFn [ , thisArg])» which shows the two named arguments callbackFn and thisArg, the latter being optional; therefore the value of the length property of that Function object is 1.

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 `Infinity` is `+∞` (see 6.1.6). This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

##### 18.1.2 NaN

The value of `NaN` is `NaN` (see 6.1.6). This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

##### 18.1.3 undefined

The value of `undefined` is `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 eval (x)

The `eval` function is the `%eval%` intrinsic object. When the `eval` function is called with one argument `x`, the following steps are taken:

1. Let `evalRealm` be the value of the `active function object`’s `[[Realm]]` internal slot.
2. Let \texttt{strictCaller} be \texttt{false}.
3. Let \texttt{directEval} be \texttt{false}.
4. Return \texttt{PerformEval(x, evalRealm, strictCaller, directEval)}.

### 18.2.1.1 Runtime Semantics: PerformEval( \texttt{x, evalRealm, strictCaller, direct} )

The abstract operation PerformEval with arguments \texttt{x, evalRealm, strictCaller, and direct} performs the following steps:

1. Assert: If \texttt{direct} is \texttt{false}, then \texttt{strictCaller} is also \texttt{false}.
2. If \texttt{Type(x)} is not String, return \texttt{x}.
3. Let \texttt{script} be the ECMAScript code that is the result of parsing \texttt{x}, interpreted as UTF-16 encoded Unicode text as described in 6.1.4, for the goal symbol \texttt{Script}. If the parse fails, throw a \texttt{SyntaxError} exception. If any early errors are detected, throw a \texttt{SyntaxError} or a \texttt{ReferenceError} exception, depending on the type of the error (but see also clause 16). Parsing and early error detection may be interweaved in an implementation dependent manner.
4. If \texttt{script} Contains \texttt{ScriptBody} is \texttt{false}, return \texttt{undefined}.
5. Let \texttt{body} be the \texttt{ScriptBody} of \texttt{script}.
6. If \texttt{strictCaller} is \texttt{true}, let \texttt{strictEval} be \texttt{true}.
7. Else, let \texttt{strictEval} be \texttt{IsStrict} of \texttt{script}.
8. Let \texttt{ctx} be the \texttt{running execution context}. If \texttt{direct} is \texttt{true}, \texttt{ctx} will be the \texttt{execution context} that performed the \texttt{direct eval}. If \texttt{direct} is \texttt{false}, \texttt{ctx} will be the \texttt{execution context} for the invocation of the \texttt{eval} function.
9. If \texttt{direct} is \texttt{true}, then
   a. Let \texttt{lexEnv} be \texttt{NewDeclarativeEnvironment(\texttt{ctx}'s\texttt{LexicalEnvironment})}.
   b. Let \texttt{varEnv} be \texttt{\texttt{ctx}'s\texttt{VariableEnvironment}}.
10. Else,
    a. Let \texttt{lexEnv} be \texttt{NewDeclarativeEnvironment(\texttt{evalRealm}.\texttt{[[GlobalEnv]])}.
    b. Let \texttt{varEnv} be \texttt{evalRealm.\texttt{[[GlobalEnv}}}.
11. If \texttt{strictEval} is \texttt{true}, let \texttt{varEnv} be \texttt{lexEnv}.
12. If \texttt{ctx} is not already suspended, suspend \texttt{ctx}.
13. Let \texttt{evalCtx} be a new ECMAScript code \texttt{execution context}.
14. Set the \texttt{evalCtx}'s \texttt{Realm} to \texttt{evalRealm}.
15. Set the \texttt{evalCtx}'s \texttt{ScriptOrModule} to \texttt{ctx}'s \texttt{ScriptOrModule}.
16. Set the \texttt{evalCtx}'s \texttt{VariableEnvironment} to \texttt{varEnv}.
17. Set the \texttt{evalCtx}'s \texttt{LexicalEnvironment} to \texttt{lexEnv}.
18. Push \texttt{evalCtx} on to the \texttt{execution context stack}; \texttt{evalCtx} is now the \texttt{running execution context}.
19. Let \texttt{result} be \texttt{EvalDeclarationInstantiation(body, varEnv, lexEnv, strictEval)}.
20. If \texttt{result.[[Type]]} is \texttt{normal}, then
    a. Let \texttt{result} be the result of evaluating \texttt{body}.
21. If \texttt{result.[[Type]]} is \texttt{normal} and \texttt{result.[[Value]]} is \texttt{empty}, then
    a. Let \texttt{result} be \texttt{NormalCompletion(\texttt{undefined})}.
22. Suspend \texttt{evalCtx} and remove it from the \texttt{execution context stack}.
23. Resume the context that is now on the top of the \texttt{execution context stack} as the \texttt{running execution context}.
24. Return \texttt{Completion(result)}.

**NOTE** The eval code cannot instantiate variable or function bindings in the variable environment of the calling context that invoked the eval if the calling context is evaluating formal parameter initializers or 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 \texttt{let}, \texttt{const}, or \texttt{class} declarations are always instantiated in a new LexicalEnvironment.

### 18.2.1.2 Runtime Semantics: EvalDeclarationInstantiation( \texttt{body, varEnv, lexEnv, strict} )

When the abstract operation EvalDeclarationInstantiation is called with arguments \texttt{body, varEnv, lexEnv, and strict}, the following steps are taken:

1. Let \texttt{varNames} be the \texttt{VarDeclaredNames} of \texttt{body}.
2. Let \( \text{varDeclarations} \) be the VarScopedDeclarations of \( \text{body} \).
3. Let \( \text{lexEnvRec} \) be \( \text{lexEnv}'s \ EnvironmentRecord \).
4. Let \( \text{varEnvRec} \) be \( \text{varEnv}'s \ EnvironmentRecord \).
5. If \( \text{strict} \) is \( \text{false} \), then
   a. If \( \text{varEnvRec} \) is a global \( \text{EnvironmentRecord} \), then
      i. For each name in \( \text{varNames} \), do
         1. If \( \text{varEnvRec} \).HasLexicalDeclaration(name) \( \text{is true} \), throw a \( \text{SyntaxError} \) exception.
         2. NOTE: \( \text{eval} \) will not create a global var declaration that would be shadowed by a global lexical declaration.
   b. Let \( \text{thisLex} \) be \( \text{lexEnv} \).
   c. Assert: the following loop will terminate.
   d. Repeat while \( \text{thisLex} \) is not the same as \( \text{varEnv} \),
      i. Let \( \text{thisEnvRec} \) be \( \text{thisLex}'s \ EnvironmentRecord \).
      ii. If \( \text{thisEnvRec} \) is not an object \( \text{EnvironmentRecord} \), then
           1. NOTE: The environment of with statements cannot contain any lexical declaration so it doesn’t need to be checked for \( \text{var/let} \) hoisting conflicts.
           2. For each name in \( \text{varNames} \), do
              a. If \( \text{thisEnvRec} \).HasBinding(name) \( \text{is true} \), then
                 i. Throw a \( \text{SyntaxError} \) exception.
              b. NOTE: A direct \( \text{eval} \) will not hoist var declaration over a like-named lexical declaration.
      iii. Let \( \text{thisLex} \) be \( \text{thisLex}'s \) outer environment reference.
6. Let \( \text{functionsToInitialize} \) be a new empty \( \text{List} \).
7. Let \( \text{declaredFunctionNames} \) be a new empty \( \text{List} \).
8. For each \( d \) in \( \text{varDeclarations} \), in reverse list order do
   a. If \( d \) is neither a \( \text{VariableDeclaration} \) or a \( \text{ForBinding} \), then
      i. Assert: \( d \) is either a \( \text{FunctionDeclaration} \) or a \( \text{GeneratorDeclaration} \).
      ii. NOTE If there are multiple \( \text{FunctionDeclarations} \) for the same name, the last declaration is used.
      iii. Let \( fn \) be the sole element of the \( \text{BoundNames} \) of \( d \).
      iv. If \( fn \) is not an element of \( \text{declaredFunctionNames} \), then
         1. If \( \text{varEnvRec} \) is a global \( \text{EnvironmentRecord} \), then
            a. Let \( fnDeifiable \) be \( ? \text{varEnvRec}.CanDeclareGlobalFunction(fn) \).
            b. If \( fnDeifiable \) is \( \text{false} \), throw a \( \text{TypeError} \) exception.
         2. Append \( fn \) to \( \text{declaredFunctionNames} \).
         3. Insert \( d \) as the first element of \( \text{functionsToInitialize} \).
9. NOTE: Annex \( \text{B.3.3.3} \) adds additional steps at this point.
10. Let \( \text{declaredVarNames} \) be a new empty \( \text{List} \).
11. For each \( d \) in \( \text{varDeclarations} \), do
    a. If \( d \) is a \( \text{VariableDeclaration} \) or a \( \text{ForBinding} \), then
      i. For each String vn in the \( \text{BoundNames} \) of \( d \), do
         1. If \( vn \) is not an element of \( \text{declaredFunctionNames} \), then
            a. If \( \text{varEnvRec} \) is a global \( \text{EnvironmentRecord} \), then
               i. Let \( vnDeifiable \) be \( ? \text{varEnvRec}.CanDeclareGlobalVar(vn) \).
               ii. If \( vnDeifiable \) is \( \text{false} \), throw a \( \text{TypeError} \) exception.
            b. If \( vn \) is not an element of \( \text{declaredVarNames} \), then
               i. Append \( vn \) to \( \text{declaredVarNames} \).
12. NOTE: No abnormal terminations occur after this algorithm step unless \( \text{varEnvRec} \) is a global \( \text{EnvironmentRecord} \) and the \( \text{global object} \) is a Proxy exotic object.
13. Let \( \text{lexDeclarations} \) be the LexicallyScopedDeclarations of \( \text{body} \).
14. For each element \( d \) in \( \text{lexDeclarations} \) do
    a. NOTE Lexically declared names are only instantiated here but not initialized.
    b. For each element \( dn \) of the \( \text{BoundNames} \) of \( d \) do
      i. If \( \text{IsConstantDeclaration} \) of \( d \) is \( \text{true} \), then
         1. Perform \( ? \text{varEnvRec}.CreateImmutableBinding(dn, true) \).
      ii. Else,
1. Perform \( \text{lexEnvRec}.\text{CreateMutableBinding}(dn, \text{false}) \).

15. For each production \( f \) in \( \text{functionsToInitialize} \), do
   a. Let \( fn \) be the sole element of the BoundNames of \( f \).
   b. Let \( fo \) be the result of performing \( \text{InstantiateFunctionObject} \) for \( f \) with argument \( \text{lexEnv} \).
   c. If \( \text{varEnvRec} \) is a global \( \text{Environment Record} \), then
      i. Perform \( \text{varEnvRec}.\text{CreateGlobalFunctionBinding}(fn, fo, \text{true}) \).
   d. Else,
      i. Let \( bindingExists \) be \( \text{varEnvRec}.\text{HasBinding}(fn) \).
         a. If \( bindingExists \) is false, then
            1. Let \( status \) be \( ! \text{varEnvRec}.\text{CreateMutableBinding}(fn, \text{true}) \).
            2. Assert: \( status \) is not an abrupt completion because of validation preceding step 12.
            3. Perform \( \text{varEnvRec}.\text{InitializeBinding}(fn, fo) \).
         b. Else,
            1. Perform \( ! \text{varEnvRec}.\text{SetMutableBinding}(fn, fo, \text{false}) \).

16. For each String \( vn \) in \( \text{declaredVarNames} \), in list order do
   a. If \( \text{varEnvRec} \) is a global \( \text{Environment Record} \), then
      i. Perform \( \text{varEnvRec}.\text{CreateGlobalVarBinding}(vn, \text{true}) \).
   b. Else,
      i. Let \( bindingExists \) be \( \text{varEnvRec}.\text{HasBinding}(vn) \).
         a. If \( bindingExists \) is false, then
            1. Let \( status \) be \( ! \text{varEnvRec}.\text{CreateMutableBinding}(vn, \text{true}) \).
            2. Assert: \( status \) is not an abrupt completion because of validation preceding step 12.
            3. Perform \( \text{varEnvRec}.\text{InitializeBinding}(vn, \text{undefined}) \).
         b. Else,
            1. Perform \( ! \text{varEnvRec}.\text{SetMutableBinding}(vn, fo, \text{false}) \).

17. Return NormalCompletion(\( \text{empty} \)).

NOTE An alternative version of this algorithm is described in B.3.5.

18.2.2 \( \text{isFinite} \) \( (\text{number}) \)

The \( \text{isFinite} \) function is the \%isFinite\% intrinsic object. When the \( \text{isFinite} \) function is called with one argument \( \text{number} \), the following steps are taken:

1. Let \( num \) be \( ? \text{ToNumber}(\text{number}) \).
2. If \( num \) is NaN, +\( \infty \), or -\( \infty \), return false.
3. Otherwise, return true.

18.2.3 \( \text{isNaN} \) \( (\text{number}) \)

The \( \text{isNaN} \) function is the \%isNaN\% intrinsic object. When the \( \text{isNaN} \) function is called with one argument \( \text{number} \), the following steps are taken:

1. Let \( num \) be \( ? \text{ToNumber}(\text{number}) \).
2. If \( num \) is NaN, return true.
3. 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 \( X \neq \text{NaN} \). The result will be true if and only if \( X \) is a NaN.

18.2.4 \( \text{parseFloat} \) \( (\text{string}) \)

The \( \text{parseFloat} \) function produces a Number value dictated by interpretation of the contents of the \( \text{string} \) argument as a decimal literal.

The \( \text{parseFloat} \) function is the \%parseFloat\% intrinsic object. When the \( \text{parseFloat} \) function is called with one argument \( \text{string} \), the following steps are taken:

1. Let \( \text{inputString} \) be \( ? \text{ToString}(\text{string}) \).
2. 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.

3. If neither `trimmedString` nor any prefix of `trimmedString` satisfies the syntax of a `StrDecimalLiteral` (see 7.1.3.1), return `NaN`.

4. Let `numberString` be the longest prefix of `trimmedString`, which might be `trimmedString` itself, that satisfies the syntax of a `StrDecimalLiteral`.

5. Let `mathFloat` be MV of `numberString`.

6. If `mathFloat` = 0, then
   a. If the first code unit of `trimmedString` is "-", return -0.
   b. Return +0.

7. 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 a 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 `0x` or `0X`, in which case a radix of 16 is assumed. If `radix` is 16, the number may also optionally begin with the code unit pairs `0x` or `0X`.

The `parseInt` function is the `%parseInt%` intrinsic object. When the `parseInt` function is called, the following steps are taken:

1. Let `inputString` be `? ToString(string)`.
2. Let `S` be a newly created substring of `inputString` consisting of the first code unit that is not a `StrWhiteSpaceChar` and all code units 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.

3. Let `sign` be 1.

4. If `S` is not empty and the first code unit of `S` is `0x002D` (HYPHEN-MINUS), let `sign` be -1.

5. If `S` is not empty and the first code unit of `S` is `0x002B` (PLUS SIGN) or `0x002D` (HYPHEN‑MINUS), remove the first code unit from `S`.

6. Let `R` be `? ToInt32(radix)`.
7. Let `stripPrefix` be `true`.

8. If `R` ≠ 0, then
   a. If `R` < 2 or `R` > 36, return `NaN`.
   b. If `R` is 16, let `stripPrefix` be `false`.

9. Else `R` = 0,
   a. Let `R` be 10.

10. 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` be 16.

11. If `S` contains a code unit 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`.

12. If `Z` is empty, return `NaN`.

13. 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.)

14. If `mathInt` = 0, then
    a. If `sign` = -1, return -0.
b. Return +0.
15. Let number be the Number value for mathInt.
16. Return sign × 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:

```
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**

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

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 kChar be the code unit value of the code unit at index k within string.
          3. If kChar is less than 0xDC00 or greater than 0xDFFF, throw a URIError exception.
          4. Let V be UTF16Decode(C, kChar).
      iii. Else,
          1. Increase k by 1.
      4. If k equals strLen, throw a URIError exception.
      5. Let kChar be the code unit value of the code unit at index k within string.
      6. If kChar is less than 0xDC00 or greater than 0xDFFF, throw a URIError exception.
      7. Let V be UTF16Decode(C, kChar).
   iv. Let Octets be the array of octets resulting by applying the UTF-8 transformation to V, and let L be the array size.
   v. Let j be 0.
   vi. Repeat, while j < L
      1. Let jOctet be the value at 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 (string, reservedSet)

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.
   iv. Let \( B \) be the 8-bit value represented by the two hexadecimal digits at index \( (k + 1) \) and \( (k + 2) \).
   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 \( V \leq 0x10000 \), 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 \(((V \cdot 0x10000) \& 0x3FF) + 0xDC00\).
     b. Let \( H \) be \(((V \cdot 0x10000) >> 10) \& 0x3FF) + 0xD800\).
     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 \( n \geq 1 \) octets, the initial octet has the \( n \) higher-order bits set to 1, followed by a bit set to 0. The remaining bits of that octet contain bits from the value of the character to be encoded. The following octets all have the higher-order bit set to 1 and the following bit set to 0, leaving 6 bits in each to contain bits from the character to be encoded. The possible UTF-8 encodings of ECMAScript characters are specified in Table 44.

<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 0zzzzzzz</td>
<td>0zzzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0080 - 0x07FF</td>
<td>00000yy yyyyyyyyy</td>
<td>10yyyyy 10zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0800 - 0xD7FF</td>
<td>xxxyyyy yyyyyyyyy</td>
<td>1110xxx 10yyyyy 10zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xD800 - 0xDBFF followed by 0xDC00 - 0xDFFF</td>
<td>1110110v vvvwwwxxxx</td>
<td>11110uuu 10uuwww 10xyyyy 10zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xD800 - 0xDBFF not followed by 0xDC00 - 0xDFFF</td>
<td>causes URIError</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xDC00 - 0xDFFF</td>
<td>causes URIError</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xE000 - 0xFFFF</td>
<td>xxxyyyyy yyyyyyyyy</td>
<td>1110xxx 10yyyyy 10zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where

\[ uuuuu = vvvv + 1 \]

to account for the addition of 0x10000 as in Surrogates, section 3.8, 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 0x0000. 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.

The `decodeURI` function is the `%decodeURI%` intrinsic object. When the `decodeURI` function is called with one argument `encodedURI`, the following steps are taken:

1. Let `uriString` be `ToString(encodedURI)`.
2. Let `reservedURISet` be a String containing one instance of each code unit valid in `uriReserved` plus "#".
3. Return `Decode(uriString, reservedURISet)`.

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.

The `decodeURIComponent` function is the `%decodeURIComponent%` intrinsic object. When the `decodeURIComponent` function is called with one argument `encodedURIComponent`, the following steps are taken:

1. Let `componentString` be `ToString(encodedURIComponent)`.
2. Let `reservedURIComponentSet` be the empty String.
3. Return `Decode(componentString, reservedURIComponentSet)`.

18.2.6.4 `encodeURI(uri)`

The `encodeURI` function computes a new version of a 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.

The `encodeURI` function is the `%encodeURI%` intrinsic object. When the `encodeURI` function is called with one argument `uri`, the following steps are taken:

1. Let `uriString` be `ToString(uri)`.
2. Let `unescapedURISet` be a String containing one instance of each code unit valid in `uriReserved` and `uriUnescaped` plus `"#"`.
3. Return `Encode(uriString, unescapedURISet)`.

NOTE The code unit `"#"` 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 a 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.

The `encodeURIComponent` function is the `%encodeURIComponent%` intrinsic object. When the `encodeURIComponent` function is called with one argument `uriComponent`, the following steps are taken:

1. Let `componentString` be `ToString(uriComponent)`.
2. Let `unescapedURIComponentSet` be a String containing one instance of each code unit valid in `uriUnescaped`.
3. 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 (…)

See 22.2.4.

18.3.12 Int16Array (…)

See 22.2.4.

18.3.13 Int32Array (…)

See 22.2.4.

18.3.14 Map (…)

See 23.1.1.

18.3.15 Number (…)

See 20.1.1.

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 (…)  
See 23.2.1.

18.3.23 String (…)  
See 21.1.1.

18.3.24 Symbol (…)  
See 19.4.1.

18.3.25 SyntaxError (…)  
See 19.5.5.4.

18.3.26 TypeError (…)  
See 19.5.5.5.

18.3.27 Uint8Array (…)  
See 22.2.4.

18.3.28 Uint8ClampedArray (…)  
See 22.2.4.

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 a 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 Object ([value])

When Object function is called with optional argument value, the following steps are taken:

1. If NewTarget is neither 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).

The length property of the Object constructor function is 1.

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, 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. If only one argument was passed, return to.
3. Let sources be the List of argument values starting with the second argument.
4. For each element nextSource of sources, in ascending index order,
   a. If nextSource is undefined or null, let keys be a new empty List.
   b. Else,
      i. Let from be ToObject(nextSource).
      ii. Let keys be ? from.[[OwnPropertyKeys]]().
   c. Repeat for each element nextKey of keys in List order,
      i. Let desc be ? from.[[GetOwnProperty]](nextKey).
      ii. If desc is not undefined and desc.[[Enumerable]] is true, then
         1. Let propValue be ? Get(from, nextKey).
         2. Perform ? Set(to, nextKey, propValue, true).
5. 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 neither Object nor Null, throw a **TypeError** exception.
2. Let obj be ObjectCreate(O).
3. If Properties is not undefined, then
4. Return obj.

19.1.2.3 Object.defineProperty (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:


19.1.2.3.1 Runtime Semantics: ObjectDefineProperties (O, Properties)

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 ? props.[[OwnPropertyKeys]]().
4. Let descriptors be a new empty List.
5. Repeat for each element nextKey of keys in List order,
   a. Let propDesc be ? props.[[GetOwnProperty]](nextKey).
   b. If propDesc is not undefined and propDesc.[[Enumerable]] is true, then
      i. Let descObj be ? Get(props, nextKey).
      ii. Let desc be ? ToPropertyDescriptor(descObj).
      iii. Append the pair (two element List) consisting of nextKey and desc to the end of descriptors.
6. 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.
7. 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. Let desc be ? ToPropertyDescriptor(Attributes).
5. 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 ? SetIntegrityLevel(O, "frozen").
3. If status is false, throw a **TypeError** exception.
4. 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. Let `key` be `ToPropertyDescriptor`(P).
3. Let `desc` be `obj`.[[GetOwnProperty]]([key]).
4. Return `FromPropertyDescriptor(desc)`. 

19.1.2.7 **Object.getOwnPropertyNames**( O )

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

1. Return `GetOwnPropertyNames(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 `GetOwnPropertySymbols(O, Symbol)`. 

19.1.2.8.1 Runtime Semantics: `GetOwnPropertyKeys`( O, Type )

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. Let `keys` be `obj`.[[GetOwnPropertyKeys]]().
3. Let `nameList` be a new empty `List`.
4. Repeat for each element `nextKey` of `keys` in `List` order,
   a. If `Type(nextKey)` is `Type`, then
      i. Append `nextKey` as the last element of `nameList`.
5. 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. Return `obj`.[[GetPrototypeOf]]().

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 `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")`. 

Object.getOwnPropertyDescriptor( O, P )

19.1.2.6
When the `getOwnPropertyDescriptor` function is called, the following steps are taken:

1. Let `obj` be `ToObject`(O).
2. Let `key` be `ToPropertyDescriptor`(P).
3. Let `desc` be `obj`.[[GetOwnProperty]]([key]).
4. Return `FromPropertyDescriptor(desc)`.

Object.getOwnPropertyNames( O )

19.1.2.7
When the `getOwnPropertyNames` function is called, the following steps are taken:

1. Return `GetOwnPropertyNames(O, String)`.

Object.getOwnPropertySymbols( O )

19.1.2.8
When the `getOwnPropertySymbols` function is called with argument `O`, the following steps are taken:

1. Return `GetOwnPropertySymbols(O, Symbol)`.

Object.getOwnPropertyKeys( O, Type )

19.1.2.8.1
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. Let `keys` be `obj`.[[GetOwnPropertyKeys]]().
3. Let `nameList` be a new empty `List`.
4. Repeat for each element `nextKey` of `keys` in `List` order,
   a. If `Type(nextKey)` is `Type`, then
      i. Append `nextKey` as the last element of `nameList`.
5. Return `CreateArrayFromList(nameList)`.

Object.getPrototypeOf( O )

19.1.2.9
When the `getPrototypeOf` function is called with argument `O`, the following steps are taken:

1. Let `obj` be `ToObject`(O).
2. Return `obj`.[[GetPrototypeOf]]().

Object.is( value1, value2 )

19.1.2.10
When the `is` function is called with arguments `value1` and `value2`, the following steps are taken:

1. Return `SameValue(value1, value2)`.

Object.isExtensible( O )

19.1.2.11
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 `isExtensible(O)`.

Object.isFrozen( O )

19.1.2.12
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. Let namelist be ? EnumerableOwnNames(obj).
3. 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 3.

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 ? O.[[PreventExtensions]]().
3. If status is false, throw a TypeError exception.
4. Return O.

19.1.2.16  Object.prototype

The initial value of Object.prototype is the intrinsic object %ObjectPrototype%.

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 ? SetIntegrityLevel(O, "sealed").
3. If status is false, throw a TypeError exception.
4. 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 ? RequireObjectCoercible(O).
2. If Type(proto) is neither Object nor Null, throw a TypeError exception.
3. If Type(O) is not Object, return O.
5. If status is false, throw a TypeError exception.
6. Return O.

19.1.3  Properties of the Object Prototype Object

The Object prototype object is the intrinsic object %ObjectPrototype%. The Object prototype object is an immutable prototype exotic 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. Let `O` be `? ToObject(this value)`.  
3. Return `? HasOwnProperty(O, P)`.

NOTE The ordering of steps 1 and 2 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the `this` value is `undefined` or `null`.

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 `? ToObject(this value)`.  
3. Repeat  
   a. Let `V` be `V.[[GetPrototypeOf]]()`.  
   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. Let `O` be `? ToObject(this value)`.  
3. Let `desc` be `O.[[GetOwnProperty]](P)`.  
4. If `desc` is `undefined`, return `false`.  
5. Return the value of `desc.[[Enumerable]]`.

NOTE 1 This method does not consider objects in the prototype chain.

NOTE 2 The ordering of steps 1 and 2 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the `this` value is `undefined` or `null`.

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 `? 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.
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 `ToObject`(this value).
4. Let is\( Array \) be \( !IsArray(O) \).
5. If is\( Array \) is `true`, let builtin\( Tag \) be "Array".
6. Else, if \( O \) is an exotic String object, let builtin\( Tag \) be "String".
7. Else, if \( O \) has an \[ParameterMap\] internal slot, let builtin\( Tag \) be "Arguments".
8. Else, if \( O \) has a [[Call]] internal method, let builtin\( Tag \) be "Function".
9. Else, if \( O \) has an [[ErrorData]] internal slot, let builtin\( Tag \) be "Error".
10. Else, if \( O \) has a [[BooleanData]] internal slot, let builtin\( Tag \) be "Boolean".
11. Else, if \( O \) has a [[NumberData]] internal slot, let builtin\( Tag \) be "Number".
12. Else, if \( O \) has a [[DateValue]] internal slot, let builtin\( Tag \) be "Date".
13. Else, if \( O \) has a [[RegExpMatcher]] internal slot, let builtin\( Tag \) be "RegExp".
14. Else, let builtin\( Tag \) be "Object".
15. Let tag be ? Get\( (O, @@toStringTag) \).
16. If Type\( (tag) \) is not String, let tag be builtin\( Tag \).
17. Return the String that is the result of concatenating "[object ", tag, and "]".

This function is the %ObjProto_toString% intrinsic object.

**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.

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

1. Return ? `ToObject`(this value).

This function is the %ObjProto_valueOf% intrinsic object.

### 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 ECMA Script 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:

```javascript
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 Runtime Semantics: 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 `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 `GeneratorBody`.
   b. Let `parameterGoal` be the grammar symbol `FormalParameters`[Y1e1d]·
   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. Let `k` be 1.
   d. Repeat, while `k < argCount - 1`
      i. Let `nextArg` be `args[k]`.
      ii. Let `nextArgString` be `? ToString(nextArg)`.
      iii. Let `P` be the result of concatenating the previous value of `P`, the string ", , " (a comma), and `nextArgString`.
      iv. Increase `k` by 1.
   e. Let `bodyText` be `args[k]`.
9. Let `bodyText` be `? ToString(bodyText)`.
10. 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.
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.
12. If `bodyText` is strict mode code, then let `strict` be true, else let `strict` be false.
13. If any static semantics errors are detected for `parameters` or `body`, throw a SyntaxError or a ReferenceError exception, depending on the type of the error. If `strict` is true, the Early Error rules for StrictFormalParameters : FormalParameters are applied. Parsing and early error detection may be interweaved in an implementation dependent manner.
14. If ContainsUseStrict of `body` is true and IsSimpleParameterList of `parameters` is false, throw a SyntaxError exception.
15. If any element of the BoundNames of `parameters` also occurs in the LexicallyDeclaredNames of `body`, throw a SyntaxError exception.
16. If `body` Contains SuperCall is true, throw a SyntaxError exception.
17. If `parameters` Contains SuperCall is true, throw a SyntaxError exception.
18. If `body` Contains SuperProperty is true, throw a SyntaxError exception.
19. If `parameters` Contains SuperProperty is true, throw a SyntaxError exception.
20. If `kind` is "generator", then
   a. If `parameters` Contains YieldExpression is true, throw a SyntaxError exception.
21. If `strict` is true, then
   a. If BoundNames of `parameters` contains any duplicate elements, throw a SyntaxError exception.
22. Let `proto` be ? GetPrototypeFromConstructor (newTarget, fallbackProto).
23. Let `F` be FunctionAllocate (proto, strict, kind).
24. Let `realmF` be the value of `F`'s [[Realm]] internal slot.
25. Let `scope` be `realmF`. [[GlobalEnv]].
26. Perform FunctionInitialize (`F`, Normal, `parameters`, `body`, `scope`).
27. If `kind` is "generator", then
   a. Let `prototype` be ObjectCreate (%GeneratorPrototype%).
   b. Perform DefinePropertyOrThrow (`F`, "prototype", PropertyDescriptor ([[Value]]: `prototype`, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false)).
28. Else, perform MakeConstructor (`F`).
29. Perform SetFunctionName (`F`, "anonymous").
30. 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 itself is a built-in function object. The value of the [[Prototype]] internal slot of the Function constructor is the intrinsic object %FunctionPrototype%.

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.

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 the intrinsic object %FunctionPrototype%. 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 ECMAScript 2015 specification.

The value of the [[Prototype]] internal slot of the Function prototype object is the intrinsic object %ObjectPrototype%. 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. Perform PrepareForTailCall().
   b. Return ? Call(func, thisArg).
3. Let argList be ? CreateListFromArrayLike(argArray).
4. Perform PrepareForTailCall().
5. Return ? Call(func, thisArg, argList).

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 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.

19.2.3.2 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 IsCallable(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. If targetHasLength is true, then
   a. Let targetLen be ? Get(Target, "length").
   b. If Type(targetLen) is not Number, let L be 0.
   c. 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.
7. Else let L be 0.
8. Perform ! DefinePropertyOrThrow(F, "length", PropertyDescriptor {[[Value]]: L, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true}).
9. Let targetName be ? Get(Target, "name").
10. If Type(targetName) is not String, let targetName be the empty string.
11. Perform SetFunctionName(F, targetName, "bound").
12. Return F.

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 IsCallable(func) is false, throw a TypeError exception.
2. Let argList be a new 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).

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 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 `? 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 }.

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 27. Function instances created using the `Function.prototype.bind` method (19.2.3.2) have the internal slots listed in Table 28.

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 the object created when that function is invoked as a constructor.

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. Set the value of O's [[BooleanData]] internal slot to b.
5. 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%.

The Boolean constructor has the following properties:

#### 19.3.2.1 Boolean.prototype

The initial value of Boolean.prototype is the intrinsic object %BooleanPrototype%.

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 the intrinsic object %BooleanPrototype%. The Boolean prototype object is an ordinary object. The Boolean prototype is itself a Boolean object; it has a [[BooleanData]] internal slot with the value false.

The value of the [[Prototype]] internal slot of the Boolean prototype object is the intrinsic object %ObjectPrototype%.

#### 19.3.3.1 thisBooleanValue ( value )

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.

#### 19.3.3.2 Boolean.prototype.constructor

The initial value of Boolean.prototype.constructor is the intrinsic object %Boolean%.

#### 19.3.3.3 Boolean.prototype.toString ()

The following steps are taken:

1. Let b be ? thisBooleanValue(this value).
2. If b is true, return "true"; else return "false".
The following steps are taken:

1. Return \texttt{? 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 \texttt{[[BooleanData]]} internal slot. The \texttt{[[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 \texttt{Symbol} property of the \texttt{global object}. When \texttt{Symbol} is called as a function, it returns a new Symbol value.

The \texttt{Symbol} constructor is not intended to be used with the \texttt{new} operator or to be subclassed. It may be used as the value of an \texttt{extends} clause of a class definition but a \texttt{super} call to the \texttt{Symbol} constructor will cause an exception.

#### 19.4.1.1 Symbol ([ \textit{description} ])

When \texttt{Symbol} is called with optional argument \textit{description}, the following steps are taken:

1. If \texttt{NewTarget} is not \texttt{undefined}, throw a \texttt{TypeError} exception.
2. If \textit{description} is \texttt{undefined}, let \texttt{descString} be \texttt{undefined}.
3. Else, let \texttt{descString} be \texttt{? ToString(description)}.
4. Return a new unique Symbol value whose \texttt{[[Description]]} value is \texttt{descString}.

#### 19.4.2 Properties of the Symbol Constructor

The value of the \texttt{[[Prototype]]} internal slot of the Symbol constructor is the intrinsic object %FunctionPrototype%.

The Symbol constructor has the following properties:

#### 19.4.2.1 Symbol.\texttt{for} ( \textit{key} )

When \texttt{Symbol.\texttt{for}} is called with argument \textit{key} it performs the following steps:

1. Let \texttt{stringKey} be \texttt{? ToString(key)}.
2. For each element \textit{e} of the GlobalSymbolRegistry \texttt{List},
   a. If \texttt{SameValue(e.\texttt{[[Key]]}, stringKey)} is \texttt{true}, return \textit{e.\texttt{[[Symbol]]]}.
3. Assert: GlobalSymbolRegistry does not currently contain an entry for \texttt{stringKey}.
4. Let \texttt{newSymbol} be a new unique Symbol value whose \texttt{[[Description]]} value is \texttt{stringKey}.
5. Append the \texttt{Record} \{ \texttt{[[Key]]: stringKey, \texttt{[[Symbol]]: newSymbol}} \} to the GlobalSymbolRegistry \texttt{List}.
6. Return \texttt{newSymbol}.

The GlobalSymbolRegistry is a \texttt{List} that is globally available. It is shared by all realms. Prior to the evaluation of any ECMAScript code it is initialized as a new empty \texttt{List}. Elements of the GlobalSymbolRegistry are Records with the structure defined in \texttt{Table 45}.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{[[Key]]}</td>
<td>A String</td>
<td>A string key used to globally identify a Symbol.</td>
</tr>
<tr>
<td>\texttt{[[Symbol]]}</td>
<td>A Symbol</td>
<td>A symbol that can be retrieved from any \texttt{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 intrinsic object `%SymbolPrototype%`.

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 the intrinsic object `%SymbolPrototype%`. 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%`.

19.4.3.1 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 Runtime Semantics: `SymbolDescriptiveString(s)`

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 `sym`'s [[Description]] value.
3. If `desc` is `undefined`, let `desc` be the empty string.
4. Assert: `Type(desc)` is String.
5. Return the result of concatenating the strings "Symbol(", `desc`, and ")".

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 ECMA-Script language operators to convert a Symbol 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 subclicable. 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. 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}.
4. 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%.

The Error constructor has the following properties:

### 19.5.2.1 Error.prototype

The initial value of Error.prototype is the intrinsic object %ErrorPrototype%.

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 the intrinsic object %ErrorPrototype%. 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%.

### 19.5.3.1 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 ? Get(O, "name").
4. If name is undefined, let name be "Error"; otherwise let name be ? ToString(name).
5. Let msg be ? Get(O, "message").
6. If msg is undefined, let msg be the empty String; otherwise let msg be ? ToString(msg).
7. If name is the empty String, return msg.
8. If msg is the empty String, return name.
9. Return the result of concatenating name, the code unit 0x003A (COLON), the code unit 0x0020 (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 value is undefined. The only specified uses of [[ErrorData]] is to identify Error and NativeError instances 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

TypeError is used to indicate an unsuccessful operation when none of the other NativeError objects are an appropriate indication of the failure cause.

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. 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}.
4. 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%.
Each NativeError constructor has a name property whose value is the String value "NativeError".

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 distinct 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%.

19.5.6.3.1 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 value is undefined. The only specified use of [[ErrorData]] is by Object.prototype.toString (19.1.3.6) to identify Error or NativeError instances.

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. If NewTarget is `undefined`, return `n`.
4. Let `O` be ` OrdinaryCreateFromConstructor(NewTarget, "%NumberPrototype%"); « [[NumberData]] ».
5. Set the value of `O`'s `[[NumberData]]` internal slot to `n`.
6. 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%`.

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 `2.220446049250313080847263361816 x 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) in 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
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.

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

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 754-2008 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 }. 

The value of Number.MAX_SAFE_INTEGER is $9007199254740991$ ($2^{53} - 1$).
20.1.2.15 Number.prototype

The initial value of `Number.prototype` is the intrinsic object `%NumberPrototype%`.

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 the intrinsic object `%NumberPrototype%`. The Number prototype object is an ordinary object. The Number prototype is itself a Number object; it has a [[NumberData]] internal slot with the value +0.

The value of the [[Prototype]] internal slot of the Number prototype object is the intrinsic object `%ObjectPrototype%`.

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. Let `f` be `? ToInteger(fractionDigits)`.
3. Assert: `f` is 0, when `fractionDigits` is `undefined`.
4. If `x` is `NaN`, return the String "NaN".
5. Let `s` be the empty String.
6. If `x < 0`, then
   a. Let `s` be "-".
   b. Let `x` be `-x`.
7. If `x = +\infty`, then
   a. Return the concatenation of the Strings `s` and "Infinity".
8. 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.
9. If `x = 0`, then
   a. Let `m` be the String consisting of `f+1` occurrences of the code unit 0x0030 (DIGIT ZERO).
   b. Let `e` be 0.
10. Else `x ≠ 0`,
    a. If `fractionDigits` is not `undefined`, then
The following steps are performed:

NOTE 1 If the toExponential method is called with more than one argument, then the behaviour is undefined (see clause 17).

1. Let e and n be integers such that $10^f \leq n < 10^{f+1}$ and for which the exact mathematical value of $n \times 10^{e+f} \cdot x$ is as close to zero as possible. If there are two such sets of e and n, pick the e and n for which $n \times 10^{e+f}$ is larger.

b. Else fractionDigits is undefined,
   
i. Let e, n, and f be integers such that $f \geq 0$, $10^f \leq n < 10^{f+1}$, the Number value for $n \times 10^{e+f}$ is x, and f is as small as possible. Note that the decimal representation of n has f+1 digits, n is not divisible by 10, and the least significant digit of n is not necessarily uniquely determined by these criteria.

c. Let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes).

11. 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.

12. If e = 0, then
   a. Let c be " + ".
   b. Let d be " 0 ".

13. Else,
   a. If e > 0, let c be " + ".
   b. Else e ≤ 0,
      i. Let c be " - ".
      ii. Let e be -e.
   c. Let d be the String consisting of the digits of the decimal representation of e (in order, with no leading zeroes).

14. Let m be the concatenation of the four Strings m, " e " , c, and d.

15. Return the concatenation of the Strings s and m.

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 10.b.i be used as a guideline:

1. Let e, n, and f be integers such that $f \geq 0$, $10^f \leq n < 10^{f+1}$, the Number value for $n \times 10^{e+f}$ is x, and f is as small as possible. If there are multiple possibilities for n, choose the value of n for which $n \times 10^{e+f}$ is closest in value to x. If there are two such possible values of n, choose the one that is even.

20.1.3.3 Number.prototype.toFixed (fractionDigits )

NOTE 1 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. Let f be ? ToInteger(fractionDigits). (If fractionDigits is undefined, this step produces the value 0.)
3. 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.
4. If x is NaN, return the String " NaN ".
5. Let s be the empty String.
6. If x < 0, then
   a. Let s be " - ".
   b. Let x be -x.
7. If x ≥ 10^21, then
   a. Let m be ! ToString(x).
8. Else x < 10^21,
   a. Let n be an integer for which the exact mathematical value of $n + 10^f \cdot x$ 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 \( 0x0030 \) (DIGIT ZERO).
      2. Let \( m \) be the concatenation of Strings \( z \) and \( m \).
      3. Let \( k \) be \( f + 1 \).
   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 \( b \).
9. Return the concatenation of the Strings \( s \) and \( m \).

If the `toFixed` method is called with more than one argument, then the behaviour is undefined (see clause 17).

NOTE 2  The output of `toFixed` may be more precise than `toString` for some values because `toString` only prints enough significant digits to distinguish the number from adjacent number values. For example,

\[
(1000000000000000128).toString() \text{ returns } "1000000000000000100", \text{ while }
(1000000000000000128).toFixed(0) \text{ returns } "1000000000000000128".
\]

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.

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` instead. Specifically, perform the following steps:

1. Let \( x \) be \(?thisNumberValue(\text{this value})\).
2. If `precision` is `undefined`, return `!ToString(x)`.
3. Let \( p \) be `?ToInteger(precision)`.
4. If \( x \) is `NaN`, return the String "NaN".
5. Let \( s \) be the empty String.
6. If \( x < 0 \), then
   a. Let \( s \) be code unit `0x002D` (HYPHEN-MINUS).
   b. Let \( x \) be `-x`.
7. If \( x = +\infty \), then
   a. Return the String that is the concatenation of \( s \) and "Infinity".
8. 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.
9. If \( x = 0 \), then
   a. Let \( m \) be the String consisting of \( p \) occurrences of the code unit `0x0030` (DIGIT ZERO).
   b. Let \( e \) be \( 0 \).
10. Else \( x \neq 0 \),
    a. Let \( e \) and \( n \) be integers such that \( 10^{p-1} \leq n < 10^p \) and for which the exact mathematical value of \( n \times 10^{e-p+1} - x \) is as close to zero as possible. If there are two such sets of \( e \) and \( n \), pick the \( e \) and \( n \) for which \( n \times 10^{e-p+1} \) is larger.
b. Let $m$ be the String consisting of the digits of the decimal representation of $n$ (in order, with no leading zeroes).
c. If $e < -6$ or $e \geq p$, then
   i. 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 $a$, ".", and $b$.
   iv. If $e > 0$, then
      1. Let $c$ be code unit 0x002B (PLUS SIGN).
   v. Else $e < 0$,
      1. Let $c$ be code unit 0x002D (HYPHEN-MINUS).
      2. Let $e$ be $-e$.
   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 0x0065 (LATIN SMALL LETTER E), $c$, and $d$.
11. If $e = p-1$, return the concatenation of the Strings $s$ and $m$.
12. If $e \geq 0$, then
   a. Let $m$ be the concatenation of the first $e+1$ elements of $m$, the code unit 0x002E (FULL STOP), and the remaining $p-(e+1)$ elements of $m$.
13. Else $e < 0$,
   a. Let $m$ be the String formed by the concatenation of code unit 0x0030 (DIGIT ZERO), code unit 0x002E (FULL STOP), $(e+1)$ occurrences of code unit 0x0030 (DIGIT ZERO), and the String $m$.
14. Return the String that is the concatenation of $s$ and $m$.

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 radix should be an integer value in the inclusive range 2 to 36. If radix not present or is undefined the Number 10 is used as the value of radix.

The following steps are performed:

1. Let $x$ be ?thisNumberValue(this value).
2. If radix is not present, let radixNumber be 10.
3. Else if radix is undefined, let radixNumber be 10.
4. Else let radixNumber be ?ToInteger(radix).
5. If radixNumber < 2 or radixNumber > 36, throw a RangeError exception.
6. If radixNumber = 10, return !ToString($x$).
7. Return the String representation of this Number value using the radix specified by `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.

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

### 20.1.3.7 Number.prototype.valueOf()

1. Return ?thisNumberValue(this value).

### 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 the `%Math%` intrinsic object and the initial value of the `Math` property of the `global 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%`.

The Math object 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 }.
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.

#### 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 $+\infty$, the result is $+\infty$.

### 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 $-\pi/2$ to $+\pi/2$.

- If $x$ is NaN, the result is NaN.
- If $x$ is greater than 1, the result is NaN.
- If $x$ is less than -1, the result is NaN.
- If $x$ is $+0$, the result is $+0$.
- If $x$ is $-0$, the result is $-0$.

### 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 $+\infty$.
- 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 $x$ is $+0$, the result is an implementation-dependent approximation to $+\pi/2$.
- If $y > 0$ and $x$ is $-0$, the result is an implementation-dependent approximation to $+\pi/2$.
- If $y$ is $+0$ and $x > 0$, the result is $+0$.
- If $y$ is $+0$ and $x$ is $+0$, the result is $+0$.
If \( y \) is +0 and \( x \) is -0, the result is an implementation-dependent approximation to +π.

