# Contents

<table>
<thead>
<tr>
<th>Section Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>v</td>
</tr>
<tr>
<td>1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>2 Conformance</td>
<td>1</td>
</tr>
<tr>
<td>3 Normative references</td>
<td>1</td>
</tr>
<tr>
<td>4 Overview</td>
<td>1</td>
</tr>
<tr>
<td>4.1 Web Scripting</td>
<td>2</td>
</tr>
<tr>
<td>4.2 Language Overview</td>
<td>2</td>
</tr>
<tr>
<td>4.2.1 Objects</td>
<td>3</td>
</tr>
<tr>
<td>4.2.2 The Strict Variant of ECMAScript</td>
<td>4</td>
</tr>
<tr>
<td>4.3 Terms and definitions</td>
<td>4</td>
</tr>
<tr>
<td>5 Notational Conventions</td>
<td>7</td>
</tr>
<tr>
<td>5.1 Syntactic and Lexical Grammars</td>
<td>7</td>
</tr>
<tr>
<td>5.1.1 Context-Free Grammars</td>
<td>7</td>
</tr>
<tr>
<td>5.1.2 The Lexical and RegExp Grammars</td>
<td>8</td>
</tr>
<tr>
<td>5.1.3 The Numeric String Grammar</td>
<td>8</td>
</tr>
<tr>
<td>5.1.4 The Syntactic Grammar</td>
<td>8</td>
</tr>
<tr>
<td>5.1.5 The JSON Grammar</td>
<td>9</td>
</tr>
<tr>
<td>5.1.6 Grammar Notation</td>
<td>9</td>
</tr>
<tr>
<td>5.2 Algorithm Conventions</td>
<td>12</td>
</tr>
<tr>
<td>5.3 Static Semantic Rules</td>
<td>13</td>
</tr>
<tr>
<td>6 Source Text</td>
<td>14</td>
</tr>
<tr>
<td>7 Lexical Conventions</td>
<td>15</td>
</tr>
<tr>
<td>7.1 Unicode Format-Control Characters</td>
<td>16</td>
</tr>
<tr>
<td>7.2 White Space</td>
<td>16</td>
</tr>
<tr>
<td>7.3 Line Terminators</td>
<td>17</td>
</tr>
<tr>
<td>7.4 Comments</td>
<td>17</td>
</tr>
<tr>
<td>7.5 Tokens</td>
<td>18</td>
</tr>
<tr>
<td>7.6 Identifier Names and Identifiers</td>
<td>19</td>
</tr>
<tr>
<td>7.6.1 Reserved Words</td>
<td>20</td>
</tr>
<tr>
<td>7.7 Punctuators</td>
<td>21</td>
</tr>
<tr>
<td>7.8 Literals</td>
<td>21</td>
</tr>
<tr>
<td>7.8.1 Null Literals</td>
<td>21</td>
</tr>
<tr>
<td>7.8.2 Boolean Literals</td>
<td>21</td>
</tr>
<tr>
<td>7.8.3 Numeric Literals</td>
<td>22</td>
</tr>
<tr>
<td>7.8.4 Regular Expression Literals</td>
<td>23</td>
</tr>
<tr>
<td>7.8.5 Template Literal Lexical Components</td>
<td>26</td>
</tr>
<tr>
<td>7.8.6 String Literals</td>
<td>28</td>
</tr>
<tr>
<td>7.9 Automatic Semicolon Insertion</td>
<td>30</td>
</tr>
<tr>
<td>7.9.1 Rules of Automatic Semicolon Insertion</td>
<td>30</td>
</tr>
<tr>
<td>7.9.2 Examples of Automatic Semicolon Insertion</td>
<td>31</td>
</tr>
<tr>
<td>8 Types</td>
<td>32</td>
</tr>
<tr>
<td>8.1 ECMAScript Language Types</td>
<td>32</td>
</tr>
<tr>
<td>8.1.1 The Undefined Type</td>
<td>33</td>
</tr>
<tr>
<td>8.1.2 The Null Type</td>
<td>33</td>
</tr>
<tr>
<td>8.1.3 The Boolean Type</td>
<td>33</td>
</tr>
<tr>
<td>8.1.4 The String Type</td>
<td>33</td>
</tr>
<tr>
<td>8.1.5 The Number Type</td>
<td>33</td>
</tr>
<tr>
<td>8.1.6 The Symbol Type</td>
<td>34</td>
</tr>
</tbody>
</table>
8.2.2 The List and Record Specification Type ................................................................. 47
8.2.3 The Completion Record Specification Type ............................................................. 47
8.2.4 The Reference Specification Type .............................................................................. 48
8.2.5 The Property Descriptor Specification Type ............................................................... 49
8.2.6 The Lexical Environment and Environment Record Specification Types ...................... 52
8.3 Ordinary Object Internal Methods and Internal Data Properties .................................... 52
8.3.1 [[GetInheritance]] ( ) .............................................................................................. 52
8.3.2 [[GetInheritance]] (V) ............................................................................................. 52
8.3.3 [[HasIntegrity]] (Level) ............................................................................................ 53
8.3.4 [[SetIntegrity]] (Level) ........................................................................................... 53
8.3.5 [[HasOwnProperty]] (P) .......................................................................................... 53
8.3.6 [[GetOwnProperty]] (P) .......................................................................................... 53
8.3.7 [[DefineOwnProperty]] (P, Desc) ............................................................................. 54
8.3.8 [[HasProperty]](P) .................................................................................................. 55
8.3.9 [[Get]] (P, Receiver) ............................................................................................... 55
8.3.10 [[Set]] (P, V, Receiver) .......................................................................................... 56
8.3.11 [[Delete]] (P) ........................................................................................................ 56
8.3.12 [[Enumerate]] () ................................................................................................... 57
8.3.13 [[OwnPropertyKeys]] () ...................................................................................... 57
8.3.14 ObjectCreate(proto, internalDataList) Abstract Operation ..................................... 57
8.3.15 Ordinary Function Objects ..................................................................................... 58
8.4 Built-in Exotic Object Internal Methods and Data Fields ............................................. 62
8.4.1 Bound Function Exotic Objects ................................................................................ 62
8.4.2 Array Exotic Objects .............................................................................................. 63
8.4.3 String Exotic Objects ............................................................................................. 65
8.4.4 Exotic Arguments Objects ...................................................................................... 67
8.4.5 Integer Indexed Delegation Exotic Objects .............................................................. 67
8.4.6 Built-in Function Objects ......................................................................................... 68
8.5 Proxy Object Internal Methods and Internal Data Properties .................................... 68
8.5.1 [[GetInheritance]] ( ) .............................................................................................. 70
8.5.2 [[GetInheritance]] (V) ............................................................................................. 70
8.5.3 [[HasIntegrity]] (Level) .......................................................................................... 70
8.5.4 [[SetIntegrity]] (Level) ............................................................................................ 70
8.5.5 [[HasOwnProperty]] (P) .......................................................................................... 70
8.5.6 [[GetOwnProperty]] (P) .......................................................................................... 71
8.5.7 [[DefineOwnProperty]] (P, Desc) ............................................................................. 72
8.5.8 [[HasProperty]](P) .................................................................................................. 73
8.5.9 [[Get]] (P, Receiver) ............................................................................................... 73
8.5.10 [[Set]] (P, V, Receiver) .......................................................................................... 74
8.5.11 [[Delete]] (P) ........................................................................................................ 74
8.5.12 [[Enumerate]] () ................................................................................................... 75
8.5.13 [[OwnPropertyKeys]] () ...................................................................................... 75
8.5.14 [[Call]] (thisArgument, argumentsList) ................................................................. 75
8.5.15 [[Construct]] (InternalMethod) ............................................................................. 76
9 Abstract Operations ........................................................................................................ 76
9.1 Type Conversion and Testing ......................................................................................... 76
9.1.1 ToNumber ............................................................................................................... 78
9.1.2 ToBoolean .............................................................................................................. 78
9.1.3 ToNumber ............................................................................................................... 78
9.1.4 ToInteger ............................................................................................................... 81
9.1.5 ToInt32: (Signed 32 Bit Integer) .............................................................................. 81
9.1.6 ToUint32: (Signed 32 Bit Integer) ............................................................................ 81
9.1.7 ToInt16: (Signed 16 Bit Integer) .............................................................................. 82
9.1.8 ToUint16: (Signed 16 Bit Integer) ............................................................................ 82
9.1.9 ToObject ................................................................................................................ 83
9.1.10 ToPropertyKey ...................................................................................................... 84
9.2 Testing and Comparison Operations ............................................................................. 84
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.7.2 The Number Constructor</td>
<td>282</td>
</tr>
<tr>
<td>15.7.3 Properties of the Number Constructor</td>
<td>283</td>
</tr>
<tr>
<td>15.7.4 Properties of the Number Prototype Object</td>
<td>285</td>
</tr>
<tr>
<td>15.7.5 Properties of Number Instances</td>
<td>289</td>
</tr>
<tr>
<td>15.8 The Math Object</td>
<td>289</td>
</tr>
<tr>
<td>15.8.1 Value Properties of the Math Object</td>
<td>289</td>
</tr>
<tr>
<td>15.8.2 Function Properties of the Math Object</td>
<td>289</td>
</tr>
<tr>
<td>15.9 Date Objects</td>
<td>298</td>
</tr>
<tr>
<td>15.9.1 Overview of Date Objects and Definitions of Abstract Operations</td>
<td>298</td>
</tr>
<tr>
<td>15.9.2 The Date Constructor Called as a Function</td>
<td>303</td>
</tr>
<tr>
<td>15.9.3 The Date Constructor</td>
<td>304</td>
</tr>
<tr>
<td>15.9.4 Properties of the Date Constructor</td>
<td>304</td>
</tr>
<tr>
<td>15.9.5 Properties of the Date Prototype Object</td>
<td>306</td>
</tr>
<tr>
<td>15.9.6 Properties of Date Instances</td>
<td>314</td>
</tr>
<tr>
<td>15.10 RegExp (Regular Expression) Objects</td>
<td>314</td>
</tr>
<tr>
<td>15.10.1 Patterns</td>
<td>314</td>
</tr>
<tr>
<td>15.10.2 Pattern Semantics</td>
<td>316</td>
</tr>
<tr>
<td>15.10.3 The RegExp Constructor Called as a Function</td>
<td>329</td>
</tr>
<tr>
<td>15.10.4 The RegExp Constructor</td>
<td>330</td>
</tr>
<tr>
<td>15.10.5 Properties of the RegExp Constructor</td>
<td>330</td>
</tr>
<tr>
<td>15.10.6 Properties of the RegExp Prototype Object</td>
<td>330</td>
</tr>
<tr>
<td>15.10.7 Properties of RegExp Instances</td>
<td>337</td>
</tr>
<tr>
<td>15.11 Error Objects</td>
<td>337</td>
</tr>
<tr>
<td>15.11.1 The Error Constructor Called as a Function</td>
<td>338</td>
</tr>
<tr>
<td>15.11.2 The Error Constructor</td>
<td>338</td>
</tr>
<tr>
<td>15.11.3 Properties of the Error Constructor</td>
<td>338</td>
</tr>
<tr>
<td>15.11.4 Properties of the Error Prototype Object</td>
<td>339</td>
</tr>
<tr>
<td>15.11.5 Properties of Error Instances</td>
<td>340</td>
</tr>
<tr>
<td>15.11.6 Native Error Types Used in This Standard</td>
<td>340</td>
</tr>
<tr>
<td>15.11.7 Native Error Object Structure</td>
<td>340</td>
</tr>
<tr>
<td>15.12 The JSON Object</td>
<td>343</td>
</tr>
<tr>
<td>15.12.1 The JSON Grammar</td>
<td>343</td>
</tr>
<tr>
<td>15.12.2 JSON.parse (text)</td>
<td>345</td>
</tr>
<tr>
<td>15.12.3 JSON.stringify (value, [space])</td>
<td>346</td>
</tr>
<tr>
<td>15.13 Binary Data Objects</td>
<td>350</td>
</tr>
<tr>
<td>15.13.1 The BinaryData Module</td>
<td>350</td>
</tr>
<tr>
<td>15.13.2 The BinaryData.Type Object</td>
<td>350</td>
</tr>
<tr>
<td>15.13.3 The BinaryData.ArrayType Object</td>
<td>350</td>
</tr>
<tr>
<td>15.13.4 The BinaryData.StructType Object</td>
<td>350</td>
</tr>
<tr>
<td>15.13.5 ArrayBuffer Objects</td>
<td>350</td>
</tr>
<tr>
<td>15.13.6 TypedArray Objects</td>
<td>354</td>
</tr>
<tr>
<td>15.13.7 DataView Objects</td>
<td>362</td>
</tr>
<tr>
<td>15.14 Map Objects</td>
<td>367</td>
</tr>
<tr>
<td>15.14.1 The Map Constructor Called as a Function</td>
<td>367</td>
</tr>
<tr>
<td>15.14.2 The Map Constructor</td>
<td>368</td>
</tr>
<tr>
<td>15.14.3 Properties of the Map Constructor</td>
<td>368</td>
</tr>
<tr>
<td>15.14.4 Properties of the Map Prototype Object</td>
<td>368</td>
</tr>
<tr>
<td>15.14.5 Properties of Map Instances</td>
<td>372</td>
</tr>
<tr>
<td>15.14.6 Map Iterator Object Structure</td>
<td>372</td>
</tr>
<tr>
<td>15.15 WeakMap Objects</td>
<td>373</td>
</tr>
<tr>
<td>15.15.1 The WeakMap Constructor Called as a Function</td>
<td>374</td>
</tr>
<tr>
<td>15.15.2 The WeakMap Constructor</td>
<td>375</td>
</tr>
<tr>
<td>15.15.3 Properties of the WeakMap Constructor</td>
<td>375</td>
</tr>
<tr>
<td>15.15.4 Properties of the WeakMap Prototype Object</td>
<td>375</td>
</tr>
<tr>
<td>15.15.5 Properties of WeakMap Instances</td>
<td>377</td>
</tr>
<tr>
<td>15.16 Set Objects</td>
<td>377</td>
</tr>
<tr>
<td>15.16.1 The Set Constructor Called as a Function</td>
<td>377</td>
</tr>
<tr>
<td>15.16.2 The Set Constructor</td>
<td>378</td>
</tr>
<tr>
<td>15.16.3 Properties of the Set Constructor</td>
<td>378</td>
</tr>
</tbody>
</table>
Introduction

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

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

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


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

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

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

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

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

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

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ECMAScript Language Specification

1 Scope
This Standard defines the ECMAScript scripting language.

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

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

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

A conforming implementation of ECMAScript is permitted to support program and regular expression syntax not described in this specification. In particular, a conforming implementation of ECMAScript is permitted to support program syntax that makes use of the "future reserved words" listed in 7.6.1.2 of this specification.

3 Normative references
The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.
ISO/IEC 9899:1996, Programming Languages – C, including amendment 1 and technical corrigenda 1 and 2
The Unicode Standard, Version 5.0, as amended by Unicode 5.1.0, or successor
Unicode Standard Annex #15, Unicode Normalization Forms, version Unicode 5.1.0, or successor
Unicode Standard Annex #31, Unicode Identifiers and Pattern Syntax, version Unicode 5.1.0, or successor.

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

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

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


4.1 Web Scripting

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

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

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

4.2 Language Overview

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

ECMAScript is object-based: basic language and host facilities are provided by objects, and an ECMAScript program is a cluster of communicating objects. An ECMAScript object is a collection of properties each with zero or more attributes that determine how each property can be used—for example, when the Writable attribute for a property is set to false, any attempt by executed ECMAScript code to change the value of the property fails. Properties are containers that hold other objects, primitive values, or functions. A primitive value is a member of one of the following built-in types: Undefined, Null, Symbol, Boolean, Number, and String; an object is a member of the remaining built-in type Object; and a function is a callable object. A function that is associated with an object via a property is a method.

ECMAScript defines a collection of built-in objects that round out the definition of ECMAScript entities. These built-in objects include the global object, the Object object, the Function object, the Array object, the String
object, the `Boolean` object, the `Number` object, the `Math` object, the `RegExp` object, the `JSON` object, and the `Error` objects `Error`, `EvalError`, `RangeError`, `ReferenceError`, `SyntaxError`, `TypeError` and `URIError`.

ECMAScript also defines a set of built-in `operators`. ECMAScript operators include various unary operations, multiplicative operators, additive operators, bitwise shift operators, relational operators, equality operators, binary bitwise operators, binary logical operators, assignment operators, and the comma operator.

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

### 4.2.1 Objects

ECMAScript does not use classes such as those in C++, Smalltalk, or Java. Instead objects may be created in various ways including via a literal notation or via `constructors` which create objects and then execute code that initialises all or part of them by assigning initial values to their properties. Each constructor is a function that has a property named "prototype" that is used to implement prototype-based inheritance and shared properties. Objects are created by using constructors in `new` expressions; for example, `new Date(2009,11)` creates a new `Date` object. Invoking a constructor without using `new` has consequences that depend on the constructor. For example, `Date()` produces a string representation of the current date and time rather than an object.

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

![Figure 1 — Object/Prototype Relationships](image)

In a class-based object-oriented language, in general, state is carried by instances, methods are carried by classes, and inheritance is only of structure and behaviour. In ECMAScript, the state and methods are carried by objects, while structure, behaviour, and state are all inherited.
All objects that do not directly contain a particular property that their prototype contains share that property and its value. Figure 1 illustrates this:

**Figure 1**

CF is a constructor (and also an object). Five objects have been created by using `new` expressions: cf1, cf2, cf3, cf4, and cf5. Each of these objects contains properties named q1 and q2. The dashed lines represent the implicit prototype relationship; so, for example, cf1’s prototype is CFp. The constructor, CF, has two properties itself, named P1 and P2, which are not visible to CFp, cf1, cf2, cf3, cf4, or cf5. The property named CFP1 in CFp is shared by cf1, cf2, cf3, cf4, and cf5 (but not by CF), as are any properties found in CFp’s implicit prototype chain that are not named q1, q2, or CFP1. Notice that there is no implicit prototype link between CF and CFp.