If \( y \) is +0 and \( x \lt 0 \), the result is an implementation-dependent approximation to +π.

If \( y \) is -0 and \( x \gt 0 \), the result is -0.

If \( y \) is -0 and \( x \gt 0 \), the result is an implementation-dependent approximation to -π.

If \( y \lt 0 \) and \( x \gt 0 \), the result is an implementation-dependent approximation to -π/2.

If \( y \lt 0 \) and \( x \) is finite and \( x \lt 0 \), the result is an implementation-dependent approximation to -π/2.

If \( y \gt 0 \) and \( y \) is finite and \( x \) is +∞, the result is 0.

If \( y \gt 0 \) and \( y \) is finite and \( x \) is -∞, the result is an implementation-dependent approximation to +π.

If \( y \lt 0 \) and \( y \) is finite and \( x \) is +∞, the result is an implementation-dependent approximation to -π/4.

If \( y \lt 0 \) and \( y \) is finite and \( x \) is -∞, the result is an implementation-dependent approximation to -3π/4.

\[ \text{Math.cbrt}(x) \]

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 +∞, the result is +∞.
- If \( x \) is -∞, the result is -∞.

\[ \text{Math.ceil}(x) \]

Returns the smallest (closest to -∞) 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 +∞, the result is +∞.
- If \( x \) is -∞, the result is -∞.

The value of \( \text{Math.ceil}(x) \) is the same as the value of \(-\text{Math.floor}(-x)\).

\[ \text{Math.clz32}(x) \]

When \( \text{Math.clz32} \) is called with one argument \( x \), the following steps are taken:

1. Let \( n \) be \( \text{ToUint32}(x) \).
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.

\[ \text{Math.cos}(x) \]

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 +\( \infty \), the result is +\( \infty \).
- If \( x \) is -\( \infty \), the result is +\( \infty \).

**NOTE** The value of \( \text{cosh}(x) \) is the same as \((e^x + e^{-x})/2\).

**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 +\( \infty \), the result is +\( \infty \).
- If \( x \) is -\( \infty \), 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 0.

- If \( x \) is \( NaN \), the result is \( NaN \).
- If \( x \) is +0, the result is +0.
- If \( x \) is -0, the result is -0.
- If \( x \) is +\( \infty \), the result is +\( \infty \).
- If \( x \) is -\( \infty \), the result is -1.

**20.2.2.16 Math.floor \( (x) \)**

Returns the greatest (closest to +\( \infty \)) Number value that is not greater than \( x \) and is equal to a mathematical integer. If \( x \) is already an integer, the result is \( x \).

- If \( x \) is \( NaN \), the result is \( NaN \).
- If \( x \) is +0, the result is +0.
- If \( x \) is -0, the result is -0.
- If \( x \) is +\( \infty \), the result is +\( \infty \).
- If \( x \) is -\( \infty \), the result is -\( \infty \).
- If \( x \) is greater than 0 but less than 1, the result is +0.

**NOTE** The value of \( \text{Math.floor}(x) \) is the same as the value of \( -\text{Math.ceil}(-x) \).

**20.2.2.17 Math.fround \( (x) \)**

When \( \text{Math.fround} \) 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 \(+0\), the result is \(+0\).
- 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 \(+0\).

**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 \((a \times b) \mod 2^{32}\).
4. If \( product \geq 2^{31} \), 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 -∞.
- If x is -0, the result is -∞.
- If x is 1, the result is +0.
- If x is +∞, the result is +∞.

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 -∞.
- 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 except that +0 is considered to be larger than -0.

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 +∞.
- 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 except that +0 is considered to be larger than -0.

20.2.2.26 Math.pow( base, exponent )

1. Return the result of Applying the ** operator with base and exponent as specified in 12.7.3.4.

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 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 +∞. 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 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 +∞ or -∞, 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 \( \frac{\exp(x) - \exp(-x)}{\exp(x) + \exp(-x)} \).

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 \( \text{NaN} \), the result is \( \text{NaN} \).
• 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). Note that, in every case, if any argument to one of these functions is \( \text{NaN} \), the result will be \( \text{NaN} \).

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 \( \text{NaN} \), 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
DaysInYear(y)
  = 365 if (y modulo 4) ≠ 0
  = 366 if (y modulo 4) = 0 and (y modulo 100) ≠ 0
  = 365 if (y modulo 100) = 0 and (y modulo 400) ≠ 0
  = 366 if (y modulo 400) = 0

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:

\[ \text{DayFromYear}(y) = 365 \times (y - 1970) + \left\lfloor \frac{(y - 1969)}{4} \right\rfloor - \left\lfloor \frac{(y - 1901)}{100} \right\rfloor + \left\lfloor \frac{(y - 1601)}{400} \right\rfloor \]

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:

\[ \text{InLeapYear}(t) = \begin{cases} 0 & \text{if DaysInYear(YearFromTime(t)) = 365} \\ 1 & \text{if DaysInYear(YearFromTime(t)) = 366} \end{cases} \]

20.3.1.4 Month Number

Months are identified by an integer in the range 0 to 11, inclusive. The mapping MonthFromTime(t) from a time value t to a month number is defined by:

\[ \text{MonthFromTime}(t) = \begin{cases} 0 & \text{if } 0 \leq \text{DayWithinYear}(t) < 31 \\ 1 & \text{if } 31 \leq \text{DayWithinYear}(t) < 59 + \text{InLeapYear}(t) \\ \text{if } 59 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 90 + \text{InLeapYear}(t) \\ \text{if } 90 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 120 + \text{InLeapYear}(t) \\ \text{if } 120 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 151 + \text{InLeapYear}(t) \\ \text{if } 151 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 181 + \text{InLeapYear}(t) \\ \text{if } 181 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 212 + \text{InLeapYear}(t) \\ \text{if } 212 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 243 + \text{InLeapYear}(t) \\ \text{if } 243 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 273 + \text{InLeapYear}(t) \\ \text{if } 273 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 304 + \text{InLeapYear}(t) \\ \text{if } 304 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 334 + \text{InLeapYear}(t) \\ \text{if } 334 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 365 + \text{InLeapYear}(t) \end{cases} \]

where

\[ \text{DayWithinYear}(t) = \text{Day}(t) - \text{DayFromYear}(\text{YearFromTime}(t)) \]

A month value of 0 specifies January; 1 specifies February; 2 specifies March; 3 specifies April; 4 specifies May; 5 specifies June; 6 specifies July; 7 specifies August; 8 specifies September; 9 specifies October; 10 specifies November; and 11 specifies December. Note that 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:

\[ \text{DateFromTime}(t) = \begin{cases} \text{DayWithinYear}(t) + 1 & \text{if MonthFromTime}(t) = 0 \\ \text{DayWithinYear}(t) - 30 & \text{if MonthFromTime}(t) = 1 \end{cases} \]
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 \( \text{WeekDay}(0) = 4 \), 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 \( \text{LocalTZA} \) measured in milliseconds which when added to UTC represents the local standard time. Daylight saving time is not reflected by \( \text{LocalTZA} \).

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 \( \text{DaylightSavingTA}(t) \), 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 LocalTime ( \( t \) )

The abstract operation LocalTime with argument \( t \) converts \( t \) from UTC to local time by performing the following steps:

1. Return \( t + \text{LocalTZA} + \text{DaylightSavingTA}(t) \).

20.3.1.10 UTC ( \( t \) )

The abstract operation UTC with argument \( t \) converts \( t \) from local time to UTC is defined by performing the following steps:

1. Return \( t - \text{LocalTZA} - \text{DaylightSavingTA}(t - \text{LocalTZA}) \).

NOTE UTC(\( \text{LocalTime}(t) \)) is not necessarily always equal to \( t \).

20.3.1.11 Hours, Minutes, Second, and Milliseconds

The following abstract operations are useful in decomposing time values:

\[
\begin{align*}
\text{HourFromTime}(t) &= \text{floor}(t / \text{msPerHour}) \mod \text{HoursPerDay} \\
\text{MinFromTime}(t) &= \text{floor}(t / \text{msPerMinute}) \mod \text{MinutesPerHour} \\
\text{SecFromTime}(t) &= \text{floor}(t / \text{msPerSecond}) \mod \text{SecondsPerMinute} \\
\text{msFromTime}(t) &= t \mod \text{msPerSecond}
\end{align*}
\]
where

\[
\begin{align*}
\text{HoursPerDay} &= 24 \\
\text{MinutesPerHour} &= 60 \\
\text{SecondsPerMinute} &= 60 \\
\text{msPerSecond} &= 1000 \\
\text{msPerMinute} &= 60000 = \text{msPerSecond} \times \text{SecondsPerMinute} \\
\text{msPerHour} &= 3600000 = \text{msPerMinute} \times \text{MinutesPerHour}
\end{align*}
\]

\[20.3.1.12 \text{ MakeTime (hour, min, sec, ms)}\]

The abstract operation MakeTime calculates a number of milliseconds from its four arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If \(\text{hour}\) is not finite or \(\text{min}\) is not finite or \(\text{sec}\) is not finite or \(\text{ms}\) is not finite, return \(\text{NaN}\).
2. Let \(h\) be \(\text{ToInteger(hour)}\).
3. Let \(m\) be \(\text{ToInteger(min)}\).
4. Let \(s\) be \(\text{ToInteger(sec)}\).
5. Let \(milli\) be \(\text{ToInteger(ms)}\).
6. Let \(t\) be \(h \times \text{msPerHour} + m \times \text{msPerMinute} + s \times \text{msPerSecond} + milli\), performing the arithmetic according to IEEE 754-2008 rules (that is, as if using the ECMAScript operators \(*\) and \(+\)).
7. Return \(t\).

\[20.3.1.13 \text{ MakeDay (year, month, date)}\]

The abstract operation MakeDay calculates a number of days from its three arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If \(\text{year}\) is not finite or \(\text{month}\) is not finite or \(\text{date}\) is not finite, return \(\text{NaN}\).
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 \(m \mod 12\).
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 \(\text{NaN}\).
8. Return \(\text{Day}(t) + dt - 1\).

\[20.3.1.14 \text{ MakeDate (day, time)}\]

The abstract operation MakeDate calculates a number of milliseconds from its two arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If \(\text{day}\) is not finite or \(\text{time}\) is not finite, return \(\text{NaN}\).
2. Return \(\text{day} \times \text{msPerDay} + \text{time}\).

\[20.3.1.15 \text{ TimeClip (time)}\]

The abstract operation TimeClip calculates a number of milliseconds from its argument, which must be an ECMAScript Number value. This operator functions as follows:

1. If \(\text{time}\) is not finite, return \(\text{NaN}\).
2. If \(\text{abs}(\text{time}) > 8.64 \times 10^{15}\), return \(\text{NaN}\).
3. Let \(\text{clippedTime}\) be \(\text{ToInteger(time)}\).
4. If \(\text{clippedTime}\) is -0, let \(\text{clippedTime}\) be +0.
5. Return \(\text{clippedTime}\).
The point of step 4 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.

20.3.1.16 Date Time String Format

ECMAScript defines a string interchange format for date-times based upon a simplification of the ISO 8601 Extended Format. The format is as follows: `YYYY-MM-DDTHH:mm:ss.sssZ`

Where the fields are as follows:

- **YYYY** is the decimal digits of the year 0000 to 9999 in the Gregorian calendar.
- **-** (hyphen) appears literally twice in the string.
- **MM** is the month of the year from 01 (January) to 12 (December).
- **DD** is the day of the month from 01 to 31.
- **T** "T" appears literally in the string, to indicate the beginning of the time element.
- **HH** is the number of complete hours that have passed since midnight as two decimal digits from 00 to 24.
- **:** (colon) appears literally twice in the string.
- **mm** is the number of complete minutes since the start of the hour as two decimal digits from 00 to 59.
- **ss** is the number of complete seconds since the start of the minute as two decimal digits from 00 to 59.
- **.** (dot) appears literally in the string.
- **sss** is the number of complete milliseconds since the start of the second as three decimal digits.
- **Z** is the time zone offset specified as "Z" (for UTC) or either "+" or "-" followed by a time expression `HH:mm`

This format includes date-only forms:

`YYYY`

`YYYY-MM`

`YYYY-MM-DD`

It also includes "date-time" forms that consist of one of the above date-only forms immediately followed by one of the following time forms with an optional time zone offset appended:

`THH:mm`

`THH:mm:ss`

`THH:mm:ss.sss`

All numbers must be base 10. If the **MM** or **DD** fields are absent "01" is used as the value. If the **HH**, **mm**, or **ss** fields are absent "00" is used as the value and the value of an absent **sss** field is "000". When the time zone offset is absent, date-only forms are interpreted as a UTC time and date-time forms are 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.

20.3.1.16.1 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.

Examples of extended years:

-283457-03-21T15:00:59.008Z  283458 B.C.
-000001-01-01T00:00:00Z  2 B.C.
+000000-01-01T00:00:00Z  1 B.C.
+000001-01-01T00:00:00Z  1 A.D.
+001970-01-01T00:00:00Z  1970 A.D.
+002009-12-15T00:00:00Z  2009 A.D.
+287396-10-12T08:59:00.992Z  287396 A.D.

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.

The length property of the Date constructor function is 7.

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. Let m be ?ToNumber(month).
   c. If date is supplied, let dt be ?ToNumber(date); else let dt be 1.
   d. If hours is supplied, let h be ?ToNumber(hours); else let h be 0.
   e. If minutes is supplied, let min be ?ToNumber(minutes); else let min be 0.
   f. If seconds is supplied, let s be ?ToNumber(seconds); else let s be 0.
   g. If ms is supplied, let milli be ?ToNumber(ms); else let milli be 0.
h. If $y$ is not NaN and $0 \leq \text{ToInteger}(y) \leq 99$, let $yr$ be $1900 + \text{ToInteger}(y)$; otherwise, let $yr$ be $y$.

i. Let \text{finalDate} be \text{MakeDate}(\text{MakeDay}(yr, m, dt), \text{MakeTime}(h, min, s, milli)).

j. Let $O$ be \text{OrdinaryCreateFromConstructor}(\text{NewTarget}, "%DatePrototype", « [[DateValue]] »).

k. Set the [[DateValue]] internal slot of $O$ to $\text{TimeClip}(\text{UTC}(\text{finalDate}))$.

l. Return $O$.

4. Else,
   a. Let $now$ be the Number that is the time value (UTC) identifying the current time.
   b. Return \text{ToDateString}($now$).

\textbf{20.3.2.2 Date (value)}

This description applies only if the Date constructor is called with exactly one argument.

When the \textbf{Date} function is called, the following steps are taken:

1. Let $\text{numberOfArgs}$ be the number of arguments passed to this function call.
2. Assert: $\text{numberOfArgs} = 1$.
3. If NewTarget is not \texttt{undefined}, then
   a. If \texttt{Type(value)} is Object and \texttt{value} has a [[DateValue]] internal slot, then
      i. Let $tv$ be \text{thisTimeValue}($value$).
   b. Else,
      i. Let $v$ be \text{ToPrimitive}($value$).
      ii. If \texttt{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.
          2. ReturnIfAbrupt($tv$).
      iii. Else,
          1. Let $tv$ be \text{ToNumber}($v$).
   c. Let $O$ be \text{OrdinaryCreateFromConstructor}(\text{NewTarget}, "%DatePrototype", « [[DateValue]] »).
   d. Set the [[DateValue]] internal slot of $O$ to $\text{TimeClip}(tv)$.
   e. Return $O$.
4. Else,
   a. Let $now$ be the Number that is the time value (UTC) identifying the current time.
   b. Return \text{ToDateString}($now$).

\textbf{20.3.2.3 Date ()}

This description applies only if the Date constructor is called with no arguments.

When the \textbf{Date} function is called, the following steps are taken:

1. Let $\text{numberOfArgs}$ be the number of arguments passed to this function call.
2. Assert: $\text{numberOfArgs} = 0$.
3. If NewTarget is not \texttt{undefined}, then
   a. Let $O$ be \text{OrdinaryCreateFromConstructor}(\text{NewTarget}, "%DatePrototype", « [[DateValue]] »).
   b. Set the [[DateValue]] internal slot of $O$ to the time value (UTC) identifying the current time.
   c. Return $O$.
4. Else,
   a. Let $now$ be the Number that is the time value (UTC) identifying the current time.
   b. Return \text{ToDateString}($now$).

\textbf{20.3.3 Properties of the Date Constructor}

The value of the [[Prototype]] internal slot of the Date constructor is the intrinsic object \texttt{%FunctionPrototype%}.

The Date constructor has the following properties:
20.3.3.1 Date.now ()

The `now` function returns a Number value that is the `time value` designating the UTC date and time of the occurrence of the call to `now`.

20.3.3.2 Date.parse ( `string` )

The `parse` function applies the `ToString` operator to its argument. If `ToString` results in an abrupt completion the `Completion Record` is immediately returned. Otherwise, `parse` interprets the resulting String as a date and time; it returns a Number, the UTC `time value` corresponding to the date and time. The String may be interpreted as a local time, a UTC time, or a time in some other time zone, depending on the contents of the String. The function first attempts to parse the format of the String according to the rules (including extended years) called out in Date Time String Format (20.3.1.16). If the String does not conform to that format the function may fall back to any implementation-specific heuristics or implementation-specific date formats. Unrecognizable Strings or dates containing illegal element values in the format String shall cause `Date.parse` to return `NaN`.

If `x` is any Date object whose milliseconds amount is zero within a particular implementation of ECMAScript, then all of the following expressions should produce the same numeric value in that implementation, if all the properties referenced have their initial values:

```
x.valueOf()
Date.parse(x.toString())
Date.parse(x.toUTCString())
Date.parse(x.toISOString())
```

However, the expression

```
Date.parse(x.toLocaleString())
```

is not required to produce the same Number value as the preceding three expressions and, in general, the value produced by `Date.parse` is implementation-dependent when given any String value that does not conform to the Date Time String Format (20.3.1.16) and that could not be produced in that implementation by the `toString` or `toUTCString` method.

20.3.3.3 Date.prototype

The initial value of `Date.prototype` is the intrinsic object `%DatePrototype%`.

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

20.3.3.4 Date.UTC ( `year`, `month` [, `date` [, `hours` [, `minutes` [, `seconds` [, `ms` ] ] ] ] ] ] ]

When the `UTC` function is called with fewer than two arguments, the behaviour is implementation-dependent. When the `UTC` function is called with two to seven arguments, it computes the date from `year`, `month` and (optionally) `date`, `hours`, `minutes`, `seconds` and `ms`. The following steps are taken:

1. Let `y` be ? `ToNumber`(`year`).
2. Let `m` be ? `ToNumber`(`month`).
3. If `date` is supplied, let `dt` be ? `ToNumber`(`date`); else let `dt` be 1.
4. If `hours` is supplied, let `h` be ? `ToNumber`(`hours`); else let `h` be 0.
5. If `minutes` is supplied, let `min` be ? `ToNumber`(`minutes`); else let `min` be 0.
6. If `seconds` is supplied, let `s` be ? `ToNumber`(`seconds`); else let `s` be 0.
7. If `ms` is supplied, let `milli` be ? `ToNumber`(`ms`); else let `milli` be 0.
8. If `y` is not `NaN` and 0 ≤ `ToInteger`(y) ≤ 99, let `yr` be 1900+`ToInteger`(y); otherwise, let `yr` be `y`.
9. Return `TimeClip(MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli)))`.

The `length` property of the `UTC` function is 7.
The UTC function differs from the Date constructor in two ways: it returns a time value as a Number, rather than creating a Date object, and it interprets the arguments in UTC rather than as local time.

20.3.4 Properties of the Date Prototype Object

The Date prototype object is the intrinsic object %DatePrototype%. 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%.

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 ()

The following steps are performed:

1. Let t be ? thisTimeValue(this value).
2. If t is NaN, return NaN.
3. Return DateFromTime(LocalTime(t)).

20.3.4.3 Date.prototype.getDay ()

The following steps are performed:

1. Let t be ? thisTimeValue(this value).
2. If t is NaN, return NaN.
3. Return WeekDay(LocalTime(t)).

20.3.4.4 Date.prototype.getFullYear ()

The following steps are performed:

1. Let t be ? thisTimeValue(this value).
2. If t is NaN, return NaN.
3. Return YearFromTime(LocalTime(t)).

20.3.4.5 Date.prototype.getHours ()

The following steps are performed:

1. Let t be ? thisTimeValue(this value).
2. If t is NaN, return NaN.
3. Return HourFromTime(LocalTime(t)).
20.3.4.6 Date.prototype.getMilliseconds ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{msFromTime}(\text{LocalTime}(t)) \).

20.3.4.7 Date.prototype.getMinutes ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{MinFromTime}(\text{LocalTime}(t)) \).

20.3.4.8 Date.prototype.getMonth ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{MonthFromTime}(\text{LocalTime}(t)) \).

20.3.4.9 Date.prototype.getSeconds ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{SecFromTime}(\text{LocalTime}(t)) \).

20.3.4.10 Date.prototype.getTime ()

The following steps are performed:

1. Return \( \text{thisTimeValue}(\text{this value}) \).

20.3.4.11 Date.prototype.getTimezoneOffset ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( (t \cdot \text{LocalTime}(t)) / \text{msPerMinute} \).

20.3.4.12 Date.prototype.getUTCDate ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{DateFromTime}(t) \).

20.3.4.13 Date.prototype.getUTCDay ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{WeekDay}(t) \).
20.3.4.14  Date.prototype.getUTCFullYear ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{YearFromTime}(t) \).

20.3.4.15  Date.prototype.getUTCHours ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{HourFromTime}(t) \).

20.3.4.16  Date.prototype.getUTCMilliseconds ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{msFromTime}(t) \).

20.3.4.17  Date.prototype.getUTCMinutes ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{MinFromTime}(t) \).

20.3.4.18  Date.prototype.getUTCMonth ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{MonthFromTime}(t) \).

20.3.4.19  Date.prototype.getUTCSeconds ()

The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue}(\text{this value}) \).
2. If \( t \) is \( \text{NaN} \), return \( \text{NaN} \).
3. Return \( \text{SecFromTime}(t) \).

20.3.4.20  Date.prototype.setDate ( date )

The following steps are performed:

1. Let \( t \) be \( \text{LocalTime}(\text{thisTimeValue}(\text{this value})) \).
2. Let \( dt \) be \( \text{ToNumber}(\text{date}) \).
3. Let \( \text{newDate} \) be \( \text{makeDate}(\text{\text{YearFromTime}(t)}, \text{\text{MonthFromTime}(t)}, \text{dt}, \text{\text{TimeWithinDay}(t)}) \).
4. Let \( u \) be \( \text{TimeClip}(\text{UTC}(\text{\text{newDate}})) \).
5. Set the \([\text{DateValue}]\) internal slot of this Date object to \( u \).
6. Return \( u \).

20.3.4.21  Date.prototype.setFullYear ( year [, month [, date ]] )
The following steps are performed:

1. Let \( t \) be \( \text{thisTimeValue(this value)} \).
2. If \( t \) is \( \text{NaN} \), let \( t \) be \( +0 \); otherwise, let \( t \) be \( \text{LocalTime(t)} \).
3. Let \( y \) be \( \text{ToNumber(year)} \).
4. If \( \text{month} \) is not specified, let \( m \) be \( \text{MonthFromTime(t)} \); otherwise, let \( m \) be \( \text{ToNumber(month)} \).
5. If \( \text{date} \) is not specified, let \( dt \) be \( \text{DateFromTime(t)} \); otherwise, let \( dt \) be \( \text{ToNumber(date)} \).
6. Let \( \text{newDate} \) be \( \text{MakeDate(MakeDay(y, m, dt), TimeWithinDay(t))} \).
7. Let \( u \) be \( \text{TimeClip(UTC(newDate))} \).
8. Set the [[DateValue]] internal slot of this Date object to \( u \).
9. Return \( u \).

The \( \text{length} \) property of the \( \text{setFullYear} \) method is 3.

\textbf{NOTE} If \( \text{month} \) is not specified, this method behaves as if \( \text{month} \) were specified with the value \( \text{getMonth()} \). If \( \text{date} \) is not specified, it behaves as if \( \text{date} \) were specified with the value \( \text{getDate()} \).

\subsection*{20.3.4.22 \texttt{Date.prototype.setHours ( hour [, min [, sec [, ms ]]])}}

The following steps are performed:

1. Let \( t \) be \( \text{LocalTime(? thisTimeValue(this value))} \).
2. Let \( h \) be \( \text{ToNumber(hour)} \).
3. If \( \text{min} \) is not specified, let \( m \) be \( \text{MinFromTime(t)} \); otherwise, let \( m \) be \( \text{ToNumber(min)} \).
4. If \( \text{sec} \) is not specified, let \( s \) be \( \text{SecFromTime(t)} \); otherwise, let \( s \) be \( \text{ToNumber(sec)} \).
5. If \( \text{ms} \) is not specified, let \( milli \) be \( \text{msFromTime(t)} \); otherwise, let \( milli \) be \( \text{ToNumber(ms)} \).
6. Let \( \text{date} \) be \( \text{MakeDate(Day(t), MakeTime(h, m, s, milli))} \).
7. Let \( u \) be \( \text{TimeClip(UTC(date))} \).
8. Set the [[DateValue]] internal slot of this Date object to \( u \).
9. Return \( u \).

The \( \text{length} \) property of the \( \text{setHours} \) method is 4.

\textbf{NOTE} If \( \text{min} \) is not specified, this method behaves as if \( \text{min} \) were specified with the value \( \text{getMinutes()} \). If \( \text{sec} \) is not specified, it behaves as if \( \text{sec} \) were specified with the value \( \text{getSeconds()} \). If \( \text{ms} \) is not specified, it behaves as if \( \text{ms} \) were specified with the value \( \text{getMilliseconds()} \).

\subsection*{20.3.4.23 \texttt{Date.prototype.setMilliseconds ( ms )}}

The following steps are performed:

1. Let \( t \) be \( \text{LocalTime(? thisTimeValue(this value))} \).
2. Let \( ms \) be \( \text{ToNumber(ms)} \).
3. Let \( \text{time} \) be \( \text{MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), ms)} \).
4. Let \( u \) be \( \text{TimeClip(UTC(MakeDate(Day(t), time)))} \).
5. Set the [[DateValue]] internal slot of this Date object to \( u \).
6. Return \( u \).

\subsection*{20.3.4.24 \texttt{Date.prototype.setMinutes ( min [, sec [, ms ]])}}

The following steps are performed:

1. Let \( t \) be \( \text{LocalTime(? thisTimeValue(this value))} \).
2. Let \( m \) be \( \text{ToNumber(min)} \).
3. If \( \text{sec} \) is not specified, let \( s \) be \( \text{SecFromTime(t)} \); otherwise, let \( s \) be \( \text{ToNumber(sec)} \).
4. If \( \text{ms} \) is not specified, let \( milli \) be \( \text{msFromTime(t)} \); otherwise, let \( milli \) be \( \text{ToNumber(ms)} \).
5. Let \( \text{date} \) be \( \text{MakeDate(Day(t), MakeTime(HourFromTime(t), m, s, milli))} \).
6. Let \( u \) be \( \text{TimeClip(UTC(date))} \).
7. Set the [[DateValue]] internal slot of this Date object to \( u \).
8. 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 ])

The following steps are performed:

1. Let \( t \) be `LocalTime(thisTimeValue(this value)).`
2. Let \( m \) be `? ToNumber(month).`
3. If `date` is not specified, let \( dt \) be `DateFromTime(t);` otherwise, let \( dt \) be `? ToNumber(date).`
4. Let `newDate` be `MakeDate(MakeDay(YearFromTime(t), m, dt), TimeWithinDay(t)).`
5. Let \( u \) be `TimeClip(UTC(newDate)).`
6. Set the [[DateValue]] internal slot of this Date object to \( u \).
7. 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 `getDate()`.

### 20.3.4.26 Date.prototype.setSeconds ( sec [, ms ])

The following steps are performed:

1. Let \( t \) be `LocalTime(thisTimeValue(this value)).`
2. Let \( s \) be `? ToNumber(sec).`
3. If `ms` is not specified, let \( milli \) be `msFromTime(t);` otherwise, let \( milli \) be `? ToNumber(ms).`
4. Let `date` be `MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s, milli)).`
5. Let \( u \) be `TimeClip(UTC(date)).`
6. Set the [[DateValue]] internal slot of this Date object to \( u \).
7. 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)

The following steps are performed:

1. Perform `? thisTimeValue(this value)`.
2. Let \( t \) be `? ToNumber(time).`
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 `? thisTimeValue(this value).`
2. Let \( dt \) be `? ToNumber(date).`
3. Let `newDate` be `MakeDate(MakeDay(YearFromTime(t), MonthFromTime(t), dt), TimeWithinDay(t)).`
4. Let \( v \) be `TimeClip(newDate).`
5. Set the [[DateValue]] internal slot of this Date object to \( v \).
6. Return \( v \).
20.3.4.29 Date.prototype.setUTCFullYear (year [, month [, date ]])

The following steps are performed:

1. Let t be ?thisTimeValue(this value).
2. If t is NaN, let t be +0.
3. Let y be ?ToNumber(year).
4. If month is not specified, let m be MonthFromTime(t); otherwise, let m be ?ToNumber(month).
5. If date is not specified, let dt be DateFromTime(t); otherwise, let dt be ?ToNumber(date).
6. Let newDate be MakeDate(MakeDay(y, m, dt), TimeWithinDay(t)).
7. Let v be TimeClip(newDate).
8. Set the [[DateValue]] internal slot of this Date object to 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 ]]])

The following steps are performed:

1. Let t be ?thisTimeValue(this value).
2. Let h be ?ToNumber(hour).
3. If min is not specified, let m be MinFromTime(t); otherwise, 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 newDate be MakeDate(Day(t), MakeTime(h, m, s, milli)).
7. Let v be TimeClip(newDate).
8. 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 getUTCMilliseconds(). 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)

The following steps are performed:

1. Let t be ?thisTimeValue(this value).
2. Let milli be ?ToNumber(ms).
3. Let time be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), milli).
4. Let v be TimeClip(MakeDate(Day(t), time)).
5. Set the [[DateValue]] internal slot of this Date object to v.
6. Return v.

20.3.4.32 Date.prototype.setUTCMinutes (min [, sec [, ms ]])

The following steps are performed:

1. Let t be ?thisTimeValue(this value).
2. Let m be ?ToNumber(min).
3. If sec is not specified, let s be SecFromTime(t).
4. Else,
a. Let $s$ be $\text{ToNumber}(sec)$.
5. If $ms$ is not specified, let $milli$ be $msFromTime(t)$.
6. Else,
   a. Let $milli$ be $\text{ToNumber}(ms)$.
7. Let $date$ be $\text{MakeDate}(\text{Day}(t), \text{MakeTime}(\text{HourFromTime}(t), m, s, milli))$.
8. Let $v$ be $\text{TimeClip}(date)$.
9. Set the $\text{[[DateValue]]}$ internal slot of this Date object to $v$.
10. Return $v$.

The length property of the $\text{setUTCMinutes}$ method is 3.

NOTE If $sec$ is not specified, this method behaves as if $sec$ were specified with the value $\text{getUTCSeconds()}$. If $ms$ is not specified, it function behaves as if $ms$ were specified with the value return by $\text{getUTCMilliseconds()}$.

20.3.43 Date.prototype.setUTCMonth ( $month$ [, $date$ ] )

The following steps are performed:

1. Let $t$ be $\text{thisTimeValue(this value)}$.
2. Let $m$ be $\text{ToNumber}(month)$.
3. If $date$ is not specified, let $dt$ be $\text{DateFromTime}(t)$.
4. Else,
   a. Let $dt$ be $\text{ToNumber}(date)$.
5. Let $newDate$ be $\text{MakeDate(MakeDay(YearFromTime(t), m, dt), TimeWithinDay(t))}$.
6. Let $v$ be $\text{TimeClip(newDate)}$.
7. Set the $\text{[[DateValue]]}$ internal slot of this Date object to $v$.
8. Return $v$.

The length property of the $\text{setUTCMonth}$ method is 2.

NOTE If $date$ is not specified, this method behaves as if $date$ were specified with the value $\text{getUTCDate()}$.

20.3.44 Date.prototype.setUTCSeconds ( $sec$ [, $ms$ ] )

The following steps are performed:

1. Let $t$ be $\text{thisTimeValue(this value)}$.
2. Let $s$ be $\text{ToNumber}(sec)$.
3. If $ms$ is not specified, let $milli$ be $msFromTime(t)$.
4. Else,
   a. Let $milli$ be $\text{ToNumber}(ms)$.
5. Let $date$ be $\text{MakeDate(\text{Day}(t), \text{MakeTime}(\text{HourFromTime}(t), \text{MinFromTime}(t), s, milli))}$.
6. Let $v$ be $\text{TimeClip(date)}$.
7. Set the $\text{[[DateValue]]}$ internal slot of this Date object to $v$.
8. Return $v$.

The length property of the $\text{setUTCSeconds}$ method is 2.

NOTE If $ms$ is not specified, this method behaves as if $ms$ were specified with the value $\text{getUTCMilliseconds()}$.

20.3.45 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.

20.3.46 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 20.3.1.16. 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 ?ToObject(this value).
2. Let tv be ?ToPrimitive(O, hint Number).
3. If Type(tv) is Number and tv is not finite, return null.
4. 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.

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.

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.

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 \( \text{NaN} \).
3. Else,
   a. Let tv be \( \text{thisTimeValue}(O) \).
4. Return \( \text{ToDateString}(tv) \).

NOTE 1 For any Date object \( d \) whose milliseconds amount is zero, the result of \( \text{Date.parse}(d.\text{toString}()) \) is equal to \( d.\text{valueOf}() \). See 20.3.3.2.

NOTE 2 The \( \text{toString} \) function is intentionally generic; it does not require that its \( \text{this} \) value be a Date object. Therefore, it can be transferred to other kinds of objects for use as a method.

20.3.4.41.1 Runtime Semantics: ToDateString(tv)

The following steps are performed:

1. Assert: \( \text{Type}(tv) \) is Number.
2. If \( tv \) is \( \text{NaN} \), 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 \( \text{time value} \) 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 20.3.1.16. 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 20.3.1.16 but with a space rather than a "T" used to separate the date and time elements.

20.3.4.44 Date.prototype.valueOf ()

The following steps are performed:

1. Return \( \text{thisTimeValue}(\text{this value}) \).

20.3.4.45 Date.prototype [ @@toPrimitive ] (\( hint \))

This function is called by ECMAScript language operators to convert a Date 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 \( \text{@@toPrimitive} \) method is called with argument \( hint \), the following steps are taken:

1. Let \( O \) be the \( \text{this} \) value.
2. If \texttt{Type}(O) is not Object, throw a \texttt{TypeError} exception.
3. If \texttt{hint} is the String value "\texttt{string}" or the String value "\texttt{default}"
   a. Let \texttt{tryFirst} be "\texttt{string}".
4. Else if \texttt{hint} is the String value "\texttt{number}"
   a. Let \texttt{tryFirst} be "\texttt{number}".
5. Else, throw a \texttt{TypeError} exception.
6. Return ? \texttt{OrdinaryToPrimitive}(O, \texttt{tryFirst}).

The value of the \texttt{name} property of this function is "\texttt{[Symbol.toPrimitive]}".
This property has the attributes \{\texttt{[Writable]}: false, \texttt{[Enumerable]}: false, \texttt{[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 \texttt{[[DateValue]]} internal slot. The \texttt{[[DateValue]]} internal slot is the \texttt{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 \texttt{String} property of the \texttt{global object}.
When called as a constructor it creates and initializes a new String object. When \texttt{String} is called as a function rather than as a constructor, it performs a type conversion.

The \texttt{String} constructor is designed to be subclassable. It may be used as the value of an \texttt{extends} clause of a class definition. Subclass constructors that intend to inherit the specified \texttt{String} behaviour must include a \texttt{super} call to the \texttt{String} constructor to create and initialize the subclass instance with a \texttt{[[StringData]]} internal slot.

21.1.1.1 \texttt{String ( value )}

When \texttt{String} is called with argument \texttt{value}, the following steps are taken:

1. If no arguments were passed to this function invocation, let \texttt{s} be "".
2. Else,
   a. If NewTarget is \texttt{undefined} and \texttt{Type(value)} is Symbol, return \texttt{SymbolDescriptiveString(value)}.
   b. Let \texttt{s} be \texttt{? String(value)}.
3. If NewTarget is \texttt{undefined}, return \texttt{s}.
4. Return ? \texttt{StringCreate(s, ? GetPrototypeFromConstructor(NewTarget, "%StringPrototype%"))}.

21.1.2 Properties of the String Constructor

The value of the \texttt{[[Prototype]]} internal slot of the String constructor is the intrinsic object \%FunctionPrototype\%.

The String constructor has the following properties:

21.1.2.1 \texttt{String.fromCharCode ( ...codeUnits )}

The \texttt{String.fromCharCode} function may be called with any number of arguments which form the rest parameter \texttt{codeUnits}. The following steps are taken:

1. Let \texttt{codeUnits} be a \texttt{List} containing the arguments passed to this function.
2. Let \texttt{length} be the number of elements in \texttt{codeUnits}.
3. Let \texttt{elements} be a new empty \texttt{List}.
4. Let nextIndex be 0.
5. Repeat while nextIndex &lt; length
   a. Let next be codeUnits[nextIndex].
   b. Let nextCU be ? ToUint16(next).
   c. Append nextCU to the end of elements.
   d. 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.fromCharCode ( ...codePoints )

The String.fromCharCode 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 the number of elements in codePoints.
3. Let elements be a new empty List.
4. Let nextIndex be 0.
5. Repeat while nextIndex &lt; length
   a. Let next be codePoints[nextIndex].
   b. Let nextCP be ? ToNumber(next).
   c. If SameValue(nextCP, ToInteger(nextCP)) is false, throw a RangeError exception.
   d. If nextCP &lt; 0 or nextCP &gt; 0x10FFFF, throw a RangeError exception.
   e. Append the elements of the UTF16Encoding of nextCP to the end of elements.
   f. 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.

21.1.2.3 String.prototype

The initial value of String.prototype is the intrinsic object %StringPrototype%.

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. Let raw be ? ToObject(? Get(cooked, "raw")).
5. Let literalSegments be ? ToLength(? Get(raw, "length")).
6. If literalSegments ≤ 0, return the empty string.
7. Let stringElements be a new empty List.
8. Let nextIndex be 0.
9. Repeat
   a. Let nextKey be ! ToString(nextIndex).
   b. Let nextSeg be ? ToString(? Get(raw, nextKey)).
   c. Append in order the code unit elements of nextSeg to the end of stringElements.
   d. 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.

e. If `nextIndex < numberOfSubstitutions`, let `next` be `substitutions[nextIndex]`.
   f. Else, let `next` be the empty String.
   g. Let `nextSub` be `ToString(next)`.
   h. Append in order the code unit elements of `nextSub` to the end of `stringElements`.
   i. Let `nextIndex` be `nextIndex + 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 the intrinsic object `%StringPrototype%`. The String prototype object is an ordinary object. The String prototype is itself a String object; it has a [[StringData]] internal slot with the value `""`.

The value of the [[Prototype]] internal slot of the String prototype object is the intrinsic object `%ObjectPrototype%`.

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 1 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. Let `position` be `ToInteger(pos)`.
4. Let `size` be the number of elements in `S`.
5. If `position < 0` or `position ≥ size`, return the empty String.
6. Return a String of length 1, containing one code unit from `S`, namely the code unit at index `position`.

NOTE 2 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 1 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. Let `position` be `? ToInteger(pos).`
4. Let `size` be the number of elements in `S`.
5. If `position < 0` or `position ≥ size`, return `NaN`.
6. Return a value of Number type, whose value is the code unit value of the element at index `position` in the String `S`.

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.

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. Let `position` be `? ToInteger(pos).`
4. Let `size` be the number of elements in `S`.
5. If `position < 0` or `position ≥ size`, return `undefined`.
6. Let `first` be the code unit value of the element at index `position` in the String `S`.
7. If `first < 0xD800` or `first > 0xDBFF` or `position+1 = size`, return `first`.
8. Let `second` be the code unit value of the element at index `position+1` in the String `S`.
9. If `second < 0xDC00` or `second > 0xDFFF`, return `first`.
10. Return `UTF16Decode(first, second)`.

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.

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 `? ToString(O).`
3. Let `args` be a `List` whose elements are the arguments passed to this function.
4. Let `R` be `S`.
5. Repeat, while `args` is not empty
   a. Remove the first element from `args` and let `next` be the value of that element.
   b. Let `nextString` be `? ToString(next)`.
   c. Let `R` be the String value consisting of the code units of the previous value of `R` followed by the code units of `nextString`.
6. Return `R`.

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

The `concat` function is intentionally generic; it does not require that its `this` value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.
21.1.3.5 String.prototype.constructor

The initial value of `String.prototype.constructor` is the intrinsic object `%String%`.

21.1.3.6 String.prototype.endsWith ( searchString [, endPosition ] )

The following steps are taken:

1. Let O be ? RequireObjectCoercible(this value).
2. Let S be ? ToString(O).
4. If isRegExp is true, throw a TypeError exception.
5. Let searchString be ? ToString(searchString).
6. Let len be the number of elements in S.
7. If endPosition is undefined, let pos be len, else let pos be ? ToInteger(endPosition).
8. Let end be min(max(pos, 0), len).
9. Let searchLength be the number of elements in searchString.
10. Let start be end - searchLength.
11. If start is less than 0, return false.
12. If the sequence of elements of S starting at start of length searchLength is the same as the full element sequence of searchString, return true.
13. Otherwise, return false.

NOTE 1 Returns true if the sequence of elements of searchString converted to a String is the same as the corresponding elements of this object (converted to a String) starting at endPosition - length(this). Otherwise returns false.

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 `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).
4. If isRegExp is true, throw a TypeError exception.
5. Let searchString be ? ToString(searchString).
6. Let pos be ? ToInteger(position). (If position is undefined, this step produces the value 0.)
7. Let len be the number of elements in S.
8. Let start be min(max(pos, 0), len).
9. Let searchLength be the number of elements in searchString.
10. If there exists any integer k not smaller than start such that k + searchLength is not greater than len, and for all nonnegative integers j less than searchLength, the code unit at index k+j of S is the same as the code unit at index j of searchString, return true; but if there is no such integer k, return false.

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 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, 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. Let searchStr be ? ToString(searchString).
4. Let pos be ? ToInteger(position). (If position is undefined, this step produces the value 0.)
5. Let len be the number of elements in S.
6. Let start be min(max(pos, 0), len).
7. Let searchString be the number of elements in searchStr.
8. 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 searchString; but if there is no such integer k, return the value -1.

NOTE 2 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 1 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. Let searchStr be ? ToString(searchString).
4. Let numPos be ? ToNumber(position). (If position is undefined, this step produces the value NaN.)
5. If numPos is NaN, let pos be +∞; otherwise, let pos be ToInteger(numPos).
6. Let len be the number of elements in S.
7. Let start be min(max(pos, 0), len).
8. Let searchString be the number of elements in searchStr.
9. 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 searchString; but if there is no such integer k, return the value -1.

NOTE 2 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 ECMA-402 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 $\text{RequireObjectCoercible}(\text{this value})$.
2. Let $S$ be $\text{ToString}(O)$.
3. Let $\text{That}$ be $\text{ToString(that)}$.

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 22.1.3.25) 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.

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 should 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 Standard Annex #15, Unicode Normalization Forms (http://www.unicode.org/reports/tr15/) and Unicode Technical Note #5, Canonical Equivalence in Applications (http://www.unicode.org/notes/tn5/). Also see Unicode Technical Standard #10, Unicode Collation Algorithm (http://www.unicode.org/reports/tr10/).

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 $\text{RequireObjectCoercible}(\text{this value})$.
2. If `regexp` is neither `undefined` nor `null`, then
   a. Let `matcher` be $\text{GetMethod}(regexp, @@match)$.
   b. If `matcher` is not `undefined`, then
      i. Return $\text{Call}(matcher, regexp, \{O\})$.
3. Let $S$ be $\text{ToString}(O)$.
4. Let $rx$ be $\text{RegExpCreate}(regexp, undefined)$.
5. Return $\text{Invoke}(rx, @@match, \{S\})$.

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 $\text{RequireObjectCoercible}(\text{this value})$.
2. Let $S$ be $\text{ToString}(O)$.
3. If `form` is not provided or `form` is `undefined`, let `form` be "NFC".
4. Let $f$ be $\text{ToString}(form)$.
5. If $f$ is not one of "NFC", "NFD", "NFKC", or "NFKD", throw a `RangeError` exception.
6. Let \( ns \) be the String value that is the result of normalizing \( S \) into the normalization form named by \( f \) as specified in http://www.unicode.org/reports/tr15/tr15-29.html.
7. Return \( ns \).