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

### 4.2.2 The Strict Variant of ECMAScript

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

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

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

### 4.3 Terms and definitions

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

**4.3.1 type**

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

**4.3.2 primitive value**

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

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

**4.3.3 object**

member of the type Object

**NOTE**  
An object is a collection of properties and has a single prototype object. The prototype may be the null value.
4.3.4 constructor
function object that creates and initialises objects

NOTE The value of a constructor’s "prototype" property is a prototype object that is used to implement inheritance and shared properties.

4.3.5 prototype
object that provides shared properties for other objects

NOTE When a constructor creates an object, that object implicitly references the constructor’s "prototype" property for the purpose of resolving property references. The constructor’s "prototype" property can be referenced by the program expression constructor.prototype, and properties added to an object’s prototype are shared, through inheritance, by all objects sharing the prototype. Alternatively, a new object may be created with an explicitly specified prototype by using the Object.create built-in function.

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

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

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

4.3.8 standard object
object whose semantics are defined by this specification.

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

NOTE Standard built-in objects are defined in this specification, and an ECMAScript implementation may specify and define others. 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 data property 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 integers

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 data property whose value is the String value. A String object can be coerced to a String value by calling the `String` constructor as a function (15.5.1).

### 4.3.20 Number value

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

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

### 4.3.21 Number type

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

### 4.3.22 Number object

Member of the `Object` type that is an instance of the standard built-in `Number` constructor

NOTE  A Number object is created by using the `Number` constructor in a `new` expression, supplying a Number value as an argument. The resulting object has an internal data property whose value is the Number value. A Number object can be coerced to a Number value by calling the `Number` constructor as a function (15.7.1).

### 4.3.23 Infinity

Number value that is the positive infinite Number value

### 4.3.24 NaN

Number value that is a IEEE 754 "Not-a-Number" value
4.3.25
function
member of the Object type that may be invoked as a subroutine

NOTE: In addition to its properties, a function contains executable code and state that determine how it behaves when invoked. A function’s code may or may not be written in ECMAScript.

4.3.26
built-in function
built-in object that is a function

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

4.3.27
property
association between a name and a value that is a part of an object

NOTE: Depending upon the form of the property the value may be represented either directly as a data value (a primitive value, an object, or a function object) or indirectly by a pair of accessor functions.

4.3.28
method
function that is the value of a property

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

4.3.29
built-in method
method that is a built-in function

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

4.3.30
attribute
internal value that defines some characteristic of a property

4.3.31
own property
property that is directly contained by its object

4.3.32
inherited property
property of an object that is not an own property but is a property (either own or inherited) of the object’s prototype

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 7. This grammar has as its terminal symbols characters (Unicode code units) that conform to the rules for SourceCharacter defined in Clause 6. It defines a set of productions, starting from the goal symbol InputElementDiv or InputElementRegExp, that describe how sequences of such characters are translated into a sequence of input elements.

Input elements other than white space and comments form the terminal symbols for the syntactic grammar for ECMAScript and are called ECMAScript tokens. These tokens are the reserved words, identifiers, literals, and punctuators of the ECMAScript language. Moreover, line terminators, although not considered to be tokens, also become part of the stream of input elements and guide the process of automatic semicolon insertion (7.9). Simple white space and single-line comments are discarded and do not appear in the stream of input elements for the syntactic grammar. A MultiLineComment (that is, a comment of the form "\/*...*/" regardless of whether it spans more than one line) is likewise simply discarded if it contains no line terminator; but if a MultiLineComment contains one or more line terminators, then it is replaced by a single line terminator, which becomes part of the stream of input elements for the syntactic grammar.

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

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

5.1.3 The Numeric String Grammar

Another grammar is used for translating Strings into numeric values. This grammar is similar to the part of the lexical grammar having to do with numeric literals and has as its terminal symbols SourceCharacter. This grammar appears in 9.3.1.

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

5.1.4 The Syntactic Grammar

The syntactic grammar for ECMAScript is given in clauses 11, 12, 13 and 14. This grammar has ECMAScript tokens defined by the lexical grammar as its terminal symbols (5.1.2). It defines a set of productions, starting from the goal symbol Script, that describe how sequences of tokens can form syntactically correct independent components of an ECMAScript program.

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

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

The syntactic grammar as presented in clauses 11, 12, 13 and 14 is actually not a complete account of which token sequences are accepted as correct ECMAScript scripts. Certain additional token sequences are also accepted, namely, those that would be described by the grammar if only semicolons were added to the sequence in certain places (such as before line terminator characters). Furthermore, certain token sequences that are described by the grammar are not considered acceptable if a terminator character appears in certain “awkward” places.
In certain cases in order to avoid ambiguities the syntactic grammar uses generalize productions that permit token sequences that are not valid ECMAScript scripts. For example, this technique is used in with object literals and object destructuring patterns. In such cases a more restrictive supplemental grammar is provided that further restricts the acceptable token sequences. In certain contexts, when explicitly specific, the input elements corresponding to such a production are parsed again using a goal symbol of a supplemental grammar. The script is syntactically in error if the tokens in the stream of input elements cannot be parsed as a single instance of the supplemental goal symbol, with no tokens left over.

5.1.5 The JSON Grammar

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

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

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

5.1.6 Grammar Notation

Terminal symbols of the lexical, RegExp, and numeric string grammars, and some of the terminal symbols of the other grammars, are shown in fixed width font both in the productions of the grammars and throughout this specification whenever the text directly refers to such a terminal symbol. These are to appear in a script either exactly as written or using equivalent Unicode escape sequences (see clause 6). All terminal symbol characters specified in this way are to be understood as the appropriate Unicode character from the ASCII range, as opposed to any similar-looking characters from other Unicode ranges.

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

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

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

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

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

The subscripted suffix "opt", which may appear after a terminal or nonterminal, indicates an optional symbol. The alternative containing the optional symbol actually specifies two right-hand sides, one that omits the optional element and one that includes it. This means that:
VariableDeclaration: Identifier Initialiser\textsubscript{opt}
is a convenient abbreviation for:
VariableDeclaration: Identifier Identifier Initialiser

and that:

\begin{align*}
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn}_{\text{opt}} \ ; \ \text{Expression}_{\text{opt}} \ ; \ \text{Expression}_{\text{opt}} \ ) \ \text{Statement} \\
\end{align*}
is a convenient abbreviation for:

\begin{align*}
\text{IterationStatement} & : \text{for} \ ( \ ; \ \text{Expression}_{\text{opt}} \ ; \ \text{Expression}_{\text{opt}} \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn} ; \ \text{Expression}_{\text{opt}} \ ; \ \text{Expression}_{\text{opt}} \ ) \ \text{Statement} \\
\end{align*}

which in turn is an abbreviation for:

\begin{align*}
\text{IterationStatement} & : \text{for} \ ( \ ; ; \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ ; \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ ; \ \text{Expression} \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn} ; \ ; \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn} ; \ ; \ \text{Expression} \ ) \ \text{Statement} \\
\end{align*}

which in turn is an abbreviation for:

\begin{align*}
\text{IterationStatement} & : \text{for} \ ( \ ; ; ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ ; \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ ; \ \text{Expression} \ ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn} ; \ ; ) \ \text{Statement} \\
\text{IterationStatement} & : \text{for} \ ( \ \text{ExpressionNoIn} ; \ ; \ \text{Expression} \ ) \ \text{Statement} \\
\end{align*}

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

When the words \textit{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:

\begin{align*}
\text{NonZeroDigit} & : \text{one of} \\
& \ {1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9} \\
\end{align*}

which is merely a convenient abbreviation for:
NonZeroDigit ::  
1  
2  
3  
4  
5  
6  
7  
8  
9

If the phrase "empty" appears as the right-hand side of a production, it indicates that the production’s right-hand side contains no terminals or nonterminals.

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

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

```
DecimalDigits :: 
DecimalDigit 
DecimalDigits DecimalDigit
```

the definition

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

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

When an alternative in a production of the lexical grammar or the numeric string grammar appears to be a multi-character token, it represents the sequence of characters that would make up such a token.
The right-hand side of a production may specify that certain expansions are not permitted by using the phrase "but not" and then indicating the expansions to be excluded. For example, the production:

```
Identifier ::=
    IdentifierName but not ReservedWord
```

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

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

```
SourceCharacter ::=
    any Unicode character
```

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

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

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

```
Block : { StatementList } 
```

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

```
Runtime Semantics: Evaluation
```

```
Block : { StatementList } 
```

1. Return the result of evaluating StatementList

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

1. Top-level step
   a. Substep.
A step or substep may be written as an "if" predicate that conditions its substeps. In this case, the substeps are only applied if the predicate is true. If a step or substep begins with the word "else", it is a predicate that is the negation of the preceding "if" predicate step at the same level.

A step may specify the iterative application of its substeps.

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

Mathematical operations such as addition, subtraction, negation, multiplication, division, and the mathematical functions defined later in this clause should always be understood as computing exact mathematical results on mathematical real numbers, which do not include infinities and do not include a negative zero that is distinguished from positive zero. Algorithms in this standard that model floating-point arithmetic include explicit steps, where necessary, to handle infinities and signed zero and to perform rounding. If a mathematical operation or function is applied to a floating-point number, it should be understood as being applied to the exact mathematical value represented by that floating-point number; such a floating-point number must be finite, and if it is \(+0\) or \(-0\) then the corresponding mathematical value is simply 0.

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

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

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

The notation \(x \bmod y\) (\(y\) must be finite and nonzero) computes a value \(k\) of the same sign as \(y\) (or zero) such that \(\text{abs}(k) < \text{abs}(y)\) and \(x-k=q\times y\) for some integer \(q\).

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

5.3 Static Semantic Rules

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

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

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

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

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

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

6 Source Text

Syntax

SourceCharacter ::= any Unicode character

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

The phrase “code point” refers to such a Unicode scalar value. “Unicode character” only refers to entities represented by single Unicode scalar values: the components of a combining character sequence are still individual “Unicode characters,” even though a user might think of the whole sequence as a single character.

In string literals, regular expression literals, template literals and identifiers, any Unicode characters may also be expressed as a Unicode escape sequence that explicitly express a code point’s numeric value. Within a comment, such an escape sequence is effectively ignored as part of the comment. Within other contexts, such an escape sequence contextually contributes one Unicode character.

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

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

Static Semantics: UTF-16 Encoding

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

1. Assert: \( 0 \leq cp \leq 0x10FFFF \)
2. If \( cp \leq 65535 \), then return \( cp \).
3. Let \( \text{c2i} \) be \( \text{Floor}(cp - 65536) / 1024 \) + 55296. NOTE 55296 is 0xD800.
4. Let $cu_2$ be $((cp - 65536) \text{mod} 1024) + 56320$. NOTE $56320$ is 0xDC00.
5. Return the code unit sequence consisting of $cu_1$ followed by $cu_2$.

7 Lexical Conventions

The source text of an ECMAScript script is first converted into a sequence of input elements, which are tokens, line terminators, comments, or white space. The source text is scanned from left to right, repeatedly taking the longest possible sequence of characters as the next input element.

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

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

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

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

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

**Syntax**

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

- `InputElementRegExp ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  RightBracePunctuator
  RegularExpressionLiteral`

- `InputElementTemplateTail ::
  WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator
  TemplateSubstitutionTail`

Commented [AWB93]: May need to also say something about `TemplateSubstitutionTail`. Also need to consider with there are any ASI issues concerning it.
7.1 Unicode Format-Control Characters

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

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

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

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

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

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Name</th>
<th>Formal Name</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>Byte Order Mark</td>
<td>&lt;BOM&gt;</td>
<td>WhiteSpace</td>
</tr>
</tbody>
</table>

7.2 White Space

White space characters are used to improve source text readability and to separate tokens (indivisible lexical units) from each other, but are otherwise insignificant. White space characters may occur between any two tokens and at the start or end of input. White space characters may occur within a `StringLiteral`, a `RegularExpressionLiteral`, a `Template`, or a `TemplateSubstitutionTail` where they are considered significant characters forming part of a literal value. They may also occur within a `Comment`, but cannot appear within any other kind of token.

The ECMAScript white space characters are listed in Table 2.

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Name</th>
<th>Formal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+0009</td>
<td>Tab</td>
<td>&lt;TAB&gt;</td>
</tr>
<tr>
<td>U+000B</td>
<td>Vertical Tab</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>U+000C</td>
<td>Form Feed</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;NBS&gt;</td>
</tr>
<tr>
<td>U+FEFF</td>
<td>Byte Order Mark</td>
<td>&lt;BOM&gt;</td>
</tr>
<tr>
<td>Other category “Zs”</td>
<td>Any other Unicode space separator</td>
<td>&lt;USP&gt;</td>
</tr>
</tbody>
</table>

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

Like white space characters, line terminator characters are used to improve source text readability and to separate tokens (indivisible lexical units) from each other. However, unlike white space characters, line terminators have some influence over the behaviour of the syntactic grammar. In general, line terminators may occur between any two tokens, but there are a few places where they are forbidden by the syntactic grammar. Line terminators also affect the process of automatic semicolon insertion (7.9). A line terminator cannot occur within any token except a StringLiteral, Template, or TemplateSubstitutionTail. Line terminators may only occur within a StringLiteral token as part of a LineContinuation.

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

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

The ECMAScript line terminator characters are listed in Table 3.

<table>
<thead>
<tr>
<th>Code Point</th>
<th>Name</th>
<th>Formal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+000A</td>
<td>Line Feed</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>U+000D</td>
<td>Carriage Return</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>U+2028</td>
<td>Line separator</td>
<td>&lt;LS&gt;</td>
</tr>
<tr>
<td>U+2029</td>
<td>Paragraph separator</td>
<td>&lt;PS&gt;</td>
</tr>
</tbody>
</table>

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

Syntax

LineTerminator ::=
  \<LF\>
  \<CR\>
  \<LS\>
  \<PS\>

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

7.4 Comments

Comments can be either single or multi-line. Multi-line comments cannot nest.
Because a single-line comment can contain any Unicode character except a LineTerminator character, and because of the general rule that a token is always as long as possible, a single-line comment always consists of all characters from the // marker to the end of the line. However, the LineTerminator at the end of the line is not considered to be part of the single-line comment; it is recognised separately by the lexical grammar and becomes part of the stream of input elements for the syntactic grammar. This point is very important, because it implies that the presence or absence of single-line comments does not affect the process of automatic semicolon insertion (see 7.9).

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

Syntax

Comment ::
  MultiLineComment
  SingleLineComment

MultiLineComment ::
  /\ MultiLineCommentChars* /

MultiLineCommentChars ::
  MultiLineNotAsteriskChar MultiLineCommentChars* PostAsteriskCommentChars* opt

PostAsteriskCommentChars ::
  MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentChars* PostAsteriskCommentChars* opt

MultiLineNotAsteriskChar ::
  SourceCharacter but not *

MultiLineNotForwardSlashOrAsteriskChar ::
  SourceCharacter but not one of / or *

SingleLineComment ::
  // SingleLineCommentChars*

SingleLineCommentChars ::
  SingleLineCommentChar SingleLineCommentChars* opt

SingleLineCommentChar ::
  SourceCharacter but not LineTerminator

7.5 Tokens

Syntax

Token ::
  IdentifierName
  Punctuator
  NumericLiteral
  StringLiteral
  Template

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

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

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

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

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

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

**Syntax**

```
Identifier :: IdentifierName but not ReservedWord

IdentifierName :: IdentifierStart IdentifierName IdentifierPart

IdentifierStart :: UnicodeIDStart $ UnicodeEscapeSequence

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

```
UnicodeIDStart ::
  any Unicode character with the Unicode property “ID_Start”.