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

### 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. Let \( n \) be ? **ToInteger**(count).
4. If \( n < 0 \), throw a **RangeError** exception.
5. If \( n \) is \(+\infty\), throw a **RangeError** exception.
6. 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.
7. 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. If **searchValue** is neither **undefined** nor **null**, then
   a. Let **replacer** be ? **GetMethod**(searchValue, @@replace).
   b. If **replacer** is not **undefined**, then
      i. Return ? **Call**(replacer, searchValue, « \( O \), replaceValue »).
5. Let **functionalReplace** be **IsCallable**(replaceValue).
6. If **functionalReplace** is **false**, then
   a. Let **replaceValue** be ? **ToString**(replaceValue).
7. 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**.
8. If **functionalReplace** is **true**, then
   a. Let **replValue** be ? **Call**(replaceValue, **undefined**, « **matched**, **pos**, **string** »).
   b. Let **replStr** be **ToString**(replValue).
9. Else,
   a. Let **captures** be a new empty **List**.
   b. Let **replStr** be **GetSubstitution**(matched, string, **pos**, **captures**, replaceValue).
10. Let **tailPos** be \( \text{pos} + \) the number of code units in **matched**.
11. Let **newString** be the String formed by concatenating the first \( \text{pos} \) 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.
12. Return **newString**.

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

#### 21.1.3.14.1 Runtime Semantics: GetSubstitution(matched, str, position, captures, replacement)

The abstract operation **GetSubstitution** performs the following steps:
1. Assert: `Type(matched)` is String.
2. Let `matchLength` be the number of code units in `matched`.
3. Assert: `Type(str)` is String.
4. Let `stringLength` be the number of code units in `str`.
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 46. These $ replaced 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 46: 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>$</td>
</tr>
<tr>
<td>0x0024, 0x0026</td>
<td>&amp;</td>
<td>matched</td>
</tr>
<tr>
<td>0x0024, 0x0060</td>
<td>'</td>
<td>If <code>position</code> is 0, the replacement is the empty String. Otherwise the replacement is the substring of <code>str</code> that starts at index 0 and whose last code unit is at index <code>position - 1</code>.</td>
</tr>
<tr>
<td>0x0024, 0x0027</td>
<td>'</td>
<td>If <code>tailPos</code> ≥ <code>stringLength</code>, the replacement is the empty String. Otherwise the replacement is the substring of <code>str</code> that starts at index <code>tailPos</code> and continues to the end of <code>str</code>.</td>
</tr>
<tr>
<td>0x0024, N, N Where 0x0031 ≤ N ≤ 0x0039</td>
<td>$n$ where n is one of 1 2 3 4 5 6 7 8 9 and $n$ is not followed by a decimal digit</td>
<td>The $n$th element of <code>captures</code>, where $n$ is a single digit in the range 1 to 9. If $n ≤ m$ and the $n$th element of <code>captures</code> is <code>undefined</code>, use the empty String instead. If $n &gt; m$, the result is implementation-defined.</td>
</tr>
<tr>
<td>0x0024, N, N Where 0x0030 ≤ N ≤ 0x0039</td>
<td>$nn$ where n is one of 0 1 2 3 4 5 6 7 8 9</td>
<td>The $nn$th element of <code>captures</code>, where $nn$ is a two-digit decimal number in the range 01 to 99. If $nn ≤ m$ and the $nn$th element of <code>captures</code> is <code>undefined</code>, use the empty String instead. If $nn$ is 00 or $nn &gt; m$, the result is implementation-defined.</td>
</tr>
<tr>
<td>0x0024</td>
<td>$</td>
<td>$</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. If `regexp` is neither `undefined` nor `null`, then
   a. Let `searcher` be `GetMethod(regexp, @@search)`.
   b. If `searcher` is not `undefined`, then
      i. Return `Call(searcher, regexp, « O »)`.
3. Let `string` be `ToString(O)`.
4. Let `rx` be `RegExpCreate(regexp, undefined)`.
5. 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:

1. Let `O` be `RequireObjectCoercible(this value)`.
2. Let `S` be `ToString(O)`.
3. Let `len` be the number of elements in `S`.
4. Let `intStart` be `ToInteger(start)`.
5. If `end` is `undefined`, let `intEnd` be `len`; else let `intEnd` be `ToInteger(end)`.
6. If `intStart < 0`, let `from` be `max(len + intStart, 0)`; otherwise let `from` be `min(intStart, len)`.
7. If `intEnd < 0`, let `to` be `max(len + intEnd, 0)`; otherwise let `to` be `min(intEnd, len)`.
8. Let `span` be `max(to - from, 0)`.
9. Return a String value containing `span` consecutive elements from `S` beginning with the element at index `from`.

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. The value of `separator` may be a String of any length or it may be an object, such as an RegExp, that has a `@@split` method.

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

1. Let `O` be `RequireObjectCoercible(this value)`.
2. If `separator` is neither `undefined` nor `null`, then
   a. Let `splitter` be `GetMethod(separator, @@split)`.
   b. If `splitter` is not `undefined`, then
      i. Return `Call(splitter, separator, « O, limit »)`.
3. Let `S` be `ToString(O)`.
4. Let `A` be `ArrayCreate(0)`.
5. Let `lengthA` be `0`.
6. If `limit` is `undefined`, let `lim` be `2^{32}-1`; else let `lim` be `ToUint32(limit)`.
7. Let `s` be the number of elements in `S`.
8. Let `p` be `0`.
9. Let `R` be `ToString(separator)`.
10. If `lim = 0`, return `A`.
11. If `separator` is `undefined`, then
    a. Perform `CreateDataProperty(A, "∅", S)`.
b. Return $A$.
12. If $s = 0$, then
   a. Let $z$ be $\text{SplitMatch}(S, 0, R)$.
   b. If $z$ is not $\text{false}$, return $A$.
   c. Perform $\text{!CreateDataProperty}(A, \"\emptyset\", S)$.
   d. Return $A$.
13. Let $q$ be $p$.
14. Repeat, while $q \neq s$
   a. Let $e$ be $\text{SplitMatch}(S, q, R)$.
   b. If $e$ is $\text{false}$, let $q$ be $q+1$.
   c. Else $e$ is an integer index $\leq s$,
      i. If $e = p$, let $q$ be $q+1$.
      ii. Else $e \neq p$,
15. Let $T$ be a String value equal to the substring of $S$ consisting of the code units at indices $p$ (inclusive) through $s$ (exclusive).
16. Perform $\text{!CreateDataProperty}(A, \text{!ToString}(\text{lengthA}), T)$.
17. Return $A$.

NOTE 1 The value of $\text{separator}$ may be 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. 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 the $\text{this}$ 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 $\text{undefined}$, then the result array contains just one String, which is the $\text{this}$ value (converted to a String). If $\text{limit}$ is not $\text{undefined}$, then the output array is truncated so that it contains no more than $\text{limit}$ elements.

NOTE 2 The $\text{split}$ function is intentionally generic; it does not require that its $\text{this}$ 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: $\text{SplitMatch}(S, q, R)$

The abstract operation $\text{SplitMatch}$ takes three parameters, a String $S$, an integer $q$, and a String $R$, and performs the following steps in order to return either $\text{false}$ 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 $\text{false}$.
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 $\text{false}$.
6. Return $q+r$.

21.1.3.18 $\text{String.prototype.startsWith}(\text{searchString}[, \text{position}])$

The following steps are taken:
1. Let \( O \) be ? \( \text{RequireObjectCoercible}(\text{this} \text{ value}) \).
2. Let \( S \) be ? \( \text{ToString}(O) \).
3. Let \( isRegExp \) be ? \( \text{IsRegExp}(\text{searchString}) \).
4. If \( isRegExp \) is \text{true}, throw a \text{TypeError} exception.
5. Let \( searchString \) be ? \( \text{ToInteger}(\text{searchString}) \).
6. Let \( pos \) be ? \( \text{ToInteger}(\text{position}) \). (If \( \text{position} \) is \text{undefined}, this step produces the value 0.)
7. Let \( len \) be the number of elements in \( S \).
8. Let \( start \) be \( \min(\max(\text{pos}, 0), \text{len}) \).
9. Let \( searchLength \) be the number of elements in \( \text{searchStr} \).
10. If \( searchLength + start \) is greater than \( \text{len} \), return \text{false}.
11. If the sequence of elements of \( S \) starting at \( start \) of length \( searchLength \) is the same as the full element sequence of \( \text{searchStr} \), return \text{true}.
12. Otherwise, return \text{false}.

\[ \text{startsWith} \]

This method returns \text{true} if the sequence of elements of \( \text{searchString} \) converted to a String is the same as the corresponding elements of this object (converted to a String) starting at index \( \text{position} \). Otherwise returns \text{false}.

\[ \text{substring} \]

The \( \text{substring} \) method takes two arguments, \( \text{start} \) and \( \text{end} \), and returns a substring of the result of converting this object to a String, starting from index \( \text{start} \) and running to, but not including, index \( \text{end} \) of the String (or through the end of the String if \( \text{end} \) is \text{undefined}). The result is a String value, not a String object.

If either argument is \text{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 \( \text{start} \) is larger than \( \text{end} \), they are swapped.

The following steps are taken:

1. Let \( O \) be ? \( \text{RequireObjectCoercible}(\text{this} \text{ value}) \).
2. Let \( S \) be ? \( \text{ToString}(O) \).
3. Let \( len \) be the number of elements in \( S \).
4. Let \( intStart \) be ? \( \text{ToInteger}(\text{start}) \).
5. If \( \text{end} \) is \text{undefined}, let \( intEnd \) be \( \text{len} \); else let \( intEnd \) be ? \( \text{ToInteger}(\text{end}) \).
6. Let \( \text{finalStart} \) be \( \min(\max(\text{intStart}, 0), \text{len}) \).
7. Let \( \text{finalEnd} \) be \( \min(\max(\text{intEnd}, 0), \text{len}) \).
8. Let \( \text{from} \) be \( \min(\text{finalStart}, \text{finalEnd}) \).
9. Let \( \text{to} \) be \( \max(\text{finalStart}, \text{finalEnd}) \).
10. Return a String whose length is \( \text{to} - \text{from} \), containing code units from \( S \), namely the code units with indices \( \text{from} \) through \( \text{to} - 1 \), in ascending order.

\[ \text{toLocaleLowerCase} \]

The \( \text{substring} \) function is intentionally generic; it does not require that its \( \text{this} \) value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

21.1.3.19 \( \text{String.prototype.substring} \) \( (\text{start}, \text{end}) \)

The \( \text{substring} \) method takes two arguments, \( \text{start} \) and \( \text{end} \), and returns a substring of the result of converting this object to a String, starting from index \( \text{start} \) and running to, but not including, index \( \text{end} \) of the String (or through the end of the String if \( \text{end} \) is \text{undefined}). The result is a String value, not a String object.

If either argument is \text{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 \( \text{start} \) is larger than \( \text{end} \), they are swapped.

The following steps are taken:

1. Let \( O \) be ? \( \text{RequireObjectCoercible}(\text{this} \text{ value}) \).
2. Let \( S \) be ? \( \text{ToString}(O) \).
3. Let \( len \) be the number of elements in \( S \).
4. Let \( \text{intStart} \) be ? \( \text{ToInteger}(\text{start}) \).
5. If \( \text{end} \) is \text{undefined}, let \( \text{intEnd} \) be \( \text{len} \); else let \( \text{intEnd} \) be ? \( \text{ToInteger}(\text{end}) \).
6. Let \( \text{finalStart} \) be \( \min(\max(\text{intStart}, 0), \text{len}) \).
7. Let \( \text{finalEnd} \) be \( \min(\max(\text{intEnd}, 0), \text{len}) \).
8. Let \( \text{from} \) be \( \min(\text{finalStart}, \text{finalEnd}) \).
9. Let \( \text{to} \) be \( \max(\text{finalStart}, \text{finalEnd}) \).
10. Return a String whose length is \( \text{to} - \text{from} \), containing code units from \( S \), namely the code units with indices \( \text{from} \) through \( \text{to} - 1 \), in ascending order.

\[ \text{toLocaleLowerCase} \]

The \( \text{substring} \) function is intentionally generic; it does not require that its \( \text{this} \) value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

21.1.3.20 \( \text{String.prototype.toLocaleLowerCase} \) \( ([\text{reserved1}, \text{reserved2}]) \)

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the \( \text{toLocaleLowerCase} \) method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the \( \text{toLocaleLowerCase} \) method is used.
This function interprets a String value as a sequence of UTF-16 encoded 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 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.

NOTE 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` ])

An ECMAScript implementation that includes the ECMA-402 Internationalization API must implement the `toLocaleUpperCase` method as specified in the ECMA-402 specification. If an ECMAScript implementation does not include the ECMA-402 API the following specification of the `toLocaleUpperCase` method is used.

This function interprets a String value as a sequence of UTF-16 encoded 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 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.

NOTE 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 UTF-16 encoded 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. 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`.
4. 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).
5. Let `cuList` be a new empty List.
6. For each code point `c` in `cpList`, in order, append to `cuList` the elements of the UTF16Encoding of `c`.
7. Let `L` be a String whose elements are, in order, the elements of `cuList`.
8. 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. Return `?thisStringValue(this value)`.

**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 UTF-16 encoded 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 UTF-16 encoded 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. 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.
4. 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. Return `?thisStringValue(this value)`.

### 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:

1. Let O be `? RequireObjectCoercible(this value)`.
2. Let S be `?ToString(O)`.
3. 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.

Several methods of String objects return Iterator objects. The abstract operation CreateStringIterator with argument \textit{string} is used to create such iterator objects. It performs the following steps:

1. Assert: Type(\textit{string}) is String.
2. Let \textit{iterator} be ObjectCreate(%StringIteratorPrototype%, \texttt{« [IteratedString], [StringIteratorNextIndex] »}).
3. Set \textit{iterator}'s [IteratedString] internal slot to \textit{string}.
4. Set \textit{iterator}'s [StringIteratorNextIndex] internal slot to 0.
5. Return \textit{iterator}.

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. In addition, %StringIteratorPrototype% has the following properties:

**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. 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(\( O \), 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 \( position \geq len \), then
   a. Set the value of the [[IteratedString]] internal slot of \( O \) to undefined.
   b. Return CreateIterResultObject(\( O \), 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 47.
### Table 47: 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[U]  ::
     Disjunction[U]

Disjunction[U]  ::
     Alternative[U]  
     Alternative[U]  | Disjunction[U]

Alternative[U]  ::
     [empty]
     Alternative[U]  Term[U]

Term[U]  ::
     Assertion[U]
     Atom[U]
     Atom[U]  Quantifier

Assertion[U]  ::
     ^
     $ 
     \ b
     \ B
     ( ? = Disjunction[U]  )
     ( ? ! Disjunction[U]  )

Quantifier ::
     QuantifierPrefix
     QuantifierPrefix  ?

QuantifierPrefix ::
     * 
     +
     ?
     { DecimalDigits }
```
Atom\[\text{u}\] ::
  PatternCharacter
  .
  \AtomEscape\[\text{u}\]
  CharacterClass\[\text{u}\]
  ( Disjunction\[\text{u}\] )
  ( ? : Disjunction\[\text{u}\] )

SyntaxCharacter :: one of
  ^ $ \ . * + ? ( ) [ ] { } |

PatternCharacter ::
  SourceCharacter but not SyntaxCharacter

AtomEscape\[\text{u}\] ::
  DecimalEscape
  CharacterEscape\[\text{u}\]
  CharacterClassEscape

CharacterEscape\[\text{u}\] ::
  ControlEscape
  c ControlLetter
  HexEscapeSequence
  RegExpUnicodeEscapeSequence\[\text{u}\]
  IdentityEscape\[\text{u}\]

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\[\text{u}\] ::
  [\#\text{u}] u LeadSurrogate \u TrailSurrogate
  [\#\text{u}] u LeadSurrogate
  [\#\text{u}] u TrailSurrogate
  [\#\text{u}] u NonSurrogate
  [\#\text{u}] u Hex4Digits
  [\#\text{u}] u \{ HexDigits \}

Each \u TrailSurrogate for which the choice of associated u LeadSurrogate is ambiguous shall be associated with the nearest possible u LeadSurrogate that would otherwise have no corresponding \u TrailSurrogate.

LeadSurrogate ::
  Hex4Digits but only if the SV of Hex4Digits is in the inclusive range 0xD800 to 0xDBFF

TrailSurrogate ::
  Hex4Digits but only if the SV of Hex4Digits is in the inclusive range 0xDC00 to 0xDFFF

NonSurrogate ::
  Hex4Digits but only if the SV of Hex4Digits is not in the inclusive range 0xD800 to 0xFFFF
IdentityEscape \[\text{U}\] ::
  [+U] SyntaxCharacter
  [-U] / 
  [-U] SourceCharacter but not UnicodeIDContinue

DecimalEscape ::
  DecimalIntegerLiteral [lookahead \notin DecimalDigit]

CharacterClassEscape :: one of
  d D s S w W

CharacterClass[\text{U}] ::
  [ [lookahead \notin \{\} ] ClassRanges[\text{U}] ] 
  [ ^ ClassRanges[\text{U}] ]

ClassRanges[\text{U}] ::
  [empty]
  NonemptyClassRanges[\text{U}]

NonemptyClassRanges[\text{U}] ::
  ClassAtom[\text{U}]
  ClassAtom[\text{U}] NonemptyClassRangesNoDash[\text{U}]
  ClassAtom[\text{U}] - ClassAtom[\text{U}] ClassRanges[\text{U}]

NonemptyClassRangesNoDash[\text{U}] ::
  ClassAtom[\text{U}]
  ClassAtomNoDash[\text{U}] NonemptyClassRangesNoDash[\text{U}]
  ClassAtomNoDash[\text{U}] - ClassAtom[\text{U}] ClassRanges[\text{U}]

ClassAtom[\text{U}] ::
  -
  ClassAtomNoDash[\text{U}]

ClassAtomNoDash[\text{U}] ::
  SourceCharacter but not one of \ or ] or -
  \ ClassEscape[\text{U}]

ClassEscape[\text{U}] ::
  DecimalEscape
  b
  [+U] -
  CharacterEscape[\text{U}]
  CharacterClassEscape

21.2.1.1 Static Semantics: Early Errors

RegExpUnicodeEscapeSequence :: u\{ HexDigits \}

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

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 a "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 corresponding non-encoded code point.

The syntax and semantics of Pattern is defined as if the source code for the 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 text 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 UTF16Decode must be used in producing 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 \(n\)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 \(n\)th element of captures is either a List that represents the value obtained by the \(n\)th set of capturing parentheses or undefined if the \(n\)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.
- AnAssertionTester 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 \( \text{ch} \) means that the escape sequence is interpreted as the character \( \text{ch} \), 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 \( \text{Pattern} :: \text{Disjunction} \) evaluates as follows:

1. Evaluate \( \text{Disjunction} \) to obtain a Matcher \( m \).
2. Return an internal closure that takes two arguments, a String \( \text{str} \) and an integer \( \text{index} \), and performs the following steps:
   a. Assert: \( \text{index} \) is the number of elements in \( \text{str} \).
   b. If \( \text{Unicode} \) is true, let \( \text{Input} \) be a List consisting of the sequence of code points of \( \text{str} \) 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 \( \text{str} \). \( \text{Input} \) will be used throughout the algorithms in 21.2.2. Each element of \( \text{Input} \) is considered to be a character.
   c. Let \( \text{InputLength} \) be the number of characters contained in \( \text{Input} \). This variable will be used throughout the algorithms in 21.2.2.
   d. Let \( \text{listIndex} \) be the index into \( \text{Input} \) of the character that was obtained from element \( \text{index} \) of \( \text{str} \).
   e. Let \( c \) be a Continuation that always returns its State argument as a successful MatchResult.
   f. Let \( \text{cap} \) be a List of \( \text{NcapturingParens undefined} \) values, indexed 1 through \( \text{NcapturingParens} \).
   g. Let \( x \) be the State (\( \text{listIndex} \), \( \text{cap} \)).
   h. Call \( m(x, c) \) and return its result.

**NOTE** A Pattern evaluates ("compiles") to an internal procedure value. RegExpBuiltinExec 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 the resulting 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).

### 21.2.3 Disjunction

The production \( \text{Disjunction} :: \text{Alternative} \) evaluates by evaluating \( \text{Alternative} \) to obtain a Matcher and returning that Matcher.

The production \( \text{Disjunction} :: \text{Alternative} | \text{Disjunction} \) evaluates as follows:

1. Evaluate \( \text{Alternative} \) to obtain a Matcher \( m_1 \).
2. Evaluate \( \text{Disjunction} \) to obtain a Matcher \( m_2 \).
3. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following steps when evaluated:
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,

```javascript
/a|ab/.exec("abc")
```

returns the result "a" and not "ab". Moreover,

```javascript
/((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:
   a. Create a Continuation `d` that takes a State argument `y` and returns the result of calling `m2(y, c)`.
   b. Call `m1(x, d)` and return its result.

### 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 \( \text{min} \), an integer (or \( \infty \)) \( \text{max} \), and Boolean \( \text{greedy} \).
3. If \( \text{max} \) is finite and less than \( \text{min} \), throw a SyntaxError exception.
4. Let \( \text{parenIndex} \) be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion’s Term. This is the total number of times the Atom \( :: ( \text{Disjunction} \) production is expanded prior to this production’s Term plus the total number of Atom \( :: ( \text{Disjunction} \) productions enclosing this Term.
5. Let \( \text{parenCount} \) be the number of left capturing parentheses in the expansion of this production’s Atom. This is the total number of Atom \( :: ( \text{Disjunction} \) 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:
   a. Call \( \text{RepeatMatcher}(m, \text{min}, \text{max}, \text{greedy}, x, c, \text{parenIndex}, \text{parenCount}) \) 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 \( \text{min} \), an integer (or \( \infty \)) \( \text{max} \), a Boolean \( \text{greedy} \), a State \( x \), a Continuation \( c \), an integer \( \text{parenIndex} \), and an integer \( \text{parenCount} \), and performs the following steps:

1. If \( \text{max} \) 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:
   a. If \( \text{min} \) is zero and \( y \)’s \( \text{endIndex} \) is equal to \( x \)’s \( \text{endIndex} \), return failure.
   b. If \( \text{min} \) is zero, let \( \text{min}2 \) be zero; otherwise let \( \text{min}2 \) be \( \text{min} - 1 \).
   c. If \( \text{max} \) is \( \infty \), let \( \text{max}2 \) be \( \infty \); otherwise let \( \text{max}2 \) be \( \text{max} - 1 \).
   d. Call \( \text{RepeatMatcher}(m, \text{min}2, \text{max}2, \text{greedy}, y, c, \text{parenIndex}, \text{parenCount}) \) and return its result.
3. Let \( \text{cap} \) be a fresh copy of \( x \)’s \( \text{captures List} \).
4. For every integer \( k \) that satisfies \( \text{parenIndex} < k \) and \( k \leq \text{parenIndex} + \text{parenCount} \), set \( \text{cap}[k] \) to undefined.
5. Let \( e \) be \( x \)’s \( \text{endIndex} \).
6. Let \( xr \) be the State \( (e, \text{cap}) \).
7. If \( \text{min} \) is not zero, return \( m(xr, d) \).
8. If \( \text{greedy} \) is \( \text{false} \), then
   a. Call \( c(x) \) and let \( z \) be its result.
   b. If \( z \) is not failure, return \( z \).
   c. Call \( m(xr, d) \) and return its result.
9. Call \( m(xr, d) \) and let \( z \) be its result.
10. If \( z \) is not failure, return \( z \).
11. Call \( c(x) \) and return its result.

**NOTE 1** An Atom followed by a Quantifier is repeated the number of times specified by the Quantifier. A Quantifier can be non-greedy, in which case the Atom pattern is repeated as few times as possible while still matching the sequel, or it can be greedy, in which case the Atom pattern is repeated as many times as possible while still matching the sequel. The Atom pattern is repeated rather than the input 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 \( (n-1)^{st} \) repetition of Atom; at which point it may turn out that more or fewer repetitions of Atom are now possible; these are exhausted (again, starting with either as few or as many as possible) before moving on to the next choice in the \( (n-1)^{st} \) repetition of Atom and so on.

Compare

```javascript
/a[a-z]{2,4}/.exec("abcdefgahi")
```

which returns "abcde" with
NOTE 3
Step 4 of the RepeatMatcher clears Atom's captures each time Atom is repeated. We can see its behaviour in the regular expression

```
/(z)((a+)?(b+)?(c))*/.exec("zaacbbbcac")
```

which returns the array

```
["zaacbbbcac", "z", "ac", "a", undefined, "c"]
```

and not

```
["zaacbbbcac", "z", "ac", "a", "bbb", "c"]
```

because each iteration of the outermost * clears all captured Strings contained in the quantified Atom, which in this case includes capture Strings numbered 2, 3, 4, and 5.

NOTE 4
Step 1 of the RepeatMatcher's d closure states that, once the minimum number of repetitions has been satisfied, any more expansions of Atom that match the empty 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\1+.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 \textbf{true}.
3. If \textit{Multiline} is \textbf{false}, return \textbf{false}.
4. If the character \textit{Input}[e-1] is one of \textit{LineTerminator}, return \textbf{true}.
5. Return \textbf{false}.

NOTE Even when the \( y \) flag is used with a pattern, \^ always matches only at the beginning of \textit{Input}, or (if \textit{Multiline} is \textbf{true}) at the beginning of a line.

The production \textit{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 \textit{endIndex}.
2. If \( e \) is equal to \textit{InputLength}, return \textbf{true}.
3. If \textit{Multiline} is \textbf{false}, return \textbf{false}.
4. If the character \textit{Input}[e] is one of \textit{LineTerminator}, return \textbf{true}.
5. Return \textbf{false}.

The production \textit{Assertion} \:: \( \backslash b \) 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 \textit{endIndex}.
2. Call \textit{IsWordChar}(e-1) and let \( a \) be the Boolean result.
3. Call \textit{IsWordChar}(e) and let \( b \) be the Boolean result.
4. If \( a \) is \textbf{true} and \( b \) is \textbf{false}, return \textbf{true}.
5. If \( a \) is \textbf{false} and \( b \) is \textbf{true}, return \textbf{true}.
6. Return \textbf{false}.

The production \textit{Assertion} \:: \( \backslash B \) 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 \textit{endIndex}.
2. Call \textit{IsWordChar}(e-1) and let \( a \) be the Boolean result.
3. Call \textit{IsWordChar}(e) and let \( b \) be the Boolean result.
4. If \( a \) is \textbf{true} and \( b \) is \textbf{false}, return \textbf{false}.
5. If \( a \) is \textbf{false} and \( b \) is \textbf{true}, return \textbf{false}.
6. Return \textbf{true}.

The production \textit{Assertion} \:: ( ? = \textit{Disjunction} ) evaluates as follows:

1. Evaluate \textit{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:
   a. Let \( d \) be a Continuation that always returns its State argument as a successful MatchResult.
   b. Call \( m(x, d) \) and let \( r \) be its result.
   c. If \( r \) is failure, return failure.
   d. Let \( y \) be \( r \)'s State.
   e. Let \( cap \) be \( y \)'s \textit{captures List}.
   f. Let \( xe \) be \( x \)'s \textit{endIndex}.
   g. Let \( z \) be the State \((xe, cap)\).
   h. Call \( c(z) \) and return its result.

The production \textit{Assertion} \:: ( ? ! \textit{Disjunction} ) evaluates as follows:

1. Evaluate \textit{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:
   a. Let \( d \) be a Continuation that always returns its State argument as a successful MatchResult.
b. Call $m(x, d)$ and let $r$ be its result.
c. If $r$ is not failure, return failure.
d. 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 $e$ is -1 or $e$ is InputLength, return false.
2. Let $c$ be the character Input[$e$].
3. If $c$ is one of the sixty-three characters below, return true.

   a b c d e f g h i j k l m n o p q r s t u v w x y z
   A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
   0 1 2 3 4 5 6 7 8 9 _

4. Return false.

21.2.2.7 Quantifier

The production Quantifier ::= QuantifierPrefix evaluates as follows:

1. Evaluate QuantifierPrefix to obtain the two results: an integer $min$ and an integer (or $\infty$) $max$.
2. Return the three results $min$, $max$, and true.

The production Quantifier ::= QuantifierPrefix ? evaluates as follows:

1. Evaluate QuantifierPrefix to obtain the two results: an integer $min$ and an integer (or $\infty$) $max$.
2. Return the three results $min$, $max$, and false.

The production QuantifierPrefix ::= * evaluates 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 \( \textit{Atom} :: \textit{PatternCharacter} \) evaluates as follows:

1. Let \( \textit{ch} \) be the character matched by \textit{PatternCharacter}.
2. Let \( \textit{A} \) be a one-element CharSet containing the character \( \textit{ch} \).
3. Call \( \textit{CharacterSetMatcher}(\textit{A}, \textit{false}) \) and return its Matcher result.

The production \( \textit{Atom} :: . \) evaluates as follows:

1. Let \( \textit{A} \) be the set of all characters except \textit{LineTerminator}.
2. Call \( \textit{CharacterSetMatcher}(\textit{A}, \textit{false}) \) and return its Matcher result.

The production \( \textit{Atom} :: \textbackslash \textit{AtomEscape} \) evaluates as follows:

1. Return the Matcher that is the result of evaluating \textit{AtomEscape}.

The production \( \textit{Atom} :: \textit{CharacterClass} \) evaluates as follows:

1. Evaluate \textit{CharacterClass} to obtain a CharSet \( \textit{A} \) and a Boolean \( \textit{invert} \).
2. Call \( \textit{CharacterSetMatcher}(\textit{A}, \textit{invert}) \) and return its Matcher result.

The production \( \textit{Atom} :: ( \textit{Disjunction} ) \) evaluates as follows:

1. Evaluate \textit{Disjunction} to obtain a Matcher \( \textit{m} \).
2. Let \( \textit{parenIndex} \) be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion's initial left parenthesis. This is the total number of times the \( \textit{Atom} :: ( \textit{Disjunction} ) \) production is expanded prior to this production's \( \textit{Atom} \) plus the total number of \( \textit{Atom} :: ( \textit{Disjunction} ) \) productions enclosing this \( \textit{Atom} \).
3. Return an internal Matcher closure that takes two arguments, a State \( \textit{x} \) and a Continuation \( \textit{c} \), and performs the following steps:
   a. Create an internal Continuation closure \( \textit{d} \) that takes one State argument \( \textit{y} \) and performs the following steps:
      i. Let \( \textit{cap} \) be a fresh copy of \( \textit{y} \)’s \textit{captures List}.
      ii. Let \( \textit{xe} \) be \( \textit{x} \)’s \textit{endIndex}.
      iii. Let \( \textit{ye} \) be \( \textit{y} \)’s \textit{endIndex}.
      iv. Let \( \textit{s} \) be a fresh List whose characters are the characters of \textit{Input} at indices \( \textit{xe} \) (inclusive) through \( \textit{ye} \) (exclusive).
      v. Set \( \textit{cap}[\textit{parenIndex}+1] \) to \( \textit{s} \).
      vi. Let \( \textit{z} \) be the State \( \textit{(ye, cap)} \).
      vii. Call \( \textit{c}(\textit{z}) \) and return its result.
   b. Call \( \textit{m}(\textit{x}, \textit{d}) \) and return its result.

The production \( \textit{Atom} :: ( ? : \textit{Disjunction} ) \) evaluates as follows:

1. Return the Matcher that is the result of evaluating \textit{Disjunction}.

21.2.2.8.1 Runtime Semantics: \textit{CharacterSetMatcher} Abstract Operation

The abstract operation \textit{CharacterSetMatcher} takes two arguments, a CharSet \( \textit{A} \) and a Boolean flag \( \textit{invert} \), and performs the following steps:

1. Return an internal Matcher closure that takes two arguments, a State \( \textit{x} \) and a Continuation \( \textit{c} \), and performs the following steps when evaluated:
   a. Let \( \textit{e} \) be \( \textit{x} \)’s \textit{endIndex}.
   b. If \( \textit{e} \) is \textit{InputLength}, return failure.
   c. Let \( \textit{ch} \) be the character \textit{Input}[\textit{e}].
   d. Let \( \textit{cc} \) be \textit{Canonicalize}(\textit{ch}).
   e. If \( \textit{invert} \) is \textit{false}, then
      i. If there does not exist a member \( \textit{a} \) of set \( \textit{A} \) such that \textit{Canonicalize}(\textit{a}) is \( \textit{cc} \), return failure.
   f. Else \( \textit{invert} \) is \textit{true},
i. If there exists a member $a$ of set $A$ such that $\text{Canonicalize}(a)$ is $cc$, return failure.

  g. Let $cap$ be $x$'s captures list.

h. Let $y$ be the State $(e+1, cap)$.

i. Call $c(y)$ and return its result.

### 21.2.2.8.2 Runtime Semantics: $\text{Canonicalize (ch)}$

The abstract operation $\text{Canonicalize}$ takes a character parameter $ch$ and performs the following steps:

1. If $\text{IgnoreCase}$ is $\text{false}$, return $ch$.

2. If $\text{Unicode}$ is $\text{true}$, then
   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 $\text{String.prototype.toUpperCase}$ using $s$ as the this value.
   d. Assert: $u$ is a String value.
   e. If $u$ does not consist of a single code unit, return $ch$.
   f. Let $cu$ be $u$'s single code unit element.
   g. If $ch$'s code unit value $\geq 128$ and $cu$'s code unit value $< 128$, return $ch$.
   h. 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 (\ followed by a nonzero decimal number), referenced in a replace $\text{String}$, 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 (?= form (this unusual behaviour is inherited from Perl). This only matters when the Disjunction contains capturing parentheses and the sequel of the pattern contains backreferences to those captures.

For example,

```
/(?=a+)/.exec("baaabac")
```

matches the empty String immediately after the first $b$ and therefore returns the array:

```
["", "aaa"]
```

To illustrate the lack of backtracking into the lookahead, consider:

```
/(?=a+)a*b\1/.exec("baaabac")
```

This expression returns

```
["aba", "a"]
```

and not:

```
["aaaba", "a"]
```
The form \( ?! \text{Disjunction} \) specifies a zero-width negative lookahead. In order for it to succeed, the pattern inside \text{Disjunction} must fail to match at the current position. The current position is not advanced before matching the sequel. \text{Disjunction} can contain capturing parentheses, but backreferences to them only make sense from within \text{Disjunction} itself. Backreferences to these capturing parentheses from elsewhere in the pattern always return \texttt{undefined} because the negative lookahead must fail for the pattern to succeed. For example,

\[
/.*?!(a+)b\backslash2c)/.exec("baaabaac")
\]

looks for an \texttt{a} not immediately followed by some positive number \( n \) of \texttt{a}'s, a \texttt{b}, another \( n \) \texttt{a}'s (specified by the first \( \backslash2 \)) and a \texttt{c}. The second \( \backslash2 \) is outside the negative lookahead, so it matches against \texttt{undefined} and therefore always succeeds. The whole expression returns the array:

\[
["baaabaac", "ba", undefined, "abaac"]
\]

In case-insensitive matches when \texttt{Unicode} is \texttt{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, \texttt{ß} (U+00DF) to \texttt{SS}. It may however map a code point outside the Basic Latin range to a character within, for example, \texttt{ſ} (U+017F) to \texttt{s}. Such characters are not mapped if \texttt{Unicode} is \texttt{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 \texttt{AtomEscape :: DecimalEscape} evaluates as follows:

1. Evaluate \texttt{DecimalEscape} to obtain an \texttt{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 \texttt{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 \texttt{SyntaxError} exception.
6. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following steps:
   a. Let \( cap \) be \( x \)'s \texttt{captures} List.
   b. Let \( s \) be \( cap[n] \).
   c. If \( s \) is \texttt{undefined}, return \( c(x) \).
   d. Let \( e \) be \( x \)'s \texttt{endIndex}.
   e. Let \( len \) be \( s \)'s length.
   f. Let \( f \) be \( e+len \).
   g. If \( f>\text{InputLength} \), return failure.
   h. If there exists an integer \( i \) between 0 (inclusive) and \( len \) (exclusive) such that \texttt{Canonicalize(s[i])} is not the same character value as \texttt{Canonicalize(Input[e+i])}, return failure.
   i. Let \( y \) be the State \( (f, cap) \).
   j. Call \( c(y) \) and return its result.

The production \texttt{AtomEscape :: CharacterEscape} evaluates as follows:

1. Evaluate \texttt{CharacterEscape} to obtain a character \( ch \).
2. Let \( A \) be a one-element CharSet containing the character \( ch \).
3. Call \texttt{CharacterSetMatcher(A, false)} and return its Matcher result.

The production \texttt{AtomEscape :: CharacterClassEscape} evaluates as follows:

1. Evaluate \texttt{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 0). 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 48.

<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 LeadSurrogate` evaluates as follows:

1. Return the character whose code is the result of evaluating `LeadSurrogate`.

The production `RegExpUnicodeEscapeSequence :: u TrailSurrogate` evaluates as follows:

1. Return the character whose code is the result of evaluating `TrailSurrogate`.

The production `RegExpUnicodeEscapeSequence :: u NonSurrogate` evaluates as follows:
1. Return the character whose code is the result of evaluating `NonSurrogate`.

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`.

The production `NonSurrogate :: Hex4Digits` evaluates as follows:

1. Return the character whose code is the SV of `Hex4Digits`.

**21.2.2.1 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.

**21.2.2.12 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` or `LineTerminator` 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.

### 21.2.2.16 NonemptyClassRangesNoDash

The production `NonemptyClassRangesNoDash :: ClassAtom` evaluates as follows:

1. Return the CharSet that is the result of evaluating `ClassAtom`.

The production `NonemptyClassRangesNoDash :: ClassAtomNoDash NonemptyClassRangesNoDash` evaluates as follows:

1. Evaluate `ClassAtomNoDash` to obtain a CharSet `A`.
2. Evaluate `NonemptyClassRangesNoDash` to obtain a CharSet `B`.
3. Return the union of CharSets `A` and `B`.

The production `NonemptyClassRangesNoDash :: ClassAtomNoDash - ClassAtom ClassRanges` evaluates as follows:
1. Evaluate `ClassAtomNoDash` to obtain a CharSet $A$.
2. Evaluate `ClassAtom` to obtain a CharSet $B$.
3. Evaluate `ClassRanges` to obtain a CharSet $C$.
4. Call `CharacterRange($A, B$)` and let $D$ be the resulting CharSet.
5. Return the union of CharSet $D$ and $C$.

`ClassRanges` can expand into a 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 `\w`) or if the first `ClassAtom`'s character value is greater than the second `ClassAtom`'s character value.

Even if the pattern ignores case, the case of the two ends of a range is significant in determining which characters belong to the range. Thus, for example, the pattern `/[E-F]/i` matches only the letters E, F, e, and f, while the pattern `/[E-f]/i` matches all upper and lower-case letters in the Unicode Basic Latin block as well as the symbols [, \, ], ^, _, and `.

A `-` character can be treated literally or it can denote a range. It is treated literally if it is the first or last character of `ClassRanges`, the beginning or end limit of a range specification, or immediately follows a range specification.

### 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 \ 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 $ch$.

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 (HYphen-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`. 
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:

2. If NewTarget is not undefined, let newTarget be NewTarget.
3. 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. If SameValue(newTarget, patternConstructor) is true, return pattern.
4. 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.
5. Else if patternIsRegExp is true, then
   a. Let P be ?Get(pattern, "source").
   b. If flags is undefined, then
      i. Let F be ?Get(pattern, "flags").
   c. Else, let F be flags.
6. Else,
   a. Let P be pattern.
   b. Let F be flags.

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 U+005C (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 (newTarget)

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. Perform ! DefinePropertyOrThrow(obj, "lastIndex", PropertyDescriptor {[[Writable]]: true, [[Enumerable]]: false,
   [[Configurable]]: false}).
3. Return obj.
21.2.3.2.2 Runtime Semantics: RegExpInitialize (obj, pattern, flags)

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. If flags is undefined, let F be the empty String.
5. 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.
6. If F contains "u", let BMP be false; else let BMP be true.
7. 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, if any elements of P were not matched by the parse, or if any Early Error conditions exist.
   b. Let patternCharacters be a List whose elements are the code unit elements of P.
8. 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[U]. Throw a SyntaxError exception if P did not conform to the grammar, if any elements of P were not matched by the parse, or if any Early Error conditions exist.
   b. Let patternCharacters be a List whose elements are the code points resulting from applying UTF-16 decoding to P's sequence of elements.
9. Set the value of obj's [[OriginalSource]] internal slot to P.
10. Set the value of obj's [[OriginalFlags]] internal slot to F.
11. 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.
12. Perform ? Set(obj, "lastIndex", 0, true).
13. Return obj.

21.2.3.2.3 Runtime Semantics: RegExpCreate (P, F)

When the abstract operation RegExpCreate with arguments P and F is called, the following steps are taken:

1. Let obj be ? RegExpAlloc(%RegExp%).

21.2.3.2.4 Runtime Semantics: EscapeRegExpPattern (P, F)

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 "\u002F", among other possibilities, but not "/\", because /// followed by F would be parsed as a SingleLineComment rather than a RegularExpressionLiteral. If P is the empty String, this specification can be met by letting S be "(?::)".
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%.

The RegExp constructor has the following properties:

21.2.4.1 RegExp.prototype

The initial value of RegExp.prototype is the intrinsic object %RegExpPrototype%. 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 the this value.

The value of the name property of this function is "get [Symbol.species]".

NOTE RegExp 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 the intrinsic object %RegExpPrototype%. 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%.

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).

21.2.5.2.1 Runtime Semantics: RegExpExec ( R, S )

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. If IsCallable(exec) is true, then
   a. Let result be ? Call(exec, R, « S »).
   b. If Type(result) is neither Object or Null, throw a TypeError exception.
21.2.5.2.2 Runtime Semantics: RegExpBuiltinExec (R, S)

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. Let global be ToBoolean(? Get(R, "global")).
6. Let sticky be ToBoolean(? Get(R, "sticky")).
7. If global is false and sticky is false, let lastIndex be 0.
8. Let matcher be the value of R's [[RegExpMatcher]] internal slot.
9. Let flags be the value of R's [[OriginalFlags]] internal slot.
10. If flags contains "u", let fullUnicode be true, else let fullUnicode be false.
11. Let matchSucceeded be false.
12. Repeat, while matchSucceeded is false
   a. If lastIndex > length, then
      i. Perform ? Set(R, "lastIndex", 0, true).
      ii. Return null.
   b. Let r be matcher(S, lastIndex).
   c. If r is failure, then
      i. If sticky is true, then
         1. Perform ? Set(R, "lastIndex", 0, true).
         2. Return null.
      ii. Let lastIndex be AdvanceStringLength(S, lastIndex, fullUnicode).
   d. Else,
      i. Assert: r is a State.
      ii. Set matchSucceeded to true.
13. Let e be r's endIndex value.
14. 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 or equal to the length of Input, then eUTF is the number of code units in S.
   b. Let e be eUTF.
15. If global is true or sticky is true, then
16. Let n be the length of r's capturesList. (This is the same value as 21.2.2.1's NcapturingParen.)
17. Let A be ArrayCreate(n + 1).
18. Assert: The value of A's "length" property is n + 1.
19. Let matchIndex be lastIndex.
20. Perform ! CreateDataProperty(A, "index", matchIndex).
22. Let matchedSubstr be the matched substring (i.e. the portion of S between offset lastIndex inclusive and offset e exclusive).
23. Perform ! CreateDataProperty(A, "\0", matchedSubstr).
24. For each integer i such that i > 0 and i ≤ n
   a. Let capture be i-th element of r's captures List.

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.
b. If \( \text{captureI} \) is \textbf{undefined}, let \( \text{capturedValue} \) be \textbf{undefined}.

c. Else if \( \text{fullUnicode} \) is \textbf{true}, then

i. Assert: \( \text{captureI} \) is a List of code points.

ii. Let \( \text{capturedValue} \) be a string whose code units are the \texttt{UTF16Encoding} of the code points of \( \text{captureI} \).

d. Else, \( \text{fullUnicode} \) is \textbf{false},

i. Assert: \( \text{captureI} \) is a List of code units.

ii. Let \( \text{capturedValue} \) be a string consisting of the code units of \( \text{captureI} \).

e. Perform \( ! \text{CreateDataProperty}(A, ! \text{ToString}(i), \text{capturedValue}) \).

25. Return \( A \).

21.2.5.2.3 \textbf{AdvanceStringIndex} ( \( S, index, \text{unicode} \) )

The abstract operation \texttt{AdvanceStringIndex} with arguments \( S, index, \) and \( \text{unicode} \) performs the following steps:

1. Assert: \texttt{Type}(\( S \)) is String.

2. Assert: \( \text{index} \) is an integer such that \( 0 \leq \text{index} < 2^{53} - 1 \).

3. Assert: \texttt{Type}(\( \text{unicode} \)) is Boolean.

4. If \( \text{unicode} \) is \textbf{false}, return \( \text{index} + 1 \).

5. Let \( \text{length} \) be the number of code units in \( S \).

6. If \( \text{index} + 1 \geq \text{length} \), return \( \text{index} + 1 \).

7. Let \( \text{first} \) be the code unit value at index \( \text{index} \) in \( S \).

8. If \( \text{first} < 0x8000 \) or \( \text{first} > 0xDBFF \), return \( \text{index} + 1 \).

9. Let \( \text{second} \) be the code unit value at index \( \text{index} + 1 \) in \( S \).

10. If \( \text{second} < 0xDC000 \) or \( \text{second} > 0xDFFF \), return \( \text{index} + 1 \).

11. Return \( \text{index} + 2 \).

21.2.5.3 \textbf{RegExp.prototype.flags}

\( \text{RegExp.prototype.flags} \) 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 \texttt{Type}(\( R \)) is not Object, throw a \texttt{TypeError} exception.