UnicodeIDContinue ::
  any Unicode character with the Unicode property “ID_Continue”
```
The definitions of the nonterminal `UnicodeEscapeSequence` is given in 7.8.6.

**Static Semantics:** `StringValue`

`Identifier :: IdentifierName but not ReservedWord`

1. Return the `StringValue` of `IdentifierName`.

`IdentifierName :: IdentifierStart IdentifierName IdentiferPart`

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

### 7.6.1 Reserved Words

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

**Syntax**

`ReservedWord :: Keyword FutureReservedWord NullLiteral BooleanLiteral`

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

#### 7.6.1.1 Keywords

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

**Syntax**

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

#### 7.6.1.2 Future Reserved Words

The following words are used as keywords in proposed extensions and are therefore reserved to allow for the possibility of future adoption of those extensions.
The following tokens are also considered to be **FutureReservedWords** when they occur within strict mode code (see 10.1.1). The occurrence of any of these tokens within strict mode code in any context where the occurrence of a **FutureReservedWord** would produce an error must also produce an equivalent error:

```
   implements private public yield
   interface package protected static
```

### 7.7 Punctuators

**Syntax**

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

```
   implements private public yield
   interface package protected static
```

#### Commented [AWB86]: It isn’t clear that extends actually needs to be reserved. It’s only usage is highly contextual.

#### Commented [AWB87]: Move to keywords
7.8.3 Numeric Literals

Syntax

NumericLiteral ::
    DecimalLiteral
    BinaryIntegerLiteral
    OctalIntegerLiteral
    HexIntegerLiteral

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

DecimalIntegerLiteral ::
    0
    NonZeroDigit DecimalDigits opt

DecimalDigits ::
    DecimalDigit
    DecimalDigits DecimalDigit

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

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

ExponentPart ::
    ExponentIndicator SignedInteger

ExponentIndicator :: one of
    e E

SignedInteger ::
    DecimalDigits
    + DecimalDigits
    - DecimalDigits

BinaryIntegerLiteral ::
    0b BinaryDigit
    0B BinaryDigit
    BinaryIntegerLiteral BinaryDigit

BinaryDigit :: one of
0 1

OctalIntegerLiteral ::
    0o OctalDigit
    0O OctalDigit
    OctalIntegerLiteral OctalDigit

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

HexIntegerLiteral ::
    0x HexDigits
    0X HexDigits

Commented [AWB78]: From March 29 meeting notes: Hex floating point literals:
Waldemar: Other languages include these things. They're rarely used
but when you want one, you really want one. Use cases are similar to
that of hex literals.
Will explore adding them.
MarkM: 0x.3.1 currently evaluates to undefined. This would be
a breaking change.
Waldemar: Not clear anyone would notice. How did other
languages deal with this?

Commented [AWB79]: The various Digit productions could be refactored to have less redundancy.
HexDigit ::
  HexDigit
  HexDigits HexDigit

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

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

NOTE For example:

3in

is an error and not the two input elements 3 and 1a.

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

Static Semantics: MV’s

A numeric literal stands for a value of the Number type. This value is determined in two steps: first, a mathematical value (MV) is derived from the literal; second, this mathematical value is rounded as described below.

- The MV of NumericLiteral :: DecimalLiteral is the MV of DecimalLiteral.
- The MV of NumericLiteral :: BinaryIntegerLiteral is the MV of BinaryIntegerLiteral.
- The MV of NumericLiteral :: OctalIntegerLiteral is the MV of OctalIntegerLiteral.
- The MV of NumericLiteral :: HexIntegerLiteral is the MV of HexIntegerLiteral.
- The MV of DecimalLiteral :: DecimalIntegerLiteral . is the MV of DecimalIntegerLiteral.
- The MV of DecimalLiteral :: DecimalDigits ExponentPart is (the MV of DecimalDigits times 10^n) times 10^v, where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: DecimalDigits is the MV of DecimalDigits times 10^n, where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: DecimalDigits ExponentPart is (the MV of DecimalDigits times 10^n) times 10^v, where n is the number of characters in DecimalDigits and v is the MV of ExponentPart.
- The MV of DecimalLiteral :: DecimalDigits is the MV of DecimalDigits times 10^n, where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: DecimalDigits ExponentPart is (the MV of DecimalDigits times 10^n) times 10^v, where n is the number of characters in DecimalDigits and v is the MV of ExponentPart.
- The MV of DecimalLiteral :: DecimalDigits is the MV of DecimalDigits.
- The MV of DecimalLiteral :: DecimalIntegerLiteral ExponentPart is the MV of DecimalIntegerLiteral times 10^n, where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: DecimalIntegerLiteral is the MV of DecimalIntegerLiteral.
- The MV of DecimalLiteral :: SignedInteger is (the MV of NonZeroDigit times 10^n) plus the MV of DecimalDigits, where n is the number of characters in DecimalDigits.
- The MV of DecimalLiteral :: SignedInteger is (the MV of DecimalDigits times 10^n) plus the MV of DecimalDigits.
- The MV of DecimalLiteral :: ExponentPart is ExponentIndicator SignedInteger is the MV of SignedInteger.
- 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.
A regular expression literal is an input element that is converted to a RegExp object (see 15.10) each time the literal is evaluated. Two regular expression literals in a program evaluate to regular expression objects that never compare to each other even if the two literals' contents are identical. A RegExp object may also be created at runtime by calling the RegExp constructor as a function (15.10.3).

The productions below describe the syntax for a regular expression literal and are used by the input element scanner to find the end of the regular expression literal. The source code comprising the RegularExpressionBody and the RegularExpressionFlags are subsequently parsed using the more stringent ECMAScript Regular Expression grammar (15.10.1).

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

### Regular Expression Literals

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

The productions below describe the syntax for a regular expression literal and are used by the input element scanner to find the end of the regular expression literal. The source code comprising the RegularExpressionBody and the RegularExpressionFlags are subsequently parsed using the more stringent ECMAScript Regular Expression grammar (15.10.1).

The MV of DecimalDigit :: 2 or of NonZeroDigit :: 2 or of HexDigit :: 2 or of OctalDigit :: 2 is 2.

The MV of DecimalDigit :: 3 or of NonZeroDigit :: 3 or of HexDigit :: 3 or of OctalDigit :: 3 is 3.

The MV of DecimalDigit :: 4 or of NonZeroDigit :: 4 or of HexDigit :: 4 or of OctalDigit :: 4 is 4.

The MV of DecimalDigit :: 5 or of NonZeroDigit :: 5 or of HexDigit :: 5 or of OctalDigit :: 5 is 5.

The MV of DecimalDigit :: 6 or of NonZeroDigit :: 6 or of HexDigit :: 6 or of OctalDigit :: 6 is 6.

The MV of DecimalDigit :: 7 or of NonZeroDigit :: 7 or of HexDigit :: 7 or of OctalDigit :: 7 is 7.

The MV of DecimalDigit :: 8 or of NonZeroDigit :: 8 or of HexDigit :: 8 is 8.

The MV of DecimalDigit :: 9 or of NonZeroDigit :: 9 or of HexDigit :: 9 is 9.

The MV of HexDigit :: a or of HexDigit :: A is 10.

The MV of HexDigit :: b or of HexDigit :: B is 11.

The MV of HexDigit :: c or of HexDigit :: C is 12.

The MV of HexDigit :: d or of HexDigit :: D is 13.

The MV of HexDigit :: e or of HexDigit :: E is 14.

The MV of HexDigit :: f or of HexDigit :: F is 15.

The MV of BinaryIntegerLiteral :: 0b BinaryDigit is the MV of BinaryDigit.

The MV of BinaryIntegerLiteral :: 0B BinaryDigit is the MV of BinaryDigit.

The MV of BinaryIntegerLiteral :: BinaryIntegerLiteral BinaryDigit is (the MV of BinaryIntegerLiteral times 2) plus the MV of BinaryDigit.

The MV of OctalIntegerLiteral :: 0o OctalDigit is the MV of OctalDigit.

The MV of OctalIntegerLiteral :: 0O OctalDigit is the MV of OctalDigit.

The MV of OctalIntegerLiteral :: OctalIntegerLiteral OctalDigit is (the MV of OctalIntegerLiteral times 8) plus the MV of OctalDigit.

The MV of HexIntegerLiteral :: 0x HexDigits is the MV of HexDigits.

The MV of HexIntegerLiteral :: 0X HexDigits is the MV of HexDigits.

The MV of HexDigits :: HexDigit is the MV of HexDigit.

The MV of HexDigits :: HexDigits HexDigit is (the MV of HexDigits times 16) plus the MV of HexDigit.

Once the exact MV for a numeric literal has been determined, it is then rounded to a value of the Number type. If the MV is 0, then the rounded value is 0; otherwise, the rounded value must be the Number value for the MV (as specified in 8.5) unless the literal is a DecimalLiteral and the literal has more than 20 significant digits, in which case the Number value may be either the Number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit or the Number value for the MV of a literal produced by replacing each significant digit after the 20th with a 9 digit and then incrementing the literal at the 20th significant digit position. A digit is significant if it is not part of an ExponentPart and

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

### 7.8.4 Regular Expression Literals

The productions below describe the syntax for a regular expression literal and are used by the input element scanner to find the end of the regular expression literal. The source code comprising the RegularExpressionBody and the RegularExpressionFlags are subsequently parsed using the more stringent ECMAScript Regular Expression grammar (15.10.1).
Syntax

RegularExpressionLiteral ::
    / RegularExpressionBody / RegularExpressionFlags

RegularExpressionBody ::
    RegularExpressionFirstChar RegularExpressionChars

RegularExpressionChars ::
    [empty]
    RegularExpressionChars RegularExpressionChar

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

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

RegularExpressionBackslashSequence ::
    \ RegularExpressionNonTerminator

RegularExpressionNonTerminator ::
    SourceCharacter but not LineTerminator

RegularExpressionClass ::
    [ RegularExpressionClassChars ]

RegularExpressionClassChars ::
    [empty]
    RegularExpressionClassChars RegularExpressionClassChar

RegularExpressionClassChar ::
    RegularExpressionNonTerminator but not one of ] or 
    RegularExpressionBackslashSequence

RegularExpressionFlags ::
    [empty]
    RegularExpressionFlags IdentifierPart

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

Static Semantics: Early Errors

RegularExpressionFlags::
    RegularExpressionFlags IdentifierPart

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

Static Semantics: BodyText

RegularExpressionLiteral ::
    / RegularExpressionBody / RegularExpressionFlags

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

Static Semantics: FlagText

RegularExpressionLiteral ::
    / RegularExpressionBody / RegularExpressionFlags
1. Return the source code that was recognised as `RegularExpressionFlags`.

### 7.8.5 Template Literal Lexical Components

**Syntax**

```
Template ::
  NoSubstitutionTemplate
  TemplateHead
NoSubstitutionTemplate ::
  ` TemplateCharactersopt`

TemplateHead ::
  ` TemplateCharactersopt $`

TemplateSubstitutionTail ::
  TemplateMiddle
  TemplateTail

TemplateMiddle ::
  } TemplateCharactersopt $`

TemplateTail ::
  } TemplateCharactersopt`

TemplateCharacters ::
  SourceCharacter but not one of `\` or ` $`
  $ [lookahead $]`
  \ EscapeSequence
  LineContinuation
```

**Static Semantics: TV's and TRV's**

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

- The TV and TRV of NoSubstitutionTemplate :: ` ` is the empty code unit sequence.
- The TV and TRV of TemplateHead :: ` $ {` is the empty code unit sequence.
- The TV and TRV of TemplateMiddle :: ` } $ {` is the empty code unit sequence.
- The TV and TRV of TemplateTail :: ` ) ` is the empty code unit sequence.
- The TV of NoSubstitutionTemplate :: ` TemplateCharacters ` is the TV of TemplateCharacters.
- The TV of TemplateHead :: ` TemplateCharacters $ {` is the TV of TemplateCharacters.
- The TV of TemplateMiddle :: ` TemplateCharacters $ {` is the TV of TemplateCharacters.
- The TV of TemplateTail :: ` TemplateCharacters ` is the TV of TemplateCharacters.
- The TV of TemplateCharacters :: TemplateCharacter 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 $ is the UTF-16 Encoding (clause 6) of the code point value of SourceCharacter.

The TV of TemplateCharacter :: $ \{lookahead \{ } \} is the code unit value 0x0024.

The TV of TemplateCharacter :: \ EscapeSequence is the CV of EscapeSequence.

The TV of TemplateCharacter :: LineContinuation is the TV of LineContinuation.

The TV of LineContinuation :: \ LineTerminatorSequence is the empty code unit sequence.

The TV of TemplateCharacter :: \ TemplateCharacters is the TRV of TemplateCharacters.

The TV of TemplateHead :: \ TemplateCharacters $ ( is the TRV of TemplateCharacters.

The TV of TemplateMiddle :: \ TemplateCharacters $ ( is the TRV of TemplateCharacters.

The TV of TemplateTail :: \ TemplateCharacters ` is the TRV of TemplateCharacters.

The TV of TemplateCharacters :: TemplateCharacter is the TRV of TemplateCharacter.

The TV of TemplateCharacters :: TemplateCharacter TemplateCharacters is a sequence consisting of the code units in the TRV of TemplateCharacter followed by all the code units in the TRV of TemplateCharacters, in order.

The TV of TemplateCharacter :: SourceCharacter but not one of \ or \ or $ is the UTF-16 Encoding (clause 6) of the code point value of SourceCharacter.

The TV of TemplateCharacter :: $ \{lookahead \{ } \} is the code unit value 0x0024.

The TV of TemplateCharacter :: \ EscapeSequence is the sequence consisting of the code unit value 0x003C followed by the code units of TRV of EscapeSequence.

The TV of TemplateCharacter :: LineContinuation is the TRV of LineContinuation.

The TV of EscapeSequence :: CharacterEscapeSequence is the TRV of the CharacterEscapeSequence.

The TV of EscapeSequence :: \ 0 \{lookahead \ DecimalDigit \} is the code unit value 0x0030.

The TV of EscapeSequence :: HexEscapeSequence is the TRV of the HexEscapeSequence.

The TV of EscapeSequence :: UnicodeEscapeSequence is the TRV of the UnicodeEscapeSequence.

The TV of CharacterEscapeSequence :: SingleEscapeCharacter is the TRV of the SingleEscapeCharacter.

The TV of CharacterEscapeSequence :: NonEscapeCharacter is the CV of the NonEscapeCharacter.

The TV of SingleEscapeCharacter :: \ one of ' \ b \ f \ n \ r \ t \ v \ is the CV of the SourceCharacter that is that single character.

The TV of HexEscapeSequence :: x HexDigit HexDigit is the sequence consisting of code unit value 0x0078 followed by TRV of the first HexDigit followed by TRV of the second HexDigit.

The TV of UnicodeEscapeSequence :: u HexDigit HexDigit HexDigit HexDigit HexDigit is the sequence consisting of code unit value 0x007785 followed by code unit value 0x0078 followed by TRV of the first HexDigit followed by TRV of the second HexDigit followed by TRV of the third HexDigit followed by TRV of the fourth HexDigit.

The TV of UnicodeEscapeSequence :: u\{ HexDigits \} is the sequence consisting of code unit value 0x0075 followed by code unit value 0x007B followed by TRV of HexDigits followed by code unit value 0x007D.

The TV of HexDigits :: HexDigit is the TRV of HexDigit.

The TV of HexDigits :: HexDigits HexDigit is the sequence consisting of TRV of HexDigits followed by TRV of HexDigit.

The TV of a HexDigit is the CV of the SourceCharacter that is that HexDigit.

The TV of LineContinuation :: \ LineTerminatorSequence is the sequence consisting of the code unit value 0x003C followed by the code units of TRV of LineTerminatorSequence.

The TV of LineTerminatorSequence :: \ is the code unit value 0x00A.

The TV of LineTerminatorSequence :: \ is the code unit value 0x00D.

The TV of LineTerminatorSequence :: \ is the code unit value 0x2028.

The TV of LineTerminatorSequence :: \ is the code unit value 0x2029.

The TV of LineTerminatorSequence :: \ is the sequence consisting of the code unit value 0x000D followed by the code unit value 0x00A.

NOTE TV excludes the code units of LineContinuation while TRV includes them.
7.8.6 String Literals

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

Syntax

StringLiteral ::
  " DoubleStringCharacters opt "
  ' SingleStringCharacters opt '

DoubleStringCharacters ::
  DoubleStringCharacter DoubleStringCharacters opt

SingleStringCharacters ::
  SingleStringCharacter SingleStringCharacters opt

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

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

LineContinuation ::
  \ LineTerminatorSequence

EscapeSequence ::
  CharacterEscapeSequence
  0 [lookahead DecimalDigit]
  HexEscapeSequence
  UnicodeEscapeSequence

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

CharacterEscapeSequence ::
  SingleEscapeCharacter
  NonEscapeCharacter

SingleEscapeCharacter ::
  one of \ " \ b \ f \ n \ r \ t \ v

NonEscapeCharacter ::
  SourceCharacter but not one of EscapeCharacter or LineTerminator

EscapeCharacter ::
  SingleEscapeCharacter
  DecimalDigit
  x
  u
HexEscapeSequence ::
  x HexDigit HexDigit

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

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

NOTE A line terminator character cannot appear in a string literal, except as part of a LineContinuation to produce the empty character sequence. The correct way to cause a line terminator character to be part of the String value of a string literal is to use an escape sequence such as \n or \u000A.

Static Semantics

Static Semantics: Early Errors

UnicodeEscapeSequence :: u{ HexDigit }

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

Static Semantics: SV’s and CV’s

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

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

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Code Unit Value</th>
<th>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>horizontal tab</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>\n</td>
<td>0x000A</td>
<td>line feed (new line)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>\v</td>
<td>0x000B</td>
<td>vertical tab</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>\f</td>
<td>0x000C</td>
<td>form feed</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>&quot;</td>
<td>0x0022</td>
<td>double quote</td>
<td>&quot;</td>
</tr>
<tr>
<td>'</td>
<td>0x0027</td>
<td>single quote</td>
<td>'</td>
</tr>
<tr>
<td>\</td>
<td>0x005C</td>
<td>backslash</td>
<td></td>
</tr>
</tbody>
</table>

The CV of `CharacterEscapeSequence :: NonEscapeCharacter` is the CV of the `NonEscapeCharacter`.

The CV of `NonEscapeCharacter :: SourceCharacter but not one of EscapeCharacter or LineTerminator` is the UTF-16 Encoding (clause 6) of the code point value of `SourceCharacter`.

The CV of `HexEscapeSequence :: x HexDigit HexDigit` is the code unit value that is \(16 \times \text{MV of the first HexDigit} + \text{MV of the second HexDigit}\).

The CV of `UnicodeEscapeSequence :: u HexDigit HexDigit HexDigit HexDigit` is the code unit value that is \(4096 \times \text{MV of the first HexDigit} + 256 \times \text{MV of the second HexDigit} + 16 \times \text{MV of the third HexDigit} + \text{MV of the fourth HexDigit}\).

The CV of `UnicodeEscapeSequence :: u { HexDigits }` is the UTF-16 Encoding (clause 6) of the MV of HexDigits.

### 7.9 Automatic Semicolon Insertion

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

#### 7.9.1 Rules of Automatic Semicolon Insertion

There are three basic rules of semicolon insertion:

1. When, as the script is parsed from left to right, a token (called the *offending token*) is encountered that is not allowed by any production of the grammar, then a semicolon is automatically inserted before the offending token if one or more of the following conditions is true:
   - The offending token is separated from the previous token by at least one `LineTerminator`.
   - The offending token is `)`, `]`, or `}`.

2. When, as the script is parsed from left to right, the end of the input stream of tokens is encountered and the parser is unable to parse the input token stream as a single complete ECMAScript `script`, then a semicolon is automatically inserted at the end of the input stream.

3. When, as the script is parsed from left to right, a token is encountered that is allowed by some production of the grammar, but the production is a *restricted production* and the token would be the first token for a terminal or nonterminal immediately following the annotation "\[no LineTerminator here\]" within the restricted production (and therefore such a token is called a restricted token), and the restricted token is separated
from the previous token by at least one LineTerminator, then a semicolon is automatically inserted before the restricted token.

However, there is an additional overriding condition on the preceding rules: a semicolon is never inserted automatically if the semicolon would then be parsed as an empty statement or if that semicolon would become one of the two semicolons in the header of a for statement (see 12.6.3).

**NOTE**

The following are the only restricted productions in the grammar:

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

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

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

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

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

The practical effect of these restricted productions is as follows:

- When a `++` or `--` token is encountered where the parser would treat it as a postfix operator, and at least one LineTerminator occurred between the preceding token and the `++` or `--` token, then a semicolon is automatically inserted before the `++` or `--` token.

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

The resulting practical advice to ECMAScript programmers is:

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

### 7.9.2 Examples of Automatic Semicolon Insertion

The source

```
{ 1 2 } 3
```

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

```
{ 1
  2 } 3
```

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

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

which is a valid ECMAScript sentence.

The source
for (a; b)

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

The source

return
a + b

is transformed by automatic semicolon insertion into the following:

return;
a + b;

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

The source

a = b
++c;

is transformed by automatic semicolon insertion into the following:

a = b;
++c;

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

The source

if (a > b)
else c = d

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

The source

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

is not transformed by automatic semicolon insertion, because the parenthesised expression that begins the
second line can be interpreted as an argument list for a function call:

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

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

8 Types

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

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

8.1 ECMAScript Language Types

An ECMAScript language type corresponds to values that are directly manipulated by an ECMAScript
programmer using the ECMAScript language. The ECMAScript language types are Undefined, Null, Boolean,
String, Number, Symbol, and Object. An ECMAScript language value is a value that is characterized by an ECMAScript language type.

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

8.1.2 The Null Type
The Null type has exactly one value, called `null`.

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

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

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

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

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 $(c_1 - 0xD800) \times 0x400 + (c_2 - 0xDC00) + 0x10000$.
- 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.

8.1.5 The Number Type
The Number type has exactly \(2^{64} \approx 18,446,744,073,709,551,616\) values, representing the double-precision 64-bit format IEEE 754 values as specified in the IEEE Standard for Binary Floating-Point Arithmetic, except that the \(9007199254740992\) (that is, \(2^{53} - 2^{52}\)) distinct “Not-a-Number” values of the IEEE Standard are represented in ECMAScript as a single special `NaN` value. (Note that the `NaN` value is produced by the program expression `NaN`.) In some implementations, external code might be able to detect a difference between various Not-a-Number values, but such behaviour is implementation-dependent; to ECMAScript code, all NaN values are indistinguishable from each other.

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

The other \( 2^{64} - 2^{53} \) values are called the finite numbers. Half of these are positive numbers and half are negative numbers; for every finite positive Number 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 remaining \( 2^{53} - 2 \) finite nonzero values are of two kinds:

1. Normalised, having the form \( s \times m \times 2^e \) where \( s \) is \( +1 \) or \( -1 \), \( m \) is a positive integer less than \( 2^{53} \) but not less than \( 2^{52} \), and \( e \) is an integer ranging from \( -1074 \) to \( 971 \), inclusive.
2. Denormalised, having the form \( s \times m \times 2^e \) where \( s \) is \( +1 \) or \( -1 \), \( m \) is a positive integer less than \( 2^{52} \), and \( e \) is \( -1073 \).

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 \( +1 \times 2^{1024} \times 2^{53} \)) and \( -2^{1024} \) (which is \( -1 \times 2^{1024} \times 2^{53} \)). 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 \( +\text{Infinity} \); if \( -2^{1024} \) was chosen, replace it with \( -\text{Infinity} \); if \( +0 \) was chosen, replace it with \( -0 \) if and only if \( x \) is less than zero; any other chosen value is used unchanged. The result is the Number value for \( x \). (This procedure corresponds exactly to the behaviour of the IEEE 754 "round to nearest" mode.)

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

### 8.1.6 The Symbol Type

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

Each possible Symbol value is unique and immutable.

Symbol values have a single observable attribute called \( [[\text{Private}]] \) whose immutable value is either `true` or `false`. A private symbol is a Symbol value whose \( [[\text{Private}]] \) attribute has the value `true`. 
8.1.7 The Object Type

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

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

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

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

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

8.1.7.1 Property Attributes

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

Table 5 — Attributes of a Data Property

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

An accessor property associates a key value with the attributes listed in Table 6.
Table 6 — Attributes of an Accessor Property

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Get]]</td>
<td>Object or Undefined</td>
<td>If the value is an Object it must be a function Object. The function’s [[Call]] internal method (8.6.2) is called with an empty arguments list to retrieve the property value each time a get access of the property is performed.</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>Object or Undefined</td>
<td>If the value is an Object it must be a function Object. The function’s [[Call]] internal method (8.6.2) is called with an arguments list containing the assigned value as its sole argument each time a set access of the property is performed. The effect of a property’s [[Set]] internal method may, but is not required to, have an effect on the value returned by subsequent calls to the property’s [[Get]] internal method.</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>Boolean</td>
<td>If true, the property is to be enumerated by a for-in enumeration (see 12.6.4). Otherwise, the property is said to be non-enumerable.</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 7 is used.

Table 7 — 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>

8.1.7.2 Object Internal Methods and Internal Data Properties

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

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

Internal data properties correspond to internal state that is associated with objects and used by various ECMAScript specification algorithms. Depending upon the specific internal data property such state may consist of values of any ECMAScript language type or of specific ECMAScript specification type values. Unless explicitly specified otherwise, internal data properties are allocated as part of the process of creating an ECMAScript object and may not be dynamically added to ECMAScript objects. Unless specified otherwise, the initial value of an internal data property is the value undefined.
Table 8 summarises the essential internal methods used by this specification that are applicable to all ECMAScript objects. Every object must have algorithms for all of the essential internal methods. However, all objects do not necessarily use the same algorithms for those methods.

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

<table>
<thead>
<tr>
<th>Internal Method</th>
<th>Signature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[GetInheritance]]</td>
<td>() → Object or Null</td>
<td>Determine the object that provides inherited properties for this object. A null value indicates that there are no inherited properties. An object.</td>
</tr>
<tr>
<td>[[SetInheritance]]</td>
<td>(Object or Null) → Boolean</td>
<td>Associate with an object another object that provides inherited properties. Passing null indicates that there are no inherited properties. Returns true indicating that the operation was completed successfully or false indicating that the operation was not successful.</td>
</tr>
<tr>
<td>[[HasIntegrity]]</td>
<td>(String) → Boolean</td>
<td>Determine whether the property structure of an object is fixed to at least the specified level. The argument is one of the values &quot;nonextensible&quot;, &quot;sealed&quot;, or &quot;frozen&quot;. Returns true indicating that the operation was completed successfully or false indicating that the operation was not successful. The integrity level of an object may be raised but may not be lowered.</td>
</tr>
<tr>
<td>[[SetIntegrity]]</td>
<td>(String) → Boolean</td>
<td>Restrict the mutability of an object's properties to that which is allowed for the specified integrity level. The argument is one of the values &quot;nonextensible&quot;, &quot;sealed&quot;, or &quot;frozen&quot;. Returns true indicating that the operation was completed successfully or false indicating that the operation was not successful. The integrity level of an object may be raised but may not be lowered.</td>
</tr>
<tr>
<td>[[HasOwnProperty]]</td>
<td>(propertyKey) → Boolean</td>
<td>Returns a Boolean value indicating whether the object already has an own property whose key is propertyKey.</td>
</tr>
<tr>
<td>[[GetProperty]]</td>
<td>(propertyKey) → Undefined or Property Descriptor</td>
<td>Returns a Property Descriptor for the own property of this object whose key is propertyKey, or undefined if no such property exists.</td>
</tr>
<tr>
<td>[[HasProperty]]</td>
<td>(propertyKey) → Boolean</td>
<td>Returns a Boolean value indicating whether the object already has either an own or inherited property whose key is propertyKey.</td>
</tr>
<tr>
<td>[[Get]]</td>
<td>(propertyKey, Receiver) → any</td>
<td>Retrieve the value of an object's property using the propertyKey parameter. If any ECMAScript code must be executed to retrieve the property value, Receiver is used as the this value when evaluating the code.</td>
</tr>
<tr>
<td>[[Set]]</td>
<td>(propertyKey, value, Receiver) → Boolean</td>
<td>Try to set the value of an object's property identified by propertyKey to value. If any ECMAScript code must be executed to set the property value, Receiver is used as the this value when evaluating the code. Returns true indicating that the property value was set or false indicating that it could not be set.</td>
</tr>
<tr>
<td>[[Delete]]</td>
<td>(propertyKey) → Boolean</td>
<td>Removes the own property identified by the propertyKey parameter from the object. Return false if the property was not deleted and is still present. Return true if the property was deleted or was not present.</td>
</tr>
<tr>
<td>[[DefineOwnProperty]]</td>
<td>(propertyKey, PropertyDescriptor) → Boolean</td>
<td>Creates or alters the named own property to have the state described by a Property Descriptor. Returns true indicating that the property was successfully created/updated or false indicating that the property could not be created or updated.</td>
</tr>
<tr>
<td>[[Enumerate]]</td>
<td>() → Object</td>
<td>Returns an iterator object over the string values of the keys of the enumerable properties of the</td>
</tr>
</tbody>
</table>
Table 9 summarises additional essential internal methods that are supported by objects that may be called as functions.

**Table 9 — Additional Essential Internal Methods of Function Objects**

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

8.1.7.3 Invariants of the Essential Internal Methods

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

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

**Definitions:**

- The target of an internal method is the object the internal method is called upon.
- A sealed property is a non-configurable own property of a target.
- A frozen property is a non-configurable non-writable own property of a target.
- A new property is a property that does not exist on a non-extensible target.
- Two property descriptors desc1 and desc2 for a property key value are incompatible if:
  1. Desc1 is produced by calling [[GetOwnPropertyDescriptor]] of target with key, and
  2. Calling [[DefineOwnProperty]] of target with arguments key and desc2 would throw a TypeError exception.

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

**[[GetInheritance]]**

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

getOwnPropertyDescriptor
Non-configurability invariant: cannot return incompatible descriptors for sealed properties.
Non-extensibility invariant: must return undefined for new properties.

Invariant checks:
  - If trap returns undefined, check if the property is configurable.
  - If property exists on target, check if the returned descriptor is compatible.
  - If returned descriptor is non-configurable, check if the property exists on the target and is also non-configurable.

**defineProperty**

Non-configurability invariant: cannot succeed (return true) for incompatible changes to sealed properties.
Non-extensibility invariant: must reject (return false) for new properties.

Invariant checks:
  - On success, if property exists on target, check if existing descriptor is compatible with argument descriptor.
  - On success, if argument descriptor is non-configurable, check if the property exists on the target and is also non-configurable.

**getOwnPropertyNames**

Non-configurability invariant: must report all sealed properties.
Non-extensibility invariant: must not list new property names.

Invariant checks:
  - Check whether all sealed target properties are present in the trap result.
  - If the target is non-extensible, check that no new properties are listed in the trap result.

**deleteProperty**

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

Invariant checks:
  - On success, check if the target property is configurable.

**getPrototypeOf**

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

**freeze** | **seal** | **preventExtensions**

Invariant checks:
  - On success, check if isFrozen(target), isSealed(target) or !isExtensible(target).

**isFrozen** | **isSealed** | **isExtensible**

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

**hasOwnProperty**

Non-configurability invariant: cannot return false for sealed properties.
Non-extensibility invariant: must return false for new properties.

Invariant checks:
  - If false is returned, check if the target property is configurable.
If false is returned, the property does not exist on target, and the target is non-extensible, throw a TypeError

```
has
```

Non-configurability invariant: cannot return false for sealed properties

Invariant checks:
if false is returned, check if the target property is configurable

```
get
```

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

Invariant checks:
if property exists on target as a data property, check whether the target property’s value and the trap result are identical (according to the egal operator)
if property exists on target as an accessor, and the accessor’s get attribute is undefined, check whether the trap result is also undefined.

```
set
```

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

Invariant checks:
on success, if property exists on target as a data property, check whether the target property’s value and the update value are identical (according to the egal operator)
on success, if property exists on target as an accessor, check whether the accessor’s set attribute is not undefined

```
keys
```

Non-configurability invariant: must report all enumerable sealed properties
Non-extensibility invariant: must not list new property names

Invariant checks:
Check whether all enumerable sealed target properties are listed in the trap result
If the target is non-extensible, check that no new properties are listed in the trap result