3. Let \( \text{result} \) be the empty String.

4. Let \( \text{global} \) be \( \texttt{ToBoolean}(? \text{Get}(R, "global")) \).

5. If \( \text{global} \) is \textbf{true}, append "g" as the last code unit of \( \text{result} \).

6. Let \( \text{ignoreCase} \) be \( \texttt{ToBoolean}(? \text{Get}(R, "ignoreCase")) \).

7. If \( \text{ignoreCase} \) is \textbf{true}, append "i" as the last code unit of \( \text{result} \).

8. Let \( \text{multiline} \) be \( \texttt{ToBoolean}(? \text{Get}(R, "multiline")) \).

9. If \( \text{multiline} \) is \textbf{true}, append "m" as the last code unit of \( \text{result} \).

10. Let \( \text{unicode} \) be \( \texttt{ToBoolean}(? \text{Get}(R, "unicode")) \).

11. If \( \text{unicode} \) is \textbf{true}, append "u" as the last code unit of \( \text{result} \).

12. Let \( \text{sticky} \) be \( \texttt{ToBoolean}(? \text{Get}(R, "sticky")) \).

13. If \( \text{sticky} \) is \textbf{true}, append "y" as the last code unit of \( \text{result} \).

14. Return \( \text{result} \).

21.2.5.4 \textbf{RegExp.prototype.global}

\( \text{RegExp.prototype.global} \) 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 \texttt{Type}(\( R \)) is not Object, throw a \texttt{TypeError} exception.

3. If \( R \) does not have an \([\text{OriginalFlags}]\) internal slot, throw a \texttt{TypeError} exception.

4. Let \( \text{flags} \) be the value of \( R \)'s \([\text{OriginalFlags}]\) internal slot.

5. If \( \text{flags} \) contains the code unit "g", return \textbf{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 `[[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 "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. Let `global` be `ToBoolean(? Get(rx, "global"))`.
5. If `global` is `false`, then
6. Else `global` is `true`,
   a. Let `fullUnicode` be `ToBoolean(? Get(rx, "unicode"))`.
   b. Perform `? Set(rx, "lastIndex", 0, true)`.
   c. Let `A` be `ArrayCreate(0)`.
   d. Let `n` be `0`.
   e. Repeat,
      i. Let `result` be `? RegExpExec(rx, S)`.
      ii. If `result` is `null`, then
          1. If `n=0`, return `null`.
          2. Else, return `A`.
      iii. Else `result` is not `null`,
          1. Let `matchStr` be `ToString(? Get(result, "\0"))`.
          2. Let `status` be `CreateDataProperty(A, ! ToString(n), matchStr)`.
          3. Assert: `status` is `true`.
          4. If `matchStr` is the empty String, then
             a. Let `thisIndex` be `? ToLength(? Get(rx, "lastIndex"))`.
             b. Let `nextIndex` be `AdvanceStringIndex(S, thisIndex, fullUnicode)`.
             c. Perform `? Set(rx, "lastIndex", nextIndex, true)`.
      5. 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. Let lengthS be the number of code unit elements in S.
5. Let functionalReplace be IsCallable(replaceValue).
6. If functionalReplace is false, then
   a. Let replaceValue be ? ToString(replaceValue).
7. Let global be ToBoolean(? Get(rx, "global").
8. If global is true, then
   a. Let fullUnicode be ToBoolean(? Get(rx, "unicode").
   b. Perform ? Set(rx, "lastIndex", 0, true).
9. Let results be a new empty List.
10. Let done be false.
11. Repeat, while done is false
   a. Let result be ? RegExpExec(rx, S).
   b. If result is null, set done to true.
   c. 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. If matchStr is the empty String, then
            a. Let thisIndex be ? ToLength(? Get(rx, "lastIndex").
            b. Let nextIndex be AdvanceStringIndex(S, thisIndex, fullUnicode).
            c. Perform ? Set(rx, "lastIndex", nextIndex, true).
12. Let accumulatedResult be the empty String value.
13. Let nextSourcePosition be 0.
14. Repeat, for each result in results,
   a. Let nCaptures be ? ToLength(? Get(result, "length").
   b. Let nCaptures be max(nCaptures - 1, 0).
   c. Let matched be ? ToString(? Get(result, "0").
   d. Let matchLength be the number of code units in matched.
   e. Let position be ? ToInteger(? Get(result, "index").
   f. Let position be max(min(position, lengthS), 0).
   g. Let n be 1.
   h. Let captures be a new empty List.
      i. Repeat while n ≤ nCaptures
         1. Let capN be ? Get(result, ! ToString(n)).
         ii. If capN is not undefined, then
            1. Let capN be ? ToString(capN).
            iii. Append capN as the last element of captures.
            iv. Let n be n+1.
      j. If functionalReplace is true, then
         i. Let replacerArgs be « matched ».
ii. Append in list order the elements of \textit{captures} to the end of the \texttt{List replacerArgs}.

iii. Append \textit{position} and \textit{S} as the last two elements of \texttt{replacerArgs}.

iv. Let \textit{replValue} be \texttt{Call(replaceValue, undefined, replacerArgs)}.

v. Let \textit{replacement} be \texttt{ToString(replValue)}.

k. Else,

i. Let \textit{replacement} be \texttt{GetSubstitution(matched, S, position, captures, replValue)}.

l. If \textit{position} \texttt{nextSourcePosition}, then

i. NOTE \textit{position} should not normally move backwards. If it does, it is an indication of an ill-behaving RegExp subclass or use of an access triggered side-effect to change the global flag or other characteristics of \textit{rx}. In such cases, the corresponding substitution is ignored.

ii. Let \textit{accumulatedResult} be the string formed by concatenating the code units of the current value of \textit{accumulatedResult} with the substring of \textit{S} consisting of the code units from \textit{nextSourcePosition} (inclusive) up to \textit{position} (exclusive) and with the code units of \textit{replacement}.

iii. Let \textit{nextSourcePosition} be \textit{position} + \textit{matchLength}.

15. If \textit{nextSourcePosition} \texttt{lengthS}, return \textit{accumulatedResult}.

16. Return the String formed by concatenating the code units of \textit{accumulatedResult} with the substring of \textit{S} consisting of the code units from \textit{nextSourcePosition} (inclusive) up through the final code unit of \textit{S} (inclusive).

The value of the \textit{name} property of this function is \texttt{"[Symbol.replace]"}.

\subsection{21.2.5.9 RegExp.prototype \texttt{[@@search]}(\texttt{string})}

When the \texttt{[@@search} method is called with argument \textit{string}, the following steps are taken:

1. Let \textit{rx} be the \texttt{this} value.
2. If \textit{Type(rx)} is not Object, throw a \texttt{TypeError} exception.
3. Let \textit{S} be \texttt{ToString(string)}.
4. Let \textit{previousLastIndex} be ? \texttt{Get(rx, "lastIndex")}.
5. Perform ? \texttt{Set(rx, "lastIndex", 0, true)}.
6. Let \textit{result} be ? \textit{RegexpExec(rx, S)}.
7. Perform ? \texttt{Set(rx, "lastIndex", previousLastIndex, true)}.
8. If \textit{result} is \texttt{null}, return \texttt{-1}.
9. Return ? \texttt{Get(result, "index")}.

The value of the \textit{name} property of this function is \texttt{"[Symbol.search]"}.

\begin{note}

The \textit{lastIndex} and \textit{global} properties of this RegExp object are ignored when performing the search. The \textit{lastIndex} property is left unchanged.

\end{note}

\subsection{21.2.5.10 get RegExp.prototype.source}

\texttt{RegExp.prototype.source} is an accessor property whose set accessor function is \texttt{undefined}. Its get accessor function performs the following steps:

1. Let \textit{R} be the \texttt{this} value.
2. If \textit{Type(R)} is not Object, throw a \texttt{TypeError} exception.
3. If \textit{R} does not have an \texttt{[OriginalSource]} internal slot, throw a \texttt{TypeError} exception.
4. If \textit{R} does not have an \texttt{[OriginalFlags]} internal slot, throw a \texttt{TypeError} exception.
5. Let \textit{src} be the value of \textit{R}'s \texttt{[OriginalSource]} internal slot.
6. Let \textit{flags} be the value of \textit{R}'s \texttt{[OriginalFlags]} internal slot.
7. Return \texttt{EscapeRegExpPattern(src, flags)}.

\subsection{21.2.5.11 RegExp.prototype \texttt{[@@split]}(\texttt{string}, \texttt{limit})}

\begin{note}

Returns an Array object into which substrings of the result of converting \textit{string} to a String have been stored. The substrings are determined by searching from left to right for matches of the \texttt{this} value regular expression; these occurrences are not part of any substring in the returned array, but serve to divide up the String value.

\end{note}
The this value may be an empty regular expression or a regular expression that can match an empty String. In this case, the regular expression does not match the empty substring at the beginning or end of the input String, nor does it match the empty substring at the end of the previous separator match. (For example, if the regular expression matches the empty String, the String is split up into individual code unit elements; the length of the result array equals the length of the String, and each substring contains one code unit.) Only the first match at a given index of the 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 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,

```javascript
/<(\/?([^<>]*))*>/<[Symbol.split]("A<B>bold</B>and<CODE> coded</CODE>")
```

evaluates to the array

```javascript
```

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 $ be ? ToString(string).
4. Let C be ? SpeciesConstructor(rx, %RegExp%).
5. Let flags be ? ToString(? Get(rx, "flags").
6. If flags contains "u", let unicodeMatching be true.
7. Else, let unicodeMatching be false.
8. If flags contains "y", let newFlags be flags.
9. Else, let newFlags be the string that is the concatenation of flags and "/y".
10. Let splitter be ? Construct(C, « rx, newFlags »).
11. Let A be ArrayCreate(0).
12. Let lengthA be 0.
13. If limit is undefined, let lim be 2³²-1; else let lim be ? ToUint32(limit).
14. Let size be the number of elements in $.
15. Let p be 0.
16. If lim = 0, return A.
17. If size = 0, then
   a. Let z be ? RegExpExec(splitter, $).
   b. If z is not null, return A.
   c. Perform ! CreateDataProperty(A, "\0", $).
   d. Return A.
18. Let q be p.
19. Repeat, while q < size
   a. Perform ? Set(splitter, "lastIndex", q, true).
   b. Let z be ? RegExpExec(splitter, $).
   c. If z is null, let q be AdvanceStringIndex($, q, unicodeMatching).
   d. Else z is not null,
      i. Let e be ? ToLength(? Get(splitter, "lastIndex").
      ii. Let e be min(e, size).
      iii. If e = p, let q be AdvanceStringIndex($, q, unicodeMatching).
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. Perform $\text{CreateDataProperty}(A, \text{ToString}(lengthA), T)$.
   3. Let $lengthA$ be $lengthA + 1$.
   4. If $lengthA = \text{lim}$, return $A$.
   5. Let $p$ be $e$.
   6. Let $numberOfCaptures$ be $\text{ToLength}(\text{Get}(z, \text{"length"}))$.
   7. Let $numberOfCaptures$ be $\max(numberOfCaptures - 1, 0)$.
   8. Let $i$ be $1$.
   9. Repeat, while $i \leq numberOfCaptures$,
      a. Let $nextCapture$ be $\text{Get}(z, \text{ToString}(i))$.
      b. Perform $\text{CreateDataProperty}(A, \text{ToString}(lengthA), nextCapture)$.
      c. Let $i$ be $i + 1$.
      d. Let $lengthA$ be $lengthA + 1$.
      e. If $lengthA = \text{lim}$, return $A$.
   10. Let $q$ be $p$.
   20. Let $T$ be a String value equal to the substring of $S$ consisting of the elements at indices $p$ (inclusive) through $size$ (exclusive).
   21. Perform $\text{CreateDataProperty}(A, \text{ToString}(lengthA), T)$.
   22. Return $A$.

The value of the $\text{name}$ property of this function is "$\text{[Symbol.split]}$".

NOTE 2 The @@split method ignores the value of the $\text{global}$ and $\text{sticky}$ properties of this RegExp object.

21.2.5.12 get RegExp.prototype.sticky

RegExp.prototype.sticky is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

   1. Let $R$ be the this value.
   2. If $\text{Type}(R)$ is not Object, throw a $\text{TypeError}$ exception.
   3. If $R$ does not have an $\text{[OriginalFlags]}$ internal slot, throw a $\text{TypeError}$ exception.
   4. Let $flags$ be the value of $R$'s $\text{[OriginalFlags]}$ 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 $\text{TypeError}$ exception.
   3. Let $string$ be $\text{ToString}(S)$.
   4. Let $match$ be $\text{RegExpExec}(R, string)$.
   5. 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 $\text{TypeError}$ exception.
   3. Let $pattern$ be $\text{ToString}(\text{Get}(R, \text{"source"}))$.
   4. Let $flags$ be $\text{ToString}(\text{Get}(R, \text{"flags"}))$.
   5. Let $result$ be the String value formed by concatenating "/", $pattern$, "/", and $flags$.
   6. Return $result$. 
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 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 ECMAScript 2015, 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.

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 9.4.2 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 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. Return `ArrayCreate(0, proto)`.

22.1.2 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. Let `array` be `ArrayCreate(0, proto)`.
6. If `Type(len)` is not Number, then
   a. Let `defineStatus` be `CreateDataProperty(array, "0", len)`.
   b. Assert: `defineStatus` is true.
   c. Let `intLen` be 1.
7. Else,
   a. Let `intLen` be `ToUint32(len)`.
   b. If `intLen ≠ len`, throw a `RangeError` exception.

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. Let `array` be `ArrayCreate(numberOfArgs, proto)`.
6. Let `k` be 0.
7. Let `items` be a zero-origined `List` containing the argument items in order.
8. Repeat, while `k < numberOfArgs`
   a. Let `Pk` be ! ToString(`k`).
   b. Let `itemK` be `items[k]`.
   c. Let `defineStatus` be `CreateDataProperty(array, `Pk`, itemK)`.
   d. Assert: `defineStatus` is true.
   e. Increase `k` by 1.
9. Assert: the value of `array`'s `length` property is `numberOfArgs`.
10. 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%`.

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 `Callable(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. If `usingIterator` is not `undefined`, then
   a. If `IsConstructor(C)` is `true`, then
      i. Let `A` be ? `Construct(C)`.
   b. Else,
      i. Let `A` be `ArrayCreate(0)`.
   c. Let `iterator` be ? `GetIterator(items, usingIterator)`.
   d. Let `k` be `0`.
   e. Repeat
      i. If `k ≥ 2^{53} - 1`, then
         1. Let `error` be `Completion([[Type]]: throw, [[Value]]: a newly created `TypeError` object, [[Target]]: empty).
         2. Return ? `IteratorClose(iterator, error)`.
      ii. Let `Pk` be ! `ToString(k)`.
      iii. Let `next` be ? `IteratorStep(iterator)`.
      iv. If `next` is `false`, then
         1. Perform ? `Set(A, "length", k, true)`.
         2. Return `A`.
   v. Let `nextValue` be ? `IteratorValue(next)`.
   vi. If `mapping` is `true`, then
         1. Let `mappedValue` be `Call(mapfn, T, « nextValue, k »)`.
         2. If `mappedValue` is an abrupt completion, return ? `IteratorClose(iterator, mappedValue)`.
         3. Let `mappedValue` be `mappedValue.[[Value]]`.
   vii. Else, let `mappedValue` be `nextValue`.
   viii. Let `defineStatus` be `CreateDataPropertyOrThrow(A, Pk, mappedValue)`.
   ix. If `defineStatus` is an abrupt completion, return ? `IteratorClose(iterator, defineStatus)`.
   x. Increase `k` by `1`.
6. NOTE: `items` is not an iterable so assume it is an array-like object.
7. Let `arrayLike` be ! `ToObject(items)`.
8. Let `len` be ? `ToLength(? `Get(arrayLike, "length")`).
9. If `IsConstructor(C)` is `true`, then
10. Else,
    a. Let `A` be `ArrayCreate(len)`.
11. Let `k` be `0`.
12. Repeat, while `k < len`
    a. Let `Pk` be ! `ToString(k)`.
    b. Let `kValue` be ? `Get(arrayLike, Pk)`.
    c. If `mapping` is `true`, then
       i. Let `mappedValue` be ? `Call(mapfn, T, « kValue, k »)`.
    d. Else, let `mappedValue` be `kValue`.
    e. Perform ? `CreateDataPropertyOrThrow(A, Pk, mappedValue)`.
    f. Increase `k` by `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. Let `k` be `0`.
7. Repeat, while `k < len`
   a. Let `kValue` be `items[k].`
   b. Let `Pk` be `ToString(k).`
   c. Perform `CreateDataPropertyOrThrow(A, Pk, kValue).
   d. Increase `k` by `1`.

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.

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 the `this` value.

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 Array prototype object is the intrinsic object %ArrayPrototype%. The Array prototype object is an Array exotic objects and has the internal methods specified for such objects. It has a `length` property whose initial value is 0 and whose attributes are { [[Writable]]: `true`, [[Enumerable]]: `false`, [[Configurable]]: `false` }.

The value of the [[Prototype]] internal slot of the Array prototype object is the intrinsic object %ObjectPrototype%.

**NOTE**  
The Array prototype object is specified to be an Array exotic object to ensure compatibility with ECMAscript code that was created prior to the ECMAscript 2015 specification.

**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 `ToObject(this value)`.
2. Let `A` be `ArraySpeciesCreate(O, 0)`.
3. Let `n` be 0.
4. 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.
5. 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. If `spreadable` is `true`, then
      i. Let `k` be 0.
      ii. Let `len` be `ToLength(? Get(E, "length"))`.
      iii. If `n + len > 2^{53} - 1`, throw a `TypeError` exception.
      iv. Repeat, while `k < len`
         1. Let `P` be `ToString(k)`.
         2. Let `exists` be `HasProperty(E, P)`.
         3. If `exists` is `true`, then
            a. Let `subElement` be `Get(E, P)`.
            b. Perform `CreateDataPropertyOrThrow(A, !ToString(n), subElement)`.
         4. Increase `n` by 1.
         5. Increase `k` by 1.
   d. Else `E` is added as a single item rather than spread,
      i. If `n*2^{53} - 1`, throw a `TypeError` exception.
      ii. Perform `CreateDataPropertyOrThrow(A, !ToString(n), E)`.
      iii. Increase `n` by 1.
6. Perform `Set(A, "length", n, true)`.
7. Return `A`.

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

**NOTE 1**  
The explicit setting of the `length` property in step 6 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 Runtime Semantics: IsConcatSpreadable ( O )**

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. If `spreadable` is not `undefined`, return `ToBoolean(spreadable)`.
4. 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 1** 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 `ToObject(this value)`.
2. Let `len` be `ToLength(ToObject(O, "length"))`.
3. Let `relativeTarget` be `ToInteger(target)`.
4. If `relativeTarget < 0`, let `to` be `max((len + relativeTarget), 0)`; else let `to` be `min(relativeTarget, len)`.
5. Let `relativeStart` be `ToInteger(start)`.
6. If `relativeStart < 0`, let `from` be `max((len + relativeStart), 0)`; else let `from` be `min(relativeStart, len)`.
7. If `end` is `undefined`, let `relativeEnd` be `len`; else let `relativeEnd` be `ToInteger(end)`.
8. If `relativeEnd < 0`, let `final` be `max((len + relativeEnd), 0)`; else let `final` be `min(relativeEnd, len)`.
9. Let `count` be `min(final-from, len-to)`.
10. If `from<to` and `to<from+count`, then
    a. Let `direction` be `-1`.
    b. Let `from` be `from + count - 1`.
    c. Let `to` be `to + count - 1`.
11. Else,
    a. Let `direction` be `1`.
12. Repeat, while `count > 0`
    a. Let `fromKey` be `ToString(from)`.
    b. Let `toKey` be `ToString(to)`.
    c. Let `fromPresent` be `HasProperty(O, fromKey)`.
    d. If `fromPresent` is `true`, then
       i. Let `fromVal` be `Get(O, fromKey)`.
       ii. Perform `Set(O, toKey, fromVal, true)`.
    e. Else `fromPresent` is `false`,
       i. Perform `DeletePropertyOrThrow(O, toKey)`.
    f. Let `from` be `from + direction`.
    g. Let `to` be `to + direction`.
    h. Let `count` be `count - 1`.
13. Return `O`.

**NOTE 2** 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 `ToObject(this value)`.
2. Return `CreateArrayIterator(O, "key+value")`.

### 22.1.3.5 Array.prototype.every (callbackfn [ , thisArg ])

22.1.3.5 Array.prototype.every (callbackfn [ , thisArg ])

The following steps are taken:

1. Let `O` be `ToObject(this value)`.
2. Return `CreateArrayIterator(O, "key+value")`. 

### 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 1** 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 `ToObject(this value)`.
2. Let `len` be `ToLength(ToObject(O, "length"))`.
3. Let `relativeTarget` be `ToInteger(target)`.
4. If `relativeTarget < 0`, let `to` be `max((len + relativeTarget), 0)`; else let `to` be `min(relativeTarget, len)`.
5. Let `relativeStart` be `ToInteger(start)`.
6. If `relativeStart < 0`, let `from` be `max((len + relativeStart), 0)`; else let `from` be `min(relativeStart, len)`.
7. If `end` is `undefined`, let `relativeEnd` be `len`; else let `relativeEnd` be `ToInteger(end)`.
8. If `relativeEnd < 0`, let `final` be `max((len + relativeEnd), 0)`; else let `final` be `min(relativeEnd, len)`.
9. Let `count` be `min(final-from, len-to)`.
10. If `from<to` and `to<from+count`, then
    a. Let `direction` be `-1`.
    b. Let `from` be `from + count - 1`.
    c. Let `to` be `to + count - 1`.
11. Else,
    a. Let `direction` be `1`.
12. Repeat, while `count > 0`
    a. Let `fromKey` be `ToString(from)`.
    b. Let `toKey` be `ToString(to)`.
    c. Let `fromPresent` be `HasProperty(O, fromKey)`.
    d. If `fromPresent` is `true`, then
       i. Let `fromVal` be `Get(O, fromKey)`.
       ii. Perform `Set(O, toKey, fromVal, true)`.
    e. Else `fromPresent` is `false`,
       i. Perform `DeletePropertyOrThrow(O, toKey)`.
    f. Let `from` be `from + direction`.
    g. Let `to` be `to + direction`.
    h. Let `count` be `count - 1`.
13. Return `O`.

**NOTE 2** 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 `ToObject(this value)`.
2. Return `CreateArrayIterator(O, "key+value")`.

### 22.1.3.5 Array.prototype.every (callbackfn [ , thisArg ])

The following steps are taken:

1. Let `O` be `ToObject(this value)`.
2. Return `CreateArrayIterator(O, "key+value")`.
The following steps are taken:

1. Let \( O \) be `ToObject(this value)`.
2. Let \( len \) be `ToLength(`\( O \), "length")`.
3. If `IsCallable(callbackfn)` is false, throw a `TypeError` exception.
4. If `thisArg` was supplied, let \( T \) be `thisArg`; else let \( T \) be `undefined`.
5. Let \( k \) be 0.
6. Repeat, while \( k < len \)
   a. Let \( P_k \) be `ToString(k)`.
   b. Let `kPresent` be `HasProperty(O, P_k)`.
   c. If `kPresent` is true, then
      i. Let `kValue` be `Get(O, P_k)`.
      ii. Let `testResult` be `ToBoolean(thisArg ? Call(callbackfn, T, « kValue, k, O »))`.
      iii. If `testResult` is false, return false.
   d. Increase \( k \) by 1.
7. Return `true`.

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`.

The following steps are taken:

1. Let \( O \) be `ToObject(this value)`.
2. Let \( len \) be `ToLength(`\( O \), "length")`.
3. Let `relativeStart` be `ToInteger(start)`.
4. If `relativeStart < 0`, let \( k \) be `max((len + relativeStart), 0)`; else let \( k \) be `min(relativeStart, len)`.
5. If `end` is `undefined`, let `relativeEnd` be `len`; else let `relativeEnd` be `ToInteger(end)`.
6. If `relativeEnd < 0`, let `final` be `max((len + relativeEnd), 0)`; else let `final` be `min(relativeEnd, len)`.

NOTE 1 `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 `?ToObject(this value)`.
2. Let \( len \) be `?ToLength(`\( O \), "length")`.
3. If `IsCallable(callbackfn)` is false, throw a `TypeError` exception.
4. If `thisArg` was supplied, let \( T \) be `thisArg`; else let \( T \) be `undefined`.
5. Let \( k \) be 0.
6. Repeat, while \( k < len \)
   a. Let \( P_k \) be `ToString(k)`.
   b. Let `kPresent` be `HasProperty(O, P_k)`.
   c. If `kPresent` is true, then
      i. Let `kValue` be `Get(O, P_k)`.
      ii. Let `testResult` be `ToBoolean(thisArg ? Call(callbackfn, T, « kValue, k, O »))`.
      iii. If `testResult` is false, return false.
   d. Increase \( k \) by 1.
7. Return `true`.

NOTE 2 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.
7. Repeat, while $k < \text{final}$
   a. Let $P_k$ be `ToString($k$).
   b. Perform `? Set($O, P_k, \text{value, true}$).
   c. Increase $k$ by 1.
8. Return $O$.

NOTE 2 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 1 `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 `ToObject(this value).`
2. Let $\text{len}$ be `ToLength(? Get($O, "length"))`. 
3. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
4. If `thisArg` was supplied, let $T$ be `thisArg`; else let $T$ be `undefined`.
5. Let $A$ be `ArraySpeciesCreate($O, 0)`. 
6. Let $k$ be 0.
7. Let $\text{to}$ be 0.
8. Repeat, while $k < \text{len}$
   a. Let $P_k$ be `ToString($k$).
   b. Let $kPresent$ be `HasProperty($O, P_k$).
   c. If $kPresent$ is `true`, then
      i. Let $kValue$ be `Get($O, P_k$).
      ii. Let $\text{selected}$ be `ToBoolean`(? `Call(callbackfn, T, « kValue, k, O »)`).
      iii. If $\text{selected}$ is `true`, then
         1. Perform `? CreateDataPropertyOrThrow($A, ToString($to$), kValue)`. 
         2. Increase $\text{to}$ by 1.
   d. Increase $k$ by 1.

NOTE 2 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 1  *predicate* should be a function that accepts three arguments and returns a value that is coercible to a Boolean value. The `find` function 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.

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

1. Let `O` be `ToObject(this value)`.
2. Let `len` be `ToLength(GetValue(O, "length"))`.
3. If `IsCallable(*predicate*)` is `false`, throw a `TypeError` exception.
4. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
5. Let `k` be `0`.
6. Repeat, while `k < len`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kValue` be `GetValue(O, Pk)`.
   c. Let `testResult` be `ToBoolean(Call(*predicate*, T, « kValue, k, O »))`.
   d. If `testResult` is `true`, return `kValue`.
   e. Increase `k` by `1`.
7. Return `undefined`.

NOTE 2  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 1  *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.

*predicate* is called with three arguments: the value of the element, the index of the element, and the object being traversed.

`findIndex` does not directly mutate the object on which it is called but the object may be mutated by the calls to *predicate*.

The range of elements processed by `findIndex` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `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.

When the `findIndex` method is called with one or two arguments, the following steps are taken:
1. Let $O$ be ?ToObject($this$ value).
2. Let $len$ be ?ToLength(? Get($O$, "$length$)).
3. If IsCallable($predicate$) is false, throw a TypeError exception.
4. If $thisArg$ was supplied, let $T$ be $thisArg$; else let $T$ be undefined.
5. Let $k$ be 0.
6. Repeat, while $k < len$
   a. Let $Pk$ be !ToString($k$).
   b. Let $kValue$ be ?Get($O$, $Pk$).
   c. Let $testResult$ be ToBoolean(? Call($predicate$, $T$, « $kValue$, $k$, $O$ »)).
   d. If $testResult$ is true, return $k$.
   e. Increase $k$ by 1.
7. Return -1.

NOTE 2 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 1 $callbackfn$ 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 $callbackfn$.

When the $forEach$ method is called with one or two arguments, the following steps are taken:

1. Let $O$ be ?ToObject($this$ value).
2. Let $len$ be ?ToLength(? Get($O$, "$length$)).
3. If IsCallable($callbackfn$) is false, throw a TypeError exception.
4. If $thisArg$ was supplied, let $T$ be $thisArg$; else let $T$ be undefined.
5. Let $k$ be 0.
6. Repeat, while $k < len$
   a. Let $Pk$ be !ToString($k$).
   b. Let $kPresent$ be ?HasProperty($O$, $Pk$).
   c. If $kPresent$ is true, then
      i. Let $kValue$ be ?Get($O$, $Pk$).
      ii. Perform ? Call($callbackfn$, $T$, « $kValue$, $k$, $O$ »).
   d. Increase $k$ by 1.
7. Return undefined.

NOTE 2 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.includes ($searchElement$ [, $fromIndex$ ])

NOTE 1 $includes$ compares $searchElement$ to the elements of the array, in ascending order, using the SameValueZero algorithm, and if found at any position, returns true; otherwise, false 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, false is returned, i.e. the array will not be searched. If it is negative, it is used as
NOTE 2

The \texttt{includes} function is intentionally generic; it does not require that its \texttt{this} value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

NOTE 3

The \texttt{includes} method intentionally differs from the similar \texttt{indexOf} method in two ways. First, it uses the \texttt{SameValueZero} algorithm, instead of \texttt{Strict Equality Comparison}, allowing it to detect NaN array elements. Second, it does not skip missing array elements, instead treating them as \texttt{undefined}.

22.1.3.12 \texttt{Array.prototype.indexOf( searchElement [, fromIndex ] )}

\texttt{indexOf} compares \texttt{searchElement} to the elements of the array, in ascending order, using the \texttt{Strict Equality Comparison} algorithm, and if found at one or more indices, returns the smallest such index; otherwise, -1 is returned.

The optional second argument \texttt{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 \texttt{fromIndex}. If the computed index is less than 0, the whole array will be searched.

NOTE 2 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.

22.1.3.13 Array.prototype.join (separator)

NOTE 1 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 ?ToObject(this value).
2. Let len be ?ToLength(? Get(O, "length")).
3. If separator is undefined, let separator be the single-element String ",, ".
4. Let sep be ?ToString(separator).
5. If len is zero, return the empty String.
6. Let element0 be Get(O, "0").
7. If element0 is undefined or null, let R be the empty String; otherwise, let R be ?ToString(element0).
8. Let k be 1.
9. 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. Let R be a String value produced by concatenating S and next.
   e. Increase k by 1.
10. Return R.

NOTE 2 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.

22.1.3.14 Array.prototype.keys ()

The following steps are taken:

1. Let O be ?ToObject(this value).
2. Return CreateArrayIterator(O, "key").

22.1.3.15 Array.prototype.lastIndexOf (searchElement [, fromIndex ])

NOTE 1 lastIndexOf compares searchElement to the elements of the array in descending order using the Strict Equality Comparison algorithm, 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 ?ToObject(this value).
2. Let len be ?ToLength(? Get(O, "length")).
3. If len is 0, return -1.
4. If argument fromIndex was passed, let n be ?ToInteger(fromIndex); else let n be len-1.
5. If n ≥ 0, then
   a. If n is -0, let k be +0; else let k be min(n, len - 1).
6. Else n < 0,
Let \( k \) be \( \text{len} + n \).

7. Repeat, while \( k \geq 0 \)
   a. Let \( k\text{Present} \) be \( \text{HasProperty}(O, !\text{ToString}(k)) \).
   b. If \( k\text{Present} \) is \text{true}, then
      i. Let \( \text{elementK} \) be \( \text{Get}(O, !\text{ToString}(k)) \).
      ii. Let \( \text{same} \) be the result of performing \text{Strict Equality Comparison} \( \text{searchElement} === \text{elementK} \).
      iii. If \( \text{same} \) is \text{true}, return \( k \).
   c. Decrease \( k \) by 1.

8. Return -1.

NOTE 2 The \text{lastIndexOf} 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.

22.1.3.16 \text{Array.prototype.map ( callbackfn [, thisArg ] )}

\text{callbackfn} should be a function that accepts three arguments. \text{map} calls \text{callbackfn} once for each element in the array, in ascending order, and constructs a new Array from the results. \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.

\text{callbackfn} is called with three arguments: the value of the element, the index of the element, and the object being traversed.

\text{map} does not directly mutate the object on which it is called but the object may be mutated by the calls to \text{callbackfn}.

The range of elements processed by \text{map} is set before the first call to \text{callbackfn}. Elements which are appended to the array after the call to \text{map} begins will not be visited by \text{callbackfn}. If existing elements of the array are changed, their value as passed to \text{callbackfn} will be the value at the time \text{map} visits them; elements that are deleted after the call to \text{map} begins and before being visited are not visited.

When the \text{map} method is called with one or two arguments, the following steps are taken:

1. Let \( O \) be \( \text{ToObject}(\text{this} \text{value}) \).
2. Let \( \text{len} \) be \( \text{ToLength(? Get}(O, "\text{length}")) \).
3. If \( \text{IsCallable}(\text{callbackfn}) \) is \text{false}, throw a \text{TypeError} exception.
4. If \text{thisArg} was supplied, let \( T \) be \text{thisArg}; else let \( T \) be \text{undefined}.
5. Let \( A \) be \( \text{ArraySpeciesCreate}(O, \text{len}) \).
6. Let \( k \) be 0.
7. Repeat, while \( k < \text{len} \)
   a. Let \( Pk \) be \( !\text{ToString}(k) \).
   b. Let \( k\text{Present} \) be \( \text{HasProperty}(O, Pk) \).
   c. If \( k\text{Present} \) is \text{true}, then
      i. Let \( \text{kValue} \) be \( \text{Get}(O, Pk) \).
      ii. Let \( \text{mappedValue} \) be \( \text{Call}(\text{callbackfn}, T, \{ \text{kValue} \}, k, O \} \).
      iii. Perform \( \text{CreateDataPropertyOrThrow}(A, Pk, \text{mappedValue}) \).
   d. Increase \( k \) by 1.
8. Return \( A \).

NOTE 2 The \text{map} 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.

22.1.3.17 \text{Array.prototype.pop ( )}

NOTE 1 The last element of the array is removed from the array and returned.
When the \texttt{pop} method is called, the following steps are taken:

1. Let $O$ be $\text{ToObject}(\text{this value})$.
2. Let $\text{len}$ be $\text{ToLength}(\text{Get}(O, \text{"length"}))$.
3. If $\text{len}$ is zero, then
   a. Perform $\text{Set}(O, \text{"length"}, 0, \text{true})$.
   b. Return \textit{undefined}.
4. Else $\text{len} > 0$,
   a. Let $\text{newLen}$ be $\text{len}$-1.
   b. Let $\text{indx}$ be $\text{ToString}(\text{newLen})$.
   c. Let $\text{element}$ be $\text{Get}(O, \text{indx})$.
   d. Perform $\text{DeletePropertyOrThrow}(O, \text{indx})$.
   e. Perform $\text{Set}(O, \text{"length"}, \text{newLen}, \text{true})$.
   f. Return $\text{element}$.

NOTE 2 The \texttt{pop} function is intentionally generic; it does not require that its \texttt{this} value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

22.1.3.18 \texttt{Array.prototype.push (...\texttt{items})}

NOTE 1 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 \texttt{push} method is called with zero or more arguments, the following steps are taken:

1. Let $O$ be $\text{ToObject}(\text{this value})$.
2. Let $\text{len}$ be $\text{ToLength}(\text{Get}(O, \text{"length"}))$.
3. Let $\text{items}$ be a \texttt{List} whose elements are, in left to right order, the arguments that were passed to this function invocation.
4. Let $\text{argCount}$ be the number of elements in $\text{items}$.
5. If $\text{len} + \text{argCount} > 2^{53}-1$, throw a \texttt{TypeError} exception.
6. Repeat, while $\text{items}$ is not empty
   a. Remove the first element from $\text{items}$ and let $E$ be the value of the element.
   b. Perform $\text{Set}(O, \text{!ToString}(\text{len}), E, \text{true})$.
   c. Let $\text{len}$ be $\text{len}$+1.
7. Perform $\text{Set}(O, \text{"length"}, \text{len}, \text{true})$.
8. Return $\text{len}$.

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

NOTE 2 The \texttt{push} function is intentionally generic; it does not require that its \texttt{this} value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

22.1.3.19 \texttt{Array.prototype.reduce (\texttt{callbackfn} [, \texttt{initialValue}] )}

\texttt{callbackfn} should be a function that takes four arguments. \texttt{reduce} calls the callback, as a function, once for each element present in the array, in ascending order.

\texttt{callbackfn} is called with four arguments: the \texttt{previousValue} (value from the previous call to \texttt{callbackfn}), the \texttt{currentValue} (value of the current element), the \texttt{currentIndex}, and the object being traversed. The first time that callback is called, the \texttt{previousValue} and \texttt{currentValue} can be one of two values. If an \texttt{initialValue} was provided in the call to \texttt{reduce}, then \texttt{previousValue} will be equal to \texttt{initialValue} and \texttt{currentValue} will be equal to the first value in the array. If no \texttt{initialValue} was provided, then \texttt{previousValue} will be equal to the first value in the array and \texttt{currentValue} will be equal to the second. It is a \texttt{TypeError} if the array contains no elements and \texttt{initialValue} is not provided.

\texttt{reduce} does not directly mutate the object on which it is called but the object may be mutated by the calls to \texttt{callbackfn}.
The range of elements processed by `reduce` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `reduce` begins will not be visited by `callbackfn`. If existing elements of the array are changed, their value as passed to `callbackfn` will be the value at the time `reduce` visits them; elements that are deleted after the call to `reduce` begins and before being visited are not visited.

When the `reduce` method is called with one or two arguments, the following steps are taken:

1. Let `O` be `ToObject(this value)`.
2. Let `len` be `ToLength(? Get(O, "length"))`.
3. If `IsCallable(callbackfn)` is false, throw a `TypeError` exception.
4. If `len` is 0 and `initialValue` is not present, throw a `TypeError` exception.
5. Let `k` be 0.
6. If `initialValue` is present, then
   a. Set `accumulator` to `initialValue`.
7. Else `initialValue` is not present,
   a. Let `kPresent` be false.
   b. Repeat, while `kPresent` is false and `k < len`
      i. Let `Pk` be `ToString(k)`.
      ii. Let `kPresent` be `HasProperty(O, Pk)`.
      iii. If `kPresent` is true, then
          1. Let `accumulator` be `Get(O, Pk)`.
          4. Increase `k` by 1.
      c. If `kPresent` is false, throw a `TypeError` exception.
8. Repeat, while `k < len`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kPresent` be `HasProperty(O, Pk)`.
   c. If `kPresent` is true, then
      i. Let `kValue` be `Get(O, Pk)`.
      ii. Let `accumulator` be `Call(callbackfn, undefined, « accumulator, kValue, k, O »)`.
      d. Increase `k` by 1.

NOTE 2 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.

### 22.1.3.20 Array.prototype.reduceRight ( `callbackfn [ , initialValue ] `)

NOTE 1 `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` (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 `ToObject(this value)`.
2. Let `len` be `ToLength(Get(O, "length"))`.
3. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
4. If `len` is 0 and `initialValue` is not present, throw a `TypeError` exception.
5. Let `k` be `len - 1`.
6. If `initialValue` is present, then
   a. Set `accumulator` to `initialValue`.
7. Else `initialValue` is not present,
   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. If `kPresent` is `true`, then
         1. Let `accumulator` be `Get(O, Pk)`.
         2. Decrease `k` by 1.
   c. If `kPresent` is `false`, throw a `TypeError` exception.
8. Repeat, while `k ≥ 0`  
   a. Let `Pk` be `ToString(k)`.
   b. Let `kPresent` be `HasProperty(O, Pk)`.
   c. If `kPresent` is `true`, then
      i. Let `kValue` be `Get(O, Pk)`.
      ii. Let `accumulator` be `Call(callbackfn, undefined, « accumulator, kValue, k, O »)`.
      d. Decrease `k` by 1.

NOTE 2  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.

### 22.1.3.21 Array.prototype.reverse ( )

NOTE 1  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 `ToObject(this value)`.
2. Let `len` be `ToLength(Get(O, "length"))`.
3. Let `middle` be `floor(len/2)`.
4. Let `lower` be `0`.
5. 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. If `lowerExists` is `true`, then
      i. Let `lowerValue` be `Get(O, lowerP)`.
   f. Let `upperExists` be `HasProperty(O, upperP)`.
   g. If `upperExists` is `true`, then
      i. Let `upperValue` be `Get(O, upperP)`.
   h. If `lowerExists` is `true` and `upperExists` is `true`, then
      i. Perform `Set(O, lowerP, upperValue, true)`.
      ii. Perform `Set(O, upperP, lowerValue, true)`.
   i. Else if `lowerExists` is `false` and `upperExists` is `true`, then
      i. Perform `Set(O, lowerP, upperValue, true)`.
The following steps are taken:

i. Perform ? DeletePropertyOrThrow(O, upperP).

j. Else if lowerExists is true and upperExists is false, then
   i. Perform ? DeletePropertyOrThrow(O, lowerP).
   ii. Perform ? Set(O, upperP, lowerValue, true).

k. Else both lowerExists and upperExists are false,
   i. No action is required.
   ii. Increase lower by 1.

6. Return O.

NOTE 2 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.

22.1.3.22 Array.prototype.shift ()

NOTE 1 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 ? ToObject(this value).
2. Let len be ? ToLength( Get(O, "length").
3. If len is zero, then
   a. Perform ? Set(O, "length", 0, true).
   b. Return undefined.
4. Let first be ? Get(O, "@0").
5. Let k be 1.
6. 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. If fromPresent is true, then
      i. Let fromVal be ? Get(O, from).
      ii. Perform ? Set(O, to, fromVal, true).
   e. Else fromPresent is false,
      i. Perform ? DeletePropertyOrThrow(O, to).
   f. Increase k by 1.
7. Perform ? DeletePropertyOrThrow(O, ! ToString(len-1)).
9. Return first.

NOTE 2 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.

22.1.3.23 Array.prototype.slice (start, end)

NOTE 1 The slice method takes two arguments, start and end, and returns an array containing the elements of the array from element start up to, but not including, element end (or through the end of the array if end is undefined). If start is negative, it is treated as length+start where length is the length of the array. If end is negative, it is treated as length+end where length is the length of the array.

The following steps are taken:

1. Let O be ? ToObject(this value).
2. Let len be ? ToLength( Get(O, "length").
3. Let relativeStart be ? ToInteger(start).
4. If relativeStart < 0, let k be max((len + relativeStart), 0); else let k be min(relativeStart, len).
5. If end is undefined, let relativeEnd be len; else let relativeEnd be ? ToInteger(end).
6. If relativeEnd < 0, let final be max((len + relativeEnd), 0); else let final be min(relativeEnd, len).
7. Let \( \text{count} \) be \( \max(f\text{inal} - k, 0) \).
8. Let \( A \) be \( \? \text{ArraySpeciesCreate}(O, \text{count}) \).
9. Let \( n \) be 0.
10. Repeat, while \( k < \text{final} \)
    a. Let \( Pk \) be \( \text{ToString}(k) \).
    b. Let \( k\text{Present} \) be \( \? \) \( \text{HasProperty}(O, Pk) \).
    c. If \( k\text{Present} \) is \( \text{true} \), then
        i. Let \( k\text{Value} \) be \( \? \) \( \text{Get}(O, Pk) \).
        ii. Perform \( \? \) \( \text{CreateDataPropertyOrThrow}(A, \text{ToString}(n), k\text{Value}) \).
    d. Increase \( k \) by 1.
    e. Increase \( n \) by 1.
11. Perform \( \? \) \( \text{Set}(A, "\text{length}", n, \text{true}) \).
12. Return \( A \).

NOTE 2
The explicit setting of the \( \text{length} \) property of the result Array in step 11 was necessary in previous editions of ECMAScript to ensure that its \( \text{length} \) was correct in situations where the trailing elements of the result Array were not present. Setting \( \text{length} \) became unnecessary starting in ES2015 when the result Array was initialized to its proper length rather than an empty Array but is carried forward to preserve backward compatibility.

NOTE 3
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.

22.1.3.24 \( \text{Array.prototype.some}(\text{callbackfn}[\text{, thisArg}]) \)

NOTE 1
\( \text{callbackfn} \) 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.

\( \text{callbackfn} \) is called with three arguments: the value of the element, the index of the element, and the object being traversed.

\( \text{some} \) does not directly mutate the object on which it is called but the object may be mutated by the calls to \( \text{callbackfn} \).

The range of elements processed by \( \text{some} \) is set before the first call to \( \text{callbackfn} \). Elements that are appended to the array after the call to \( \text{some} \) begins will not be visited by \( \text{callbackfn} \). If existing elements of the array are changed, their value as passed to \( \text{callbackfn} \) will be the value at the time that \( \text{some} \) visits them; elements that are deleted after the call to \( \text{some} \) begins and before being visited are not visited. \( \text{some} \) acts like the "exists" quantifier in mathematics. In particular, for an empty array, it returns \( \text{false} \).