```
enumerate
```

Non-configurability invariant: must report all enumerable sealed properties

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

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

Unless otherwise specified, the standard ECMAScript objects are ordinary objects and behave as described in 8.3. Some standard objects are exotic objects and have behaviour defined in 8.4.
Exotic objects may implement internal methods in any manner unless specified otherwise: for example, one possibility is that [[Get]] and [[Set]] for a particular exotic object indeed fetch and store property values but [[HasOwnProperty]] always generates false. However, if any specified manipulation of an exotic object’s internal properties is not supported by an implementation, that manipulation must throw a TypeError exception when attempted.

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

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

The [[DefineOwnProperty]] internal method of all objects must not permit the addition of a new property to an object if the [[Extensible]] internal method of that object has been observed by ECMAScript code to be false. If the result of calling the [[IsExtensible]] internal method of an object has been observed by ECMAScript code to be false then it must not subsequently become true.

8.1.7.4 Well-Known Symbols and Intrinsics

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

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

<table>
<thead>
<tr>
<th>Specification Name</th>
<th>Value and Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>@@create</td>
<td>A method used to allocate an object. Called from the <code>[[Construct]]</code> internal method.</td>
</tr>
<tr>
<td>@@hasInstance</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>@@isRegExp</td>
<td>A Boolean value that if true indicates that an object may be used as a regular expression.</td>
</tr>
<tr>
<td>@@iterator</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>@@ToPrimitive</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>A string value that is used in the creation of the default string description of an object. Called by the built-in method <code>Object.prototype.toString</code>.</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>ECMAScript Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Object%</td>
<td>The initial value of the global object property named “Object”.</td>
</tr>
<tr>
<td>%ObjectPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %Object%.</td>
</tr>
<tr>
<td>%ObjProto_toString%</td>
<td>The initial value of the “toString” data property of the intrinsic %ObjectPrototype%.</td>
</tr>
<tr>
<td>%Function%</td>
<td>The initial value of the global object property named “Function”.</td>
</tr>
<tr>
<td>%FunctionPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %Function%.</td>
</tr>
<tr>
<td>%Array%</td>
<td>The initial value of the global object property named “Array”.</td>
</tr>
<tr>
<td>%ArrayPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %Array%.</td>
</tr>
<tr>
<td>%ArrayIteratorPrototype%</td>
<td>The prototype object used for iterator objects created by the CreateArrayIterator abstract operation.</td>
</tr>
<tr>
<td>%Map%</td>
<td>The initial value of the global object property named “Map”.</td>
</tr>
<tr>
<td>%MapPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %Map%.</td>
</tr>
<tr>
<td>%MapIteratorPrototype%</td>
<td>The prototype object used for iterator objects created by the CreateMapIterator abstract operation.</td>
</tr>
<tr>
<td>%WeakMap%</td>
<td>The initial value of the global object property named “WeakMap”.</td>
</tr>
<tr>
<td>%WeakMapPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %WeakMap%.</td>
</tr>
<tr>
<td>%Set%</td>
<td>The initial value of the global object property named “Set”.</td>
</tr>
<tr>
<td>%SetPrototype%</td>
<td>The initial value of the “prototype” data property of the intrinsic %Set%.</td>
</tr>
<tr>
<td>%SetIteratorPrototype%</td>
<td>The prototype object used for iterator objects created by the CreateSetIterator abstract operation.</td>
</tr>
<tr>
<td>%GeneratorFunction%</td>
<td>The initial value of the name “GeneratorFunction” exported from the built-in module “std:iteration”</td>
</tr>
<tr>
<td>%Generator%</td>
<td>The initial value of the name “Generator” exported from the built-in module “std:iteration”</td>
</tr>
<tr>
<td>%ErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%EvalErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>%RangeErrorPrototype%</td>
<td></td>
</tr>
<tr>
<td>ReferenceErrorPrototype%</td>
<td>%SyntaxErrorPrototype%</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>%TypeErrorPrototype%</td>
<td>%URIErrorPrototype%</td>
</tr>
<tr>
<td>%ArrayBuffer%</td>
<td>%DateViewPrototype%</td>
</tr>
</tbody>
</table>
8.2 ECMAScript Specification Types

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

8.2.1 Data Blocks

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

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

A block is one of:

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

A number-block is one of:

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

A uintk is an integer in the range [0, 2k). An intk is an integer in the range [-2k-1, 2k-1). A floatk is a floating-point number representable as a k-bit IEEE754 value.

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

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

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

- [[Class]] = "Data"
- [[Value]] : reference[block] – a reference to a block in the program store
- [[DataType]] : reference[Type] – a reference to a Type object describing this object’s data block
8.2.2 The List and Record Specification Type

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

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

For notational convenience within this specification, an object literal-like syntax can be used to express a Record value. For example, {
  [[field1]]: 42, [[field2]]: false, [[field3]]: empty
} defines a Record value that has three fields each of which is initialized to a specific value. Field name order is not significant. Any fields that are not explicitly listed are considered to be absent.

In specification text and algorithms, dot notation may be used to refer to a specific field of a Record value. For example, if \text{R} is the record shown in the previous paragraph then \text{R.[[field2]]} is shorthand for “the field of \text{R} named [[field2]]”.

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

8.2.3 The Completion Record Specification Type

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

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

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

8.2.3.1 NormalCompletion

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

1. Return NormalCompletion(argument).

Is a short hand that is defined as follows:

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

8.2.3.2 Implicit Completion Values

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

Generally means the same thing as:

1. Return NormalCompletion("Infinity").

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

1. Return NormalCompletion(undefined).

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

8.2.3.3 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).

8.2.3.4 ReturnIfAbrupt

Algorithms steps that say

1. ReturnIfAbrupt(argument).

mean the same things as:

1. If argument is an abrupt completion, then return argument.
2. Else if argument is a Completion Record, then let argument be argument.[[value]].

8.2.4 The Reference Specification Type

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

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

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

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

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

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

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

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

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

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

8.2.4.3 GetThisValue (V)
1. ReturnIfAbrupt(V).
2. If Type(V) is not Reference, return V.
3. If IsUnresolvableReference(V), throw a ReferenceError exception.
4. If IsSuperReference(V), then
   a. Return the value of the thisValue component of the reference V.
5. Return GetBase(V).
8.2.5 The Property Descriptor Specification Type

The Property Descriptor type is used to explain the manipulation and reification of Object property attributes. Values of the Property Descriptor type are Records composed of named fields where each field’s name is an attribute name and its value is a corresponding attribute value as specified in 8.1.6.1. In addition, any field may be present or absent.

Property Descriptor values may be further classified as data property descriptors and accessor property descriptors based upon the existence or use of certain fields. A data property descriptor is one that includes any fields named either [[Value]] or [[Writable]]. An accessor property descriptor is one that includes any fields named either [[Get]] or [[Set]]. Any property descriptor may have fields named [[Enumerable]] and [[Configurable]]. A Property Descriptor value may not be both a data property descriptor and an accessor property descriptor; however, it may be neither. A generic property descriptor is a Property Descriptor value that is neither a data property descriptor nor an accessor property descriptor. A fully populated property descriptor is one that is either an accessor property descriptor or a data property descriptor and that has all of the fields that correspond to the property attributes defined in either 8.1.6.1 Table 5 or Table 6.

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

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

8.2.5.1 IsAccessorDescriptor ( Desc )

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

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

8.2.5.2 IsDataDescriptor ( Desc )

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

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

8.2.5.3 IsGenericDescriptor ( Desc )

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

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

8.2.5.4 FromPropertyDescriptor ( Desc )

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

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

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

8.2.55 ToPropertyDescriptor ( Obj )

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

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

### 8.2.5.6 CompletePropertyDescriptor ( Desc, LikeDesc )

When the abstract operation CompletePropertyDescriptor is called with Property Descriptor \( \text{Desc} \), the following steps are taken:

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

### 8.2.6 The Lexical Environment and Environment Record Specification Types

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

### 8.3 Ordinary Object Internal Methods and Internal Data Properties

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

All ordinary objects have an internal data property called \([[[\text{Prototype}]])\). The value of this property is either null or an object and is used for implementing inheritance. Data properties of the \([[[\text{Prototype}]]) object are inherited (are visible as properties of the child object) for the purposes of get access, but not for set access. Accessor properties are inherited for both get access and set access.

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

In the following algorithm descriptions, assume \( O \) is an ordinary ECMAScript object, \( P \) is a property key value, \( V \) is any ECMAScript language value, \( \text{Desc} \) is a Property Description record, and \( \Delta \) is a Boolean flag.

#### 8.3.1 \([[[\text{GetInheritance}]]) ( )

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

1. Return the value of the \([[[\text{Prototype}]]) internal data property of \( O \).

#### 8.3.2 \([[[\text{SetInheritance}]]) ( V )

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

8.3.3 [[HasIntegrity]] (Level)
When the [[HasIntegrity]] internal method of O is called, the following steps are taken:
1. Assert: Level is one of "nonextensible", "sealed", or "frozen".
2. If Level is "nonextensible", then
   a. Return Boolean negation of the value of the [[Extensible]] internal data property of O.
3. Return the result of TestIntegrityLevel(O, Level).

8.3.4 [[SetIntegrity]] (Level)
When the [[SetIntegrity]] internal method of O is called, the following steps are taken:
1. Assert: Level is one of "nonextensible", "sealed", or "frozen".
2. Set the value of the [[Extensible]] internal data property of O to false.
3. If Level is not "nonextensible", then
   a. Return the result of SetIntegrityLevel(O, Level).
4. Return true.

8.3.5 [[HasOwnProperty]] (P)
When the [[HasOwnProperty]] internal method of O is called with property key P, the following steps are taken:
1. Assert: IsPropertyKey(P) is true.
2. If O does not have an own property with key P, return false.
3. Return true.

8.3.6 [[GetOwnProperty]] (P)
When the [[GetOwnProperty]] internal method of O is called with property key P, the following steps are taken:
1. Return the result of OrdinaryGetOwnProperty with arguments O and P.

8.3.6.1 OrdinaryGetOwnProperty (O, P)
When the abstract operation OrdinaryGetOwnProperty is called with Object O and with property key P, the following steps are taken:
1. Assert: IsPropertyKey(P) is true.
2. If O does not have an own property with key P, return undefined.
3. Let D be a newly created Property Descriptor with no fields.
4. Let X be O’s own property whose key is P.
5. If X is a data property, then
   a. Set D.[[Value]] to the value of X’s [[Value]] attribute.
   b. Set D.[[Writable]] to the value of X’s [[Writable]] attribute.
6. Else X is an accessor property, so
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.

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

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

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

8.3.7.1 OrdinaryDefineOwnProperty $(O, P, \text{Desc})$

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

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

8.3.7.2 IsCompatiblePropertyDescriptor $(\text{Extensible}, \text{Desc}, \text{Current})$

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

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

8.3.7.3 ValidateAndApplyPropertyDescriptor $(O, P, \text{extensible}, \text{Desc}, \text{current})$

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

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

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

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

b. Return \texttt{false}, if the \texttt{[\[Enumerable\]]} field of \texttt{Desc} is present and the \texttt{[\[Enumerable\]]} fields of \texttt{current} and \texttt{Desc} are the Boolean negation of each other.

6. If \texttt{IsGenericDescriptor(Desc)} is \texttt{true}, then no further validation is required.

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

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

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

10. If \texttt{O} is not \texttt{undefined}, then
    a. For each attribute field of \texttt{Desc} that is present, set the correspondingly named attribute of the property named \texttt{P} of object \texttt{O} to the value of the field.

11. Return \texttt{true}.

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

\subsection{8.3.8 \texttt{[[HasProperty]]}(P)}

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

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

\subsection{8.3.9 \texttt{[[Get\]]}(P, Receiver)}

When the \texttt{[\[Get\]]} internal method of \texttt{O} is called with property key \texttt{P} and ECMA-Script language value \texttt{Receiver} the following steps are taken:

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

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

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

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

8.3.11 [[Delete]] (P)

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

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

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

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

Enumerated properties do not include properties whose property key is a Symbol. Properties of the object being enumerated may be deleted during enumeration. If a property that has not yet been visited during enumeration is deleted, then it will not be visited. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be visited in the active enumeration. A property name must not be visited more than once in any enumeration.

Enumerating the properties of an object includes enumerating properties of its prototype, and the prototype of the prototype, and so on, recursively; but a property of a prototype is not enumerated if it is “shadowed” because some previous object in the prototype chain has a property with the same name. The values of `[[Enumerable]]` attributes are not considered when determining if a property of a prototype object is shadowed by a previous object on the prototype chain.

The following is an informative algorithm that conforms to these rules:

1. Let `obj` be `O`.
2. Let `proto` be the result of calling the [[GetInheritance]] internal method of `O` with no arguments.
3. ReturnIfAbrupt(`proto`).
4. If `proto` is the value null, then
   a. Let `propList` be a new empty List.
5. Else
   a. Let `propList` be the result of calling the [[Enumerate]] internal method of `proto`.
6. ReturnIfAbrupt(`propList`).
7. For each `name` that is the property key of an own property of `O`
   a. If `name` is not a private Symbol, then
      i. Let `desc` be the result of calling OrdinaryGetOwnProperty with arguments `O` and `name`.
      ii. If `desc.Enumerable` is true, then add `name` as an element of `propList`.
5. Order the elements of `propList` in an implementation defined order.
8. Return `propList`.

3.13 [[OwnPropertyKeys]]()

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

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

3.14 ObjectCreate(proto, internalDataList) Abstract Operation

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

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

### 8.3.15 Ordinary Function Objects

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

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

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

### Table 13 -- Internal Data Properties of Ordinary Function Objects

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

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

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

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

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

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

### 8.3.15.2 `[[Construct]]` (argumentsList)

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

1. Return the result of `OrdinaryCreateFunction(F, argumentsList)`.

### 8.3.15.2.1 OrdinaryConstruct (F, argumentsList)

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

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

Commented [AWB1427]: At Jan 29, 2012 TC39 several people suggested that this fall back was unnecessary complexity and that it should throw. However, that means that a ordinary function whose `__proto__` is set to `undefined` will throw if re-used. I’m not sure that is desirable. It’s a breaking change for the reality web.

Commented [AWB 326]: May need to update section number.
8. ReturnIfAbrupt(result).
9. If Type(result) is Object then return result.
10. Return obj.

8.3.15.3 [[Get]] (P, Receiver)

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

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

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

8.3.15.4 [[GetProperty]] (P)

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

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

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

8.3.15.5 FunctionAllocate Abstract Operation

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

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

8.3.15.6 FunctionInitialize Abstract Operation

The abstract operation FunctionInitialize requires the arguments: a function object F, `kind` which is one of (Normal, Method, Arrow), an parameter list production specified by ParameterList, a body production specified by Body, a Lexical Environment specified by Scope, a Boolean flag Strict, and optionally, an object homeObject and a property `key methodName`. FunctionInitialize performs the following steps:
1. Set the [[Prototype]] internal data property of F to functionPrototype.
2. Set the [[Scopes]] internal data property of F to the value of Scopes.