When the \( \text{some} \) method is called with one or two arguments, the following steps are taken:

1. Let \( O \) be \( \? \) \( \text{ToObject}(\text{this value}) \).
2. Let \( \text{len} \) be \( \? \) \( \text{ToLength}(\? \) \( \text{Get}(O, "\text{length}") \)).
3. If \( \text{IsCallable}(\text{callbackfn}) \) is \( \text{false} \), throw a \( \text{TypeError} \) exception.
4. If \( \text{thisArg} \) was supplied, let \( T \) be \( \text{thisArg} \); else let \( T \) be \( \text{undefined} \).
5. Let \( k \) be 0.
6. Repeat, while \( k < \text{len} \)
    a. Let \( Pk \) be \( \text{ToString}(k) \).
    b. Let \( k\text{Present} \) be \( \? \) \( \text{HasProperty}(O, Pk) \).
    c. If \( k\text{Present} \) is \( \text{true} \), then
        i. Let \( k\text{Value} \) be \( \? \) \( \text{Get}(O, Pk) \).
ii. Let \( testResult \) be \( \text{ToBoolean}(? \text{Call}(\text{callbackfn}, T, \« kValue, k, O »)) \).

iii. If \( testResult \) is \( \text{true} \), return \( \text{true} \).

d. Increase \( k \) by 1.

7. Return \( \text{false} \).

**NOTE 2** 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.

### 22.1.3.25 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 \( x > y \).

Upon entry, the following steps are performed to initialize evaluation of the `sort` function:

1. Let \( obj \) be `ToObject(this value)`.
2. Let \( len \) be `ToLength(? Get(obj, "length"))`.

Within this specification of the `sort` method, an object, \( obj \), is said to be `sparse` if the following algorithm returns `true`:

1. For each integer \( i \) in the range \( 0 \leq i < \text{len} \)
   a. Let \( elem \) be \( obj.[[GetOwnProperty]](\« ToString(\( i \)) \») \).
   b. If \( elem \) is `undefined`, return `true`.
2. Return `false`.

The `sort` order is the ordering, after completion of this function, of the integer indexed property values of \( obj \) whose integer indexes are less than \( \text{len} \). 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 \( \text{SortCompare} \) does not act as a consistent comparison function.

Let \( \text{proto} \) be \( obj.[[GetPrototypeOf]]() \). If \( \text{proto} \) 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
- \( 0 \leq j < \text{len} \)
- \( \text{HasProperty}(	ext{proto}, \text{ToString}(j)) \) is `true`.

The sort order is also implementation defined if \( obj \) is sparse and any of the following conditions are true:

- \( \text{IsExtensible}(obj) \) is `false`.
- Any integer index property of \( obj \) whose name is a nonnegative integer less than \( \text{len} \) 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 [[GetOwnProperty]] is not the ordinary object implementation of these internal methods.
- If any index property of \( obj \) whose name is a nonnegative integer less than \( \text{len} \) is an accessor property or is a data property whose [[Writable]] attribute is `false`.
- If \( comparefn \) is `undefined` and the application of `ToString` to any value passed as an argument to `SortCompare` modifies \( obj \) or any object on \( obj \)'s prototype chain.
- If \( comparefn \) is `undefined` and all applications of `ToString` to any specific value passed as an argument to `SortCompare`, do not produce the same result.

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 `old[j]` existed, then `new[\pi(j)]` is exactly the same value as `old[j]`. But if property `old[j]` did not exist, then `new[\pi(j)]` does not exist.
- Then for all nonnegative integers \( j \) and \( k \), each less than `len`, if `SortCompare(old[j], old[k]) < 0` (see `SortCompare` below), then `new[\pi(j)] < new[\pi(k)]`.

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

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

- Calling `comparefn(a, b)` always returns the same value `v` when given a specific pair of values `a` and `b` as its two arguments. Furthermore, `Type(v)` is `Number`, and `v` is not `NaN`. Note that this implies that exactly one of \( a \preceq_{\text{CF}} b \), \( a \approx_{\text{CF}} b \), and \( a \succeq_{\text{CF}} b \) will be true for a given pair of `a` and `b`.
- Calling `comparefn(a, b)` does not modify `obj` or any object on `obj`'s prototype chain.
- \( a \approx_{\text{CF}} a \) (reflexivity)
- If \( a \approx_{\text{CF}} b \) then \( b \approx_{\text{CF}} a \) (symmetry)
- If \( a \approx_{\text{CF}} b \) and \( b \approx_{\text{CF}} c \), then \( a \approx_{\text{CF}} c \) (transitivity of \( \approx_{\text{CF}} \))
- If \( a \prec_{\text{CF}} b \) and \( b \prec_{\text{CF}} c \), then \( a \prec_{\text{CF}} c \) (transitivity of \( \prec_{\text{CF}} \))
- If \( a \succ_{\text{CF}} b \) and \( b \succ_{\text{CF}} c \), then \( a \succ_{\text{CF}} c \) (transitivity of \( \succ_{\text{CF}} \))

**NOTE 1** The above conditions are necessary and sufficient to ensure that `comparefn` divides the set \( S \) into equivalence classes and that these equivalence classes are totally ordered.

**NOTE 2** The `sort` function is intentionally generic; it does not require that its `this` value be an `Array` object. Therefore, it can be transferred to other kinds of objects for use as a method.

### 22.1.3.25.1 Runtime Semantics: `SortCompare(x, y)`

The `SortCompare` abstract operation is called with two arguments `x` and `y`. It also has access to the `comparefn` argument passed to the current invocation of the `sort` method. The following steps are taken:

1. If `x` and `y` are both `undefined`, return `+0`.
2. If `x` is `undefined`, return 1.
3. If \( y \) is `undefined`, return `-1`.
4. If the argument `comparefn` is not `undefined`, then
   a. Let \( v \) be `? ToNumber(\? Call(comparefn, undefined, \[ x, y \]))`.
   b. If \( v \) is `NaN`, return `+0`.
   c. Return \( v \).
5. Let `xString` be `? ToString(x)`.
7. Let `xSmaller` be the result of performing Abstract Relational Comparison `xString < yString`.
8. If `xSmaller` is `true`, return `-1`.
9. Let `ySmaller` be the result of performing Abstract Relational Comparison `yString < xString`.
10. If `ySmaller` is `true`, 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.

### 22.1.3.26 Array.prototype.splice (start, deleteCount, ...items )

**NOTE 1** 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 `? ToObject(\this value)`.
2. Let `len` be `? ToLength(\? Get(O, "length"))`.
3. Let `relativeStart` be `? ToInteger(start)`.
4. If `relativeStart < 0`, let `actualStart` be `max((\len + relativeStart), 0)`, else let `actualStart` be `\min(relativeStart, \len)`.
5. If the number of actual arguments is 0, then
   a. Let `insertCount` be `0`.
   b. Let `actualDeleteCount` be `0`.
6. Else if the number of actual arguments is 1, then
   a. Let `insertCount` be `0`.
   b. Let `actualDeleteCount` be `\len - actualStart`.
7. Else,
   a. Let `insertCount` be the number of actual arguments minus `2`.
   b. Let `dc` be `? ToInteger(deleteCount)`.
   c. Let `actualDeleteCount` be `\min(max(dc, 0), \len - actualStart)`.
8. If `\len + insertCount - actualDeleteCount > 2^{53}-1`, throw a `TypeError` exception.
9. Let `A` be `? ArraySpeciesCreate(O, actualDeleteCount)`.
10. Let \( k \) be `0`.
11. Repeat, while \( k < actualDeleteCount \)
   a. Let `from` be `! ToString(actualStart+k)`.
   b. Let `fromPresent` be `? HasProperty(O, from)`.
   c. If `fromPresent` is `true`, then
      i. Let `fromValue` be `? Get(O, from)`.
      ii. Perform `? CreateDataPropertyOrThrow(A, ! ToString(k), fromValue)`.
   d. Increment \( k \) by `1`.
13. 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.
14. Let `itemCount` be the number of elements in `items`. 
15. 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. If `fromPresent` is `true`, then
         1. Let `fromValue` be `? Get(O, from)`.
         2. Perform `? Set(O, to, fromValue, true)`.
      v. Else `fromPresent` is `false`,
         1. Perform `? DeletePropertyOrThrow(O, to)`.
   c. Let `k` be `len`.
   d. Repeat, while `k > (len - actualDeleteCount + itemCount)`
      i. Perform `? DeletePropertyOrThrow(O, ! ToString(k-1))`.
      ii. Decrease `k` by 1.
16. 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. If `fromPresent` is `true`, then
         1. Let `fromValue` be `? Get(O, from)`.
         2. Perform `? Set(O, to, fromValue, true)`.
      v. Else `fromPresent` is `false`,
         1. Perform `? DeletePropertyOrThrow(O, to)`.
   vi. Decrease `k` by 1.
17. Let `k` be `actualStart`.
18. Repeat, while `items` is not empty
   a. Remove the first element from `items` and let `E` be the value of that element.
   b. Perform `? Set(O, ! ToString(k), E, true)`.
   c. Increase `k` by 1.
20. Return `A`.

NOTE 2 The explicit setting of the `length` property of the result Array in step 19 was necessary in previous editions of ECMAScript to ensure that its length was correct in situations where the trailing elements of the result Array were not present. Setting `length` became unnecessary starting in ES2015 when the result Array was initialized to its proper length rather than an empty Array but is carried forward to preserve backward compatibility.

NOTE 3 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.

22.1.3.27 `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 1 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 ? ToObject(this value).
2. Let len be ? ToLength(? Get(array, "length")).
3. 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).
4. If len is zero, return the empty String.
5. Let firstElement be ? Get(array, "0").
6. If firstElement is undefined or null, then
   a. Let R be the empty String.
   b. Let argCount be the number of actual arguments.
   c. If argCount > 0, then
      a. If len+argCount > 2^53-1, throw a TypeError exception.
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 firstElement is undefined or null, then
   a. Let R be the empty String.
   b. Let argCount be the number of actual arguments.
   c. If argCount > 0, then
      a. If len+argCount > 2^53-1, throw a TypeError exception.
7. Else,
   a. Let R be ? ToString(? Invoke(firstElement, "toLocaleString")).
8. Let k be 1.
9. 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. If nextElement is undefined or null, then
      i. Let R be the empty String.
   d. Else,
      i. Let R be ? ToString(? Invoke(nextElement, "toLocaleString")).
9. Let k be k+1.
10. Return R.

NOTE 2 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 3 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.

22.1.3.28 Array.prototype.toString ( )

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

1. Let array be ? ToObject(this value).
2. Let func be ? Get(array, "join").
3. If IsCallable(func) is false, let func be the intrinsic function %ObjProto_toString%.

NOTE 4 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.

22.1.3.29 Array.prototype.unshift ( ...items )

NOTE 1 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 ? ToObject(this value).
2. Let len be ? ToLength(? Get(O, "length")).
3. Let argCount be the number of actual arguments.
4. If argCount > 0, then
   a. If len+argCount > 2^53-1, throw a TypeError exception.
b. Let \( k \) be \( \text{len} \).

c. Repeat, while \( k > 0 \),
   i. Let \( \text{from} \) be \( \text{ToString}(k-1) \).
   ii. Let \( \text{to} \) be \( \text{ToString}(k+\text{argCount}-1) \).
   iii. Let \( \text{fromPresent} \) be \( \text{HasProperty}(\text{O}, \text{from}) \).
   iv. If \( \text{fromPresent} \) is \text{true}, then
      1. Let \( \text{fromValue} \) be \( \text{Get}(\text{O}, \text{from}) \).
      2. Perform \( \text{Set}(\text{O}, \text{to}, \text{fromValue}, \text{true}) \).
   v. Else \( \text{fromPresent} \) is \text{false},
      1. Perform \( \text{DeletePropertyOrThrow}(\text{O}, \text{to}) \).
   vi. Decrease \( k \) by 1.

d. Let \( j \) be 0.

e. Let \( \text{items} \) be a \text{List} whose elements are, in left to right order, the arguments that were passed to this function invocation.

f. Repeat, while \( \text{items} \) is not empty
   i. Remove the first element from \( \text{items} \) and let \( E \) be the value of that element.
   ii. Perform \( \text{Set}(\text{O}, \text{ToString}(j), E, \text{true}) \).
   iii. Increase \( j \) by 1.

5. Perform \( \text{Set}(\text{O}, \text{"length"}, \text{len+argCount}, \text{true}) \).
6. Return \( \text{len+argCount} \).

The \text{length} property of the \text{unshift} method is 1.

\textbf{NOTE 2} The \text{unshift} 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.

\textbf{22.1.3.30 Array.prototype.values}()

The following steps are taken:

1. Let \( \text{O} \) be \( \text{ToObject(this value)} \).
2. Return \( \text{CreateArrayIterator} \text{O, "value"} \).

This function is the \%ArrayProto_values\% intrinsic object.

\textbf{22.1.3.31 Array.prototype[@@iterator]}()

The initial value of the \text{@@iterator} property is the same function object as the initial value of the \text{Array.prototype.values} property.

\textbf{22.1.3.32 Array.prototype[@@unscopables]}

The initial value of the \text{@@unscopables} data property is an object created by the following steps:

1. Let \( \text{blackList} \) be \text{ObjectCreate(null)}.
2. Perform \( \text{CreateDataProperty} \text{blackList, "copyWithin", true} \).
3. Perform \( \text{CreateDataProperty} \text{blackList, "entries", true} \).
4. Perform \( \text{CreateDataProperty} \text{blackList, "fill", true} \).
5. Perform \( \text{CreateDataProperty} \text{blackList, "find", true} \).
6. Perform \( \text{CreateDataProperty} \text{blackList, "findIndex", true} \).
7. Perform \( \text{CreateDataProperty} \text{blackList, "includes", true} \).
8. Perform \( \text{CreateDataProperty} \text{blackList, "keys", true} \).
9. Perform \( \text{CreateDataProperty} \text{blackList, "values", true} \).
10. Assert: Each of the above calls will return \text{true}.
11. Return \text{blackList}.

This property has the attributes { [[Writable]]: \text{false}, [[Enumerable]]: \text{false}, [[Configurable]]: \text{true} }. 
22.14 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.

22.14.1 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 Reducing the value of the `length` property has the side-effect of deleting own array elements whose array index is between the old and new length values. However, non-configurable properties can not be deleted. 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 non-configurable array indexed property of the array will result in the length being set to a numeric value that is one greater than that non-configurable numeric own property name. See 9.4.2.1.

22.15 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.

22.15.1 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`.

22.15.2 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. In addition, `%ArrayIteratorPrototype% has the following properties:

22.15.2.1 `%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 [22.15.3], 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 a's [[ArrayLength]] internal slot.
9. Else,
   a. Let len be ToLength(? Get(a, "length")).
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", return CreateIterResultObject(index, false).
13. Let elementKey be ! ToString(index).
14. Let elementValue be ? Get(a, elementKey).
15. If itemKind is "value", let result be elementValue.
16. Else,
   a. Assert: itemKind is "key+value".
   b. Let result be CreateArrayFromList([« index, elementValue »]).
17. 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 49.

<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 integer index to be examined by this iteration.</td>
</tr>
<tr>
<td>[[ArrayIterationKind]]</td>
<td>A String value that identifies what is 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 50, for each of the nine supported element types. Each constructor in Table 50 has a corresponding distinct prototype object.
Table 50: 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></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 acts as the abstract superclass of the various `TypedArray` constructors. Because it is an abstract class constructor it will throw an error when invoked. The `TypedArray` constructors do not perform a super call to it.

#### 22.2.1.1 `%TypedArray%()`

The `%TypedArray%` constructor performs the following steps:

1. Throw a `TypeError` exception.

The `length` property of the `%TypedArray%` constructor function is 0.

### 22.2.2 Properties of the `%TypedArray%` Intrinsic Object

The value of the `[[Prototype]]` internal slot of `%TypedArray%` is the intrinsic object `%FunctionPrototype%`.

The `name` property of the `%TypedArray%` constructor function is "`TypedArray`".
The %TypedArray% constructor 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 and `mapfn` is not `undefined`, then
   a. If `IsCallable(mapfn)` is `false`, throw a `TypeError` exception.
   b. Let `mapping` be `true`.
4. Else, let `mapping` be `false`.
5. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
6. Let `arrayLike` be `?IterableToArrayLike(source)`.
7. Let `len` be `?ToLength(?Get(arrayLike, "length"))`.
8. Let `targetObj` be `?TypedArrayCreate(C, «len»)`.
9. Let `k` be `0`.
10. Repeat, while `k < len`
    a. Let `Pk` be `!ToString(k)`.
    b. Let `kValue` be `?Get(arrayLike, Pk)`.
    c. If `mapping` is `true`, then
       i. Let `mappedValue` be `?Call(mapfn, T, «kValue, k»)`.
    d. Else, let `mappedValue` be `kValue`.
    e. Perform `?Set(targetObj, Pk, mappedValue, true)`.
    f. Increase `k` by `1`.
11. Return `targetObj`.

### 22.2.2.1 Runtime Semantics: IterableToArrayLike( items )

The abstract operation `IterableToArrayLike` performs the following steps:

1. Let `usingIterator` be `?GetMethod(items, @@iterator)`.
2. If `usingIterator` is not `undefined`, then
   a. Let `iterator` be `?GetIterator(items, usingIterator)`.
   b. Let `values` be a new empty `List`.
   c. Let `next` be `true`.
   d. Repeat, while `next` is not `false`
      i. Let `next` be `?IteratorStep(iterator)`.
      ii. If `next` is not `false`, then
         1. Let `nextValue` be `?IteratorValue(next)`.
         2. Append `nextValue` to the end of the `List values`.
   e. Return `CreateArrayFromList(values)`.
3. NOTE: `items` is not an `Iterable` so assume it is already an array-like object.
4. Return `!ToObject(items)`.

### 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 `?TypedArrayCreate(C, «len»)`.
6. Let `k` be `0`.
7. Repeat, while `k < len`
a. Let \textit{kValue} be \textit{items}[k].

b. Let \textit{Pk} be !\textit{ToString}(k).

c. Perform \textit{? Set(newObj, Pk, kValue, true)}.

d. Increase \textit{k} by 1.

8. Return \textit{newObj}.

\textbf{NOTE:} The \textit{items} argument is assumed to be a well-formed rest argument value.

### 22.2.2.3 \%TypedArray%\texttt{.prototype}

The initial value of \%TypedArray%\texttt{.prototype} is the \%TypedArrayPrototype% intrinsic object.

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

### 22.2.4 get \%TypedArray% [ @@species ]

\%TypedArray%@@species\texttt{] is an accessor property whose set accessor function is \textit{undefined}. Its get accessor function performs the following steps:

1. Return the \texttt{this} value.

\textbf{NOTE:} \%TypedArrayPrototype% methods normally use their \texttt{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\texttt{.}

The \%TypedArrayPrototype% object is an ordinary object. It does not have a [[ViewedArrayBuffer]] or any other of the internal slots that are specific to \texttt{TypedArray} instance objects.

#### 22.2.3.1 get \%TypedArray%.prototype.buffer

\%TypedArray%\texttt{.prototype.buffer} is an accessor property whose set accessor function is \textit{undefined}. Its get accessor function performs the following steps:

1. Let \textit{O} be the \texttt{this} value.

2. If \texttt{Type} \textit{(O)} is not Object, throw a \texttt{TypeError} exception.

3. If \textit{O} does not have a [[ViewedArrayBuffer]] internal slot, throw a \texttt{TypeError} exception.

4. Let \textit{buffer} be the value of \textit{O}’s [[ViewedArrayBuffer]] internal slot.

5. Return \textit{buffer}.

#### 22.2.3.2 get \%TypedArray%.prototype.byteLength

\%TypedArray%\texttt{.prototype.byteLength} is an accessor property whose set accessor function is \textit{undefined}. Its get accessor function performs the following steps:

1. Let \textit{O} be the \texttt{this} value.

2. If \texttt{Type} \textit{(O)} is not Object, throw a \texttt{TypeError} exception.

3. If \textit{O} does not have a [[ViewedArrayBuffer]] internal slot, throw a \texttt{TypeError} exception.

4. Let \textit{buffer} be the value of \textit{O}’s [[ViewedArrayBuffer]] internal slot.

5. If \texttt{IsDetachedBuffer(buffer)} is \textit{true}, return 0.

6. Let \textit{size} be the value of \textit{O}’s [[ByteLength]] internal slot.

7. Return \textit{size}.

#### 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:

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 `offset` be the value of \( O \)'s [[ByteOffset]] internal slot.
7. Return `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 [[ArrayLength]] internal slot is accessed in place of performing a [[Get]] of "length" and the actual copying of values in step 12 must be performed in a manner that preserves the bit-level encoding of the source data.

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.

### 22.2.3.5.1 Runtime Semantics: ValidateTypedArray (O)

When called with argument \( O \), the following steps are taken:

1. If `Type(\( O \))` is not Object, throw a **TypeError** exception.
2. If \( O \) does not have a [[TypedArrayName]] internal slot, 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.
6. Return `buffer`.

### 22.2.3.6 %TypedArray%.prototype.entries ()

The following steps are taken:

1. Let \( O \) be the **this** value.
2. Perform ? ValidateTypedArray(\( O \)).
3. Return `CreateArrayIterator(\( O \), "key+value")`.

### 22.2.3.7 %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 [[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.
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 21.1.3.6 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.

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 21.1.3.7.

When the `filter` method is called with one or two arguments, the following steps are taken:

1. Let `O` be the `this` value.
2. Perform ? `ValidateTypedArray(O)`.
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 `kept` be a new empty `List`.
7. Let `k` be `0`.
8. Let `captured` be `0`.
9. Repeat, while `k < len`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kValue` be ? `Get(O, Pk)`.
   c. Let `selected` be `ToBoolean(? `Call(callbackfn, T, « kValue, k, O »)`).
   d. If `selected` is `true`, then
      i. Append `kValue` to the end of `kept`.
      ii. Increase `captured` by `1`.
   e. Increase `k` by `1`.
10. Let `A` be ? `TypedArraySpeciesCreate(O, « captured »)`.
11. Let `n` be `0`.
12. For each element `e` of `kept`
   a. Perform ! `Set(A, ! ToString(n), e, true)`.
   b. Increment `n` by `1`.
13. Return `A`.

This function is not generic. The `this` value must be an object with a `[[TypedArrayName]]` internal slot.

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 21.1.3.8 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 `predicate` 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.

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 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 predicate 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.

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 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.

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 22.1.3.12 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.

22.2.3.14 %TypedArray%.prototype.includes (searchElement [, fromIndex ])

%TypedArray%.prototype.includes is a distinct function that implements the same algorithm as Array.prototype.includes 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.

22.2.3.15 %TypedArray%.prototype.join (separator)

%TypedArray%.prototype.join is a distinct function that implements the same algorithm as Array.prototype.join as defined in 22.1.3.13 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.

22.2.3.16 %TypedArray%.prototype.keys ()

The following steps are taken:
1. Let \( O \) be the \texttt{this} value.
2. Perform ? \texttt{ValidateTypedArray}(\( O \)).
3. Return \texttt{CreateArrayIterator}(\( O \), "key").

22.2.3.17 \%TypedArray\%.prototype.lastIndexOf (\( searchElement \[, fromIndex \] \))

\%TypedArray\%.prototype.lastIndexOf is a distinct function that implements the same algorithm as \texttt{Array.prototype.lastIndexOf} as defined in 22.1.3.15 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.

This function is not generic. \texttt{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.

22.2.3.18 get \%TypedArray\%.prototype.length

\%TypedArray\%.prototype.length is an accessor property whose set accessor function is \texttt{undefined}. Its get accessor function performs the following steps:

1. Let \( O \) be the \texttt{this} value.
2. If \texttt{Type}(\( O \)) is not Object, throw a \texttt{TypeError} exception.
3. If \( O \) does not have a [[TypedArrayName]] internal slot, throw a \texttt{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 \texttt{IsDetachedBuffer}(\( buffer \)) is \texttt{true}, return 0.
7. Let \( length \) be the value of \( O \)'s [[ArrayLength]] internal slot.
8. Return \( length \).

This function is not generic. The \texttt{this} value must be an object with a [[TypedArrayName]] internal slot.

22.2.3.19 %TypedArray%.prototype.map (\( callbackFn \[, thisArg \] \))

The interpretation and use of the arguments of \%TypedArray\%.prototype.map are the same as for \texttt{Array.prototype.map} as defined in 22.1.3.16.

When the \texttt{map} method is called with one or two arguments, the following steps are taken:

1. Let \( O \) be the \texttt{this} value.
2. Perform ? \texttt{ValidateTypedArray}(\( O \)).
3. Let \( len \) be the value of \( O \)'s [[ArrayLength]] internal slot.
4. If \texttt{IsCallable}(\( callbackFn \)) is \texttt{false}, throw a \texttt{TypeError} exception.
5. If \( thisArg \) was supplied, let \( T \) be \( thisArg \); else let \( T \) be \texttt{undefined}.
6. Let \( A \) be ? \texttt{TypedArraySpeciesCreate}(\( O \), "\( len \) »).
7. Let \( k \) be 0.
8. Repeat, while \( k < len \)
   a. Let \( Pk \) be ! \texttt{ToString}(\( k \)).
   b. Let \( kValue \) be ? \texttt{Get}(\( O \), \( Pk \)).
   c. Let \( mappedValue \) be ? \texttt{Call}(\( callbackFn \), \( T \), "\( kValue \), \( k \), \( O \) »).
   d. Perform ? \texttt{Set}(\( A \), \( Pk \), \( mappedValue \), \texttt{true}).
   e. Increase \( k \) by 1.
9. Return \( A \).

This function is not generic. The \texttt{this} value must be an object with a [[TypedArrayName]] internal slot.

22.2.3.20 %TypedArray%.prototype.reduce (\( callbackFn \[, initialValue \] \))
%TypedArray%.prototype.reduce is a distinct function that implements the same algorithm as
Array.prototype.reduce as defined in 22.1.3.20 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 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.

22.2.3.21 %TypedArray%.prototype.reduceRight ( callbackfn [, initialValue ])

%TypedArray%.prototype.reduceRight is a distinct function that implements the same algorithm as
Array.prototype.reduceRight as defined in 22.1.3.20 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 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.

22.2.3.22 %TypedArray%.prototype.reverse ( )

%TypedArray%.prototype.reverse is a distinct function that implements the same algorithm as
Array.prototype.reverse as defined in 22.1.3.21 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.

22.2.3.23 %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.

22.2.3.23.1 %TypedArray%.prototype.set ( array [, offset ])

Sets 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 is any ECMAScript language value other than an Object with a [[TypedArrayName]] internal slot. If it is
   such an Object, the definition in 22.2.3.23.2 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.
7. If targetOffset < 0, throw a RangeError exception.
8. Let targetBuffer be the value of target’s [[ViewedArrayBuffer]] internal slot.
9. If IsDetachedBuffer(targetBuffer) is true, throw a TypeError exception.
10. Let targetLength be the value of target’s [[ArrayLength]] internal slot.
11. Let targetName be the String value of target’s [[TypedArrayName]] internal slot.
12. Let targetElementSize be the Number value of the Element Size value specified in Table 50 for targetName.
13. Let `targetType` be the String value of the Element Type value in Table 50 for `targetName`.
14. Let `targetByteOffset` be the value of `target`'s `[[ByteOffset]]` internal slot.
15. Let `src` be `ToObject(array)`.
16. Let `srcLength` be `ToLength( Get(src, "length"))`.
17. If `srcLength + targetOffset > targetLength`, throw a `RangeError` exception.
18. Let `targetByteIndex` be `targetOffset × targetElementSize + targetByteOffset`.
19. Let `k` be 0.
20. Let `limit` be `targetByteIndex + targetElementSize × srcLength`.
21. Repeat, while `targetByteIndex < limit`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kNumber` be `ToNumber( Get(src, Pk))`.
   c. If `IsDetachedBuffer(targetBuffer)` is `true`, throw a `TypeError` exception.
   d. Perform `SetValueInBuffer(targetBuffer, targetByteIndex, targetType, kNumber)`.
   e. Set `k` to `k + 1`.
   f. Set `targetByteIndex` to `targetByteIndex + targetElementSize`.
22. Return `undefined`.

### 22.2.3.23.2 `%TypedArray%.prototype.set(targetArray [ , offset ] )`

Sets multiple values in this `TypedArray`, reading the values from the `targetArray` 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: `targetArray` has a `[[TypedArrayName]]` internal slot. If it does not, the definition in 22.2.3.23.1 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 `ToObject(offset)`.
7. If `targetOffset < 0`, throw a `RangeError` exception.
8. Let `targetBuffer` be the value of `target`'s `[[ViewedArrayBuffer]]` internal slot.
9. If `IsDetachedBuffer(targetBuffer)` is `true`, throw a `TypeError` exception.
10. Let `targetLength` be the value of `target`'s `[[ArrayLength]]` internal slot.
11. Let `srcBuffer` be the value of `targetArray`'s `[[ViewedArrayBuffer]]` internal slot.
12. If `IsDetachedBuffer(srcBuffer)` is `true`, throw a `TypeError` exception.
13. Let `targetName` be the String value of `target`'s `[[TypedArrayName]]` internal slot.
14. Let `targetType` be the String value of the Element Type value in Table 50 for `targetName`.
15. Let `targetElementSize` be the Number value of the Element Size value specified in Table 50 for `targetName`.
16. Let `targetByteOffset` be the value of `target`'s `[[ByteOffset]]` internal slot.
17. Let `srcName` be the String value of `targetArray`'s `[[TypedArrayName]]` internal slot.
18. Let `srcType` be the String value of the Element Type value in Table 50 for `srcName`.
19. Let `srcElementSize` be the Number value of the Element Size value specified in Table 50 for `srcName`.
20. Let `srcLength` be the value of `targetArray`'s `[[ArrayLength]]` internal slot.
21. Let `srcByteOffset` be the value of `targetArray`'s `[[ByteOffset]]` internal slot.
22. If `srcLength + targetOffset > targetLength`, throw a `RangeError` exception.
23. If `SameValue(srcBuffer, targetBuffer)` is `true`, then
   a. Let `srcBuffer` be `CloneArrayBuffer(targetBuffer, srcByteOffset, %ArrayBuffer%)`.
   b. NOTE: `%ArrayBuffer%` is used to clone `targetBuffer` because it is known to not have any observable side-effects.
   c. Let `srcByteIndex` be 0.
24. Else, let `srcByteIndex` be `srcByteOffset`.
25. Let `targetByteIndex` be `targetOffset × targetElementSize + targetByteOffset`.
26. Let `limit` be `targetByteIndex + targetElementSize × srcLength`.
27. If `SameValue(srcType, targetType)` is `false`, then
   a. Repeat, while `targetByteIndex < limit`
      i. Let `value` be `GetViewFromBuffer(srcBuffer, srcByteIndex, srcType)`.
      ii. Perform `SetValueInBuffer(targetBuffer, targetByteIndex, targetType, value)`.
iii. Set `srcByteIndex` to `srcByteIndex + srcElementSize`.
iv. Set `targetByteIndex` to `targetByteIndex + targetElementSize`.

28. Else,
a. NOTE: If `srcType` and `targetType` are the same, the transfer must be performed in a manner that preserves the bit-level encoding of the source data.
b. Repeat, while `targetByteIndex < limit`
   i. Let `value` be `GetValueFromBuffer(srcBuffer, srcByteIndex, "Uint8")`.
   ii. Perform `SetValueInBuffer(targetBuffer, targetByteIndex, "Uint8", value)`.
   iii. Set `srcByteIndex` to `srcByteIndex + 1`.
   iv. Set `targetByteIndex` to `targetByteIndex + 1`.

29. Return `undefined`.

### 22.2.3.24 `%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 22.1.3.23. The following steps are taken:

1. Let `O` be the `this` value.
2. Perform `ValidateTypedArray(O)`.
3. Let `len` be the value of `O's` `[[ArrayLength]]` internal slot.
4. Let `relativeStart` be `ToInteger(start)`.
5. If `relativeStart < 0`, let `k` be `max((len + relativeStart), 0)`; else let `k` be `min(relativeStart, len)`.
6. If `end` is `undefined`, let `relativeEnd` be `len`; else let `relativeEnd` be `ToInteger(end)`.
7. If `relativeEnd < 0`, let `final` be `max((len + relativeEnd), 0)`; else let `final` be `min(relativeEnd, len)`.
8. Let `count` be `max(final - k, 0)`.
9. Let `A` be `TypedArraySpeciesCreate(O, « count »)`.
10. Let `srcName` be the String value of `O's` `[[TypedArrayName]]` internal slot.
11. Let `srcType` be the String value of the Element Type value in Table 50 for `srcName`.
12. Let `targetName` be the String value of `A's` `[[TypedArrayName]]` internal slot.
13. Let `targetType` be the String value of the Element Type value in Table 50 for `targetName`.
14. If `SameValue(srcType, targetType)` is `false`, then
   a. Let `n` be 0.
   b. Repeat, while `k < final`
      i. Let `Pk` be `ToString(k)`.
      ii. Let `kValue` be `Get(O, Pk)`.
      iii. Perform `Set(A, ! ToString(n), kValue, true)`.
      iv. Increase `k` by 1.
      v. Increase `n` by 1.
15. Else if `count > 0`, then
   a. Let `srcBuffer` be the value of `O's` `[[ViewedArrayBuffer]]` internal slot.
   b. If `IsDetachedBuffer(srcBuffer)` is `true`, throw a `TypeError` exception.
   c. Let `targetBuffer` be the value of `A's` `[[ViewedArrayBuffer]]` internal slot.
   d. Let `elementSize` be the Number value of the Element Size value specified in Table 50 for `srcType`.
   e. NOTE: If `srcType` and `targetType` are the same, the transfer must be performed in a manner that preserves the bit-level encoding of the source data.
   f. Let `srcByteOffset` be the value of `O's` `[[ByteOffset]]` internal slot.
   g. Let `targetByteIndex be A's` `[[ByteOffset]]` internal slot.
   h. Let `srcByteIndex be (k × elementSize) + srcByteOffset`.
   i. Let `limit` be `targetByteIndex + count × elementSize`.
   j. Repeat, while `targetByteIndex < limit`
      i. Let `value` be `GetValueFromBuffer(srcBuffer, srcByteIndex, "Uint8")`.
      ii. Perform `SetValueInBuffer(targetBuffer, targetByteIndex, "Uint8", value)`.
      iii. Increase `srcByteIndex` by 1.
      iv. Increase `targetByteIndex` by 1.
This function is not generic. The `this` value must be an object with a `[[TypedArrayName]]` internal slot.

22.2.3.25 `%TypedArray%.prototype.some ( callbackfn [ , thisArg ] )

 `%TypedArray%.prototype.some` is a distinct function that implements the same algorithm as `Array.prototype.some` as defined in 22.1.3.24 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.

22.2.3.26 `%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 22.1.3.25. 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 `sort` function. These steps are used instead of the entry steps in 22.1.3.25:

1. Let `obj` be the `this` value.
2. Let `buffer` be `? ValidateTypedArray(obj)`.
3. Let `len` be the value of `obj`'s `[[ArrayLength]]` internal slot.

The implementation defined sort order condition for exotic objects is not applied by `%TypedArray%.prototype.sort`.

The following version of `SortCompare` is used by `%TypedArray%.prototype.sort`. It performs a numeric comparison rather than the string comparison used in 22.1.3.25. `SortCompare` has access to the `comparefn` and `buffer` values of the current invocation of the `sort` method.

When the TypedArray `SortCompare` abstract operation is called with two arguments `x` and `y`, the following steps are taken:

1. Assert: Both `Type(x)` and `Type(y)` is Number.
2. If the argument `comparefn` is not `undefined`, then
   a. Let `v` be `? Call(comparefn, undefined, « x, y »)`.
   b. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
   c. If `v` is `NaN`, return `+0`.
   d. Return `v`.
3. If `x` and `y` are both `NaN`, return `+0`.
4. If `x` is `NaN`, return `1`.
5. If `y` is `NaN`, return `-1`.
6. If `x < y`, return `-1`.
7. If `x > y`, return `1`.
8. If `x` is `-0` and `y` is `+0`, return `-1`.
9. If `x` is `+0` and `y` is `-0`, return `1`.
10. Return `+0`.

NOTE Because `NaN` always compares greater than any other value, `NaN` property values always sort to the end of the result when `comparefn` is not provided.

22.2.3.27 `%TypedArray%.prototype.subarray( begin, end )`
Returns a new %TypedArray% object whose element type is the same as this %TypedArray% and whose ArrayBuffer is the same as the ArrayBuffer of this %TypedArray%, referencing the elements at begin, inclusive, up to end, exclusive. If either begin or end is negative, it refers to an index from the end of the array, as opposed to from the beginning.

1. Let O be the 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 a [[ViewedArrayBuffer]] internal slot.
5. Let buffer be the value of O's [[ViewedArrayBuffer]] internal slot.
6. Let srcLength be the value of O's [[ArrayLength]] internal slot.
7. Let relativeBegin be ? ToInteger(begin).
8. If relativeBegin < 0, let beginIndex be max((srcLength + relativeBegin), 0); else let beginIndex be min(relativeBegin, srcLength).
9. If end is undefined, let relativeEnd be srcLength; else, let relativeEnd be ? ToInteger(end).
10. If relativeEnd < 0, let endIndex be max((srcLength + relativeEnd), 0); else let endIndex be min(relativeEnd, srcLength).
11. Let newLength be max(endIndex - beginIndex, 0).
12. Let constructorName 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 50 for constructorName.
14. Let srcByteOffset be the value of O's [[ByteOffset]] internal slot.
15. Let beginByteOffset be srcByteOffset + beginIndex * elementSize.
16. Let argumentsList be « buffer, beginByteOffset, newLength ».
17. Return %TypedArray%SpeciesCreate(O, argumentsList).

This function is not generic. The this value must be an object with a [[TypedArrayName]] internal slot.

22.2.3.28 %TypedArray%.prototype.toLocaleString ([ reserved1 , reserved2 ])

%TypedArray%.prototype.toLocaleString is a distinct function that implements the same algorithm as Array.prototype.toLocaleString as defined in 22.1.3.27 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.

NOTE If the ECMAScript implementation includes the ECMA-402 Internationalization API this function is based upon the algorithm for Array.prototype.toLocaleString that is in the ECMA-402 specification.

22.2.3.29 %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 22.1.3.28.

22.2.3.30 %TypedArray%.prototype.values ()

The following steps are taken:

1. Let O be the this value.
2. Perform ? ValidateTypedArray(O).
3. Return CreateArrayIterator(O, "value").

22.2.3.31 %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.

22.2.3.32 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 Type(O) is not Object, return `undefined`.
3. If O does not have a [[TypedArrayName]] internal slot, return `undefined`.
4. Let name be the value of O's [[TypedArrayName]] internal slot.
5. Assert: name is a String value.
6. Return name.

This property has the attributes { [[Enumerable]]: false, [[Configurable]]: true }.

The initial value of the name property of this function is "get [Symbol.toStringTag]".

### 22.2.4 The TypedArray Constructors

Each of the 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 50.

The `TypedArray` intrinsic constructor functions are single functions whose behaviour is overloaded based upon the number and types of its arguments. The actual behaviour of a call of `TypedArray` depends upon the number and kind of arguments that are passed to it.

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.

The `length` property of the `TypedArray` constructor function is 3.

#### 22.2.4.1 TypedArray ()

This description applies only if the `TypedArray` function is called with no arguments.

1. If NewTarget is `undefined`, throw a `TypeError` exception.
2. Let `constructorName` be the String value of the Constructor Name value specified in Table 50 for this `TypedArray` constructor.
3. Return `? AllocateTypedArray(constructorName, NewTarget, "%TypedArrayPrototype%", 0)`.

#### 22.2.4.2 TypedArray ( length )

This description applies only if the `TypedArray` function is called with at least one argument 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. If `length` is `undefined`, throw a `TypeError` exception.
4. Let `numberLength` be `? ToNumber(length)`.
5. Let `elementLength` be `ToLength(numberLength)`.
6. If `SameValueZero(numberLength, elementLength)` is `false`, throw a `RangeError` exception.
7. Let `constructorName` be the String value of the Constructor Name value specified in Table 50 for this `TypedArray` constructor.
22.2.4.2.1 Runtime Semantics: \texttt{AllocateTypedArray}(constructorName, newTarget, defaultProto [ , length ])

The abstract operation \texttt{AllocateTypedArray} with arguments constructorName, newTarget, defaultProto and optional argument length is used to validate and create an instance of a TypedArray constructor. constructorName is required to be the name of a TypedArray constructor in Table 50. If the length argument is passed an ArrayBuffer of that length is also allocated and associated with the new TypedArray instance. \texttt{AllocateTypedArray} provides common semantics that is used by all of the \texttt{TypedArray} overloads. \texttt{AllocateTypedArray} performs the following steps:

1. Let proto be \texttt{GetPrototypeOf}(newTarget, defaultProto).
2. Let obj be \texttt{IntegerIndexedObjectCreate}(proto, « [[ViewedArrayBuffer]], [[TypedArrayName]], [[ByteLength]],
[[ByteOffset]], [[ArrayLength]] »).
3. Assert: The [[ViewedArrayBuffer]] internal slot of obj is \texttt{undefined}.
4. Set obj's [[TypedArrayName]] internal slot to constructorName.
5. 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.
6. Else,
   a. Perform \texttt{AllocateTypedArrayBuffer}(obj, length).
7. Return obj.

22.2.4.2.2 Runtime Semantics: \texttt{AllocateTypedArrayBuffer}(O, length)

The abstract operation \texttt{AllocateTypedArrayBuffer} with arguments O and length allocates and associates an ArrayBuffer with the TypedArray instance O. It performs the following steps:

1. Assert: O is an Object that has a [[ViewedArrayBuffer]] internal slot.
2. Assert: The [[ViewedArrayBuffer]] internal slot of O is \texttt{undefined}.
3. Assert: length ≥ 0.
4. Let constructorName be the String value of O's [[TypedArrayName]] internal slot.
5. Let elementSize be the Element Size value in Table 50 for constructorName.
6. Let byteLength be elementSize \times length.
7. Let data be \texttt{AllocateArrayBuffer}(O, byteLength).
8. Set O's [[ViewedArrayBuffer]] internal slot to data.
9. Set O's [[ByteLength]] internal slot to byteLength.
10. Set O's [[ByteOffset]] internal slot to 0.
11. Set O's [[ArrayLength]] internal slot to length.
12. Return O.

22.2.4.3 \texttt{TypedArray}(typedArray)

This description applies only if the \texttt{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.

\texttt{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 \texttt{undefined}, throw a \texttt{TypeError} exception.
3. Let constructorName be the String value of the Constructor Name value specified in Table 50 for this \texttt{TypedArray} constructor.
4. Let O be ? \texttt{AllocateTypedArray}(constructorName, NewTarget, "%TypedArrayPrototype%").
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 \texttt{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 50 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 `srcType` be the String value of the Type value in Table 50 for `srcName`.
13. Let `srcElementSize` be the Element Size value in Table 50 for `srcName`.
14. Let `srcByteOffset` be the value of `srcArray`'s `[[ByteOffset]]` internal slot.
15. Let `elementSize` be the Element Size value in Table 50 for `constructorName`.
16. Let `byteLength` be `elementSize × elementLength`.
17. If `SameValue(elementType, srcType)` is true, then
   a. Let `data` be ? `CloneArrayBuffer(srcData, srcByteOffset)`.
18. Else,
   a. Let `bufferConstructor` be ? `SpeciesConstructor(srcData, %ArrayBufferData%)`.
   b. Let `data` be ? `AllocateArrayBuffer(bufferConstructor, byteLength)`.
   c. If `IsDetachedBuffer(srcData)` is true, throw a `TypeError` exception.
   d. Let `srcByteIndex` be `srcByteOffset`.
   e. Let `targetByteIndex` be 0.
   f. Let `count` be `elementLength`.
   g. Repeat, while `count > 0`
      i. Let `value` be `GetValueFromBuffer(srcData, srcByteIndex, srcType)`.
      ii. Perform `SetValueInBuffer(data, targetByteIndex, elementType, value)`.
      iii. Set `srcByteIndex` to `srcByteIndex + srcElementSize`.
      iv. Set `targetByteIndex` to `targetByteIndex + elementSize`.
      v. 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`.

### 22.2.4.4 `TypedArray ( object )`

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 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. Let `constructorName` be the String value of the Constructor Name value specified in Table 50 for this `TypedArray` constructor.
4. Let `O` be ? `AllocateTypedArray(constructorName, NewTarget, "%TypedArrayPrototype%")`.
5. Let `arrayLike` be ? `IterableToArrayLike(object)`.
6. Let `len` be ? `ToLength(? `Get(arrayLike, "length"))`.
7. Perform ? `AllocateTypedArrayBuffer(O, len)`.
8. Let `k` be 0.
9. Repeat, while `k < len`
    a. Let `Pk` be ? `ToString(k)`.
    b. Let `kValue` be ? `Get(arrayLike, Pk)`.
    c. Perform ? `Set(O, Pk, kValue, true)`.
    d. Increase `k` by 1.
10. Return `O`.