3. Set the [[Code]] internal data property of F to ParameterList.
4. Set the [[FormalParameters]] internal data property of F to Body.
5. If the homeObject argument was provided, set the [[HomeObject]] internal data property of F to homeObject.
6. If the methodName argument was provided, set the [[MethodName]] internal data property of F to methodName.
7. Set the [[Strict]] internal data property of F to Strict.
8. If kind is Arrow, then set the [[ThisMode]] internal data property of F to let.
9. Else if Strict is true, then set the [[ThisMode]] internal data property of F to strict.
10. Else set the [[ThisMode]] internal data property of F to global.
11. Let len be the ExpectedArgumentCount of ParameterList.
12. Call the [[DefineOwnProperty]] internal method of F with arguments “length” and Property Descriptor {
   [[Value]]: len, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false
13. If Strict is true, then
   a. Perform the AddRestrictedFunctionProperties abstract operation with argument F.
14. Return F.

8.3.15.7 FunctionCreate Abstract Operation

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

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

8.3.15.7 GeneratorFunctionCreate Abstract Operation

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

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

8.3.15.8 AddRestrictedFunctionProperties Abstract Operation

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

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

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

1. Let the scope be the Global Environment.
2. Let formalParameters be the syntactic production: FormalParameters : (empty).
3. Let body be the syntactic production: FunctionBody ; ThrowTypeError.
4. Let \( F \) be the result of the abstract operation FunctionCreate with arguments Normal, formalParameters, body, scope, and true.

5. Call the [[SetIntegrity]] internal method of \( F \) with argument "nonextensible".

6. Let %ThrowTypeError% be \( F \).

### 8.3.15 MakeConstructor Abstract Operation

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

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

### 8.4 Built-in Exotic Object Internal Methods and Data Fields

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

#### 8.4.1 Bound Function Exotic Objects

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

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

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

<table>
<thead>
<tr>
<th>Internal Data Property</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[BoundTargetFunction]]</td>
<td>Callable Object</td>
<td>The wrappered 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 wrappered function.</td>
</tr>
<tr>
<td>[[BoundArguments]]</td>
<td>List of Any</td>
<td>A list of values that whose elements are used as the first arguments to any call to the wrappered function.</td>
</tr>
</tbody>
</table>

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

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

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

8.4.1.2 [[Construct]]

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

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

8.4.1.3 BoundFunctionCreate Abstract Operation

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

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

8.4.2 Array Exotic Objects

An `Array` object is an exotic object that gives special treatment to a certain class of property names. A property name \( P \) (in the form of a String value) is an array index if and only if `ToString(ToUint32(P))` is equal to \( P \) and `ToUint32(P)` is not equal to \( 2^{32} - 1 \). A property whose property name is an array index is also called an element. Every Array object has a `length` property whose value is always a nonnegative integer less than \( 2^{32} \). The value of the `length` property is numerically greater than the name of every property whose name is an array index; whenever a property of an Array object is created or changed, other properties are adjusted as necessary to maintain this invariant. Specifically, whenever a property is added whose name is an array index, the `length` property is changed, if necessary, to be one more than the numeric value of that array index; and whenever the `length` property is changed, every property whose name is an array index whose value is not smaller than the new length is automatically deleted. This constraint applies only to own properties of an Array object and is unaffected by `length` or array index properties that may be inherited from its prototypes.

Exotic Array objects have the same internal data properties as ordinary objects. They also have an `[[ArrayInitializationState]]` internal data property.
Exotic Array objects always have a non-configurable property named "length".

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

8.4.2.1 [[DefineOwnProperty]] ( P, Desc)

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

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

8.4.2.2 ArrayCreate Abstract Operation

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

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

8.4.2.3 ArraySetLength Abstract Operation

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

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

8.4.3 String Exotic Objects

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

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

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

8.4.3.1 [[HasOwnProperty]] (P)

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

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

8.4.3.2 [[GetOwnProperty]] (P)

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

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

8.4.3.3 [[DefineOwnProperty]] (P, Desc)

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

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

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

8.4.3.4 [[Enumerate]] ()

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

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

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

8.4.4 Exotic Arguments Objects

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

Exotic arguments objects have the same internal data properties as ordinary objects. They also have a \( [[\text{PrototypeMap}]] \) internal data.

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

8.4.5 Integer Indexed Delegation Exotic Objects

An integer indexed object is an exotic object that delegates \( [[\text{Get}]] \) and \( [[\text{Set}]] \) handling of integer property keys to methods of the object.

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

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

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

When the \( [[\text{Get}]] \) 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. If SameValue(\( O, \text{Receiver} \)) is \text{true}, then
   a. Let \( inIndex \) be ToInteger(\( P \)).
   b. If SameValue(\( \text{ToString}(\text{inIndex}, P) \) is \text{true}, then
      i. Let \( args \) be a new List containing \( \text{inIndex} \).
      ii. Return the result of calling the \( [[\text{Get}]](\text{Receiver}) \) on \( O \) passing \( P \) and \( args \) as arguments.
2. Return the result of calling the default ordinary object \( [[\text{Get}]] \) internal method (8.3.7) on \( O \) passing \( P \) and \( \text{Receiver} \) as arguments.

Commented [AWB1231]: TODO
Commented [AWB1332]: TODO
Commented [AWB1239]: TODO move arguments internal methods here.
Commented [AWB1340]: Issue: does the TypedArray spec, WebIDL specs require that such indexed properties show up using \( [[\text{GetProperty}]] \), keys, etc? If so, some more internal method over-rides will be needed.
Commented [AWB1341]: If we make this a private symbol that is not exposed, then it is just a specification device. If we make it an exposed symbol (whether private or not) it becomes a ES programmer extension point.
8.4.5.2 \[\text{[[Set]]}(P, V, \text{Receiver})\]

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

1. If \(\text{SameValue}(O, \text{Receiver})\) is \(\text{true}\), then
   a. Let \(\text{intIndex}\) be \(\text{ToInteger}(P)\).
   b. If \(\text{SameValue}(\text{ToString}(\text{intIndex}), P)\) is \(\text{true}\), then
      i. Let \(\text{args}\) be a new List containing \(\text{intIndex}\) and \(V\).
      ii. Return the result of \(\text{ToBoolean}(\text{Invoke}(O, \_[@@elementSet] \text{args}))\).
2. Return the result of calling the default ordinary object \[\text{[[Set]]}\] internal method (8.3.3) on \(O\) passing \(P, V,\) and \(\text{Receiver}\) as arguments.

8.4.5.3 \[\text{IntegerIndexedObjectCreate Abstract Operation}\]

The abstract operation \[\text{IntegerIndexedObjectCreate}\] with argument \(\text{prototype}\) is used to specify the creation of new Integer Indexed exotic objects. It performs the following steps:

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

8.4.6 Built-in Function Objects

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

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

\[\text{[[Call]]}\] and \[\text{[[Construct]]}\]

8.5 Proxy Object Internal Methods and Internal Data Properties

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

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

The \[\text{[[ProxyHandler]]}\] and \[\text{[[ProxyTarget]]}\] internal data properties of a proxy object are always initialized when the object is created and typically may not be modified. Some proxy objects are created in a manner that permits them to be subsequently revoked. When a proxy is revoked, its \[\text{[[ProxyHandler]]}\] internal data property is set to a special revoked proxy handler object and its \[\text{[[ProxyTarget]]}\] internal data property is set to \(\text{null}\).
Because proxy permit arbitrary ECMAScript code to be used to in the implementation of internal methods, it is possible to define a proxy object whose handler methods violates the invariants defined in 8.1.6.2. Some of the internal method invariants defined in 8.1.6.2 are essential integrity invariants. These invariants are explicitly enforced by the proxy internal methods specified in this section. An ECMAScript implementation must be robust in the presence of all possible invariant violations.

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

8.5.1 [[GetInheritance]]

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

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

NOTE [[GetInheritance]] for proxy objects enforces the following invariant:
   - [[GetInheritance]] applied to the proxy object must return the same value as [[GetInheritance]] applied to the proxy object’s target object.

8.5.2 [[SetInheritance]]

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

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

NOTE [[SetInheritance]] for proxy objects enforces the following invariant:
   - If the target object is not extensible, the argument value must be the same as the result of [[SetInheritance]] applied to target object.
8.5.3 [[HasIntegrity]] (Level)

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

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

NOTE

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

8.5.4 [[SetIntegrity]] (Level)

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

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

NOTE

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

8.5.5 [[HasOwnProperty]] (P)

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

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

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

8.5.6 [[GetPropertyOwnProperty]] (P)

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

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

13. Let extensibleTarget be the result of IsExtensible(target).
14. ReturnIfAbrupt(extensibleTarget).
15. Set extensibleTarget to ToBoolean(extensibleTarget).
16. Let resultDesc be ToPropertyDescriptor(trapResultObj).
17. ReturnIfAbrupt(resultDesc).
18. Call CompletePropertyDescriptor(resultDesc, targetDesc).
19. Let isValid be the result of IsCompatiblePropertyDescriptor (extensibleTarget, resultDesc, targetDesc).
20. If isValid is false, then throw a TypeError exception.
21. If resultDesc.[[Configurable]] is false, then
   a. If targetDesc is undefined or targetDesc.[[Configurable]] is true, then
      i. Throw a TypeError exception.
22. Return resultDesc.

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

8.5.7 [[DefineOwnProperty]] (P, Desc)

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

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

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

8.5.8 \[[\text{HasProperty}]\] (P)

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

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

NOTE \[[\text{HasProperty}]\] for proxy objects enforces the following invariants:

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

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

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

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

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

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

(i) If trapResult is not undefined, then throw a TypeError exception.

12. Return trapResult.

NOTE

The value reported for a property must be the same as the value of the corresponding target object property if the target object property is a non-writable, non-configurable data property.

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

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

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

1. Assert: IsPropertyKey(P) is true.

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

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

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

5. ReturnIfAbrupt(trap).

6. If trap is undefined, then

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

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

8. ReturnIfAbrupt(trapResult).

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

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

11. ReturnIfAbrupt(targetDesc).

12. If targetDesc is not undefined, then

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

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

13. Return true.

NOTE

For proxy objects enforces the following invariants:

- Cannot change the value of a property to be different from the value of the corresponding target object property if the corresponding corresponding target object property is a non-writable, non-configurable data property.

- Cannot set the value of a property if the corresponding corresponding target object property is a non-configurable accessor property that has undefined as its [[Get]] attribute.

8.5.11 [[Delete]] (P)

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

1. Assert: IsPropertyKey(P) is true.

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

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

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

5. ReturnIfAbrupt(trap).

6. If trap is undefined, then

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

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

8. ReturnIfAbrupt(trapResult).

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

NOTE [[Delete]] for proxy objects enforces the following invariant:
- A property cannot be deleted, if it exists as a non-configurable own property of the target object.

8.5.12 [[Enumerate]] ( )

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

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

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

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

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

8.5.13 [[OwnPropertyKeys]] ( )

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

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

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

8.5.14 [[Call]] (thisArgument, argumentsList)

The [[Call]] internal method of an exotic Proxy object O is called with parameters thisArgument and argumentsList, a List of ECMAScript language values. The following steps are taken:
1. Let \( \text{handler} \) be the value of the \([[\text{Proxy}\text{Handler}]]\) internal data property of \( O \).
2. Let \( \text{target} \) be the value of the \([[\text{Proxy}\text{Target}]]\) internal data property of \( O \).
3. Let \( \text{trap} \) be the result of GetMethod(\( \text{handler} \), "apply").
4. ReturnIfAbrupt(\( \text{trap} \)).
5. If \( \text{trap} \) is \( \text{undefined} \), then
   a. Return the result of calling the \([[\text{Call}]]\) internal method of \( \text{target} \) with arguments \( \text{thisArgument} \) and \( \text{argumentsList} \).
6. Let \( \text{argArray} \) be the result of CreateArrayFromList(\( \text{argumentsList} \)).
7. Return the result of calling the \([[\text{Call}]]\) internal method of \( \text{trap} \) with \( \text{handler} \) as the \( \text{this} \) value and a new List containing \( \text{target} \), \( \text{thisArgument} \), and \( \text{argArray} \).

NOTE An exotic object only has a \([[\text{Call}]]\) internal method if the initial value of its \([[\text{Proxy}\text{Target}]]\) internal data property is an object that has a \([[\text{Call}]]\) internal method.

8.5.15 \([[\text{Construct}]]\) Internal Method

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

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

NOTE 1 An exotic object only has a \([[\text{Construct}]]\) internal method if the initial value of its \([[\text{Proxy}\text{Target}]]\) internal data property is an object that has a \([[\text{Construct}]]\) internal method.

NOTE 2 The result of \([[\text{Construct}]]\) must be an Object.

9 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.

9.1 Type Conversion and Testing

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

9.1.1 ToPrimitive

The abstract operation ToPrimitive takes an input argument and an optional argument \( \text{PreferredType} \). 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 \( \text{PreferredType} \) to favour that type. Conversion occurs according to Table 15:
Table 15 — ToPrimitive Conversions

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

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

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

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

1. Assert: Type(O) is Object
2. Assert: Type(hint) is String and its value is either "string" or "number".
3. If hint is "string", then
   a. Let tryFirst be "toString".
   b. Let trySecond be "valueOf".
4. Else,
   a. Let tryFirst be "valueOf".
   b. Let trySecond be "toString".
5. Let first be the result of Get(O, tryFirst).
6. ReturnIfAbrupt(first).
7. If IsCallable(tryFirst) is true then,
   a. Let result be the result of calling the [[Call]] internal method of first, with O as thisArgument and an empty List as argumentsList.
   b. ReturnIfAbrupt(result).
   c. If result is an ECMAScript language value and Type(result) is not Object, then return result.
8. Let second be the result of Get(O, trySecond).
9. ReturnIfAbrupt(second).
10. If IsCallable(second) is true then,
    a. Let result be the result of calling the [[Call]] internal method of second, with O as thisArgument and an empty argument list.
    b. ReturnIfAbrupt(result).
    c. If result is an ECMAScript language value and Type(result) is not Object, then return result.
11. Throw a TypeError exception.
NOTE When ToPrimitive is called with no hint, then it generally behaves as if the hint were Number. However, objects may over-ride this behaviour by defining a@@ToPrimitive method. Of the objects defined in this specification only Date objects (see 15.9.6) over-ride the default ToPrimitive behaviour. Date objects treat no hint as if the hint were String.

9.1.2 ToBoolean

The abstract operation ToBoolean converts its argument to a value of type Boolean according to Table 16:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If argument is an abrupt completion, return the argument. Otherwise return ToBoolean(argument.[value]).</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return false</td>
</tr>
<tr>
<td>Null</td>
<td>Return false</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return the input argument (no conversion)</td>
</tr>
<tr>
<td>Number</td>
<td>Return false if the argument is +0, -0, or NaN; otherwise return true.</td>
</tr>
<tr>
<td>String</td>
<td>Return false if the 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>

9.1.3 ToNumber

The abstract operation ToNumber converts its argument to a value of type Number according to Table 17:

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

9.1.3.1 ToNumber Applied to the String Type

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

Syntax

```
StringNumericLiteral ::=  
  StrWhiteSpaceOpt  
  StrNumericLiteralStrWhiteSpaceOpt  
  StrWhiteSpaceOptStrNumericLiteralStrWhiteSpaceOpt
```

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StrWhiteSpace :::
  StrWhiteSpaceChar StrWhiteSpace

StrWhiteSpaceChar :::
  StrWhiteSpace
  LineTerminator

StrNumericLiteral :::
  StrDecimalLiteral
  HexIntegerLiteral

StrDecimalLiteral :::
  StrUnsignedDecimalLiteral
  + StrUnsignedDecimalLiteral
  - StrUnsignedDecimalLiteral

StrUnsignedDecimalLiteral :::
  Infinity
  DecimalDigits . DecimalDigits ExponentPart
  . DecimalDigits ExponentPart
  DecimalDigits ExponentPart

DecimalDigits :::
  DecimalDigit
  DecimalDigits DecimalDigit

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

ExponentPart :::
  ExponentIndicator SignedInteger

ExponentIndicator :::
  one of e E

SignedInteger :::
  DecimalDigits
  + DecimalDigits
  - DecimalDigits

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

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

NOTE
Some differences should be noted between the syntax of a StringNumericLiteral and a NumericLiteral (see 7.8.3):
• A StringNumericLiteral may be preceded and/or followed by white space and/or line terminators.
• A StringNumericLiteral that is decimal may have any number of leading 0 digits.
• A StringNumericLiteral that is decimal may be preceded by + or – to indicate its sign.
• A StringNumericLiteral that is empty or contains only white space is converted to 0.
• Infinity and –Infinity are recognised as a StringNumericLiteral but not as a NumericLiteral.

Runtime Semantics
The conversion of a String to a Number value is similar overall to the determination of the Number value for a numeric literal (see 7.8.3), but some of the details are different, so the process for converting a String numeric
literals to a value of Number type is given here in full. This value is determined in two steps: first, a mathematical value (MV) is derived from the String numeric literal; second, this mathematical value is rounded as described below.

- The MV of StringNumericLiteral :: [empty] is 0.
- The MV of StringNumericLiteral :: StrWhiteSpace is 0.
- The MV of StringNumericLiteral :: StrWhiteSpace StrNumericLiteral StrWhiteSpace is the MV of StrNumericLiteral, no matter whether white space is present or not.
- The MV of StrNumericLiteral :: StrDecimalLiteral is the MV of StrDecimalLiteral.
- The MV of StrNumericLiteral :: StrHexIntegerLiteral is the MV of StrHexIntegerLiteral.
- The MV of StrDecimalLiteral :: StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.
- The MV of StrDecimalLiteral :: + StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.
- The MV of StrDecimalLiteral :: - StrUnsignedDecimalLiteral is the negative of the MV of StrUnsignedDecimalLiteral. (Note that if the MV of StrUnsignedDecimalLiteral is 0, the negative of this MV is also 0. The rounding rule described below handles the conversion of this signless mathematical zero to a floating-point \( +0 \) or \( -0 \) as appropriate.)
- The MV of StrUnsignedDecimalLiteral :: Infinity is \( 10^{308} \) (a value so large that it will round to \( \pm \infty \)).
- The MV of StrUnsignedDecimalLiteral :: Decimals is the MV of DecimalDigits.
- The MV of StrUnsignedDecimalLiteral :: Decimals :: Decimals is the MV of the first DecimalDigits plus (the MV of the second DecimalDigits times \( 10^n \)), where \( n \) is the number of characters in the second DecimalDigits.
- The MV of StrUnsignedDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrUnsignedDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrUnsignedDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrUnsignedDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrDecimalLiteral :: Decimals is the MV of DecimalDigits.
- The MV of StrDecimalLiteral :: Decimals :: Decimals is (the MV of the first DecimalDigits times \( 10^n \)) times \( 10^n \), where \( n \) is the number of characters in the second DecimalDigits and \( e \) is the MV of ExponentPart.
- The MV of StrDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits.
- The MV of StrDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits times \( 10^n \), where \( e \) is the MV of ExponentPart.
- The MV of StrDecimalLiteral :: Decimals :: ExponentPart is the MV of DecimalDigits.
- The MV of DecimalDigits :: DecimalDigit is the MV of DecimalDigit.
- The MV of DecimalDigits :: DecimalDigit :: DecimalDigits is (the MV of DecimalDigits times \( 10^n \)) plus the MV of DecimalDigit.
- The MV of ExponentPart :: ExponentIndicator SignedInteger is the MV of SignedInteger.
- The MV of SignedInteger :: DecimalDigits is the MV of DecimalDigits.
- The MV of SignedInteger :: + DecimalDigits is the MV of DecimalDigits.
- The MV of SignedInteger :: - DecimalDigits is the negative of the MV of DecimalDigits.
- The MV of DecimalDigit :: 0 or of HexDigit :: 0 is 0.
- The MV of DecimalDigit :: 1 or of HexDigit :: 1 is 1.
- The MV of DecimalDigit :: 2 or of HexDigit :: 2 is 2.
- The MV of DecimalDigit :: 3 or of HexDigit :: 3 is 3.
- The MV of DecimalDigit :: 4 or of HexDigit :: 4 is 4.
- The MV of DecimalDigit :: 5 or of HexDigit :: 5 is 5.
- The MV of DecimalDigit :: 6 or of HexDigit :: 6 is 6.
- The MV of DecimalDigit :: 7 or of HexDigit :: 7 is 7.
- The MV of DecimalDigit :: 8 or of HexDigit :: 8 is 8.
- The MV of DecimalDigit :: 9 or of HexDigit :: 9 is 9.
- The MV of HexDigit :: a or of HexDigit :: A is 10.
- The MV of HexDigit :: b or of HexDigit :: B is 11.
- The MV of HexDigit :: c or of HexDigit :: C is 12.
• The MV of HexDigit ::: d or of HexDigit ::: D is 13.
• The MV of HexDigit ::: e or of HexDigit ::: E is 14.
• The MV of HexDigit ::: f or of HexDigit ::: F is 15.

• The MV of HexIntegerLiteral ::: 0x HexDigit is the MV of HexDigit.
• The MV of HexIntegerLiteral ::: 0X HexDigit is the MV of HexDigit.
• The MV of HexIntegerLiteral ::: HexIntegerLiteral HexDigit is (the MV of HexIntegerLiteral times 16) plus the MV of HexDigit.

Once the exact MV for a String numeric literal has been determined, it is then rounded to a value of the Number type. If the MV is 0, then the rounded value is +0 unless the first non white space character in the String numeric literal is ‘-’, in which case the rounded value is −0. Otherwise, the rounded value must be the Number value for the MV (in the sense defined in 8.5), unless the literal includes a StrUnsignedDecimalLiteral and the literal has more than 20 significant digits, in which case the Number value may be either the Number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit or the Number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit and then incrementing the literal at the 20th digit position. A digit is significant if it is not part of an ExponentPart and

• it is not 0; or
• there is a nonzero digit to its left and there is a nonzero digit, not in the ExponentPart, to its right.

9.1.4 ToInteger

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

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

9.1.5 ToInt32: (Signed 32 Bit Integer)

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

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

NOTE

Given the above definition of ToInt32:

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

9.1.6 ToUint32: (Unsigned 32 Bit Integer)

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

1. Let number be the result of calling ToNumber on the input argument.
2. ReturnIfAbrupt(number).
3. If number is NaN, return +0, −0, +∞, or −∞, return +0.
4. Let \( int \) be \( \text{sign}(\text{number}) \times \text{floor}(\text{abs}(\text{number})) \).
5. Let \( int32bit \) be \( int \mod 2^{32} \).
6. Return \( int32bit \).

NOTE Given the above definition of ToUint32:
- Step 6 is the only difference between ToUint32 and ToInt32.
- The ToUint32 abstract operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.
- ToUint32(ToInt32(x)) is equal to ToUint32(x) for all values of \( x \). (It is to preserve this latter property that \( +\infty \) and \( -\infty \) are mapped to \( +0 \)).
- ToUint32 maps \( -0 \) to \( +0 \).

9.1.7 ToUint16: (Unsigned 16 Bit Integer)
The abstract operation ToUint16 converts its argument to one of \( 2^{16} \) integer values in the range 0 through \( 2^{16} - 1 \), inclusive. This abstract operation functions as follows:
1. Let \( \text{number} \) be the result of calling ToNumber on the input argument.
2. ReturnIfAbrupt(\( \text{number} \)).
3. If \( \text{number} \) is NaN, +0, \( -0 \), \( +\infty \), or \( -\infty \), return \( +0 \).
4. Let \( int \) be \( \text{sign}(\text{number}) \times \text{floor}(\text{abs}(\text{number})) \).
5. Let \( int16bit \) be \( int \mod 2^{16} \).
6. Return \( int16bit \).

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

9.1.8 ToString
The abstract operation ToString converts its argument to a value of type String according to Table 18:

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>&quot;undefined&quot;</td>
</tr>
<tr>
<td>Null</td>
<td>&quot;null&quot;</td>
</tr>
<tr>
<td>Boolean</td>
<td>If argument is true, then return &quot;true&quot;. If argument is false, then return &quot;false&quot;.</td>
</tr>
<tr>
<td>Number</td>
<td>See 9.8.1.</td>
</tr>
<tr>
<td>String</td>
<td>Return argument (no conversion)</td>
</tr>
<tr>
<td>Symbol</td>
<td>&quot;[object Symbol]&quot;</td>
</tr>
<tr>
<td>Object</td>
<td>Apply the following steps: 1. Let ( \text{primValue} ) be ToPrimitive(( \text{argument} ), hint String). 2. Return ToString(( \text{primValue} )).</td>
</tr>
</tbody>
</table>

9.1.8.1 ToString Applied to the Number Type
The abstract operation ToString converts a Number \( m \) to String format as follows:
1. If \( m \) is NaN, return the String "NaN".
2. If \( m \) is\( +0 \) or \( -0 \), return the String "0".
3. If \( m \) is less than zero, return the String concatenation of the String "-" and ToString(\( -m \)).
4. If \( m \) is \( +\infty \), return the String "Infinity".
5. Otherwise, let $n$, $k$, and $s$ be integers such that $k \geq 1$, $10^{k-1} \leq s < 10^k$, the Number value for $s \times 10^{n-k}$ is $m$, and $k$ is as small as possible. Note that $k$ is the number of digits in the decimal representation of $s$, that $s$ is not divisible by 10, and that the least significant digit of $s$ is not necessarily uniquely determined by these criteria.

6. If $k \leq n \leq 21$, return the String consisting of the $k$ digits of the decimal representation of $s$ (in order, with no leading zeroes), followed by $n-k$ occurrences of the character ‘0’.

7. If $0 < n \leq 21$, return the String consisting of the most significant $n$ digits of the decimal representation of $s$, followed by a decimal point ‘.’, followed by the remaining $k-n$ digits of the decimal representation of $s$.

8. If $-6 < n \leq 0$, return the String consisting of the character ‘0’, followed by a decimal point ‘.’, followed by $-n$ occurrences of the character ‘0’, followed by the $k$ digits of the decimal representation of $s$.

9. Otherwise, if $k = 1$, return the String consisting of the single digit of $s$, followed by lowercase character ‘e’, followed by a plus sign ‘+’ or minus sign ‘-‘ according to whether $n-1$ is positive or negative, followed by the decimal representation of the integer $\text{abs}(n-1)$ (with no leading zeroes).

10. Return the String consisting of the most significant digit of the decimal representation of $s$, followed by a decimal point '.', followed by the remaining $k-1$ digits of the decimal representation of $s$, followed by the lowercase character ‘e’, followed by a plus sign ‘+’ or minus sign ‘-‘ according to whether $n-1$ is positive or negative, followed by the decimal representation of the integer $\text{abs}(n-1)$ (with no leading zeroes).

NOTE 1 The following observations may be useful as guidelines for implementations, but are not part of the normative requirements of this Standard:

• If $x$ is any Number value other than $-0$, then ToNumber(ToString($x$)) is exactly the same Number value as $x$.

• The least significant digit of $s$ is not always uniquely determined by the requirements listed in step 5.

NOTE 2 For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 5 be used as a guideline:

Otherwise, let $n$, $k$, and $s$ be integers such that $k \geq 1$, $10^{k-1} \leq s < 10^k$, the Number value for $s \times 10^{n-k}$ is $m$, and $k$ is as small as possible. If there are multiple possible values 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:


9.1.9 ToObject

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

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

9.1.10 ToPropertyKey

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

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

9.2 Testing and Comparison Operations

9.2.1 CheckObjectCoercible

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

Table 20 — CheckObjectCoercible Results

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

9.2.2 IsCallable

The abstract operation IsCallable determines if its argument, which must be an ECMAScript language value or a Completion Record, is a callable function Object according to Table 21:
Table 21 — IsCallable Results

<table>
<thead>
<tr>
<th>Argument Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion Record</td>
<td>If argument is an abrupt completion, return argument. Otherwise return IsCallable(argument.[[value]])</td>
</tr>
<tr>
<td>Undefined</td>
<td>Return false</td>
</tr>
<tr>
<td>Null</td>
<td>Return false</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return false</td>
</tr>
<tr>
<td>Number</td>
<td>Return false</td>
</tr>
<tr>
<td>String</td>
<td>Return false</td>
</tr>
<tr>
<td>Symbol</td>
<td>Return false</td>
</tr>
<tr>
<td>Object</td>
<td>If argument has a [[Call]] internal method, then return true, otherwise return false.</td>
</tr>
</tbody>
</table>

9.2.3 SameValue(x, y)

The internal comparison abstract operation SameValue(x, y), where x and y are ECMAScript language values, produces true or false. Such a comparison is performed as follows:

1. ReturnIfAbrupt(x).
2. ReturnIfAbrupt(y).
3. If Type(x) is different from Type(y), return false.
4. If Type(x) is Undefined, return true.
5. If Type(x) is Null, return true.
6. If Type(x) is Number, then
   a. If x is NaN and y is NaN, return true.
   b. If x is +0 and y is -0, return false.
   c. If x is -0 and y is +0, return false.
   d. If x is the same Number value as y, return true.
   e. Return false.
7. If Type(x) is String, then
   a. If x and y are exactly the same sequence of code units (same length and same code units in corresponding positions) return true, otherwise, return false.
8. If Type(x) is Boolean, then
   a. If x and y are both true or both false, then return true; otherwise, return false.
9. If Type(x) is Symbol, then
   a. If x and y are the same Symbol value, then return true; otherwise, return false.
10. Return true if x and y are the same Object value. Otherwise, return false.

9.2.4 SameValueZero(x, y)

The internal comparison abstract operation SameValueZero(x, y), where x and y are ECMAScript language values, produces true or false. Such a comparison is performed as follows:

1. ReturnIfAbrupt(x).
2. ReturnIfAbrupt(y).
3. If Type(x) is different from Type(y), return false.
4. If Type(x) is Undefined, return true.
5. If Type(x) is Null, return true.
6. If Type(x) is Number, then
   a. If x is NaN and y is NaN, return true.
   b. If x is +0 and y is -0, return true.
   c. If x is -0 and y is +0, return true.
   d. If x is the same Number value as y, return true.
   e. Return false.
7. If Type(x) is String, then
   a. If x and y are exactly the same sequence of code units (same length and same code units in corresponding positions) return true; otherwise, return false.
8. If Type(x) is Boolean, then
   a. If x and y are both true or both false, then return true; otherwise, return false.

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

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

NOTE SameValueZero differs from SameValue only in its treatment of +0 and -0.

9.2.5 IsConstructor

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

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

9.2.6 IsPropertyKey

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

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

9.2.7 IsExtensible (O)

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

1. Assert: Type(O) is Object.
2. Let notExtensible be the result of calling the [[HasIntegrity]] internal method of O with argument "nonextensible".
3. ReturnIfAbrupt(notExtensible).
4. If notExtensible is true, then return false; else return true.

9.3 Operations on Objects

9.3.1 Get (O, P)

The abstract operation Get is used to retrieve the value of an specific property of an object. The operation is called with arguments O and P where O is the object and P is the property key. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Return the result of calling the [[Get]] internal method of O passing P and O as the arguments.

9.3.2 Put (O, P, V, Throw)

The abstract operation Put is used to set the value of a specific property of an object. The operation is called with arguments O, P, V, and Throw where O is the object, P is the property key, V is the new value for the property and Throw is a Boolean flag. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Assert: Type(Throw) is Boolean.
4. Let success be the result of calling the [[Set]] internal method of O passing P, V, and O as the arguments.
5. ReturnIfAbrupt(success).
6. If success is false and Throw is true, then throw a TypeError exception.
7. Return success.

9.3.3 CreateOwnDataProperty (O, P, V)

The abstract operation CreateOwnDataProperty is used to create a new own property of an object. The operation is called with arguments O, P, and V where O is the object, P is the property key, and V is the new value for the property. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Assert: O does not have an own property whose key is P.
4. Let newDesc be the Property Descriptor {[[Value]]: V, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
5. Return the result of calling the [[DefineOwnProperty]] internal method of O passing P and newDesc as arguments.

NOTE This abstract operation creates a property whose attributes as set to the same defaults used for properties created by the ECMAScript language assignment operator.

9.3.4 DefinePropertyOrThrow (O, P, desc)

The abstract operation DefinePropertyOrThrow is used to call the [[DefineOwnProperty]] internal method of an object in a manner that will throw a TypeError exception if the requested property update cannot be performed. The operation is called with arguments O, P, and desc where O is the object, P is the property key, and desc is the Property Descriptor for the property. This abstract operation perform, the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Let success be the result of calling the [[DefineOwnProperty]] internal method of O passing P and desc as arguments.
4. ReturnIfAbrupt(success).
5. If success is false, then throw a TypeError exception.

9.3.5 DeletePropertyOrThrow (O, P)

The abstract operation Put is used to remove a specific own property of an object. It throws an exception if the property is not configurable. The operation is called with arguments O and P where O is the object and P is the property key. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Let success be the result of calling the [[Delete]] internal method of O passing P as the argument.
4. ReturnIfAbrupt(success).
5. If success is false, then throw a TypeError exception.

9.3.6 HasProperty (O, P)

The abstract operation HasProperty is used to determine whether an object has a property with the specified property key. The property may be either an own or inherited. A Boolean value is return. The operation is called with arguments O and P where O is the object and P is the property key. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: IsPropertyKey(P) is true.
3. Return the result of calling the [[HasProperty]] internal method of O with argument P.
9.3.7 GetMethod (O, P)

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

1. Assign: Type(\( O \)) is Object.
2. Assign: IsPropertyKey(\( P \)) is true.
3. Let \( \text{func} \) be the result of calling the \([\text{Get}]\) internal method of \( O \) passing \( P \) and \( O \) as the arguments.
4. ReturnIfAbrupt(\( \text{func} \)).
5. If \( \text{func} \) is undefined, then return undefined.
6. If IsCallable(\( \text{func} \)) is false, then throw a TypeError exception.
7. Return \( \text{func} \).

9.3.8 Invoke(\( O, P, [\text{args}] \))

The abstract operation Invoke is used to call a method property of an object. The operation is called with arguments \( P, O \), and optionally \( \text{args} \) where \( P \) is the property key, \( O \) serves as both the lookup point for the property and the this value of the call, and \( \text{args} \) is the list of arguments values passed to the method. If \( \text{args} \) is not present, an empty List is used as its value. This abstract operation performs the following steps:

1. Assign: \( P \) is a valid property key.
2. If \( \text{args} \) was not passed, then let \( \text{args} \) be a new empty List.
3. Let \( \text{obj} \) be ToObject(\( O \)).
4. ReturnIfAbrupt(\( \text{obj} \)).
5. Let \( \text{func} \) be the result of GetMethod(\( \text{obj}, P \)).
6. ReturnIfAbrupt(\( \text{func} \)).
7. If \( \text{func} \) is undefined, throw a TypeError exception.
8. Return the result of calling the \([\text{Call}]\) internal method of \( \text{func} \) passing \( O \) as thisArgument and \( \text{args} \) as argumentsList.

9.3.9 SetIntegrityLevel (O, level)

The abstract operation SetIntegrityLevel is used to fix the set of own properties of an object. This abstract operation performs the following steps:

1. Assign: Type(\( O \)) is Object.
2. Assign: \( \text{level} \) is either "sealed" or "frozen".
3. Let \( \text{keys} \) be the result of calling the \([\text{OwnProperty}]\) internal method of \( O \).
4. ReturnIfAbrupt(\( \text{keys} \)).
5. Let \( \text{pendingException} \) be undefined.
6. If \( \text{level} \) is "sealed", then
   a. Repeat for each element \( k \) of \( \text{keys} \) the following steps:
      i. Let \( \text{status} \) be the result of DefinePropertyOrThrow(\( O, k, \text{PropertyDescriptor} \) [[Configurable]: false]).
      ii. If \( \text{status} \) is an Abrupt Completion, then
         1. If \( \text{pendingException} \) is undefined, then set \( \text{pendingException} \) to status.
   b. Else, repeat for each element \( k \) of \( \text{keys} \)
      i. Let \( \text{status} \) be the result of calling the \([\text{DefineOwnProperty}]\) internal method of \( O \) with \( k \) and
         ii. If \( \text{status} \) is an Abrupt Completion, then
            1. If \( \text{pendingException} \) is undefined, then set \( \text{pendingException} \) to status.
   iii. Else,
      i. Let \( \text{currentDesc} \) be status.[[value]].
      2. If \( \text{currentDesc} \) is not undefined, then
         a. If IsAccessorDescriptor(\( \text{currentDesc} \)) is true, then
            i. Let \( \text{desc} \) be PropertyDescriptor(\( [{\text{[[Configurable]]}: \text{false}, [[Writable]]: \text{false}] \).
            b. Else,
               i. Let \( \text{desc} \) be PropertyDescriptor ( \( [[\text{Configurable}]]: \text{false},
                   [[Writable]]: \text{false} \)).
c. Let status be the result of DefinePropertyOrThrow(O, k, desc).

d. If status is an Abrupt Completion, then
   i. If pendingException is undefined, then set pendingException to status.

8. If pendingException is not undefined, then return pendingException.
9. Return the result of calling the [[PreventExtensions]] internal method of O.

9.3.10 TestIntegrityLevel(O, level)

The abstract operation TestIntegrityLevel is used to determine if the set of own properties of an object are fixed. This abstract operation performs the following steps:

1. Assert: Type(O) is Object.
2. Assert: level is either "sealed" or "frozen".
3. Let status be the result of IsExtensible(O).
4. ReturnIfAbrupt(status).
5. If status is true, then return false.
6. NOTE If the object is extensible, none of its properties are examined.
7. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of O.
8. ReturnIfAbrupt(keys).
9. Let pendingException be undefined.
10. Let configurable be false.
11. Let writable be false.
12. Repeat for each element k of keys,
   a. Let status be the result of calling the [[GetOwnProperty]] internal method of O with k.
   b. If status is an Abrupt Completion, then
      i. If pendingException is undefined, then set pendingException to status.
      ii. Let configurable be true.
   c. Else,
      i. Let currentDesc be status.[[value]].
      ii. If currentDesc is not undefined, then
         1. Set configurable to configurable logically ored with currentDesc.[[Configurable]].
         2. If IsDataDescriptor(currentDesc) is true, then
            a. Set writable to writable logically ored with currentDesc.[[Writable]].

13. If pendingException is not undefined, then return pendingException.
14. If level is "frozen" and writable is true, then return false.
15. If configurable is true, then return false.
16. Return true.

9.3.11 CreateArrayFromList(elements)

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

1. Assert: elements is a List whose elements are all ECMAScript language values.
2. Let array be the result of the abstract operation ArrayCreate with argument 0.
3. Let n be 0.
4. For each element e of elements
   a. Call CreateOwnDataProperty(array, ToString(n), e).
   b. Assert: the call in step 4.a will never result in an abrupt completion.
   c. Increment n by 1.
5. Return array.

9.3.12 OrdinaryHasInstance(C, O)

The abstract operation OrdinaryHasInstance implements the default algorithm for determining if an object O inherits from the instance object inheritance path provided by constructor C. This abstract operation performs the following steps:

1. If IsCallable(C) is false, return false.
2. If C has a \[[\text{BoundTargetFunction}]\] internal data property, then
   a. Let BC be the value of C's \[[\text{BoundTargetFunction}]\] internal data property.
   b. Return the result of instanceofOperator\((O, BC)\) (see 11.8).