### 22.2.4.5 `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 constructorName be the String value of the Constructor Name value specified in Table 50 for this TypedArray constructor.
4. Let O be ? AllocateTypedArray(constructorName, NewTarget, "%TypedArrayPrototype%").
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 50 for constructorName.
7. Let offset be ? ToInteger(byteOffset).
8. If offset < 0, throw a RangeError exception.
9. If offset is -0, let offset be +0.
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 [[ArrayBufferData]] 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. Let newByteLength be newLength × elementSize.
   c. 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.

22.2.4.6 TypedArrayCreate ( constructor, argumentList )

The abstract operation TypedArrayCreate with arguments constructor and argumentList is used to specify the creation of a new TypedArray object using a constructor function. It performs the following steps:

1. Let newTypedArray be ? Construct(constructor, argumentList).
3. If argumentList is a List of a single Number; then
   a. If the value of newTypedArray's [[ArrayLength]] internal slot < argumentList[0], throw a TypeError exception.
4. Return newTypedArray.

22.2.4.7 TypedArraySpeciesCreate ( exemplar, argumentList )

The abstract operation TypedArraySpeciesCreate with arguments exemplar and argumentList is used to specify the creation of a new TypedArray object using a constructor function that is derived from exemplar. It performs the following steps:

1. Assert: exemplar is an Object that has a [[TypedArrayName]] internal slot.
2. Let defaultConstructor be the intrinsic object listed in column one of Table 50 for the value of exemplar's [[TypedArrayName]] internal slot.
3. Let constructor be ? SpeciesConstructor(exemplar, defaultConstructor).
4. Return ? TypedArrayCreate(constructor, argumentList).

22.2.5 Properties of the TypedArray Constructors

The value of the [[Prototype]] internal slot of each TypedArray constructor is the %TypedArray% intrinsic object.

Each TypedArray constructor has a name property whose value is the String value of the constructor name specified for it in Table 50.
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 50 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 intrinsic 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%`. 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 50 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` instance inherits properties from the corresponding `TypedArray` prototype object. Each `TypedArray` instance has 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 `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. Set `map`'s `[[MapData]]` internal slot to a new empty `List`.
4. If `iterable` is not present, let `iterable` be `undefined`.
5. If `iterable` is either `undefined` or `null`, let `iter` be `undefined`.
6. Else,
   a. Let `adder` be `Get(map, "set")`.
   b. If `IsCallable(adder)` is `false`, throw a `TypeError` exception.
   c. Let `iter` be `GetIterator(iterable)`.
7. If `iter` is `undefined`, return `map`.
8. Repeat
   a. Let `next` be `IteratorStep(iter)`.
   b. If `next` is `false`, return `map`.
   c. Let `nextItem` be `IteratorValue(next)`.
   d. If `Type(nextItem)` is not `Object`, then
      i. Let `error` be `Completion([[Type]]: throw, [[Value]]: a newly created `TypeError` object, [[Target]]: empty).
      ii. Return `IteratorClose(iter, error)`.
   e. Let `k` be `Get(nextItem, "0")`.
   f. If `k` is an abrupt completion, return `IteratorClose(iter, k)`.
   g. Let `v` be `Get(nextItem, "1")`.
   h. If `v` is an abrupt completion, return `IteratorClose(iter, v)`.
   i. Let `status` be `Call(adder, map, « k.[[Value]], v.[[Value]] »)`.
   j. If `status` is an abrupt completion, return `IteratorClose(iter, status)`.

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%`.

The Map constructor has the following properties:

23.1.2.1 `Map.prototype`

The initial value of `Map.prototype` is the intrinsic object `%MapPrototype%`.

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 the `this` value.

The value of the `name` property of this function is "get [Symbol.species]".
Methods that create derived collection objects should call @@species to determine the constructor to use to create the derived objects. Subclass constructor may over-ride @@species to change the default constructor assignment.

23.1.3 Properties of the Map Prototype Object

The Map prototype object is the intrinsic object %MapPrototype%. The value of the [[Prototype]] internal slot of the Map prototype object is the intrinsic object %ObjectPrototype%. 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 Map Iterator 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 ] )

When the forEach method is called with one or two arguments, the following steps are taken:
1. Let \( M \) be the \texttt{this} value.
2. If \( \text{Type}(M) \) is not Object, throw a \texttt{TypeError} exception.
3. If \( M \) does not have a [[MapData]] internal slot, throw a \texttt{TypeError} exception.
4. If \( \text{IsCallable}(\text{callbackfn}) \) is \texttt{false}, throw a \texttt{TypeError} exception.
5. If \texttt{thisArg} was supplied, let \( T \) be \texttt{thisArg}; else let \( T \) be \texttt{undefined}.
6. Let \( entries \) be the \texttt{List} that is the value of \( M \)'s [[MapData]] internal slot.
7. Repeat for each \texttt{Record} \( \{[[\text{Key}]], [[\text{Value}]]\} \) \( e \) that is an element of \( entries \), in original key insertion order
   a. If \( e.[[\text{Key}]] \) is not empty, then
      i. Perform \( \text{? Call}(\text{callbackfn}, T, « \text{e}.[[\text{Value}]], \text{e}.[[\text{Key}]], M ») \).
8. Return \texttt{undefined}.

\texttt{callbackfn} should be a function that accepts three arguments. \texttt{forEach} calls \texttt{callbackfn} once for each key/value pair present in the map object, in key insertion order. \texttt{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 \texttt{thisArg} parameter is provided, it will be used as the \texttt{this} value for each invocation of \texttt{callbackfn}. If it is not provided, \texttt{undefined} is used instead.

\texttt{callbackfn} is called with three arguments: the value of the item, the key of the item, and the Map object being traversed.

\texttt{forEach} does not directly mutate the object on which it is called but the object may be mutated by the calls to \texttt{callbackfn}. Each entry of a map’s [[MapData]] is only visited once. New keys added after the call to \texttt{forEach} begins are visited. A key will be revisited if it is deleted after it has been visited and then re-added before the \texttt{forEach} call completes. Keys that are deleted after the call to \texttt{forEach} begins and before being visited are not visited unless the key is added again before the \texttt{forEach} call completes.

### 23.1.3.6 \texttt{Map.prototype.get( key )}

The following steps are taken:

1. Let \( M \) be the \texttt{this} value.
2. If \( \text{Type}(M) \) is not Object, throw a \texttt{TypeError} exception.
3. If \( M \) does not have a [[MapData]] internal slot, throw a \texttt{TypeError} exception.
4. Let \( entries \) be the \texttt{List} that is the value of \( M \)'s [[MapData]] internal slot.
5. Repeat for each \texttt{Record} \( \{[[\text{Key}]], [[\text{Value}]]\} \) \( p \) that is an element of \( entries \),
   a. If \( p.[[\text{Key}]] \) is not empty and \( \text{SameValueZero}(p.[[\text{Key}]], \text{key}) \) is \texttt{true}, return \( p.[[\text{Value}]] \).
6. Return \texttt{undefined}.

### 23.1.3.7 \texttt{Map.prototype.has( key )}

The following steps are taken:

1. Let \( M \) be the \texttt{this} value.
2. If \( \text{Type}(M) \) is not Object, throw a \texttt{TypeError} exception.
3. If \( M \) does not have a [[MapData]] internal slot, throw a \texttt{TypeError} exception.
4. Let \( entries \) be the \texttt{List} that is the value of \( M \)'s [[MapData]] internal slot.
5. Repeat for each \texttt{Record} \( \{[[\text{Key}]], [[\text{Value}]]\} \) \( p \) that is an element of \( entries \),
   a. If \( p.[[\text{Key}]] \) is not empty and \( \text{SameValueZero}(p.[[\text{Key}]], \text{key}) \) is \texttt{true}, return \texttt{true}.
6. Return \texttt{false}.

### 23.1.3.8 \texttt{Map.prototype.keys( )}

The following steps are taken:

1. Let \( M \) be the \texttt{this} value.
2. Return \( \text{? CreateMapIterator}(M, "key") \).
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 $\text{[[MapData]]}$ internal slot, throw a TypeError exception.
4. Let $\text{entries}$ be the $\text{List}$ that is the value of $M$’s $\text{[[MapData]]}$ internal slot.
5. Repeat for each $\text{Record} \{ \text{[[Key]]}, \text{[[Value]]} \} p$ that is an element of $\text{entries}$,
   i. If $p.\text{[[Key]]}$ is not empty and $\text{SameValueZero}(p.\text{[[Key]]}, \text{key})$ is true, then
   ii. Set $p.\text{[[Value]]}$ to $\text{value}$.
6. Return $M$.

6. If $\text{key}$ is -0, let $\text{key}$ be +0.
7. Let $p$ be the $\text{Record} \{ \text{[[Key]]}: \text{key}, \text{[[Value]]}: \text{value} \}$.
8. Append $p$ as the last element of $\text{entries}$.

23.1.3.10 **get Map.prototype.size**

Map.prototype.size is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let $M$ be the this value.
2. If Type($M$) is not Object, throw a TypeError exception.
3. If $M$ does not have a $\text{[[MapData]]}$ internal slot, throw a TypeError exception.
4. Let $\text{entries}$ be the $\text{List}$ that is the value of $M$’s $\text{[[MapData]]}$ internal slot.
5. Let $\text{count}$ be 0.
6. For each $\text{Record} \{ \text{[[Key]]}, \text{[[Value]]} \} p$ 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 **Map.prototype.values ()**

The following steps are taken:

1. Let $M$ be the this value.
2. Return $\text{? CreateMapIterator}(M, \text{"value"})$.

23.1.3.12 **Map.prototype [ @@iterator ] ()**

The initial value of the @@iterator property is the same function object as the initial value of the entries property.

23.1.3.13 **Map.prototype [ @@toStringTag ]**

The initial value of the @@toStringTag property is the String value "Map".

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true ).

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 CreateMapIterator Abstract Operation

Several methods of Map objects return Iterator objects. The abstract operation CreateMapIterator with arguments `map` and `kind` is used to create such iterator objects. It performs the following steps:

1. If `Type(map)` is not Object, throw a `TypeError` exception.
2. If `map` does not have a `[[MapData]]` internal slot, throw a `TypeError` exception.
3. Let `iterator` be `ObjectCreate(%MapIteratorPrototype%, « [Map], [[MapNextIndex]], [[MapIterationKind]] »).
4. Set `iterator`'s `[[Map]]` internal slot to `map`.
5. Set `iterator`'s `[[MapNextIndex]]` internal slot to 0.
6. Set `iterator`'s `[[MapIterationKind]]` internal slot to `kind`.
7. Return `iterator`.

23.1.5.2 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. In addition, `%MapIteratorPrototype%` has the following properties:

23.1.5.2.1 %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 `CreateArrayFromList('e.[[Key]], e.[[Value]]')`.
      iv. Return `CreateIterResultObject(result, false)`.
11. Set the `[[Map]]` internal slot of `O` to `undefined`.
12. Return `CreateIterResultObject(undefined, true)`.

23.1.5.2.2 %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 51.
Table 51: Internal Slots of Map Iterator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Map]]</td>
<td>The Map object that is being iterated.</td>
</tr>
<tr>
<td>[[MapNextIndex]]</td>
<td>The integer index of the next Map data element to be examined by this iterator.</td>
</tr>
<tr>
<td>[[MapIterationKind]]</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>

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. Set set's [[SetData]] internal slot to a new empty List.
4. If iterable is not present, let iterable be undefined.
5. If iterable is either undefined or null, let iter be undefined.
6. Else,
   a. Let adder be ? Get(set, "add").
   b. If IsCallable(adder) is false, throw a TypeError exception.
   c. Let iter be ? GetIterator(iterable).
7. If iter is undefined, return set.
8. Repeat
   a. Let next be ? IteratorStep(iter).
   b. If next is false, return set.
   c. Let nextValue be ? IteratorValue(next).
   d. Let status be Call(adder, set, « nextValue.[[Value]] »).
   e. If status is an abrupt completion, return ? IteratorClose(iter, status).

23.2.2 Properties of the Set Constructor

The value of the [[Prototype]] internal slot of the Set constructor is the intrinsic object %FunctionPrototype%.

The Set constructor has the following properties:
23.2.2.1 Set.prototype

The initial value of `Set.prototype` is the intrinsic `%SetPrototype%` object.

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 the `this` value.

The value of the `name` property of this function is "get [Symbol.species]."

NOTE Methods that create derived collection objects should call @@species to determine the constructor to use to create the derived objects. Subclass constructor may over-ride @@species to change the default constructor assignment.

23.2.3 Properties of the Set Prototype Object

The Set prototype object is the intrinsic object `%SetPrototype%`. The value of the [[Prototype]] internal slot of the Set prototype object is the intrinsic object `%ObjectPrototype%`. 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 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. Replace the element of `entries` whose value is `e` with an element whose value is empty.
6. Return `undefined`.

NOTE The existing [[SetData]] `List` is preserved because there may be existing Set Iterator objects that are suspended midway through iterating over that `List`.

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 ])

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. Perform `? Call(callbackfn, T, « e, e, S »)`.
8. Return `undefined`.

**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 is 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 `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 `forEach` call completes. New values added after the call to `forEach` begins are visited.

### 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`:
   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.
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. 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 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. 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. Return CreateIterResultObject(CreateArrayFromList(« e, e »), false).
          2. 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 52.
### Table 52: Internal Slots of Set Iterator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[IteratedSet]]</code></td>
<td>The Set object that is being iterated.</td>
</tr>
<tr>
<td><code>[[SetNextIndex]]</code></td>
<td>The integer index of the next Set data element to be examined by this iterator</td>
</tr>
<tr>
<td><code>[[SetIterationKind]]</code></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;. &quot;key&quot; and &quot;value&quot; have the same meaning.</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 a key/value pair with a specific key, but no mechanism 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. 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:


### 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 ([ iterative ])

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. Set `map`'s [[WeakMapData]] internal slot to a new empty List.
4. If `iterable` is not present, let `iterable` be `undefined`.
5. If `iterable` is either `undefined` or `null`, let `iter` be `undefined`.
6. Else,
   a. Let `adder` be `Get(map, "set")`.
   b. If `IsCallable(adder)` is `false`, throw a **TypeError** exception.
   c. Let `iter` be `GetIterator(iterable)`.
7. If `iter` is `undefined`, return `map`.
8. Repeat
   a. Let `next` be `IteratorStep(iter)`.
   b. If `next` is `false`, return `map`.
   c. Let `nextItem` be `IteratorValue(next)`.
   d. If `Type(nextItem)` is not `Object`, then
      i. Let `error` be `Completion`([[Type]]: throw, [[Value]]: a newly created **TypeError** object, [[Target]]: empty).
      ii. Return `IteratorClose(iter, error)`.
   e. Let `k` be `Get(nextItem, "0")`.
   f. If `k` is an abrupt completion, return `IteratorClose(iter, k)`.
   g. Let `v` be `Get(nextItem, "1")`.
   h. If `v` is an abrupt completion, return `IteratorClose(iter, v)`.
   i. Let `status` be `Call(adder, map, « k.[[Value]], v.[[Value]] »)`.
   j. 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%`.

The WeakMap constructor has the following properties:

#### 23.3.2.1 WeakMap.prototype

The initial value of **WeakMap.prototype** is the intrinsic object `%WeakMapPrototype%`.

This property has the attributes (`[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false`).

### 23.3.3 Properties of the WeakMap Prototype Object

The WeakMap prototype object is the intrinsic object `%WeakMapPrototype%`. The value of the [[Prototype]] internal slot of the WeakMap prototype object is the intrinsic object `%ObjectPrototype%`. 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 \( \text{entries} \) be the List that is the value of \( M \)'s [[WeakMapData]] internal slot.
5. If Type(\( \text{key} \)) is not Object, return false.
6. Repeat for each Record \([[\text{Key}]], [[\text{Value}]]) \( p \) that is an element of \( \text{entries} \),
   a. If \( p.[[\text{Key}]] \) is not empty and SameValue(\( p.[[\text{Key}]], \text{key} \)) is true, then
      i. Set \( p.[[\text{Key}]] \) to empty.
      ii. Set \( p.[[\text{Value}]] \) to empty.
      iii. Return true.
7. Return false.

The value \( \text{empty} \) 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 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 \( \text{entries} \) be the List that is the value of \( M \)'s [[WeakMapData]] internal slot.
5. If Type(\( \text{key} \)) is not Object, return undefined.
6. Repeat for each Record \([[\text{Key}]], [[\text{Value}]]) \( p \) that is an element of \( \text{entries} \),
   a. If \( p.[[\text{Key}]] \) is not empty and SameValue(\( p.[[\text{Key}]], \text{key} \)) is true, return \( p.[[\text{Value}]] \).
7. Return undefined.

### 23.3.4 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 \( \text{entries} \) be the List that is the value of \( M \)'s [[WeakMapData]] internal slot.
5. If Type(\( \text{key} \)) is not Object, return false.
6. Repeat for each Record \([[\text{Key}]], [[\text{Value}]]) \( p \) that is an element of \( \text{entries} \),
   a. If \( p.[[\text{Key}]] \) is not empty and SameValue(\( p.[[\text{Key}]], \text{key} \)) is true, return true.
7. Return false.

### 23.3.5 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 \( \text{entries} \) be the List that is the value of \( M \)'s [[WeakMapData]] internal slot.
5. If Type(\( \text{key} \)) is not Object, throw a TypeError exception.
6. Repeat for each Record \([[\text{Key}]], [[\text{Value}]]) \( p \) that is an element of \( \text{entries} \),
   a. If \( p.[[\text{Key}]] \) is not empty and SameValue(\( p.[[\text{Key}]], \text{key} \)) is true, then
      i. Set \( p.[[\text{Value}]] \) to value.
      ii. Return \( M \).
7. Let \( p \) be the Record \([[\text{Key}]: \text{key}, [\text{Value}]: \text{value}]\).
8. Append $p$ as the last element of $\text{entries}$.

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 mechanism is provided for enumerating the objects it holds. If an object that is contained 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. Set set's [[WeakSetData]] internal slot to a new empty List.
4. If iterable is not present, let iterable be undefined.
5. If iterable is either undefined or null, let iter be undefined.
6. Else,
   a. Let adder be ? Get(set, "add").
   b. If IsCallable(adder) is false, throw a TypeError exception.
c. Let \( \text{iter} \) be `GetIterator(iterable)`.
7. If \( \text{iter} \) is `undefined`, return `set`.
8. Repeat
   a. Let \( \text{next} \) be `IteratorStep(\text{iter})`.
   b. If \( \text{next} \) is `false`, return `set`.
   c. Let \( \text{nextValue} \) be `IteratorValue(\text{next})`.
   d. Let \( \text{status} \) be `Call(adder, set, « \text{nextValue} »)`.
   e. If \( \text{status} \) is an abrupt completion, return `IteratorClose(\text{iter}, \text{status})`.

### 23.4.2 Properties of the WeakSet Constructor

The value of the `[[Prototype]]` internal slot of the WeakSet constructor is the intrinsic object `%FunctionPrototype%`.

The WeakSet constructor has the following properties:

#### 23.4.2.1 WeakSet.prototype

The initial value of `WeakSet.prototype` is the intrinsic `%WeakSetPrototype%` object.

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

#### 23.4.3 Properties of the WeakSet Prototype Object

The WeakSet prototype object is the intrinsic object `%WeakSetPrototype%`. The value of the `[[Prototype]]` internal slot of the WeakSet prototype object is the intrinsic object `%ObjectPrototype%`. 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 \( \text{entries} \) be the List that is the value of \( S \)'s `[[WeakSetData]]` internal slot.
6. Repeat for each \( e \) that is an element of \( \text{entries} \),
   a. If \( e \) is not empty and `SameValue(e, value)` is `true`, then
      i. Return \( S \).
5. Append `value` as the last element of `\( \text{entries} \)`.
8. Return \( S \).

#### 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 `\( \text{entries} \)` be the List that is the value of \( S \)'s `[[WeakSetData]]` internal slot.
6. Repeat for each `e` that is an element of `\( \text{entries} \)`,
   a. If `e` is not empty and `SameValue(e, value)` is `true`, then
      i. Replace the element of `\( \text{entries} \)` whose value is `e` with an element whose value is `empty`.
ii. 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.

23.4.3.4 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) is true, 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. 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. Assert: byteLength is an integer value ≥ 0.
3. Let block be ? CreateByteDataBlock(byteLength).
4. Set obj's [[ArrayBufferData]] internal slot to block.
5. Set obj's [[ArrayBufferByteLength]] internal slot to byteLength.
6. 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 an [[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 use the DetachArrayBuffer abstract operation. However, an ECMAScript implementation or host environment may define such operations.

24.1.1.4 CloneArrayBuffer (srcBuffer, srcByteOffset [ , cloneConstructor ])

The abstract operation CloneArrayBuffer takes three parameters, an ArrayBuffer srcBuffer, an integer srcByteOffset and optionally a constructor function cloneConstructor. It creates a new ArrayBuffer whose data is a copy of srcBuffer’s data starting at srcByteOffset. This operation performs the following steps:

1. Assert: Type(srcBuffer) is Object and it has an [[ArrayBufferData]] internal slot.
2. If cloneConstructor is not present, then
   a. Let cloneConstructor be ? SpeciesConstructor(srcBuffer, %ArrayBuffer%).
   b. If IsDetachedBuffer(srcBuffer) is true, throw a TypeError exception.
3. Else, Assert: IsConstructor(cloneConstructor) is true.
4. Let srcLength be the value of srcBuffer's [[ArrayBufferByteLength]] internal slot.
5. Assert: srcByteOffset ≤ srcLength.
7. Let targetBlock be the value of srcBuffer's [[ArrayBufferData]] internal slot.
9. If IsDetachedBuffer(targetBuffer) is true, throw a TypeError exception.
10. Let targetBlock be the value of targetBuffer's [[ArrayBufferData]] internal slot.
11. Perform CopyDataBlockBytes(targetBlock, 0, srcBlock, srcByteOffset, cloneLength).
12. Return targetBuffer.

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 an integer value ≥ 0.
4. Let block be arrayBuffer's [[ArrayBufferData]] internal slot.
5. Let elementSize be the Number value of the Element Size value specified in Table 50 for Element Type type.
6. Let rawValue be a List of elementSize containing, in order, the elementSize 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
24.1.1.6 SetValueInBuffer (arrayBuffer, bytIndex, type, value [, isLittleEndian ])

The abstract operation SetValueInBuffer takes five parameters, an ArrayBuffer `arrayBuffer`, an integer `bytIndex`, 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 `bytIndex` to represent a value of `type`.
3. Assert: `bytIndex` is an integer value ≥ 0.
4. Assert: `Type(value)` is Number.
5. Let `block` be `arrayBuffer`'s `[[ArrayBufferData]]` internal slot.
6. Assert: `block` is not `undefined`.
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 GetValueFromBuffer abstract operation.
8. If `type` is "Float32", then
   a. Set `rawBytes` 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 IEEE 754-2008 binary64 format Not-a-Number encoding. An implementation must always choose the same encoding for each implementation distinguishable `NaN` value.
9. Else, if `type` is "Float64", then
   a. Set `rawBytes` 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 IEEE 754-2008 binary32 format Not-a-Number encoding. An implementation must always choose the same encoding for each implementation distinguishable `NaN` value.
10. Else,
    a. Let `n` be the Number value of the Element Size specified in Table 50 for Element Type `type`.
    b. Let `convOp` be the abstract operation named in the Conversion Operation column in Table 50 for Element Type `type`.
    c. Let `intValue` be `convOp`(value).
    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,
       i. 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.
11. Store the individual bytes of `rawBytes` into `block`, in order, starting at `block[bytIndex]`.
12. 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. If SameValueZero(numberLength, byteLength) is false, throw a RangeError exception.

24.1.3 Properties of the ArrayBuffer Constructor

The value of the [[Prototype]] internal slot of the ArrayBuffer constructor is the intrinsic object %FunctionPrototype%.

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 intrinsic object %ArrayBufferPrototype%.

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 the this value.

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 behaviour by redefining its @@species property.

24.1.4 Properties of the ArrayBuffer Prototype Object

The ArrayBuffer prototype object is the intrinsic object %ArrayBufferPrototype%. 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. If relativeStart < 0, let first be max((len + relativeStart), 0); else let first be min(relativeStart, len).
8. If end is **undefined**, let relativeEnd be len; else let relativeEnd be ? ToInteger(end).
9. If relativeEnd < 0, let final be max((len + relativeEnd), 0); else let final be min(relativeEnd, len).
10. Let newLen be max(final-first, 0).
11. Let ctor be ? SpeciesConstructor(O, `%ArrayBuffer%`).
12. Let new be ? Construct(ctor, « newLen »).
13. If new does not have an [[ArrayBufferData]] internal slot, throw a **TypeError** exception.
14. If IsDetachedBuffer(new) is **true**, throw a **TypeError** exception.
15. If SameValue(new, O) is **true**, throw a **TypeError** exception.
16. If the value of new’s [[ArrayBufferByteLength]] internal slot < newLen, throw a **TypeError** exception.
17. NOTE: Side-effects of the above steps may have detached O.
18. If IsDetachedBuffer(O) is **true**, throw a **TypeError** exception.
19. Let fromBuf be the value of O’s [[ArrayBufferData]] internal slot.
20. Let toBuf be the value of new’s [[ArrayBufferData]] internal slot.
21. Perform CopyDataBlockBytes(toBuf, 0, fromBuf, first, newLen).
22. Return new.

**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. If numberIndex ≠ getIndex or getIndex < 0, throw a RangeError exception.
6. Let isLittleEndian be ToBoolean(isLittleEndian).
7. Let buffer be the value of view’s [[ViewedArrayBuffer]] internal slot.
8. If IsDetachedBuffer(buffer) is true, throw a TypeError exception.
9. Let viewOffset be the value of view’s [[ByteOffset]] internal slot.
10. Let viewSize be the value of view’s [[ByteLength]] internal slot.
11. Let elementSize be the Number value of the Element Size value specified in Table 50 for Element Type type.
12. If getIndex + elementSize > viewSize, throw a RangeError exception.
13. Let bufferIndex be getIndex + viewOffset.
14. 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. If numberIndex ≠ getIndex or getIndex < 0, throw a RangeError exception.
6. Let numberValue be ? ToNumber(value).
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 50 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, numberValue, isLittleEndian).

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 byteLength 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. If `numberOffset ≠ offset` or `offset < 0`, throw a `RangeError` exception.
7. If `IsDetachedBuffer(buffer)` is `true`, throw a `TypeError` exception.
8. Let `bufferByteLength` be the value of `buffer`'s `[[ArrayBufferByteLength]]` internal slot.
9. If `offset > bufferByteLength`, throw a `RangeError` exception.
10. If `byteLength` is `undefined`, then
    a. Let `viewByteLength` be `bufferByteLength - offset`.
   b. If `offset + viewByteLength > bufferByteLength`, throw a `RangeError` exception.
12. Set `O`'s `[[DataView]]` internal slot to `true`.
13. Set `O`'s `[[ViewedArrayBuffer]]` internal slot to `buffer`.
14. Set `O`'s `[[ByteLength]]` internal slot to `viewByteLength`.
15. Set `O`'s `[[ByteOffset]]` internal slot to `offset`.

### Properties of the DataView Constructor

The value of the `[[Prototype]]` internal slot of the `DataView` constructor is the intrinsic object `%FunctionPrototype%`.

The DataView constructor has the following properties:

#### DataView.prototype

The initial value of `DataView.prototype` is the intrinsic object `%DataViewPrototype%`.

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

#### Properties of the DataView Prototype Object

The DataView prototype object is the intrinsic object `%DataViewPrototype%`. The value of the `[[Prototype]]` internal slot of the DataView prototype object is the intrinsic object `%ObjectPrototype%`. The DataView prototype object is an ordinary object. It does not have a `[[DataView]], [[ViewedArrayBuffer]], [[ByteLength]],` or `[[ByteOffset]]` internal slot.

#### 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`.

#### 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.
6. Let `size` be the value of $O$'s [[ByteLength]] internal slot.
7. Return `size`.

### 24.2.4.3 get DataView.prototype.byteOffset

DataView.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.
6. Let `offset` be the value of $O$'s [[ByteOffset]] internal slot.
7. Return `offset`.

### 24.2.4.4 DataView.prototype.constructor

The initial value of DataView.prototype.constructor is the intrinsic object `%DataView%`.

### 24.2.4.5 DataView.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**.

### 24.2.4.6 DataView.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 ? `GetViewValue(v, byteOffset, littleEndian, "Float64")`.

### 24.2.4.7 DataView.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 ? `GetViewValue(v, byteOffset, true, "Int8")`.

### 24.2.4.8 DataView.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 ? `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 **false**.
3. Return ? `GetViewValue(v, byteOffset, littleEndian, "Int32")`. 
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 `? GetValueValue(v, byteOffset, littleEndian, "Int32")`.

### 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 `? GetValueValue(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`.

### 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`.

### 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`.

### 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 `? SetValueValue(v, byteOffset, littleEndian, "Float64", value)`.

### 24.2.4.15 DataView.prototype.setInt8 ( `byteOffset`, `value` )

When the `setInt8` method is called with arguments `byteOffset` and `value`, the following steps are taken:

1. Let `v` be the `this` value.
2. Return `? SetValueValue(v, byteOffset, true, "Int8", value)`.

### 24.2.4.16 DataView.prototype.setInt16 ( `byteOffset`, `value` [, `littleEndian` ] )

When the `setInt16` 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`.

When the `setInt16` 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`.

When the `setInt32` 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 `? GetValueValue(v, byteOffset, littleEndian, "Int32")`.

When the `setInt16` 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`.
When the `setInt16` 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 `SetViewValue(v, byteOffset, littleEndian, "Int16", value)`.

### 24.2.4.17 DataView.prototype.setInt32 ( `byteOffset`, `value` [, `littleEndian` ] )

When the `setInt32` 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 `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 `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 `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 `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 `[[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 the `%JSON%` intrinsic object and the initial value of the `JSON` property of the `global 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 the ECMA-404 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%`. 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. 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.
3. Let `scriptText` be the result of concatenating `("", JText, and ")`.
4. 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.
5. Let `unfiltered` be `completion. [[Value]]`.
6. Assert: `unfiltered` will be either a primitive value or an object that is defined by either an `ArrayLiteral` or an `ObjectLiteral`.
7. 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 `InternalizeJSONProperty(root, rootName)`.
8. Else,
   a. Return `unfiltered`.

The `length` property of the `parse` function is 2.

JSON allows Unicode code units 0x2028 (LINE SEPARATOR) and 0x2029 (PARAGRAPH SEPARATOR) 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 4:

```latex
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 UTF16Encoding 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 2 above verifies that `JText` conforms to that subset. When `scriptText` is
24.3.1 Runtime Semantics: `InternalizeJSONProperty(holder, name)`

The abstract operation `InternalizeJSONProperty` is a recursive abstract operation that takes two parameters: a `holder` object and the String `name` of a property in that object. `InternalizeJSONProperty` uses the value of `reviver` that was originally passed to the above parse function.

1. Let `val` be ? `Get(holder, name)`.
2. If `Type(val)` is Object, then
   a. Let `isArray` be ? `IsArray(val)`.
   b. If `isArray` is `true`, then
      i. Set `I` to `0`.
      ii. Let `len` be ? `ToLength(? `Get(val, "length")`).
      iii. Repeat while `I < len`,
          1. Let `newElement` be ? `InternalizeJSONProperty(val, ! `ToString(I))`.
          2. If `newElement` is `undefined`, then
          3. Else,
             a. Perform ? `CreateDataProperty(val, ! `ToString(I), newElement)`.
             b. NOTE This algorithm intentionally does not throw an exception if `CreateDataProperty` returns `false`.
      4. Add 1 to `I`.
   c. Else,
      i. Let `keys` be ? `EnumerableOwnNames(val)`.
      ii. For each String `P` in `keys` do,
          1. Let `newElement` be ? `InternalizeJSONProperty(val, P)`.
          2. If `newElement` is `undefined`, then
          3. Else,
             a. Perform ? `CreateDataProperty(val, P, newElement)`.
             b. NOTE This algorithm intentionally does not throw an exception if `CreateDataProperty` returns `false`.
3. Add 1 to `I`.

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 a new 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,
      i. Let `isArray` be `? isArray(replacer)`.
      ii. If `isArray` is `true`, then
          1. Let `PropertyList` be a new empty `List`.
          2. Let `len` be `? ToLength(? Get(replacer, "length")).`
          3. Let `k` be 0.
         4. Repeat while `k<len`,
            a. Let `v` be `? Get(replacer, ! ToString(k))`.
            b. Let `item` be `undefined`.
            c. If `Type(v)` is String, let `item` be `v`.
            d. Else if `Type(v)` is Number, let `item` be `! ToString(v)`.
            e. Else if `Type(v)` is Object, then
               i. If `v` has a [[StringData]] or [[NumberData]] internal slot, let `item` be `? ToString(v)`.
            f. If `item` is not `undefined` and `item` is not currently an element of `PropertyList`, then
               i. Append `item` to the end of `PropertyList`.
            g. Let `k` be `k+1`.
   5. If `Type(space)` is Object, then
      a. If `space` has a [[NumberData]] internal slot, then
         i. Let `space` be `? ToNumber(space)`.
      b. Else if `space` has a [[StringData]] internal slot, then
         i. Let `space` be `? ToString(space)`.
   6. If `Type(space)` is Number, then
      a. Let `space` be `min(10, ToInteger(space))`.
      b. Set `gap` to a String containing `space` occurrences of code unit 0x0020 (SPACE). This will be the empty String if `space` is less than 1.
   7. Else if `Type(space)` is String, then
      a. If the number of elements in `space` is 10 or less, set `gap` to `space`; otherwise set `gap` to a String consisting of the first 10 elements of `space`.
   8. Else,
      a. Set `gap` to the empty String.
   9. Let `wrapper` be `ObjectCreate(%ObjectPrototype%)`.
10. Let `status` be `CreateDataProperty(wrapper, the empty String, value)`.
11. Assert: `status` is `true`.
12. Return `? SerializeJSONProperty(the empty String, wrapper)`.

The `length` property of the `stringify` function is 3.

NOTE 1  JSON structures are allowed to be nested to any depth, but they must be acyclic. If `value` is or contains a cyclic structure, then the `stringify` function must throw a `TypeError` exception. This is an example of a value that cannot be `stringify`ed:

```
a = [];
a[0] = a;
my_text = JSON.stringify(a); // This must throw a TypeError.
```  

NOTE 2  Symbolic primitive values are rendered as follows:

- The `null` value is rendered in JSON text as the String `null`.
- The `undefined` value is not rendered.
- The `true` value is rendered in JSON text as the String `true`.
- The `false` value is rendered in JSON text as the String `false`.
NOTE 3  String values are wrapped in QUOTATION MARK (" character) code units. The code units " and \ are escaped with \prefixes. Control characters code units are replaced with escape sequences \uhhhh, or with the shorter forms, \b (BACKSPACE), \f (FORM FEED), \n (LINE FEED), \r (CARRIAGE RETURN), \t (CHARACTER TABULATION).

NOTE 4  Finite numbers are stringified as if by calling ToString(number). NaN and Infinity regardless of sign are represented as the String null.

NOTE 5  Values that do not have a JSON representation (such as undefined and functions) do not produce a String. Instead they produce the undefined value. In arrays these values are represented as the String null. In objects an unrepresentable value causes the property to be excluded from stringification.

NOTE 6  An object is rendered as U+007B (LEFT CURLY BRACKET) followed by zero or more properties, separated with a U+002C (COMMA), closed with a U+007D (RIGHT CURLY BRACKET). A property is a quoted String representing the key or property name, a U+003A (COLON), and then the stringified property value. An array is rendered as an opening U+005B (LEFT SQUARE BRACKET) followed by zero or more values, separated with a U+002C (COMMA), closed with a U+005D (RIGHT SQUARE BRACKET).

24.3.2.1 Runtime Semantics: SerializeJSONProperty (key, holder)

The abstract operation SerializeJSONProperty with arguments key, and 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. If Type(value) is Object, then
   a. Let toJSON be ? Get(value, "toJSON").
   b. If IsCallable(toJSON) is true, then
      i. Let value be ? Call(toJSON, value, « key »).
3. If ReplacerFunction is not undefined, then
   a. Let value be ? Call(ReplacerFunction, holder, « key, value »).
4. If Type(value) is Object, then
   a. If value has a [[NumberData]] internal slot, then
      i. Let value be ? ToNumber(value).
   b. Else if value has a [[StringData]] internal slot, then
      i. Let value be ? ToString(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 QuoteJSONString(value).
9. If Type(value) is Number, then
   a. If value is finite, return ! ToString(value).
   b. Else, return "null".
10. If Type(value) is Object and IsCallable(value) is false, then
    a. Let isArray be ? IsArray(value).
    b. If isArray is true, return ? SerializeJSONArray(value).
    c. Else, return ? SerializeJSONObject(value).
11. Return undefined.

24.3.2.2 Runtime Semantics: QuoteJSONString (value)

The abstract operation QuoteJSONString with argument value wraps a String value in QUOTATION MARK code units and escapes certain other code units within it.

1. Let product be code unit 0x0022 (QUOTATION MARK).
2. For each code unit \( C \) in \( value \)
   a. If \( C \) is 0x0022 (QUOTATION MARK) or 0x005C (REVERSE SOLIDUS), then
      i. Let \( product \) be the concatenation of \( product \) and code unit 0x005C (REVERSE SOLIDUS).
      ii. Let \( product \) be the concatenation of \( product \) and \( C \).
   b. Else if \( C \) is 0x0008 (BACKSPACE), 0x000C (FORM FEED), 0x000A (LINE FEED), 0x000D (CARRIAGE RETURN), or
      0x0009 (CHARACTER TABULATION), then
      i. Let \( product \) be the concatenation of \( product \) and code unit 0x005C (REVERSE SOLIDUS).
      ii. Let \( product \) be the concatenation of \( product \) and \( C \).
   c. Else if \( C \) has a code unit value less than 0x0020 (SPACE), then
      i. Let \( product \) be the concatenation of \( product \) and code unit 0x005C (REVERSE SOLIDUS).
      ii. Let \( product \) be the concatenation of \( product \) and \( C \).
      iii. Let \( product \) be the concatenation of \( product \) and \( C \).
      iv. Let \( product \) be the concatenation of \( product \) and \( C \).
   d. Else,
      i. Let \( product \) be the concatenation of \( product \) and \( C \).

3. Let \( product \) be the concatenation of \( product \) and code unit 0x0022 (QUOTATION MARK).
4. Return \( product \).

24.3.2.3 Runtime Semantics: SerializeJSONObject ( \( value \) )

The abstract operation SerializeJSONObject with argument \( value \) serializes an object. It has access to the \( stack \), \( indent \), \( gap \),
and \( PropertyList \) values of the current invocation of the \( stringify \) method.

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. If \( PropertyList \) is not \( undefined \), then
   a. Let \( K \) be \( PropertyList \).
6. Else,
   a. Let \( K \) be ? \( EnumerableOwnNames \) (\( value \)).
7. Let \( partial \) be a new empty List.
8. For each element \( P \) of \( K \),
   a. Let \( strP \) be ? SerializeJSONProperty (\( P \), \( value \)).
   b. If \( strP \) is not \( undefined \), then
      i. Let \( member \) be \( QuoteJSONString \) (\( P \)).
      ii. Let \( member \) be the concatenation of \( member \) and the string ":".
      iii. If \( gap \) is not the empty String, then
         1. Let \( member \) be the concatenation of \( member \) and code unit 0x0020 (SPACE).
         4. Let \( member \) be the concatenation of \( member \) and \( strP \).
      v. Append \( member \) to \( partial \).
9. If \( partial \) is empty, then
   a. Let \( final \) be "{}".
10. 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 0x002C (COMMA). A comma is not inserted either before the first String
The abstract operation SerializeJSONArray with argument value serializes an array. It has access to the stack, indent, and gap values of the current invocation of the stringify method.

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 a new empty List.
6. Let len be ToLength(? Get(value, "length")).
7. Let index be 0.
8. Repeat while index < len
   a. Let strP be ? SerializeJSONProperty(! ToString(index), value).
      b. If strP is undefined, then
         i. Append "null" to partial.
      c. Else,
         i. Append strP to partial.
      d. Increment index by 1.
9. If partial is empty, then
   a. Let final be "[]".
10. 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 0x002C (COMMA). A comma is not inserted either before the first String or after the last String.
      ii. Let final be the result of concatenating "[", code unit 0x000A (LINE FEED), indent, properties, code unit 0x000A (LINE FEED), stepback, and "]".
    b. Else,
       i. Let separator be the result of concatenating code unit 0x002C (COMMA), code unit 0x000A (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 0x000A (LINE FEED), indent, properties, code unit 0x000A (LINE FEED), stepback, and "]".
11. Remove the last element of stack.
12. Let indent be stepback.

24.3.2.4 Runtime Semantics: SerializeJSONArray ( value )

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
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 property described in Table 53:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>@@iterator</td>
<td>A function that returns an Iterator object.</td>
<td>The returned object must conform to the Iterator interface.</td>
</tr>
</tbody>
</table>

25.1.1.2 The Iterator Interface

An object that implements the Iterator interface must include the property in Table 54. Such objects may also implement the properties in Table 55.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>next</td>
<td>A function that returns an IteratorResult object.</td>
<td>The returned object must conform to the IteratorResult interface. If a previous call to the next method of an Iterator has returned an IteratorResult object whose done property is true, then all subsequent calls to the next method of that object should also return an IteratorResult object whose done property is true. However, this requirement is not enforced.</td>
</tr>
</tbody>
</table>

NOTE 1 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 Iterator objects that expect to be used in such a manner must be prepared to deal with being called with no arguments.
### Table 55: Iterator Interface Optional Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>return</strong></td>
<td>A function that returns an <code>IteratorResult</code> object.</td>
<td>The returned object must conform to the <code>IteratorResult</code> interface. Invoking this method notifies the <code>Iterator</code> object that the caller does not intend to make any more <code>next</code> method calls to the <code>Iterator</code>. The returned <code>IteratorResult</code> object will typically have a <code>done</code> property whose value is <strong>true</strong>, and a <code>value</code> property with the value passed as the argument of the <code>return</code> method. However, this requirement is not enforced.</td>
</tr>
<tr>
<td><strong>throw</strong></td>
<td>A function that returns an <code>IteratorResult</code> object.</td>
<td>The returned object must conform to the <code>IteratorResult</code> interface. Invoking this method notifies the <code>Iterator</code> object that the caller has detected an error condition. The argument may be used to identify the error condition and typically will be an exception object. A typical response is to <code>throw</code> the value passed as the argument. If the method does not <code>throw</code>, the returned <code>IteratorResult</code> object will typically have a <code>done</code> property whose value is <strong>true</strong>.</td>
</tr>
</tbody>
</table>

**NOTE 2** Typically callers of these methods should check for their existence before invoking them. Certain ECMAScript language features including `for-of`, `yield*`, and array destructuring call these methods after performing an existence check. Most ECMAScript library functions that accept `Iterable` objects as arguments also conditionally call them.

#### 25.1.1.3 The `IteratorResult` Interface

The `IteratorResult` interface includes the properties listed in **Table 56**:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>done</strong></td>
<td>Either <strong>true</strong> or <strong>false</strong>.</td>
<td>This is the result status of an <code>iterator next</code> method call. If the end of the iterator was reached <code>done</code> is <strong>true</strong>. If the end was not reached <code>done</code> is <strong>false</strong> and a value is available. If a <code>done</code> property (either own or inherited) does not exist, it is considered to have the value <strong>false</strong>.</td>
</tr>
<tr>
<td><strong>value</strong></td>
<td>Any ECMAScript language value.</td>
<td>If done is <strong>false</strong>, this is the current iteration element value. If done is <strong>true</strong>, this is the return value of the iterator, if it supplied one. If the iterator does not have a return value, <code>value</code> is <strong>undefined</strong>. In that case, the <code>value</code> property may be absent from the conforming object if it does not inherit an explicit <code>value</code> property.</td>
</tr>
</tbody>
</table>

#### 25.1.2 The `%IteratorPrototype% Object

The value of the `[[Prototype]]` internal slot of the `%IteratorPrototype% object is the intrinsic object `%ObjectPrototype%`. 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:

```javascript
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 functions that are usually created by evaluating `GeneratorDeclaration`, `GeneratorExpression`, and `GeneratorMethod` syntactic productions. They may also be created by calling the `%GeneratorFunction%` intrinsic.

### Figure 2 (Informative): Generator Objects Relationships

GeneratorFunction Objects

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.

25.2.1.1 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]]`.

**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 27 or Table 57. In addition to being the value of the prototype property of the `%GeneratorFunction%` intrinsic, it is the `%Generator% intrinsic (see Figure 2).

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 ECMAScript function object and has the internal slots listed in Table 27. 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 name

The specification for the name property of Function instances given in 19.2.4.2 also applies to GeneratorFunction instances.

25.2.4.3 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 when the generator function object is invoked using [[Call]].

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

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%.

The initial value of the [[Extensible]] internal slot of the Generator 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 \texttt{this} value.
2. Return \? \( \text{GeneratorResume}(g, value) \).

### 25.3.1.3 \texttt{Generator.prototype.return ( value )}

The \texttt{return} method performs the following steps:

1. Let \( g \) be the \texttt{this} value.
2. Let \( C \) be \texttt{Completion}([[Type]]: return, [[Value]]: value, [[Target]]: empty).
3. Return \? \( \text{GeneratorResumeAbrupt}(g, C) \).

### 25.3.1.4 \texttt{Generator.prototype.throw ( exception )}

The \texttt{throw} method performs the following steps:

1. Let \( g \) be the \texttt{this} value.
2. Let \( C \) be \texttt{Completion}([[Type]]: throw, [[Value]]: exception, [[Target]]: empty).
3. Return \? \( \text{GeneratorResumeAbrupt}(g, C) \).

### 25.3.1.5 \texttt{Generator.prototype [ @@toStringTag ]}

The initial value of the \texttt{@@toStringTag} property is the String value "Generator".

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

### 25.3.2 Properties of Generator Instances

Generator instances are initially created with the internal slots described in Table 57.

<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: \texttt{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 (\texttt{generator}, \texttt{generatorBody})

The abstract operation \texttt{GeneratorStart} with arguments \texttt{generator} and \texttt{generatorBody} performs the following steps:

1. Assert: The value of \texttt{generator}'s [[GeneratorState]] internal slot is \texttt{undefined}.
2. Let \texttt{genContext} be the running execution context.
3. Set the Generator component of \texttt{genContext} to \texttt{generator}.
4. Set the code evaluation state of \texttt{genContext} such that when evaluation is resumed for that execution context the following steps will be performed:
   a. Let \texttt{result} be the result of evaluating \texttt{generatorBody}.
   b. Assert: If we return here, the generator either threw an exception or performed either an implicit or explicit return.
   c. Remove \texttt{genContext} from the execution context stack and restore the execution context that is at the top of the execution context stack as the running execution context.
   d. Set \texttt{generator}'s [[GeneratorState]] internal slot to "completed".
   e. Once a generator enters the "completed" state it never leaves it and its associated execution context is never resumed. Any execution state associated with \texttt{generator} can be discarded at this point.
   f. If \texttt{result} is a normal completion, let \texttt{resultValue} be \texttt{undefined}. 
g. Else,
   i. If result.[[Type]] is return, let resultValue be result.[[Value]].
   ii. Else, return Completion(result).

h. 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(undefined).

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. If state is "completed", return CreateIterResultObject(undefined, true).
3. Assert: state is either "suspendedStart" or "suspendedYield".
4. Let genContext be the value of generator's [[GeneratorContext]] internal slot.
5. Let methodContext be the running execution context.
7. Set generator's [[GeneratorState]] internal slot to "executing".
8. Push genContext onto the execution context stack; genContext is now the running execution context.
9. 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.
10. Assert: When we return here, genContext has already been removed from the execution context stack and methodContext is the currently running execution context.
11. Return Completion(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. 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".
3. If state is "completed", then
   a. If abruptCompletion.[[Type]] is return, then
      i. Return CreateIterResultObject(abruptCompletion.[[Value]], true).
   b. Return Completion(abruptCompletion).
4. Assert: state is "suspendedYield".
5. Let genContext be the value of generator's [[GeneratorContext]] internal slot.
6. Let methodContext be the running execution context.
7. Set 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 abruptCompletion as the result of the operation that suspended it. Let result be the completion record 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 Completion(result).

25.3.3.5 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:
   a. Return resumptionValue.
   b. 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 58.
### 25.4.1.1 IfAbruptRejectPromise (value, capability)

IfAbruptRejectPromise is a short hand 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, then
   a. Perform ? Call(capability.[[Reject]], undefined, « value.[[Value]] »).
   b. 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 PerformPromiseThen abstract operation, and are used by a PromiseReactionJob.

PromiseReaction records have the fields listed in Table 59.

<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 (25.4.1.3.2).
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 (25.4.1.3.1).
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 }. 

---

Table 58: PromiseCapability Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Promise]]</td>
<td>An object</td>
<td>An object that is usable as a promise.</td>
</tr>
<tr>
<td>[[Resolve]]</td>
<td>A function object</td>
<td>The function that is used to resolve the given promise object.</td>
</tr>
<tr>
<td>[[Reject]]</td>
<td>A function object</td>
<td>The function that is used to reject the given promise object.</td>
</tr>
</tbody>
</table>
25.4.1.3.1 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.\[[\text{Value}]\] \) is true, return undefined.
5. Set \( alreadyResolved.\[[\text{Value}]\] \) to true.
6. Return \( \text{RejectPromise}(promise, reason) \).

The \textbf{length} property of a promise reject function is 1.

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.\[[\text{Value}]\] \) is true, return undefined.
5. Set \( alreadyResolved.\[[\text{Value}]\] \) to true.
6. If \( \text{SameValue}(resolution, promise) \) is true, then
   a. Let \( selfResolutionError \) be a newly created \texttt{TypeError} object.
   b. Return \( \text{RejectPromise}(promise, selfResolutionError) \).
7. If \( \text{Type}(resolution) \) is not Object, then
   a. Return \( \text{FulfillPromise}(promise, resolution) \).
8. Let \( then \) be \( \text{Get}(resolution, "\text{then}"") \).
9. If \( then \) is an abrupt completion, then
   a. Return \( \text{RejectPromise}(promise, then.\[[\text{Value}]\]) \).
10. Let \( thenAction \) be \( then.\[[\text{Value}]\] \).
11. If \( \text{IsCallable}(thenAction) \) is false, then
   a. Return \( \text{FulfillPromise}(promise, resolution) \).
12. Perform \( \text{EnqueueJob("PromiseJobs", PromiseResolveThenableJob, \"promise, resolution, thenAction \")} \).
13. Return undefined.

The \textbf{length} property of a promise resolve function is 1.

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 \( \text{TriggerPromiseReactions}(reactions, value) \).

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 \texttt{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 (25.4.1.5.1).
5. Set the [[Capability]] internal slot of executor to promiseCapability.
6. Let promise be ? Construct\(C\), « executor »).
7. If IsCallable(promiseCapability. [[Resolve]]) is false, throw a TypeError exception.
8. If IsCallable(promiseCapability. [[Reject]]) is false, throw a TypeError exception.
9. Set promiseCapability. [[Promise]] to promise.
10. Return promiseCapability.

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 resolve and reject, the following steps are taken:

1. Assert: \(F\) has a [[Capability]] internal slot whose value is a PromiseCapability Record.
2. Let promiseCapability be the value of \(F\)’s [[Capability]] internal slot.
3. If promiseCapability. [[Resolve]] is not undefined, throw a TypeError exception.
4. If promiseCapability. [[Reject]] is not undefined, throw a TypeError exception.
5. Set promiseCapability. [[Resolve]] to resolve.
6. Set promiseCapability. [[Reject]] to reject.
7. Return undefined.

The length property of a GetCapabilitiesExecutor function is 2.

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 false.
2. If \(x\) does not have a [[PromiseState]] internal slot, return false.
3. Return true.

25.4.1.7 RejectPromise \(promise, reason\)

When the RejectPromise abstract operation is called with arguments promise and reason, 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 [[PromiseRejectReactions]] internal slot.
3. Set the value of promise’s [[PromiseResult]] internal slot to reason.
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 "rejected".
7. If the value of promise’s [[PromisesHandled]] internal slot is false, perform HostPromiseRejectionTracker(promise, "reject").
8. Return TriggerPromiseReactions(reactions, reason).
The abstract operation TriggerPromiseReactions takes a collection of PromiseReactionRecords and enqueues a new Job for each record. Each such Job processes the [[Handler]] of the PromiseReactionRecord, and if the [[Handler]] is a function calls it passing the given argument.

1. Repeat for each reaction in reactions, in original insertion order
   a. Perform EnqueueJob("PromiseJobs", PromiseReactionJob, « reaction, argument »).
2. Return undefined.

HostPromiseRejectionTracker is an implementation-defined abstract operation that allows host environments to track promise rejections.

An implementation of HostPromiseRejectionTracker must complete normally in all cases. The default implementation of HostPromiseRejectionTracker is to do nothing.

NOTE 1 HostPromiseRejectionTracker is called in two scenarios:

- When a promise is rejected without any handlers, it is called with its operation argument set to "reject".
- When a handler is added to a rejected promise for the first time, it is called with its operation argument set to "handle".

A typical implementation of HostPromiseRejectionTracker might try to notify developers of unhandled rejections, while also being careful to notify them if such previous notifications are later invalidated by new handlers being attached.

NOTE 2 If operation is "handle", an implementation should not hold a reference to promise in a way that would interfere with garbage collection. An implementation may hold a reference to promise if operation is "reject", since it is expected that rejections will be rare and not on hot code paths.

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.\\([\text{Capabilities}]\\).
3. Let handler be reaction.\\([\text{Handler}]\\).
4. If handler is "Identity", let handlerResult be NormalCompletion\(\text{argument}\).
5. Else if handler is "Thrower", let \text{handlerResult} be Completion\\(([[\text{Type}}])\text{throw}[[\text{Value}}]:\text{argument}, [[\text{Target}}]):\text{empty}\\).
6. Else, let \text{handlerResult} be Call\(\text{handler}, \text{undefined}, \text{argument}\).
7. If \text{handlerResult} is an abrupt completion, then
   a. Let status be Call\(\text{promiseCapability}.\\([\text{Reject}]\), \text{undefined}, \text{handlerResult}.\\([\text{Value}]\) »).
   b. NextJob Completion\(\text{status}\).
8. Let status be Call\(\text{promiseCapability}.\\([\text{Resolve}]\), \text{undefined}, \text{handlerResult}.\\([\text{Value}]\) »).
9. NextJob Completion\(\text{status}\).

The job PromiseResolveThenableJob with parameters promiseToResolve, thenable, and then performs the following steps:

1. Let resolvingFunctions be CreateResolvingFunctions\(\text{promiseToResolve}\).
2. Let \text{thenCallResult} be Call\(\text{then}, \text{thenable}, \text{resolvingFunctions}.\\([\text{Resolve}]\), \text{resolvingFunctions}.\\([\text{Reject}]\) »).
3. If `thenCallResult` is an abrupt completion, then
   a. Let `status` be `Call(resolvingFunctions.«[Reject]», undefined, « thenCallResult.«[Value]» »).
   b. NextJob Completion(`status`).
4. NextJob Completion(`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]],
   [[PromiseResult]], [[PromiseFulrocessingFunctions]], [[PromiseRejectReactiCompressions]], [[PromiseIsHandled]] »).
4. Set `promise`'s `[[PromiseState]]` internal slot to "pending".
5. Set `promise`'s `[[PromiseFulrocessingFunctions]]` internal slot to a new empty List.
6. Set `promise`'s `[[PromiseRejectReactiCompressions]]` internal slot to a new empty List.
7. Set `promise`'s `[[PromiseIsHandled]]` internal slot to `false`.
8. Let `resolvingFunctions` be `CreateResolvingFunctions(promise)`.
9. Let `completion` be `Call(executor, undefined, « resolvingFunctions.«[Resolve]», resolvingFunctions.«[Reject]» »).`
10. If `completion` is an abrupt completion, then
    a. Perform ? `Call(resolvingFunctions.«[Reject]», undefined, « completion.«[Value]» »).
11. 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
25.4.4 Properties of the Promise Constructor

The value of the `[[Prototype]]` internal slot of the Promise constructor is the intrinsic object %FunctionPrototype%.

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.

1. Let \( C \) be the this value.
2. If `Type(C)` is not Object, throw a TypeError exception.
4. Let `iterator` be GetIterator(iterable).
5. IfAbruptRejectPromise(iterator, promiseCapability).
6. Let `iteratorRecord` be Record { [[Iterator]]: iterator, [[Done]]: false }.
7. Let `result` be PerformPromiseAll(iteratorRecord, \( C \), promiseCapability).
8. If `result` is an abrupt completion, then
   a. If `iteratorRecord.([[Done]])` is false, let `result` be IteratorClose(iterator, result).
   b. IfAbruptRejectPromise(result, promiseCapability).
9. Return `Completion(result)`.

NOTE The all function requires its this value to be a constructor function that supports the parameter conventions of the Promise constructor.

25.4.4.1.1 Runtime Semantics: PerformPromiseAll( iteratorRecord, constructor, resultCapability )

When the PerformPromiseAll abstract operation is called with arguments `iteratorRecord`, `constructor`, and `resultCapability`, the following steps are taken:

1. Assert: `constructor` is a constructor function.
2. Assert: `resultCapability` is a PromiseCapability record.
3. Let `values` be a new empty List.
4. Let `remainingElementsCount` be a new Record { [[Value]]: 1 }.
5. Let `index` be 0.
6. Repeat
   a. Let `next` be IteratorStep(iteratorRecord.([[Iterator]])).
   b. If `next` is an abrupt completion, set `iteratorRecord.([[Done]])` to true.
   c. ReturnIfAbrupt(next).
   d. If `next` is false, then
      i. Set `iteratorRecord.([[Done]])` to true.
      ii. Set `remainingElementsCount.([[Value]])` to `remainingElementsCount.([[Value]])` - 1.
      iii. If `remainingElementsCount.([[Value]])` is 0, then
         1. Let `valuesArray` be CreateArrayFromList(values).
         2. Perform ? Call(resultCapability.([[Resolve]]), undefined, « valuesArray »).
      iv. Return `resultCapability.([[Promise]])`.
   e. Let `nextValue` be IteratorValue(next).
   f. If `nextValue` is an abrupt completion, set `iteratorRecord.([[Done]])` to true.
   g. ReturnIfAbrupt(nextValue).
   h. Append undefined to `values`.
   i. Let `nextPromise` be ? Invoke(constructor, "resolve", « nextValue »).
   j. Let `resolveElement` be a new built-in function object as defined in Promise.all Resolve Element Functions.
   k. Set the `[[AlreadyCalled]]` internal slot of `resolveElement` to a new Record { [[Value]]: false }.
l. Set the [[Index]] internal slot of resolveElement to index.
m. Set the [[Values]] internal slot of resolveElement to values.
n. Set the [[Capabilities]] internal slot of resolveElement to resultCapability.
o. Set the [[RemainingElements]] internal slot of resolveElement to remainingElementsCount.
p. Set remainingElementsCount.[[Value]] to remainingElementsCount.[[Value]] + 1.
q. Perform ? Invoke(nextPromise, "then", « resolveElement, resultCapability.[[Reject]] »).
r. Set index to index + 1.

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, then
    a. Let valuesArray be CreateArrayFromList(values).
    b. Return ? Call(promiseCapability.[[Resolve]], undefined, « valuesArray »).
11. Return undefined.

The length property of a Promise.all resolve element function is 1.

25.4.4.2 Promise.prototype

The initial value of Promise.prototype is the intrinsic object %PromisePrototype%. 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.
4. Let iterator be GetIterator(iterable).
5. IfAbruptRejectPromise(iterator, promiseCapability).
6. Let iteratorRecord be Record {[[Iterator]]: iterator, [[Done]]: false}.
7. Let result be PerformPromiseRace(iteratorRecord, promiseCapability, C).
8. If result is an abrupt completion, then
    a. If iteratorRecord.[[Done]] is false, let result be IteratorClose(iterator, result).
    b. IfAbruptRejectPromise(result, promiseCapability).
9. Return Completion(result).

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.
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 Runtime Semantics: PerformPromiseRace (iteratorRecord, promiseCapability, C)

When the `PerformPromiseRace` abstract operation is called with arguments `iteratorRecord`, `promiseCapability`, and `C`, the following steps are taken:

1. Repeat
   a. Let `next` be `IteratorStep(iteratorRecord.[[Iterator]])`.
   b. If `next` is an abrupt completion, set `iteratorRecord.[[Done]]` to `true`.
   c. ReturnIfAbrupt(`next`).
   d. If `next` is `false`, then
      i. Set `iteratorRecord.[[Done]]` to `true`.
      ii. Return `promiseCapability.[[Promise]]`.
   e. Let `nextValue` be `IteratorValue(next)`.
   f. If `nextValue` is an abrupt completion, set `iteratorRecord.[[Done]]` to `true`.
   g. ReturnIfAbrupt(`nextValue`).
   h. Let `nextPromise` be ? `Invoke(C, "resolve", «nextValue»)`.
   i. Perform ? `Invoke(nextPromise, "then", «promiseCapability.[[Resolve]], promiseCapability.[[Reject]]»)`.

### 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 `promiseCapability` be ? `NewPromiseCapability(C)`.
5. Return `promiseCapability.[[Promise]]`.

The `reject` function expects 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 `Type(C)` is not Object, throw a `TypeError` exception.
3. If `IsPromise(x)` is `true`, then
   a. Let `xConstructor` be ? `Get(x, "constructor")`.
   b. If `SameValue(xConstructor, C)` is `true`, return `x`.
4. Let `promiseCapability` be ? `NewPromiseCapability(C)`.
6. Return `promiseCapability.[[Promise]]`.

The `resolve` function expects its `this` value to be a constructor function that supports the parameter conventions of the `Promise` constructor.

### 25.4.4.6 get Promise [ @@species ]

`Promise[@@species]` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Return the `this` value.
The value of the name property of this function is "get [Symbol.species]."

NOTE Promise 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.

25.4.5 Properties of the Promise Prototype Object

The Promise prototype object is the intrinsic object %PromisePrototype%. The value of the [[Prototype]] internal slot of the Promise prototype object is the intrinsic object %ObjectPrototype%. 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 Promise.prototype.catch ( onRejected )

When the catch method is called with argument onRejected, the following steps are taken:

1. Let promise be the this value.
2. Return ? Invoke(promise, "then", « undefined, onRejected »).

25.4.5.2 Promise.prototype.constructor

The initial value of Promise.prototype.constructor is the intrinsic object %Promise%.

25.4.5.3 Promise.prototype.then ( onFulfilled, onRejected )

When the then method is called with arguments onFulfilled and onRejected, the following steps are taken:

1. Let promise be the this value.
2. If IsPromise(promise) is false, throw a TypeError exception.
3. Let C be ? SpeciesConstructor(promise, %Promise%).
4. Let resultCapability be ? NewPromiseCapability(C).
5. Return PerformPromiseThen(promise, onFulfilled, onRejected, resultCapability).

25.4.5.3.1 PerformPromiseThen ( promise, onFulfilled, onRejected, resultCapability )

The abstract operation PerformPromiseThen performs the “then” operation on promise using onFulfilled and onRejected as its settlement actions. The result is 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", then
   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", then
   a. Let value be the value of promise’s [[PromiseResult]] internal slot.
   b. Perform EnqueueJob("PromiseJobs", PromiseReactionJob, « fulfillReaction, value »).
9. Else,
   a. Assert: The value of promise’s [[PromiseState]] internal slot is "rejected".
   b. Let reason be the value of promise’s [[PromiseResult]] internal slot.
   c. If the value of promise’s [[PromisesHandled]] internal slot is false, perform HostPromiseRejectionTracker(promise, "handle").
Perform `EnqueueJob("PromiseJobs", PromiseReactionJob, « rejectReaction, reason »).

10. Set `promise's` [[PromisesHandled]] internal slot to `true`.
11. 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 60.

<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: &quot;pending&quot;, &quot;fulfilled&quot;, and &quot;rejected&quot;.</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>
<tr>
<td>[[PromisesHandled]]</td>
<td>A boolean indicating whether the promise has ever had a fulfillment or rejection handler; used in unhandled rejection tracking.</td>
</tr>
</tbody>
</table>

26 Reflection

26.1 The Reflect Object

The Reflect object is the `%Reflect% intrinsic object and the initial value of the Reflect property of the global object. The Reflect object is an ordinary object.

The value of the [[Prototype]] internal slot of the Reflect object is the intrinsic object `%ObjectPrototype%`.

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. Perform PrepareForTailCall().
4. 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`.
3. Else, if `IsConstructor(newTarget)` is `false`, throw a `TypeError` exception.
4. Let `args` be `CreateListFromArrayLike(argumentsList)`.
5. 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. Let `desc` be `ToPropertyDescriptor(attributes)`.
4. Return `target[[DefineOwnProperty]](key, 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. Return `target[[Delete]](key)`.

**26.1.5 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. If `receiver` is not present, then
   a. Let `receiver` be `target`.
4. Return `target[[Get]](key, receiver)`.

**26.1.6 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. Let `desc` be `target.[[GetOwnProperty]](key)`.
4. Return `FromPropertyDescriptor(desc)`.

**26.1.7 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 `target.[[GetPrototypeOf]]()`.

**26.1.8 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)`.

### 26.1.9 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 ? target. [[IsExtensible]]().

### 26.1.10 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 ? target. [[OwnPropertyKeys]]().
3. Return CreateArrayFromList(keys).

### 26.1.11 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 ? target. [[PreventExtensions]]().

### 26.1.12 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. If receiver is not present, then
   a. Let receiver be target.

### 26.1.13 Reflect.setPrototypeOf (target, proto)

When the setPrototypeOf function is called with arguments target and proto, 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.

### 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 proxy exotic object. Proxy is not intended to be called as a function and will throw an exception when called in that manner.

#### 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.

#### 26.2.2 Properties of the Proxy Constructor
The value of the \[\text{Prototype}\] internal slot of the \text{Proxy} constructor is the intrinsic object \%FunctionPrototype\%.

The \text{Proxy} constructor does not have a \text{prototype} property because proxy exotic objects do not have a \[\text{Prototype}\] internal slot that requires initialization.

The \text{Proxy} constructor has the following properties:

26.2.2.1 \texttt{Proxy.revocable (target, handler)}

The \texttt{Proxy.revocable} function is used to create a revocable Proxy object. When \texttt{Proxy.revocable} is called with arguments \texttt{target} and \texttt{handler}, the following steps are taken:

1. Let \(p\) be \? \texttt{ProxyCreate(target, handler)}.
2. Let \(revoker\) be a new built-in function object as defined in 26.2.2.1.1.
3. Set the \[\text{RevocableProxy}\] internal slot of \(revoker\) to \(p\).
4. Let \(result\) be \texttt{ObjectCreate(\%ObjectPrototype\%).}
5. Perform \texttt{CreateDataProperty(result, "proxy", p)}.
6. Perform \texttt{CreateDataProperty(result, "revoke", revoker)}.
7. Return \(result\).

26.2.2.1.1 \textbf{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 \[\text{RevocableProxy}\] internal slot.

When a Proxy revocation function, \(F\), is called, the following steps are taken:

1. Let \(p\) be the value of \(F\)'s \[\text{RevocableProxy}\] internal slot.
2. If \(p\) is \texttt{null}, return \texttt{undefined}.
3. Set the value of \(F\)'s \[\text{RevocableProxy}\] internal slot to \texttt{null}.
4. Assert: \(p\) is a Proxy object.
5. Set the \[\text{ProxyTarget}\] internal slot of \(p\) to \texttt{null}.
6. Set the \[\text{ProxyHandler}\] internal slot of \(p\) to \texttt{null}.
7. Return \texttt{undefined}.

The \texttt{length} property of a Proxy revocation function is 0.

26.3 \textbf{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 \texttt{ImportDeclaration} that includes a \texttt{NameSpaceImport}.

In addition to the properties specified in 9.4.6 each Module Namespace Object has the following own properties:

26.3.1 \texttt{@@toStringTag}

The initial value of the \texttt{@@toStringTag} property is the String value \"Module\".

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

26.3.2 \texttt{[ @@iterator ] ()}

When the \texttt{@@iterator} method is called with no arguments, the following steps are taken:

1. Let \(N\) be the this value.
2. If \(N\) is not a module namespace exotic object, throw a \texttt{TypeError} exception.
3. Let \texttt{exports} be the value of \(N\)'s \[\text{Exports}\] internal slot.
4. Return `CreateListIterator(exports)`.

The value of the `name` property of this function is `"[Symbol.iterator]"`. 
Annex A
Grammar Summary
(informative)

A.1 Lexical Grammar

SourceCharacter ::
    any Unicode code point

InputElementDiv ::
    WhiteSpace
    LineTerminator
    Comment
    CommonToken
    DivPunctuator
    RightBracePunctuator

InputElementRegExp ::
    WhiteSpace
    LineTerminator
    Comment
    CommonToken
    RightBracePunctuator
    RegularExpressionLiteral

InputElementRegExpOrTemplateTail ::
    WhiteSpace
    LineTerminator
    Comment
    CommonToken
    RegularExpressionLiteral
    TemplateSubstitutionTail

InputElementTemplateTail ::
    WhiteSpace
    LineTerminator
    Comment
    CommonToken
    DivPunctuator
    TemplateSubstitutionTail

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

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

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

CommonToken ::
  IdentifierName
  Punctuator
  NumericLiteral
  StringLiteral
  Template

IdentifierName ::
  IdentifierStart
  IdentifierName IdentifierPart

IdentifierStart ::
  UnicodeIDStart
  $  
  \ UnicodeEscapeSequence
IdentifierPart ::
    UnicodeIDContinue
    $
    _
    \
    UnicodeEscapeSequence
    <ZWNJ>
    <ZWJ>

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

UnicodeIDContinue ::
    any Unicode code point with the Unicode property “ID_Continue”

ReservedWord ::
    Keyword
    FutureReservedWord
    NullLiteral
    BooleanLiteral

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

FutureReservedWord ::
    enum
    await

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:

    implements package protected
    interface private public

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

DivPunctuator ::
    /
    /=

RightBracePunctuator ::
    }

NullLiteral ::
    null

BooleanLiteral ::
    true
    false

NumericLiteral ::
    DecimalLiteral
BinaryIntegerLiteral  
OctalIntegerLiteral  
HexIntegerLiteral

DecimalLiteral ::  
   DecimalIntegerLiteral . DecimalDigits\text{opt} ExponentPart\text{opt} . DecimalDigits ExponentPart\text{opt}  
   DecimalIntegerLiteral ExponentPart\text{opt}

DecimalIntegerLiteral ::  
   0  
   NonZeroDigit DecimalDigits\text{opt}

DecimalDigits ::  
   DecimalDigit  
   DecimalDigits DecimalDigit

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

NonZeroDigit :: \text{one of}  
   1 2 3 4 5 6 7 8 9

ExponentPart ::  
   ExponentIndicator SignedInteger

ExponentIndicator :: \text{one of}  
   e E

SignedInteger ::  
   DecimalDigits  
   + DecimalDigits  
   - DecimalDigits

BinaryIntegerLiteral ::  
   0b BinaryDigits  
   0B BinaryDigits

BinaryDigits ::  
   BinaryDigit  
   BinaryDigits BinaryDigit

BinaryDigit :: \text{one of}  
   0 1

OctalIntegerLiteral ::  
   0o OctalDigits  
   0O OctalDigits

OctalDigits ::  
   OctalDigit  
   OctalDigits OctalDigit

OctalDigit :: \text{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

StringLiteral ::
    " DoubleStringCharacters opt "
    ' SingleStringCharacters opt '

DoubleStringCharacters ::
    DoubleStringCharacter DoubleStringCharacters opt

SingleStringCharacters ::
    SingleStringCharacter SingleStringCharacters opt

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

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

LineContinuation ::
    \ LineTerminatorSequence

EscapeSequence ::
    CharacterEscapeSequence
    \ [lookahead ∉ DecimalDigit]
    HexEscapeSequence
    UnicodeEscapeSequence

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 ::
    \ HexDigit HexDigit

UnicodeEscapeSequence ::
u Hex4Digits
u{ HexDigits }

Hex4Digits ::
  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 ::
  ` TemplateCharacters\opt ` 

TemplateHead ::
  ` TemplateCharacters\opt $\`

TemplateSubstitutionTail ::
  TemplateMiddle
A.2 Expressions

IdentifierReference[Yield] :
  Identifier
  [-Yield] yield

BindingIdentifier[Yield] :
  Identifier
  [-Yield] yield

Identifier :
  IdentifierName but not ReservedWord

LabelIdentifier[Yield] :
  Identifier
  [-Yield] yield

PrimaryExpression[Yield] :
  this
  IdentifierReference[?Yield]
  Literal
  ArrayLiteral[?Yield]
  ObjectLiteral[?Yield]
  FunctionExpression
  ClassExpression[?Yield]
  GeneratorExpression
  RegularExpressionLiteral
  TemplateLiteral[?Yield]
  CoverParenthesizedExpressionAndArrowParameterList[?Yield]

CoverParenthesizedExpressionAndArrowParameterList[Yield] :
  ( Expression[In, ?Yield] )
  ( )
  ( ... BindingIdentifier[?Yield] )
  ( ... BindingPattern[?Yield] )
  ( Expression[In, ?Yield] , ... BindingIdentifier[?Yield] )
When processing the production PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList the interpretation of CoverParenthesizedExpressionAndArrowParameterList is refined using the following grammar:

**ParenthesizedExpression[Yield]** :

( Expression[In, ?Yield] )

**Literal** :

NullLiteral
BooleanLiteral
NumericLiteral
StringLiteral

**ArrayLiteral[Yield]** :

[ Elisionopt ]
[ ElementList[?Yield] ]
[ ElementList[?Yield], Elisionopt ]

**ElementList[?Yield]** :

Elisionopt AssignmentExpression[In, ?Yield]
Elisionopt SpreadElement[?Yield]
ElementList[?Yield], Elisionopt AssignmentExpression[In, ?Yield]
ElementList[?Yield], Elisionopt SpreadElement[?Yield]

**Elision** :

,
Elision,

**SpreadElement[?Yield]** :

... AssignmentExpression[In, ?Yield]

**ObjectLiteral[Yield]** :

{ }
{ PropertyDefinitionList[?Yield] }
{ PropertyDefinitionList[?Yield], }

**PropertyDefinitionList[?Yield]** :

PropertyDefinition[?Yield]
PropertyDefinitionList[?Yield], PropertyDefinition[?Yield]

**PropertyDefinition[?Yield]** :

IdentifierReference[?Yield]
CoverInitializedName[?Yield]
PropertyName[?Yield] : AssignmentExpression[In, ?Yield]
MethodDefinition[?Yield]

**PropertyName[?Yield]** :

LiteralPropertyName
ComputedPropertyName[?Yield]

**LiteralPropertyName** :

IdentifierName
ComputedPropertyName[Yield] :
    [ AssignmentExpression[In, ?Yield] ]

CoverInitializedName[Yield] :
    IdentifierReference[?Yield] Initializer[In, ?Yield]

Initializer[In, Yield] :
    = AssignmentExpression[?In, ?Yield]

TemplateLiteral[Yield] :
    NoSubstitutionTemplate
    TemplateHead Expression[In, ?Yield] TemplateSpans[?Yield]

TemplateSpans[?Yield] :
    TemplateTail
    TemplateMiddleList[?Yield] TemplateTail

TemplateMiddleList[?Yield] :
    TemplateMiddle Expression[In, ?Yield]
    TemplateMiddleList[?Yield] TemplateMiddle Expression[In, ?Yield]

MemberExpression[?Yield] :
    PrimaryExpression[?Yield]
    MemberExpression[?Yield] [ Expression[In, ?Yield] ]
    MemberExpression[?Yield] . IdentifierName
    MemberExpression[?Yield] TemplateLiteral[?Yield]
    SuperProperty[?Yield]
    MetaProperty
        new MemberExpression[?Yield] Arguments[?Yield]

SuperProperty[?Yield] :
    super [ Expression[In, ?Yield] ]
    super . IdentifierName

MetaProperty :
    NewTarget

NewTarget :
    new . target

NewExpression[?Yield] :
    MemberExpression[?Yield]
    new NewExpression[?Yield]

CallExpression[?Yield] :
    MemberExpression[?Yield] Arguments[?Yield]
    SuperCall[?Yield]
    CallExpression[?Yield] Arguments[?Yield]
    CallExpression[?Yield] [ Expression[In, ?Yield] ]
    CallExpression[?Yield] . IdentifierName
    CallExpression[?Yield] TemplateLiteral[?Yield]
SuperCall[Yield] :
  super Arguments[Yield]

Arguments[Yield] :
  ( )
  ( ArgumentList[Yield] )

ArgumentList[Yield] :
  AssignmentExpression[In, Yield]
  ... AssignmentExpression[In, Yield]
  ArgumentList[Yield] ; AssignmentExpression[In, Yield]
  ArgumentList[Yield] ; ... AssignmentExpression[In, Yield]

LeftHandSideExpression[Yield] :
  NewExpression[Yield]
  CallExpression[Yield]

UpdateExpression[Yield] :
  LeftHandSideExpression[Yield]
  LeftHandSideExpression[Yield] [no LineTerminator here] ++
  LeftHandSideExpression[Yield] [no LineTerminator here] --
  ++ UnaryExpression[Yield]
  -- UnaryExpression[Yield]

UnaryExpression[Yield] :
  UpdateExpression[Yield]
  delete UnaryExpression[Yield]
  void UnaryExpression[Yield]
  typeof UnaryExpression[Yield]
  + UnaryExpression[Yield]
  - UnaryExpression[Yield]
  ~ UnaryExpression[Yield]
  ! UnaryExpression[Yield]

ExponentiationExpression[Yield] :
  UnaryExpression[Yield]
  UpdateExpression[Yield] ** ExponentiationExpression[Yield]

MultiplicativeExpression[Yield] :
  ExponentiationExpression[Yield]
  MultiplicativeExpression[Yield] MultiplicaitveOperator ExponentiationExpression[Yield]

MultiplicaitveOperator : one of
  * / %

AdditiveExpression[Yield] :
  MultiplicaitveExpression[Yield]
  AdditiveExpression[Yield] + MultiplicaitveExpression[Yield]
  AdditiveExpression[Yield] - MultiplicaitveExpression[Yield]

ShiftExpression[Yield] :
  AdditiveExpression[Yield]
  ShiftExpression[Yield] << AdditiveExpression[Yield]
ShiftExpression[?Yield]  >> AdditiveExpression[?Yield]  
ShiftExpression[?Yield]  >>> AdditiveExpression[?Yield]  

RelationalExpression[In, Yield] :
ShiftExpression[?Yield]  
RelationalExpression[?In, ?Yield]  < ShiftExpression[?Yield]  
RelationalExpression[?In, ?Yield]  > ShiftExpression[?Yield]  
RelationalExpression[?In, ?Yield]  <= ShiftExpression[?Yield]  
RelationalExpression[?In, ?Yield]  >= ShiftExpression[?Yield]  
RelationalExpression[?In, ?Yield]  instanceof ShiftExpression[?Yield]  
[In] RelationalExpression[In, ?Yield]  in ShiftExpression[?Yield]  

EqualityExpression[In, Yield] :
RelationalExpression[?In, ?Yield]  
EqualityExpression[?In, ?Yield]  == RelationalExpression[?In, ?Yield]  
EqualityExpression[?In, ?Yield]  != RelationalExpression[?In, ?Yield]  
EqualityExpression[?In, ?Yield]  === RelationalExpression[?In, ?Yield]  
EqualityExpression[?In, ?Yield]  !== RelationalExpression[?In, ?Yield]  

BitwiseANDExpression[In, Yield] :
EqualityExpression[?In, ?Yield]  
BitwiseANDExpression[?In, ?Yield]  & EqualityExpression[?In, ?Yield]  

BitwiseXORExpression[In, Yield] :
BitwiseANDExpression[?In, ?Yield]  
BitwiseXORExpression[?In, ?Yield]  ^ BitwiseANDExpression[?In, ?Yield]  

BitwiseORExpression[In, Yield] :
BitwiseXORExpression[?In, ?Yield]  
BitwiseORExpression[?In, ?Yield]  | BitwiseXORExpression[?In, ?Yield]  

LogicalANDExpression[In, Yield] :
BitwiseORExpression[?In, ?Yield]  
LogicalANDExpression[?In, ?Yield]  & BitwiseORExpression[?In, ?Yield]  

LogicalORExpression[In, Yield] :
LogicalANDExpression[?In, ?Yield]  
LogicalORExpression[?In, ?Yield]  || LogicalANDExpression[?In, ?Yield]  

ConditionalExpression[In, Yield] :
LogicalORExpression[?In, ?Yield]  

AssignmentExpression[In, Yield] :
ConditionalExpression[?In, ?Yield]  
[Yield] YieldExpression[?In]  
ArrowFunction[?In, ?Yield]  
LeftHandSideExpression[?Yield]  = AssignmentExpression[?In, ?Yield]  
LeftHandSideExpression[?Yield]  AssignmentOperator AssignmentExpression[?In, ?Yield]  

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] :
   [ Elision opt AssignmentRestElement[Yield] opt ]
   [ AssignmentElementList[Yield] ]
   [ AssignmentElementList[Yield], Elision opt AssignmentRestElement[Yield] opt ]

AssignmentPropertyList[Yield] :
   AssignmentProperty[Yield]
   AssignmentPropertyList[Yield], AssignmentProperty[Yield]

AssignmentElementList[Yield] :
   AssignmentElisionElement[Yield]
   AssignmentElementList[Yield], AssignmentElisionElement[Yield]

AssignmentElisionElement[Yield] :
   Elision opt AssignmentElement[Yield]

AssignmentProperty[Yield] :
   IdentifierReference[Yield] Initializer[In, Yield] opt
  (PropertyName[Yield] : AssignmentElement[Yield]

AssignmentElement[Yield] :
   DestructuringAssignmentTarget[Yield] Initializer[In, Yield] opt

AssignmentRestElement[Yield] :
   ... DestructuringAssignmentTarget[Yield]

DestructuringAssignmentTarget[Yield] :
   LeftHandSideExpression[Yield]

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

Expression[In, Yield] :
   AssignmentExpression[In, Yield]
   Expression[In, Yield], AssignmentExpression[In, Yield]

A.3 Statements

Statement[Yield, Return] :
   BlockStatement[Yield, ?Return]
   VariableStatement[Yield]
   EmptyStatement
   ExpressionStatement[Yield]
let
const

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] :

doStatement[Yield]

classDeclaration[Yield]

lexicalDeclaration[In, 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 :

{ StatementList } 

statementList[Yield, Return] :

statementListItem[Yield, Return]

statementList[Yield, Return] statementListItem[Yield, Return]

statementListItem[Yield, Return] :

statement[Yield, Return]

declaration[Yield]

lexicalDeclaration[In, Yield] :

letOrConst bindingList[In, Yield] ;

letOrConst :

let

const

bindingList[In, Yield] :

lexicalBinding[In, Yield]

bindingList[In, Yield] , lexicalBinding[In, Yield]

lexicalBinding[In, Yield] :

bindingIdentifier[Yield] initializer[In, Yield] opt

bindingPattern[Yield] initializer[In, Yield]

variableStatement[Yield] :
```javascript
var VariableDeclarationList[In, ?Yield] ;

VariableDeclarationList[In, Yield] :
  VariableDeclaration[?In, ?Yield]
  VariableDeclarationList[In, ?Yield] , VariableDeclaration[?In, ?Yield]

VariableDeclaration[In, Yield] :
  BindingIdentifier[?Yield] Initializer[?In, ?Yield] opt
  BindingPattern[?Yield] Initializer[?In, ?Yield]

BindingPattern[?Yield] :
  ObjectBindingPattern[?Yield]
  ArrayBindingPattern[?Yield]

ObjectBindingPattern[?Yield] :
  { }
  { BindingPropertyList[?Yield] }
  { BindingPropertyList[?Yield] , }

ArrayBindingPattern[?Yield] :
  [ Elision opt BindingRestElement[?Yield] opt ]
  [ BindingElementList[?Yield] ]

BindingPropertyList[?Yield] :
  BindingProperty[?Yield]
  BindingPropertyList[?Yield] , BindingProperty[?Yield]

BindingElementList[?Yield] :
  BindingElisionElement[?Yield]
  BindingElementList[?Yield] , BindingElisionElement[?Yield]

BindingElisionElement[?Yield] :
  Elision opt BindingElement[?Yield]

BindingProperty[?Yield] :
  SingleNameBinding[?Yield]
  PropertyName[?Yield] : BindingElement[?Yield]

BindingElement[?Yield] :
  SingleNameBinding[?Yield]
  BindingPattern[?Yield] Initializer[?In, ?Yield] opt

SingleNameBinding[?Yield] :
  BindingIdentifier[?Yield] Initializer[?In, ?Yield] opt

BindingRestElement[?Yield] :
  ... BindingIdentifier[?Yield]
  ... BindingPattern[?Yield]

EmptyStatement :
  ;

ExpressionStatement[?Yield] :
```

IfStatement[Yield, Return] :
  if ( Expression[In, ?Yield] ) Statement[?Yield, ?Return]

IterationStatement[Yield, Return] :
  do Statement[?Yield, ?Return] while ( Expression[In, ?Yield] )
  while ( Expression[In, ?Yield] ) Statement[?Yield, ?Return]
  for ( [lookahead ∈ { let []}] Expression[?Yield] opt ; Expression[In, ?Yield] opt ; Expression[In, ?Yield] opt )
    Statement[?Yield, ?Return]
  for ( var VariableDeclarationList[?Yield] ; Expression[In, ?Yield] opt ; Expression[In, ?Yield] opt )
    Statement[?Yield, ?Return]
  for ( LexicalDeclaration[?Yield] Expression[In, ?Yield] opt ; Expression[In, ?Yield] opt )
    Statement[?Yield, ?Return]
  for ( [lookahead ∈ { let []}] LeftHandSideExpression[?Yield] in Expression[In, ?Yield] )
    Statement[?Yield, ?Return]
  for ( ForDeclaration[?Yield] in Expression[In, ?Yield] ) Statement[?Yield, ?Return]
  for ( [lookahead ≠ let] LeftHandSideExpression[?Yield] of AssignmentExpression[In, ?Yield] )
    Statement[?Yield, ?Return]
  for ( ForDeclaration[?Yield] of AssignmentExpression[In, ?Yield] ) Statement[?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;
  return [no LineTerminator here] Expression[In, ?Yield];

WithStatement[Yield, Return] :
  with ( Expression[In, ?Yield] ) Statement[?Yield, ?Return]

SwitchStatement[Yield, Return] :
  switch ( Expression[In, ?Yield] ) CaseBlock[?Yield, ?Return]

CaseBlock[Yield, Return] :
  { CaseClauses[?Yield, ?Return] opt }
CaseClauses[Yield, Return] :
  CaseClause[Yield, ?Return]

CaseClause[Yield, Return] :

DefaultClause[Yield, Return] :

LabelledStatement[Yield, Return] :
  LabelIdentifier[?Yield] : LabelledItem[?Yield, ?Return]

LabelledItem[Yield, Return] :
  Statement[?Yield, ?Return]
  FunctionDeclaration[?Yield]

ThrowStatement[Yield] :
  throw [no LineTerminator here] Expression[In, ?Yield] ;

TryStatement[Yield, Return] :

Catch[Yield, Return] :
  catch ( CatchParameter[?Yield] ) Block[?Yield, ?Return]

Finally[Yield, Return] :
  finally Block[?Yield, ?Return]

CatchParameter[Yield] :
  BindingIdentifier[?Yield]
  BindingPattern[?Yield]

DebuggerStatement :
  debugger ;

A.4 Functions and Classes

FunctionDeclaration[Yield, Default] :
  function BindingIdentifier[?Yield] ( FormalParameters ) { FunctionBody }
[+Default] function ( FormalParameters ) { FunctionBody }

FunctionExpression :
  function BindingIdentifier opt ( FormalParameters ) { FunctionBody }

StrictFormalParameters[Yield] :
  FormalParameters[?Yield]

FormalParameters[Yield] :
  [empty]
  FormalParameterList[?Yield]

FormalParameterList[Yield] :
When the production `ArrowParameters : CoverParenthesizedExpressionAndArrowParameterList` is recognized, the following grammar is used to refine the interpretation of `CoverParenthesizedExpressionAndArrowParameterList`:

```
ArrowFormalParameters[Yield] :
( StrictFormalParameters[Yield] )
```

GeneratorExpression :
    function * BindingIdentifier[Yield] opt ( FormalParameters[Yield] ) { GeneratorBody }

GeneratorBody :
    FunctionBody[Yield]

YieldExpression[In] :
    yield
    yield [no LineTerminator here] AssignmentExpression[?In, Yield]
    yield [no LineTerminator here] * AssignmentExpression[?In, Yield]

ClassDeclaration[Yield, Default] :
    class BindingIdentifier[Yield] ClassTail[Yield]
    [+Default] class ClassTail[Yield]

ClassExpression[Yield] :
    class BindingIdentifier[Yield] opt ClassTail[Yield]

ClassTail[Yield] :
    ClassHeritage[Yield] opt { ClassBody[Yield] 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]

A.5 Scripts and Modules

Script :
    ScriptBody opt

ScriptBody :
    StatementList

Module :
    ModuleBody opt

ModuleBody :
    ModuleItemList

ModuleItemList :
    ModuleItem
    ModuleItemList ModuleItem

ModuleItem :
    ImportDeclaration
ExportDeclaration
StatementListItem

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[In] ;

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 :::
  WhiteSpace 
  LineTerminator

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 ::
$0x$ HexDigits
$0X$ HexDigits

$\text{HexDigit} :: \text{one of}$

$0 1 2 3 4 5 6 7 8 9 a b c d e f A B C D E F$

All grammar symbols not explicitly defined by the StringNumericLiteral grammar have the definitions used in the Lexical Grammar for numeric literals.

A.7 Universal Resource Identifier Character Classes

$\text{uri} ::=
\text{uriCharacters}_{\text{opt}}$

$\text{uriCharacters} ::=
\text{uriCharacter} \text{uriCharacters}_{\text{opt}}$

$\text{uriCharacter} ::=
\text{uriReserved}
\text{uriUnescaped}
\text{uriEscaped}$

$\text{uriReserved} ::\text{one of}$

$; / ? : @ & = \pm \$ ,

$\text{uriUnescaped} ::=
\text{uriAlpha}
\text{DecimalDigit}
\text{uriMark}$

$\text{uriEscaped} ::=
\% \text{HexDigit} \text{HexDigit}$

$\text{uriAlpha} ::\text{one of}$

$\text{uriAlpha} ::\text{one of}$

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

$W X Y Z$

$\text{uriMark} ::\text{one of}$

$- _ . ! \sim \ast \( )$

A.8 Regular Expressions

$\text{Pattern}_{[u]} ::$

$\text{Disjunction}_{[?u]}$

$\text{Disjunction}_{[u]} ::$

$\text{Alternative}_{[?u]}$

$\text{Alternative}_{[?u]} \mid \text{Disjunction}_{[?u]}$

$\text{Alternative}_{[u]} ::$

[empty]

$\text{Alternative}_{[?u]} \text{Term}_{[?u]}$

$\text{Term}_{[u]} ::$

$\text{Assertion}_{[?u]}$

$\text{Atom}_{[?u]}$
Atom\[?u\]  Quantifier

Assertion\[?u\] ::
  ^
  \$
  \b
  \B
  (? = Disjunction\[?u\] )
  (? ! Disjunction\[?u\] )

Quantifier ::
  QuantifierPrefix
  QuantifierPrefix ?

QuantifierPrefix ::
  *
  +
  ?
  \{ DecimalDigits \}
  \{ DecimalDigits , \}
  \{ DecimalDigits , DecimalDigits \}

Atom\[?u\] ::
  PatternCharacter
  .
  \ AtomEscape\[?u\]
  CharacterClass\[?u\]
  ( Disjunction\[?u\] )
  (? : Disjunction\[?u\] )

SyntaxCharacter :: one of
  ^ \$ \ . * + ? ( ) [ ] { } |

PatternCharacter ::
  SourceCharacter but not SyntaxCharacter

AtomEscape\[?u\] ::
  DecimalEscape
  CharacterEscape\[?u\]
  CharacterClassEscape

CharacterEscape\[?u\] ::
  ControlEscape
c  ControlLetter
  HexEscapeSequence
  RegExpUnicodeEscapeSequence\[?u\]
  IdentityEscape\[?u\]

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[u] ::
    [-u] u LeadSurrogate \u TrailSurrogate
    [-u] u LeadSurrogate
    [-u] u TrailSurrogate
    [-u] u NonSurrogate
    [-u] u Hex4Digits
    [-u] u{ HexDigits }

Each \u TrailSurrogate for which the choice of associated u LeadSurrogate is ambiguous shall be associated with the nearest possible u LeadSurrogate that would otherwise have no corresponding \u TrailSurrogate.

LeadSurrogate ::
    Hex4Digits but only if the SV of Hex4Digits is in the inclusive range 0xD800 to 0xDBFF

TrailSurrogate ::
    Hex4Digits but only if the SV of Hex4Digits is in the inclusive range 0xDC00 to 0xDFFF

NonSurrogate ::
    Hex4Digits but only if the SV of Hex4Digits is not in the inclusive range 0xD800 to 0xDFFF

IdentityEscape[u] ::
    [-u] SyntaxCharacter
    [-u] /
    [-u] SourceCharacter but not UnicodeIDContinue

DecimalEscape ::
    DecimalIntegerLiteral [lookahead ∉ DecimalDigit]

CharacterClassEscape :: one of
    d D s S w W

CharacterClass[u] ::
    [ [lookahead ∉ { ^ }] ClassRanges[?u] ]
    [ ^ ClassRanges[?u] ]

ClassRanges[u] ::
    [empty]
    NonemptyClassRanges[?u]

NonemptyClassRanges[u] ::
    ClassAtom[?u]
    ClassAtom[?u] NonemptyClassRangesNoDash[?u]
    ClassAtom[?u] - ClassAtom[?u] ClassRanges[?u]

NonemptyClassRangesNoDash[u] ::
    ClassAtom[?u]
    ClassAtomNoDash[?u] NonemptyClassRangesNoDash[?u]
    ClassAtomNoDash[?u] - ClassAtom[?u] ClassRanges[?u]

ClassAtom[u] ::
    -
    ClassAtomNoDash[?u]

ClassAtomNoDash[u] ::
SourceCharacter but not one of \ or ] or -
\ ClassEscape[?]\n
ClassEscape[?] ::
  DecimalEscape
  b
  [^U] -
  CharacterEscape[?]\n  CharacterClassEscape
Annex B
Additional ECMAScript Features for Web Browsers
(normative)

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.

NOTE This annex describes various legacy features and other characteristics of web browser based ECMAScript implementations. All of the language features and behaviours specified in this annex have one or more undesirable characteristics and in the absence of legacy usage would be removed from this specification. However, the usage of these features by large numbers of existing web pages means that web browsers must continue to support them. The specifications in this annex define the requirements for interoperable implementations of these legacy features.

These features are not considered part of the core ECMAScript language. Programmers should not use or assume the existence of these features and behaviours when writing new ECMAScript code. ECMAScript implementations are discouraged from implementing these features unless the implementation is part of a web browser or is required to run the same legacy ECMAScript code that web browsers encounter.

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 ::
  OctalDigit
  LegacyOctalIntegerLiteral OctalDigit

DecimalIntegerLiteral ::
  NonOctalDecimalIntegerLiteral
    NonOctaDigit
      NonZeroDigit DecimalDigits
          OctalDigit
      NonOctalDecimalIntegerLiteral

NonOctalDecimalIntegerLiteral ::
  NonOctalDigit
    LegacyOctalLikeDecimalIntegerLiteral NonOctaDigit
      NonOctalDecimalIntegerLiteral DecimalDigit
    LegacyOctalLikeDecimalIntegerLiteral
      OctalDigit
      LegacyOctalLikeDecimalIntegerLiteral OctalDigit

NonOctalDigit :: one of
```
B.1.1.1 Static Semantics

- The MV of `LegacyOctalIntegerLiteral :: θ 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 :: θ 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 :: θ OctalDigit` is the MV of `OctalDigit`.
- 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

```plaintext
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 in strict mode or when parsing `TemplateCharacter`.

B.1.2.1 Static Semantics

- The SV of `EscapeSequence :: LegacyOctalEscapeSequence` is the SV of the `LegacyOctalEscapeSequence`.
- The SV of `LegacyOctalEscapeSequence :: OctalDigit` is the 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 (that is, 8^2) times the MV of the `ZeroToThree`) plus (8 times the MV of the first `OctalDigit`) plus the MV of the second `OctalDigit`.
- The MV of `ZeroToThree :: θ` 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 when parsing source code using the goal symbol `Module`:

**Syntax**

**Comment ::**

* `MultiLineComment`
* `SingleLineComment`
* `SingleLineHTMLOpenComment`
* `SingleLineHTMLCloseComment`
* `SingleLineDelimitedComment`

**MultiLineComment ::**

/* FirstCommentLine opt LineTerminator MultiLineCommentChars opt */ HTMLCloseComment opt

**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 but not one of * or LineTerminator

**SingleLinePostAsteriskCommentChars ::**

* `SingleLineNotForwardSlashOrAsteriskChar` SingleLineDelimitedCommentChars opt
* `SingleLinePostAsteriskCommentChars` opt

**SingleLineNotForwardSlashOrAsteriskChar ::**

SourceCharacter but not one of / or * or LineTerminator

**WhiteSpaceSequence ::**

WhiteSpace `WhiteSpaceSequence` opt

**SingleLineDelimitedCommentSequence ::**

WhiteSpace
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\[U\] ::
   \[+U\] Assertion\[U\]
   \[+U\] Atom\[U\]
   \[+U\] Atom\[U\] Quantifier
   \[-U\] QuantifiableAssertion Quantifier
   \[-U\] Assertion
   \[-U\] ExtendedAtom Quantifier
   \[-U\] ExtendedAtom

Assertion\[U\] ::
   \^  
   \$  
   \ \ b
   \ \ B
   \[+U\] ( \ ? = Disjunction\[U\] )
   \[+U\] ( \ ? \ ! Disjunction\[U\] )
   \[-U\] QuantifiableAssertion

QuantifiableAssertion ::
   ( \ ? = Disjunction )
   ( \ ? \ ! Disjunction )

ExtendedAtom ::
   .
   \ \ AtomEscape
   CharacterClass
   ( Disjunction )
   ( \ ? : Disjunction )
   InvalidBracedQuantifier
   ExtendedPatternCharacter

InvalidBracedQuantifier ::
   \{ DecimalDigits \}
   \{ DecimalDigits , \}
   \{ DecimalDigits , DecimalDigits \}

ExtendedPatternCharacter ::
   SourceCharacter but not one of \^ \ $. \* + ? ( ) [ ] |
AtomEscape \[u\] ::
  [-u] DecimalEscape
  [-u] CharacterEscape\[u\]
  [-u] CharacterClassEscape
  [-u] DecimalEscape but only if the integer value of DecimalEscape is \(_\leq \text{NcapturingParens}_\)
  [-u] CharacterClassEscape
  [-u] CharacterEscape

CharacterEscape\[u\] ::
  ControlEscape
c ControlLetter
HexEscapeSequence
RegExpUnicodeEscapeSequence \[?u\]
  [-u] LegacyOctalEscapeSequence
IdentityEscape\[u\]

IdentityEscape \[u\] ::
  [-u] SyntaxCharacter
  [-u] /
  [-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 \[u\] - ClassAtom \[u\] ClassRanges \[u\]
  [-u] ClassAtomNoDashInRange - ClassAtomInRange ClassRanges

ClassAtom \[u\] ::
  -
  ClassAtomNoDash \[?u\]

ClassAtomNoDash \[u\] ::
  \ ClassEscape \[?u\]
  SourceCharacter but not one of } or -

ClassAtomInRange ::
  -
  ClassAtomNoDashInRange

ClassAtomNoDashInRange ::
  \ ClassEscape
  SourceCharacter but not one of } or -

ClassEscape \[u\] ::
  b
  [-u] DecimalEscape
  [-u] CharacterEscape \[u\]
  [-u] CharacterClassEscape
[+] DecimalEscape but only if the integer value of DecimalEscape is 0
[~U] CharacterClassEscape
[~U] c ClassControlLetter
[~U] CharacterEscape

ClassControlLetter ::
  DecimalDigit

NOTE When the same left hand sides occurs with both [+] and [~] guards it is to control the disambiguation priority.

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 “ExtendedAtom :: ( Disjunction )”.

Term (21.2.2.5) includes the following additional evaluation rules:

The production Term :: QuantifiableAssertion Quantifier evaluates the same as the production Term :: Atom Quantifier but with QuantifiableAssertion substituted for Atom.

The production Term :: ExtendedAtom Quantifier evaluates the same as the production Term :: Atom Quantifier but with ExtendedAtom substituted for Atom.

The production Term :: ExtendedAtom evaluates the same as the production Term :: Atom but with ExtendedAtom substituted for Atom.

Assertion (21.2.2.6) includes the following additional evaluation rule:

The production Assertion :: QuantifiableAssertion evaluates by evaluating QuantifiableAssertion to obtain a Matcher and returning that Matcher.

Assertion (21.2.2.6) evaluation rules for the Assertion :: (? = Disjunction) and Assertion :: (? ! Disjunction) productions are also used for the QuantifiableAssertion productions, but with QuantifiableAssertion substituted for Assertion.

Atom (21.2.2.8) evaluation rules for the Atom productions except for Atom :: PatternCharacter are also used for the ExtendedAtom productions, but with ExtendedAtom substituted for Atom. The following evaluation rules are also added:

The production ExtendedAtom :: InvalidBracedQuantifier evaluates as follows:

1. Throw a SyntaxError exception.

The production ExtendedAtom :: ExtendedPatternCharacter evaluates as follows:

1. Let ch be the character represented by ExtendedPatternCharacter.
2. Let A be a one-element CharSet containing the character ch.
3. Call CharSetMatcher(A, 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.

NonemptyClassRanges (21.2.2.15) includes the following additional evaluation rule:

The production NonemptyClassRanges :: ClassAtomInRange - ClassAtomInRange ClassRanges evaluates as follows:
1. Evaluate the first `ClassAtomInRange` to obtain a CharSet \( A \).
2. Evaluate the second `ClassAtomInRange` to obtain a CharSet \( B \).
3. Evaluate `ClassRanges` to obtain a CharSet \( C \).
4. Call `CharacterRangeOrUnion(A, B)` and let \( D \) be the resulting CharSet.
5. Return the union of CharSets \( D \) and \( C \).

NonemptyClassRangesNoDash (21.2.2.16) includes the following additional evaluation rule:

The production `NonemptyClassRangesNoDash :: ClassAtomNoDashInRange - ClassAtomInRange ClassRanges` evaluates as follows:

1. Evaluate `ClassAtomNoDashInRange` to obtain a CharSet \( A \).
2. Evaluate `ClassAtomInRange` to obtain a CharSet \( B \).
3. Evaluate `ClassRanges` to obtain a CharSet \( C \).
4. Call `CharacterRangeOrUnion(A, B)` and let \( D \) be the resulting CharSet.
5. Return the union of CharSets \( D \) and \( C \).

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 ClassRanges` 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 `ClassAtomNoDash :: SourceCharacter` but not one of \( ] \) or `-` evaluates by returning a one-element CharSet containing the character represented by `SourceCharacter`.

The production `ClassAtomNoDashInRange :: \ ClassEscape` evaluates by evaluating `ClassEscape` to obtain a CharSet and returning that CharSet.

The production `ClassAtomNoDashInRange :: SourceCharacter` but not one of \( ] \) or `-` evaluates by returning a one-element CharSet containing the character represented by `SourceCharacter`.

ClassEscape (21.2.2.19) includes the following additional evaluation rules:

The production `ClassEscape :: DecimalEscape` but only if ... evaluates as follows:

1. Evaluate `DecimalEscape` to obtain an EscapeValue \( E \).
2. Assert: \( E \) is a character.
3. Let \( ch \) be \( E \)'s character.
4. Return the one-element CharSet containing the character \( ch \).

The production `ClassEscape :: c ClassControlLetter` evaluates as follows:

1. Let \( ch \) be the character matched by `ClassControlLetter`.
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 \( j \).

**B.1.4.1.1 Runtime Semantics: CharacterRangeOrUnion Abstract Operation**

The abstract operation `CharacterRangeOrUnion` 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, then
   a. Let \( C \) be the CharSet containing the single character `-` (U+002D (HYPHEN-MINUS)).
   b. Return the union of CharSets \( A \), \( B \) and \( C \).
2. Return `CharacterRange(A, B)`.
B.2 Additional Built-in Properties

When the ECMA-Script 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

The entries in Table 61 are added to Table 7.

Table 61: Additional Well-known Intrinsic Objects

<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>Global Name</th>
<th>ECMA-Script Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>%escape%</td>
<td>escape</td>
<td>The escape function (B.2.1.1)</td>
</tr>
<tr>
<td>%unescape%</td>
<td>unescape</td>
<td>The unescape function (B.2.1.2)</td>
</tr>
</tbody>
</table>

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 \(0x00FF\) 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 \(0x00FF\), a four-digit escape sequence of the form %uxxxx is used.

The escape function is the %escape% intrinsic object. When the escape function is called with one argument string, the following steps are taken:

1. Let string be ?ToNumber(string).
2. Let length be the number of code units in string.
3. Let R be the empty string.
4. Let k be 0.
5. Repeat, while \(k < \text{length}\),
   a. Let char be the code unit (represented as a 16-bit unsigned integer) at index k within string.
   b. If char is one of the code units in "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789@*_+-./", then
      i. Let S be a String containing the single code unit char.
   c. Else if char ≥ 256, then
      i. Let S be a String containing six code units "%uwxxyz" where wxyz are the code units of the four hexadecimal digits encoding the value of char.
   d. Else, char < 256
      i. Let S be a String containing three code units "%xy" where xy are the code units of two hexadecimal digits encoding the value of char.
   e. Let R be a new String value computed by concatenating the previous value of R and S.
   f. Increase k by 1.
6. Return 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 unescape (string)

The unescape function is a property of the global object. It computes a new version of a String value in which each escape sequence of the sort that might be introduced by the escape function is replaced with the code unit that it represents.
The `unescape` function is the `%unescape%` intrinsic object. When the `unescape` function is called with one argument `string`, the following steps are taken:

1. Let `string` be `ToString(string)`.
2. Let `length` be the number of code units in `string`.
3. Let `R` be the empty String.
4. Let `k` be 0.
5. Repeat, while `k ≠ length`
   a. Let `c` be the code unit at index `k` within `string`.
   b. If `c` is `%`, then
      i. If `k ≤ length-6` and the code unit at `k+1` within `string` is `u` and the four code units at indices `k+2`, `k+3`, `k+4`, and `k+5` within `string` are all hexadecimal digits, then
         1. Let `c` be the code unit whose value is the integer represented by the four hexadecimal digits at indices `k+2`, `k+3`, `k+4`, and `k+5` within `string`.
         2. Increase `k` by 5.
      ii. Else if `k ≤ length-3` and the two code units at indices `k+1` and `k+2` within `string` are both hexadecimal digits, then
         1. Let `c` be the code unit whose value is the integer represented by two zeroes plus the two hexadecimal digits at indices `k+1` and `k+2` within `string`.
         2. Increase `k` by 2.
   c. Let `R` be a new String value computed by concatenating the previous value of `R` and `c`.
   d. Increase `k` by 1.
6. 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 `ToObject(this value)`.
2. Return `O.[[GetPrototypeOf]]()`.

**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. If `Type(proto)` is neither Object nor Null, return `undefined`.
3. If `Type(O)` is not Object, return `undefined`.
4. Let `status` be `O.[[SetPrototypeOf]]([proto])`.
5. If `status` is `false`, throw a `TypeError` exception.
6. 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 \( \text{RequireObjectCoercible}(\text{this value}) \).
2. Let \( S \) be \( \text{ToString}(O) \).
3. Let \( \text{intStart} \) be \( \text{ToInteger}(\text{start}) \).
4. If \( \text{length} \) is \( \text{undefined} \), let \( \text{end} \) be \( +\infty \); otherwise let \( \text{end} \) be \( \text{ToInteger}(\text{length}) \).
5. Let \( \text{size} \) be the number of code units in \( S \).
6. If \( \text{intStart} \) is undefined, let \( \text{end} \) be \( +\infty \); otherwise let \( \text{end} \) be \( \text{ToInteger}(\text{end}) \).
7. Let \( \text{resultLength} \) be \( \min(\max(\text{end}, 0), \text{size} - \text{intStart}) \).
8. If \( \text{resultLength} \leq 0 \), return the empty String "".
9. Return a String containing \( \text{resultLength} \) consecutive code units from \( S \) beginning with the code unit at index \( \text{intStart} \).

### B.2.3.2 String.prototype.anchor (name)

When the \( \text{anchor} \) method is called with argument \( \text{name} \), the following steps are taken:

1. Let \( S \) be the \( \text{this} \) value.
2. Return \( \text{CreateHTML}(S, "a", "name", \text{name}) \).

#### B.2.3.2.1 Runtime Semantics: CreateHTML (string, tag, attribute, value)

The abstract operation \( \text{CreateHTML} \) is called with arguments \( \text{string} \), \( \text{tag} \), \( \text{attribute} \), and \( \text{value} \). The arguments \( \text{tag} \) and \( \text{attribute} \) must be String values. The following steps are taken:

1. Let \( \text{str} \) be \( \text{RequireObjectCoercible}(\text{string}) \).
2. Let \( \text{S} \) be \( \text{ToString}(<\text{str}>\text{S}>) \).
3. Let \( \text{p1} \) be the String value that is the concatenation of "<" and \( \text{tag} \).
4. If \( \text{attribute} \) is not the empty String, then
   a. Let \( \text{V} \) be \( \text{ToString}(\text{value}) \).
   b. Let \( \text{escapedV} \) be the String value that is the same as \( \text{V} \) except that each occurrence of the code unit 0x0022 (QUOTATION MARK) in \( \text{V} \) has been replaced with the six code unit sequence "\&quot;.".
   c. Let \( \text{p1} \) be the String value that is the concatenation of the following String values:
      - The String value of \( \text{p1} \)
      - Code unit 0x0020 (SPACE)
      - The String value of \( \text{attribute} \)
      - Code unit 0x003D (EQUALS SIGN)
      - Code unit 0x0022 (QUOTATION MARK)
      - The String value of \( \text{escapedV} \)
      - Code unit 0x0022 (QUOTATION MARK)
5. Let \( \text{p2} \) be the String value that is the concatenation of \( \text{p1} \) and ">".
6. Let \( \text{p3} \) be the String value that is the concatenation of \( \text{p2} \) and \( \text{S} \).
7. Let \( \text{p4} \) be the String value that is the concatenation of \( \text{p3} \), "\</\text{tag}>", and "\>".
8. Return \( \text{p4} \).

### B.2.3.3 String.prototype.big ()

When the \( \text{big} \) method is called with no arguments, the following steps are taken:

1. Let \( S \) be the \( \text{this} \) value.
2. Return \( \text{CreateHTML}(S, "big", "", ")" \).

### B.2.3.4 String.prototype.blink ()

When the \( \text{blink} \) method is called with no arguments, the following steps are taken:

1. Let \( S \) be the \( \text{this} \) value.
2. Return \( \text{CreateHTML}(S, "\text{blink}\", "", ")" \).
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.2.3.6  String.prototype.fixed ()

When the **fixed** method is called with no arguments, the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "tt", "", ""\)).

B.2.3.7  String.prototype.fontcolor ( color )

When the **fontcolor** method is called with argument \( color \), the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "font", "color", color\)).

B.2.3.8  String.prototype.fontsize ( size )

When the **fontsize** method is called with argument \( size \), the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "font", "size", size\)).

B.2.3.9  String.prototype.italics ()

When the **italics** method is called with no arguments, the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "i", "", ""\)).

B.2.3.10  String.prototype.link ( url )

When the **link** method is called with argument \( url \), the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "a", "href", url\)).

B.2.3.11  String.prototype.small ()

When the **small** method is called with no arguments, the following steps are taken:

1. Let \( S \) be the **this** value.
2. Return ? CreateHTML(\( S, "small", "", ""\)).

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, "sup", "", ").

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 ? thisTimeValue(this value).
2. If t is NaN, return NaN.
3. 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 ? thisTimeValue(this value).
2. If t is NaN, let t be +0; otherwise, let t be LocalTime(t).
3. Let y be ? ToNumber(year).
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 ≤ ToInteger(y) ≤ 99, let yyyy be ToInteger(y) + 1900.
6. Else, let yyyy be y.
7. Let d be MakeDay(yyyy, 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 \textit{pattern}.
   b. Let \( F \) be \textit{flags}.
5. Return \(? \text{RegExpInitialize}(O, P, F)\).

NOTE The \textit{compile} method completely reinitializes the \textit{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 \texttt{__proto__} Property Names in Object Initializers**

The following Early Error rule is added to those in 12.2.6.1. When \textit{ObjectLiteral} appears in a context where \textit{ObjectAssignmentPattern} is required the Early Error rule is not applied. In addition, it is not applied when initially parsing a \textit{CoverParenthesizedExpressionAndArrowParameterList}.

\[
\text{ObjectLiteral} : \{ \text{PropertyDefinitionList} \} \\
\text{ObjectLiteral} : \{ \text{PropertyDefinitionList} \ , \}
\]

- It is a Syntax Error if \text{PropertyNameList} of \text{PropertyDefinitionList} contains any duplicate entries for \texttt{"__proto__"} and at least two of those entries were obtained from productions of the form \text{PropertyDefinition} : \textit{PropertyName} : \textit{AssignmentExpression}.

NOTE The \textit{List} returned by \text{PropertyNameList} does not include string literal property names defined as using a \textit{ComputedPropertyName}.

In 12.2.6.9 the PropertyDefinitionEvaluation algorithm for the production \text{PropertyDefinition} : \textit{PropertyName} : \textit{AssignmentExpression} is replaced with the following definition:

\[
\text{PropertyDefinition} : \textit{PropertyName} : \textit{AssignmentExpression}
\]

1. Let \textit{propKey} be the result of evaluating \textit{PropertyName}.
2. ReturnIfAbrupt(\textit{propKey}).
3. Let \textit{exprValueRef} be the result of evaluating \textit{AssignmentExpression}.
4. Let \textit{propValue} be \textit{GetValue}(\textit{exprValueRef}).
5. If \textit{propKey} is the String value \texttt{"__proto__"} and if \text{IsComputedPropertyKey}(\textit{propKey}) is \texttt{false}, then
   a. If \text{Type}(\textit{propValue}) is either Object or Null, then
      i. Return \textit{object}[[SetPrototypeOf]](\textit{propValue}).
   b. Return NormalCompletion(\textit{empty}).
6. If \text{IsAnonymousFunctionDefinition}(\textit{AssignmentExpression}) is \texttt{true}, then
   a. Let \textit{hasNameProperty} be \text{? HasOwnProperty}(\textit{propValue}, \texttt{"name"}).
   b. If \textit{hasNameProperty} is \texttt{false}, perform \text{SetFunctionName}(\textit{propValue}, \textit{propKey}).
7. Assert: \textit{enumerable} is \texttt{true}.
8. Return \text{CreateDataPropertyOrThrow}(\textit{object}, \textit{propKey}, \textit{propValue}).

**B.3.2 Labelled Function Declarations**

Prior to ECMAScript 2015, the specification of \textit{LabelledStatement} did not allow for the association of a statement label with a \textit{FunctionDeclaration}. However, a labelled \textit{FunctionDeclaration} was an allowable extension for non-strict code and most browser-hosted ECMAScript implementations supported that extension. In ECMAScript 2015, the grammar productions for \textit{LabelledStatement} permits use of \textit{FunctionDeclaration} as a \textit{LabelledItem} but 13.13.1 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 highlighted text:

\[
\text{LabelledItem} : \textit{FunctionDeclaration}
\]
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 ECMAScript 2015, 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 `FunctionDeclaration` whose `BindingIdentifier` is the name `f` occurs 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 occurrences of `f` as an `IdentifierReference` are 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 `FunctionDeclaration` whose `BindingIdentifier` is the name `f` occurs 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`.
   - There may be occurrences of `f` as an `IdentifierReference` within the `StatementList` of the `Block` containing the declaration of `f`.
   - There is at least one occurrence of `f` as an `IdentifierReference` within another function `h` that is nested within `g` and no other declaration of `f` shadows the references to `f` from within `h`.
   - All invocations of `h` occur after the declaration of `f` has been evaluated.

3. A function is declared and possibly used within a single block but also referenced within subsequent blocks.
   - A `FunctionDeclaration` whose `BindingIdentifier` is the name `f` occurs 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`.
   - There may be occurrences of `f` as an `IdentifierReference` within the `StatementList` of the `Block` containing the declaration of `f`.
   - There is at least one occurrence of `f` as an `IdentifierReference` within the function code of `g` that lexically follows the `Block` containing the declaration of `f`.

The first use case is interoperable with the semantics of `Block` level function declarations provided by ECMAScript 2015. Any pre-existing ECMAScript code that employs that use case will operate using the Block level function declarations semantics defined by clauses 9, 13, and 14 of this specification.

ECMAScript 2015 interoperability for the second and third use cases requires the following extensions to the clause 9, clause 14, clause 18.2.1 and clause 15.1.11 semantics.

If an ECMAScript implementation has a mechanism for reporting diagnostic warning messages, a warning should be produced when code contains a `FunctionDeclaration` for which these compatibility semantics are applied and introduce observable differences from non-compatibility semantics. For example, if a `var` binding is not introduced because its introduction would create an early error, a warning message should not be produced.

### B.3.3.1 Changes to FunctionDeclarationInstantiation

During `FunctionDeclarationInstantiation` the following steps are performed in place of step 29:
1. If \textit{strict} is \texttt{false}, then
   a. For each \texttt{FunctionDeclaration} \texttt{f} that is directly contained in the \texttt{StatementList} of a \texttt{Block}, \texttt{CaseClause}, or \texttt{DefaultClause},
      i. Let \texttt{F} be StringValue of the \texttt{BindingIdentifier} of \texttt{FunctionDeclaration} \texttt{f}.
      ii. If replacing the \texttt{FunctionDeclaration} \texttt{f} with a \texttt{VariableStatement} that has \texttt{F} as a \texttt{BindingIdentifier} would not produce any Early Errors for \texttt{func} and \texttt{F} is not an element of BoundNames of \texttt{argumentsList}, then
         1. NOTE A var binding for \texttt{F} is only instantiated here if it is neither a VarDeclaredName, the name of a formal parameter, or another \texttt{FunctionDeclaration}.
   2. If \texttt{instantiatedVarNames} does not contain \texttt{F}, then
      a. Perform \texttt{! varEnvRec.CreateMutableBinding(F, false)}.
      b. Perform \texttt{varEnvRec.InitializeBinding(F, undefined)}.
      c. Append \texttt{F} to \texttt{instantiatedVarNames}.
   3. When the \texttt{FunctionDeclaration} \texttt{f} is evaluated, perform the following steps in place of the \texttt{FunctionDeclaration} Evaluation algorithm provided in \texttt{14.1.21}:
      a. Let \texttt{fenv} be the running execution context’s VariableEnvironment.
      b. Let \texttt{fenvRec} be \texttt{fenv’s EnvironmentRecord}.
      c. Let \texttt{benv} be the running execution context’s LexicalEnvironment.
      d. Let \texttt{benvRec} be \texttt{benv’s EnvironmentRecord}.
      e. Let \texttt{fobj} be \texttt{! benvRec.GetBindingValue(F, false)}.
      f. Perform \texttt{! fenvRec.SetMutableBinding(F, fobj, false)}.
      g. Return \texttt{NormalCompletion(\texttt{empty})}.

\textbf{B.3.3.2 Changes to GlobalDeclarationInstantiation}

During \texttt{GlobalDeclarationInstantiation} the following steps are performed in place of step 14:

   1. Let \texttt{strict} be IsStrict of \texttt{script}
   2. If \texttt{strict} is \texttt{false}, then
      a. Let \texttt{declaredFunctionOrVarNames} be a new empty \texttt{List}.
      b. Append to \texttt{declaredFunctionOrVarNames} the elements of \texttt{declaredFunctionNames}.
      c. Append to \texttt{declaredFunctionOrVarNames} the elements of \texttt{declaredVarNames}.
      d. For each \texttt{FunctionDeclaration} \texttt{f} that is directly contained in the \texttt{StatementList} of a \texttt{Block}, \texttt{CaseClause}, or \texttt{DefaultClause} Contained within \texttt{script},
         i. Let \texttt{F} be StringValue of the \texttt{BindingIdentifier} of \texttt{FunctionDeclaration} \texttt{f}.
         ii. If replacing the \texttt{FunctionDeclaration} \texttt{f} with a \texttt{VariableStatement} that has \texttt{F} as a \texttt{BindingIdentifier} would not produce any Early Errors for \texttt{script}, then
            1. If \texttt{envRec} HasLexicalDeclaration(\texttt{F}) is \texttt{false}, then
               a. Let \texttt{fnDefinable} be \texttt{? envRec.CanDeclareGlobalFunction(F)}.
               b. If \texttt{fnDefinable} is \texttt{true}, then
                  i. NOTE A var binding for \texttt{F} is only instantiated here if it is neither a VarDeclaredName nor the name of another \texttt{FunctionDeclaration}.
                  ii. If \texttt{declaredFunctionOrVarNames} does not contain \texttt{F}, then
                     i. Perform \texttt{? envRec.CreateGlobalFunctionBinding(F, undefined, false)}.
                     ii. Append \texttt{F} to \texttt{declaredFunctionOrVarNames}.
                  iii. When the \texttt{FunctionDeclaration} \texttt{f} is evaluated, perform the following steps in place of the \texttt{FunctionDeclaration} Evaluation algorithm provided in \texttt{14.1.21}:
                     i. Let \texttt{genv} be the running execution context’s VariableEnvironment.
                     ii. Let \texttt{genvRec} be \texttt{genv’s EnvironmentRecord}.
                     iii. Let \texttt{benv} be the running execution context’s LexicalEnvironment.
                     iv. Let \texttt{benvRec} be \texttt{benv’s EnvironmentRecord}.
                     v. Let \texttt{fobj} be \texttt{! benvRec.GetBindingValue(F, false)}.
                     vi. Perform \texttt{? genvRec.SetMutableBinding(F, fobj, false)}.
                     vii. Return \texttt{NormalCompletion(\texttt{empty})}.

\textbf{B.3.3.3 Changes to EvalDeclarationInstantiation}
During EvalDeclarationInstantiation the following steps are performed in place of step 9:

1. If strict is false, then
   a. Let declaredFunctionOrVarNames be a new empty List.
   b. Append to declaredFunctionOrVarNames the elements of declaredFunctionNames.
   c. Append to declaredFunctionOrVarNames the elements of declaredVarNames.
   d. For each FunctionDeclaration f that is directly contained in the StatementList of a Block, CaseClause, or DefaultClause Contained within body,
      i. Let F be StringValue of the BindingIdentifier of FunctionDeclaration f.
      ii. If replacing the FunctionDeclaration f with a VariableStatement that has F as a BindingIdentifier would not produce any Early Errors for body, then
         1. Let bindingExists be false.
         2. Let thisLex be lexEnv.
         3. Assert: the following loop will terminate.
         4. Repeat while thisLex is not the same as varEnv,
            a. Let thisEnvRec be thisLex's EnvironmentRecord.
            b. If thisEnvRec is not an object Environment Record, then
               i. If thisEnvRec.HasBinding(F) is true, then
                  i. Let bindingExists be true.
               c. Let thisLex be thisLex's outer environment reference.
         5. If bindingExists is false and varEnvRec is a global Environment Record, then
            a. If varEnvRec.HasLexicalDeclaration(F) is false, then
               i. Let fnDemissible be ? varEnvRec.CanDeclareGlobalFunction(F).
            h. Else, 
               i. Let fnDemissible be false.
         6. Else,
            a. Let fnDemissible be true.
         7. If bindingExists is false and fnDemissible is true, then
            a. If declaredFunctionOrVarNames does not contain F, then
               i. If varEnvRec is a global Environment Record, then
                  i. Perform ? varEnvRec.CreateGlobalFunctionBinding(F, undefined, true).
               ii. Else,
                  i. Let bindingExists be varEnvRec.HasBinding(F).
                  ii. If bindingExists is false, then
                     i. Perform ! varEnvRec.CreateMutableBinding(F, true).
                     ii. Perform ! varEnvRec.InitializeBinding(F, undefined).
            h. When the FunctionDeclaration f is evaluated, perform the following steps in place of the FunctionDeclaration Evaluation algorithm provided in 14.1.21:
               i. Let genv be the running execution context's VariableEnvironment.
               ii. Let genvRec be genv's EnvironmentRecord.
               iii. Let benv be the running execution context's LexicalEnvironment.
               iv. Let benvRec be benv's EnvironmentRecord.
               v. Let fobj be ! benvRec.GetBindingValue(F, false).
               vii. Return NormalCompletion(empty).

B.3.4 FunctionDeclarations in IfStatement Statement Clauses

The following rules for IfStatement augment those in 13.6:

IfStatement[Yield, Return] :
The above rules are only applied when parsing code that is not strict mode code. If any such code is match by one of these rules subsequent processing of that code takes places as if each matching occurrence of `FunctionDeclaration[?Yield]` 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 13.15.1 is replaced with the following:

\[
\text{Catch} : \text{catch} \ ( \text{CatchParameter} ) \ \text{Block}
\]

- It is a Syntax Error if `BoundNames` of `CatchParameter` contains any duplicate elements.
- 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 `CatchParameter` is `CatchParameter : BindingIdentifier` and that element is only bound by a `VariableStatement`, 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.

This modified behaviour also applies to `var` and `function` declarations introduced by direct `eval` calls contained within the `Block` of a `Catch` clause. This change is accomplished by modify the algorithm of 18.2.1.2 as follows:

Step 5.d.ii.2.a.i is replaced by:

1. If `thisEnvRec` is not the Environment Record for a `Catch` clause, throw a `SyntaxError` exception.
2. If `name` is bound by any syntactic form other than a `FunctionDeclaration`, a `VariableStatement`, the `VariableDeclarationList` of a for statement, or the `ForBinding` of a for-in statement, throw a `SyntaxError` exception.

Step 9.d.ii.4.b.i is replaced by:

1. If `thisEnvRec` is not the Environment Record for a `Catch` clause, let `bindingExists` be `true`. 
Annex C
The Strict Mode of ECMAScript
(informative)

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).
- A conforming implementation, when processing strict mode code, 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`.
- A conforming implementation, when processing strict mode code, 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 `LeftHandSideExpression` must not evaluate to an unresolvable `Reference`. If it does a `ReferenceError` exception is thrown (6.2.3.2). The `LeftHandSideExpression` 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 (12.15).
- The identifier `eval` or `arguments` may not appear as the `LeftHandSideExpression` of an Assignment operator (12.15) or of a `UpdateExpression` (12.4) or as the `UnaryExpression` operated upon by a Prefix Increment (12.4.6) or a Prefix Decrement (12.4.7) operator.
- Arguments objects for strict mode functions define non-convertible accessor properties named "caller" and "callee" which throw a `TypeError` exception on access (9.2.7).
- 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. (9.2.12).
- 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 (9.2.1.2, 19.2.3.1, 19.2.3.3).
- 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 (12.5.3.1).
- When a `delete` operator occurs within strict mode code, a `TypeError` is thrown if the property to be deleted has the attribute `[[Configurable]]: false` (12.5.3.2).
- Strict mode code may not include a `WithStatement`. The occurrence of a `WithStatement` in such a context is a `SyntaxError` (13.1.1.1).
- It is a `SyntaxError` if a `TryStatement` with a `Catch` occurs within strict mode code and the `Identifier` of the `Catch` production is `eval` or `arguments` (13.1.5.1).
- 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, 19.2.1.1.1).
- 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 (16.2).
Annex D
Corrections and Clarifications in ECMAScript 2015 with Possible Compatibility Impact
(informative)

8.1.1.4.15-8.1.1.4.18: Edition 5 and 5.1 used a property existence test to determine whether a global object property corresponding to a new global declaration already existed. ECMAScript 2015 uses an own property existence test. This corresponds to what has been most commonly implemented by web browsers.

9.4.2.1: 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. ECMAScript 2015 specifies that the current array length must be captured after the possible occurrence of such side-effects.

20.3.1.15: Previous editions permitted the TimeClip abstract operation to return either +0 or -0 as the representation of a 0 time value. ECMAScript 2015 specifies that +0 always returned. This means that for ECMAScript 2015 the time value of a Date object is never observably -0 and methods that return time values never return -0.

20.3.1.16: 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 20.3.1.16 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. ECMAScript 2015 specifies the result to be the String value is "Invalid Date".

21.2.3.1, 21.2.3.2.4: 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.

22.1.3.25, 22.1.3.25.1: Previous editions did not specify how a NaN value returned by a comparefn was interpreted by Array.prototype.sort. ECMAScript 2015 specifies that such as value is treated as if +0 was returned from the comparefn. ECMAScript 2015 also specifies that ToNumber is applied to the result returned by a comparefn. In previous editions, the effect of a comparefn result that is not a Number value was implementation dependent. In practice, implementations call ToNumber.
Annex E
Additions and Changes That Introduce Incompatibilities with Prior Editions
(informative)

7.1.3.1: In ECMAScript 2015, ToNumber applied to a String value now recognizes and converts BinaryIntegerLiteral and OctalIntegerLiteral numeric strings. In previous editions such strings were converted to NaN.

6.2.3: In ECMAScript 2015, Function calls are not allowed to return a Reference value.

11.6: In ECMAScript 2015, the valid code points for an IdentifierName are specified in terms of the Unicode properties “ID_Start” and “ID_Continue”. In previous editions, the valid IdentifierName or Identifier code points were specified by enumerating various Unicode code point categories.

11.9.1: In ECMAScript 2015, Automatic Semicolon Insertion adds a semicolon at the end of a do-while statement if the semicolon is missing. This change aligns the specification with the actual behaviour of most existing implementations.

12.2.6.1: In ECMAScript 2015, it is no longer an early error to have duplicate property names in Object Initializers.

12.15.1: In ECMAScript 2015, 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.

13.2: In ECMAScript 2015, a StatementList beginning with the token let followed by the input elements LineTerminator then Identifier is the start of a LexicalDeclaration. In previous editions, automatic semicolon insertion would always insert a semicolon before the Identifier input element.

13.5: In ECMAScript 2015, a StatementListItem beginning with the token let followed by the token [ is the start of a LexicalDeclaration. In previous editions such a sequence would be the start of an ExpressionStatement.

13.6.7: In ECMAScript 2015, the normal completion value of an IfStatement is never the value empty. If no Statement part is evaluated or if the evaluated Statement part produces a normal completion whose value is empty, the completion value of the IfStatement is undefined.

13.7: In ECMAScript 2015, if the ( token of a for statement is immediately followed by the token sequence let [ then the let is treated as the start of a LexicalDeclaration. In previous editions such a token sequence would be the start of an Expression.

13.7: In ECMAScript 2015, if the ( token of a for-in statement is immediately followed by the token sequence let [ then the let is treated as the start of a ForDeclaration. In previous editions such a token sequence would be the start of an LeftHandSideExpression.

13.7: Prior to ECMAScript 2015, an initialization expression could appear as part of the VariableDeclaration that precedes the in keyword. The value of that expression was always discarded. In ECMAScript 2015, the ForBinding in that same position does not allow the occurrence of such an initializer.

13.7: In ECMAScript 2015, the completion value of an IterationStatement is never the value empty. If the Statement part of an IterationStatement is not evaluated or if the final evaluation of the Statement part produces a completion whose value is empty, the completion value of the IterationStatement is undefined.

13.11.7: In ECMAScript 2015, the normal completion value of a WithStatement is never the value empty. If evaluation of the Statement part of a WithStatement produces a normal completion whose value is empty, the completion value of the WithStatement is undefined.
13.12.11: In ECMAScript 2015, the completion value of a `SwitchStatement` is never the value `empty`. If the `CaseBlock` part of a `SwitchStatement` produces a completion whose value is `empty`, the completion value of the `SwitchStatement` is `undefined`.

13.15: In ECMAScript 2015, it is an early error for a `Catch` clause to contain a `var` declaration for the same `Identifier` that appears as the `Catch` clause parameter. In previous editions, such a variable declaration would be instantiated in the enclosing variable environment but the declaration’s `Initializer` value would be assigned to the `Catch` parameter.

13.15, 18.2.1.2: In ECMAScript 2015, a runtime `SyntaxError` is thrown if a `Catch` clause evaluates a non-strict direct `eval` whose `eval` code includes a `var` or `FunctionDeclaration` declaration that binds the same `Identifier` that appears as the `Catch` clause parameter.

13.15.8: In ECMAScript 2015, the completion value of a `TryStatement` is never the value `empty`. If the `Block` part of a `TryStatement` evaluates to a normal completion whose value is `empty`, the completion value of the `TryStatement` is `undefined`.

14.3.9: In ECMAScript 2015, 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 the previous edition, they were constructors and had a `prototype` property.

19.1.2.5: In ECMAScript 2015, 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 the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.6: In ECMAScript 2015, 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 the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.7: In ECMAScript 2015, if the argument to `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 the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.9: In ECMAScript 2015, if the argument to `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 the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.11: In ECMAScript 2015, if the argument to `Object.isExtensible` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.12: In ECMAScript 2015, if the argument to `Object.isFrozen` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.13: In ECMAScript 2015, if the argument to `Object.isSealed` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.14: In ECMAScript 2015, if the argument to `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 the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.1.2.15: In ECMAScript 2015, if the argument to `Object.preventExtensions` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In the previous edition, a non-object argument always causes a `TypeError` to be thrown.
19.1.2.17: In ECMAScript 2015, if the argument to `Object.seal` is not an object it is treated as if it was a non-extensible ordinary object with no own properties. In the previous edition, a non-object argument always causes a `TypeError` to be thrown.

19.2.3.2: In ECMAScript 2015, the `[[Prototype]]` internal slot of a `bound function` is set to the `[[GetPrototypeOf]]` value of its target function. In the previous edition, `[[Prototype]]` was always set to `%FunctionPrototype%`.

19.2.4.1: In ECMAScript 2015, the `length` property of function instances is configurable. In previous editions it was non-configurable.

19.5.6.2: In ECMAScript 2015, the `[[Prototype]]` internal slot of a `NativeError` constructor is the `Error` constructor. In previous editions it was the `Function` prototype object.

20.3.4 In ECMAScript 2015, the `Date` prototype object is not a `Date` instance. In previous editions it was a `Date` instance whose `TimeValue` was `NaN`.

21.1.3.10 In ECMAScript 2015, the `String.prototype.localeCompare` function must treat Strings that are canonically equivalent according to the Unicode standard as being identical. In previous editions implementations were permitted to ignore canonical equivalence and could instead use a bit-wise comparison.

21.1.3.22 and 21.1.3.24 In ECMAScript 2015, lowercase/upper 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 ECMAScript 2015, 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 7 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 ECMAScript 2015, 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 ECMAScript 2015, 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 ECMAScript 2015, `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.
Annex F

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(informative)

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Annex G

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