3. If Type\((O)\) is not Object, return false.
4. Let P be the result of Get\((C, \"prototype\")\).
5. ReturnIfAbrupt\((P)\).
6. If Type\((P)\) is not Object, throw a TypeError exception.
7. Repeat
   a. Set O to the result of calling the [[GetInheritance]] internal method of O with no arguments.
   b. ReturnIfAbrupt\((O)\).
   c. If O is null, return false.
   d. If SameValue\((P, O)\) is true, return true.
9.3.13 GetPrototypeFromConstructor \((\text{constructor, intrinsicDefaultProto})\)

The abstract operation GetPrototypeFromConstructor determines the [[Prototype]] value that should be used to create an object corresponding to a specific constructor. The value is retrieved from the constructor's prototype property, if it exists. Otherwise the supplied default is used for [[Prototype]]. This abstract operation performs the following steps:

1. Assert: intrinsicProto is a string value that is this specification’s name of an intrinsic object. The corresponding object must be an intrinsic that is intended to be used as the [[Prototype]] value of an object.
2. If IsConstructor\((\text{constructor})\) is false, then throw a TypeError exception.
3. Let proto be the result of Get\((\text{constructor}, \"prototype\")\).
4. ReturnIfAbrupt\((\text{proto})\).
5. If Type\((\text{proto})\) is not Object, then
   a. If \text{constructor} has a [[Realm]] internal data property, let realm be \text{constructor}’s [[Realm]].
   b. Else,
      i. Let ctx be the running execution context.
      ii. Let realm be ctx's Realm.
   c. Let proto be realm’s intrinsic object named intrinsicDefaultProto.
6. Return proto.

NOTE If \text{constructor} does not supply a [[Prototype]] value, the default value that is used is obtained from the Code Realm of the \text{constructor} function rather than from the running execution context. This accounts for the possibility that a built-in @@create method from a different Code Realm might be installed on \text{constructor}.

9.3.14 OrdinaryCreateFromConstructor \((\text{constructor, intrinsicDefaultProto, internalDataList})\)

The abstract operation OrdinaryCreateFromConstructor creates an ordinary object whose [[Prototype]] value is retrieved from a constructor's prototype property, if it exists. Otherwise the supplied default is used for [[Prototype]]. The optional internalDataList is a List of the names of internal data property names that should be defined as part of the object. If the list is not provided, an empty List is used. This abstract operation performs the following steps:

1. Assert: intrinsicDefaultProto is a string value that is this specification’s name of an intrinsic object. The corresponding object must be an intrinsic that is intended to be used as the [[Prototype]] value of an object.
2. Let proto be the result of GetPrototypeFromConstructor\((\text{constructor, intrinsicDefaultProto})\).
3. ReturnIfAbrupt\((\text{proto})\).
4. Return the result of the abstract operation ObjectCreate\((\text{proto}, \text{internalDataList})\).

10 Executable Code and Execution Contexts

10.1 Types of Executable Code

There are four types of ECMAScript executable code:
• Global code is source text that is treated as an ECMAScript Script. The global code of a particular Script does not include any source text that is parsed as part of a FunctionBody, GeneratorBody, ConciseBody, ClassBody, or ModuleBody.

• Eval code is the source text supplied to the built-in eval function. More precisely, if the parameter to the built-in eval function is a String, it is treated as an ECMAScript Script. The eval code for a particular invocation of eval is the global code portion of that Script.

• Function code is source text that is parsed to supply the value of the [[Code]] internal data property (see 8.3.15) of function and generator objects. The function code of a particular function or generator does not include any source text that is parsed as the function code of a nested FunctionBody, GeneratorBody, ConciseBody, or ClassBody.

• Module code is source text that is parse code that is provided as a ModuleBody. It is the code that is directly evaluated when a module is initialized. The module code of a particular module does not include any source text that is parsed as part of a nested FunctionBody, GeneratorBody, ConciseBody, ClassBody, or ModuleBody.

NOTE Function code is generally provided as the bodies of Function Definitions (13.1), Arrow Function Definitions (13.2), Method Definitions (13.3) and Generator Definitions (13.4). Function code is also derived from the last argument to the Function constructor (15.3).

10.1.1 Strict Mode Code

An ECMAScript Script syntactic unit may be processed using either unrestricted or strict mode syntax and semantics. When processed using strict mode the four types of ECMAScript code are referred to as module code, strict global code, strict eval code, and strict function code. Code is interpreted as strict mode code in the following situations:

• Global code is strict global code if it begins with a Directive Prologue that contains a Use Strict Directive (see 14.1).

• Module code is always strict code.

• All code contained in a ClassBody is strict code.

• Eval code is strict eval code if it begins with a Directive Prologue that contains a Use Strict Directive or if the call to eval is a direct call (see 15.1.2.1.1) to the eval function that is contained in strict mode code.

• Function code that is part of a FunctionDeclaration, FunctionExpression, or accessor PropertyDefinition is strict function code if its FunctionDeclaration, FunctionExpression, or PropertyDefinition is contained in strict mode code or if the function code begins with a Directive Prologue that contains a Use Strict Directive.

• Function code that is supplied as the last argument to the built-in Function constructor is strict function code if the last argument is a String that when processed as a FunctionBody begins with a Directive Prologue that contains a Use Strict Directive.

10.1.2 Non-ECMAScript Functions

An ECMAScript implementation may support the evaluation of function objects whose evaluative behaviour is expressed in some implementation defined form of executable code other than via ECMAScript code. Whether a function object is an ECMAScript code function or a non-ECMAScript function is not semantically observable from the perspective of an ECMAScript code function that calls or is called by such a non-ECMAScript function.

10.2 Lexical Environments

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

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

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

A global environment is a Lexical Environment which does not have an outer environment. The global environment’s outer environment reference is null. A global environment’s environment record may be prepopulated with identifier bindings and includes an associated global object whose properties provide some of the global environment’s identifier bindings. This global object is the value of a global environment’s this binding. As ECMAScript code is executed, additional properties may be added to the global object and the initial properties may be modified.

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

Lexical Environments and Environment Record values are purely specification mechanisms and need not correspond to any specific artefact of an ECMAScript implementation. It is impossible for an ECMAScript program to directly access or manipulate such values.

10.2.1 Environment Records

There are two primary kinds of Environment Record values used in this specification: declarative environment records and object environment records. Declarative environment records are used to define the effect of ECMAScript language syntactic elements such as FunctionDeclarations, VariableDeclarations, and Catch clauses that directly associate identifier bindings with ECMAScript language values. Object environment records are used to define the effect of ECMAScript elements such as WithStatement that associate identifier bindings with the properties of some object. Global Environment Records and Function Environment Records are specializations that are used for specifically for Script global declarations and for top-level declarations within functions.

For specification purposes Environment Record values can be thought of as existing in a simple object-oriented hierarchy where Environment Record is an abstract class with three concrete subclasses, declarative environment record, object environment record, and global environment record. Function environment records are a subclass of declarative environment record. The abstract class includes the abstract specification methods defined in Table 22. These abstract methods have distinct concrete algorithms for each of the concrete subclasses.
### Table 22 — 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 an identifier. Return true if it does and false if it does not. The String value N is the text of the identifier.</td>
</tr>
<tr>
<td>CreateMutableBinding(N, D)</td>
<td>Create a new but uninitialised mutable binding in an environment record. The String value N is the text of the bound name. If the optional Boolean argument D is true the binding is may be subsequently deleted.</td>
</tr>
<tr>
<td>CreateImmutableBinding(N)</td>
<td>Create a new but uninitialised immutable binding in an environment record. The String value N is the text of the bound name.</td>
</tr>
<tr>
<td>InitialiseBinding(N,V)</td>
<td>Set the value of an already existing but uninitialised binding in an environment record. The String value N is the text of the bound name. V is the value for the binding and is a value of any ECMAScript language type.</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. S is used to identify strict mode references.</td>
</tr>
<tr>
<td>GetBindingValue(N,S)</td>
<td>Returns the value of an already existing binding from an environment record. The String value N is the text of the bound name. S is used to identify strict mode references. If S is true and the binding does not exist or is uninitialised throw a ReferenceError exception.</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>

**10.2.1.1 Declarative Environment Records**

Each declarative environment record is associated with an ECMAScript program scope containing variable, constant, let, class, module, import, and/or function declarations. A declarative environment record binds the set of identifiers defined by the declarations contained within its scope.

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

**10.2.1.1.1 HasBinding(N)**

The concrete environment record method HasBinding for declarative environment records simply determines if the argument identifier is one of the identifiers bound by the record:

1. Let envRec be the declarative environment record for which the method was invoked.
2. If envRec has a binding for the name that is the value of N, return true.
3. If it does not have such a binding, return false.

10.2.1.1.2 CreateMutableBinding (N, D)

The concrete Environment Record method CreateMutableBinding for declarative environment records creates a new mutable binding for the name N that is uninitialised. A binding must not already exist in this Environment Record for N. If Boolean argument D is provided and has the value true the new binding is marked as being subject to deletion.

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

10.2.1.1.3 CreateImmutableBinding (N)

The concrete Environment Record method CreateImmutableBinding for declarative environment records creates a new immutable binding for the name N that is uninitialised. A binding must not already exist in this environment record for N.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Assert: envRec does not already have a binding for N.
3. Create an immutable binding in envRec for N and record that it is uninitialised.

10.2.1.1.4 InitialiseBinding (N,V)

The concrete Environment Record method InitialiseBinding for declarative environment records is used to set the bound value of the current binding of the identifier whose name is the value of the argument N to the value of argument V. An uninitialised binding for N must already exist.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Assert: envRec must have an uninitialised binding for N.
3. Set the bound value for N in envRec to V.
4. Record that the binding for N in envRec has been initialised.

10.2.1.1.5 SetMutableBinding (N,V,S)

The concrete Environment Record method SetMutableBinding for declarative environment records attempts to change the bound value of the current binding of the identifier whose name is the value of the argument N to the value of argument V. A binding for N must already exist. If the binding is an immutable binding, a TypeError is thrown if S is true.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Assert: envRec must have a binding for N.
3. If the binding for N in envRec has not yet been initialized throw a ReferenceError exception.
4. Else if the binding for N in envRec is a mutable binding, change its bound value to V.
5. Else this must be an attempt to change the value of an immutable binding so if S is true throw a TypeError exception.
6. Return NormalCompletion(empty)

10.2.1.1.6 GetBindingValue (N,S)

The concrete Environment Record method GetBindingValue for declarative environment records simply returns the value of its bound identifier whose name is the value of the argument N. The binding must already exist. If S is true and the binding is an uninitialised immutable binding throw a ReferenceError exception.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Assert: envRec has a binding for N.
3. If the binding for N in envRec is an uninitialised binding, then
   a. If S is false, return the value undefined, otherwise throw a ReferenceError exception.
4. Else,
   a. Return the value currently bound to $N$ in $envRec$.

10.2.1.1.7 DeleteBinding($N$)

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

1. Let $envRec$ be the declarative environment record for which the method was invoked.
2. If $envRec$ does not have a binding for the name that is the value of $N$, return true.
3. If the binding for $N$ in $envRec$ cannot be deleted, return false.
4. Remove the binding for $N$ from $envRec$.
5. Return true.

10.2.1.1.8 HasThisBinding()

Regular Declarative Environment Records do not provide a this binding.

1. Return false.

10.2.1.1.9 HasSuperBinding()

Regular Declarative Environment Records do not provide a super binding.

1. Return false.

10.2.1.10 WithBaseObject()

Declarative Environment Records always return undefined as their WithBaseObject.

1. Return undefined.

10.2.1.2 Object Environment Records

Each object environment record is associated with an object called its binding object. An object environment record binds the set of identifier names that directly correspond to the property names of its binding object. Property names that are not an IdentifierName are not included in the set of bound identifiers. Both own and inherited properties are included in the set regardless of the setting of their [[Enumerable]] attribute. Because properties can be dynamically added and deleted from objects, the set of identifiers bound by an object environment record may potentially change as a side-effect of any operation that adds or deletes properties. Any bindings that are created as a result of such a side-effect are considered to be a mutable binding even if the Writable attribute of the corresponding property has the value false. Immutable bindings do not exist for object environment records.

Object environment records created for with statements (12.10) can provide their binding object as an implicit this value for use in function calls. The capability is controlled by a withEnvironment Boolean value that is associated with each object environment record. By default, the value of withEnvironment is false for any object environment record.

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

10.2.1.2.1 HasBinding($N$)

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

1. Let $envRec$ be the object environment record for which the method was invoked.
2. Let $bindings$ be the binding object for $envRec$.
3. Return the result of HasProperty($bindings$, $N$).
10.2.1.2.2 CreateMutableBinding (N, D)

The concrete Environment Record method CreateMutableBinding for object environment records creates in an environment record's associated binding object a property whose name is the String value and initialises it to the value undefined. A property named N must not already exist in the binding object. If Boolean argument D is provided and has the value true the new property's [[Configurable]] attribute is set to true, otherwise it is set to false.

1. Let envRec be the object environment record for which the method was invoked.
2. Let bindings be the binding object for envRec.
3. Assert: The result of HasProperty(bindings, N) is false.
4. If D is true then let configValue be true otherwise let configValue be false.
5. Return the result of DefinePropertyOrThrow(bindings, N, Property Descriptor { [[Value]]: undefined, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: configValue}).

10.2.1.2.3 CreateImmutableBinding (N)

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

10.2.1.2.4 InitialiseBinding (N,V)

The concrete Environment Record method InitialiseBinding for object environment records is used to set the bound value of the current binding of the identifier whose name is the value of the argument N to the value of argument V. An uninitialised binding for N must already exist.

1. Let envRec be the object environment record for which the method was invoked.
2. Assert: envRec must have an uninitialised binding for N.
3. Record that the binding for N in envRec has been initialised.
4. Call the SetMutableBinding concrete method of envRec with N, V, and false as arguments.

10.2.1.2.5 SetMutableBinding (N,V,S)

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

1. Let envRec be the object environment record for which the method was invoked.
2. Let bindings be the binding object for envRec.
3. Return the result of Put(bindings, N, V, and S).

10.2.1.2.6 GetBindingValue(N,S)

The concrete Environment Record method GetBindingValue for object environment records returns the value of its associated binding object's property whose name is the String value of the argument identifier N. The property should already exist but if it does not the result depends upon the value of the S argument:

1. Let envRec be the object environment record for which the method was invoked.
2. Let bindings be the binding object for envRec.
3. Let value be the result of HasProperty(bindings, N).
4. ReturnIfAbrupt(value).
5. If value is false, then
   a. If S is false, return the value undefined, otherwise throw a ReferenceError exception.
6. Return the result of Get(bindings, N).
10.2.1.2.7 DeleteBinding (N)

The concrete Environment Record method DeleteBinding for object environment records can only delete bindings that correspond to properties of the environment object whose [[Configurable]] attribute have the value true.

1. Let envRec be the object environment record for which the method was invoked.
2. Let bindings be the binding object for envRec.
3. Return the result of calling the [[Delete]] internal method of bindings passing N as the argument.

10.2.1.2.8 HasThisBinding ()

Regular Object Environment Records do not provide a this binding.

1. Return false.

10.2.1.2.9 HasSuperBinding ()

Regular Object Environment Records do not provide a super binding.

1. Return false.

10.2.1.2.10 WithBaseObject()

Object Environment Records return undefined as their WithBaseObject unless their withEnvironment flag is true.

1. Let envRec be the object environment record for which the method was invoked.
2. If the withEnvironment flag of envRec is true, return the binding object for envRec.
3. Otherwise, return undefined.

10.2.1.3 Function Environment Records

A function environment record is a declarative environment record that is used to represent the outer most scope of a function that provides a this binding. In addition to its identifier bindings, a function environment record contains the this value used within its scope. If such a function references super, its function environment record also contains the state that is used to perform super method invocations from within the function.

Function environment records store their this binding as the value of their thisValue. If the associated function references super, the environment record stores in HomeObject the object that the function is bound to as a method and in MethodName the property key used for unqualified super invocations from within the function. The default value for HomeObject and MethodName is undefined.

Methods environment records support all of Declarative Environment Record methods listed in Table 22 and share the same specifications for all of those methods except for HasThisBinding and HasSuperBinding. In addition, declarative environment records support the methods listed in Table 23:

<table>
<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>GetSuperBase()</td>
<td>Return the object that is the base for super property accesses bound in this environment record. The object is derived from this environment record’s HomeObject binding. If the value is Empty, return undefined.</td>
</tr>
<tr>
<td>GetMethodName()</td>
<td>Return the value of this environment record’s MethodName binding.</td>
</tr>
</tbody>
</table>
The behaviour of the additional concrete specification methods for Function Environment Records is defined by the following algorithms:

10.2.1.3.1 HasThisBinding ()

Function Environment Records always provide a this binding.

1. Return true.

10.2.1.3.2 HasSuperBinding ()

1. If this environment record’s HomeObject has the value Empty, then return false. Otherwise, return true.

10.2.1.3.3 GetThisBinding ()

1. Return the value of this environment record’s thisValue.

10.2.1.3.4 GetSuperBase ()

1. Let home be the value of this environment record’s HomeObject.
2. If home has the value Empty, then return undefined.
3. Assert Type(home) is Object.
4. Return the result of calling home’s [[GetInheritance]] internal method.

10.2.1.3.5 GetMethodName ()

1. Return the value of this environment record’s MethodName.

10.2.1.4 Global Environment Records

A global environment record is used to represent the outermost scope that is shared by all of the ECMAScript Script elements that are processed in a common Realm (10.3). A global environment provides the bindings for built-in globals (15.1), properties of the global object, and for all declarations that are not function code and that occur within Script productions.

A global environment record is logically a single record but it is specified as a composite encapsulating an object environment record and a declarative environment record. The object environment record has as its base object the global object of the associated Realm. This global object is also the value of the global environment record’s thisValue. The object environment record component of a global environment record contains the bindings for all built-in globals (15.1) and all bindings introduced by a FunctionDeclaration or VariableStatement contained in global code. The bindings for all other ECMAScript declarations in global code are contained in the declarative environment record component of the global environment record.

Properties may be created directly on a global object. Hence, the object environment record component of a global environment record may contain both bindings created explicitly by FunctionDeclaration or VariableStatement declarations and binding created implicitly as properties of the global object. In order to identify which bindings were explicitly created using declarations, a global environment record maintains a list of the names bound using its CreateGlobalVarBindings and CreateGlobalFunctionBindings concrete methods.

Global environment records have the additional state components listed in Table 24 and the additional methods listed in Table 25.
Table 24 -- Components of Global Environment Records

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ObjectEnvironment</td>
<td>A Object Environment Record whose base object is the global object. Contains global built-in bindings as well as bindings for FunctionDeclaration or VariableStatement declarations in global code for the associated Realm.</td>
</tr>
<tr>
<td>DeclarativeEnvironment</td>
<td>A Declarative Environment Record that contains bindings for all declarations in global for the associated Realm code except for FunctionDeclaration and VariableStatement declarations.</td>
</tr>
<tr>
<td>VarNames</td>
<td>A List containing the string names bound by FunctionDeclaration or VariableStatement declarations in global code for the associated Realm.</td>
</tr>
</tbody>
</table>

Table 25 — 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 VariableStatement or a FunctionDeclaration.</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>CanDeclareGlobalVar (N)</td>
<td>Determines if a corresponding CreateGlobalVarBinding call would succeed if called for the same argument N.</td>
</tr>
<tr>
<td>CanDeclareGlobalFunction (N)</td>
<td>Determines if a corresponding CreateGlobalFunctionBinding call would succeed if called for the same argument N.</td>
</tr>
<tr>
<td>CreateGlobalVarBinding(N, D)</td>
<td>Used to create global var bindings in the ObjectEnvironmentComponent of the environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values approate for a var. The String value N is the text of the bound name. V is the initial value of the binding If the optional Boolean argument D is true the binding is may be subsequently deleted. This is logically equivalent to CreateMutableBinding but it allows var declarations to receive special treatment.</td>
</tr>
<tr>
<td>CreateGlobalFunctionBinding(N, V, D)</td>
<td>Used to create and initialize global function bindings in the ObjectEnvironmentComponent of the environment record. The binding will be a mutable binding. The corresponding global object property will have attribute values approate for a function. The String value N is the text of the bound name. If the optional Boolean argument D is true the binding is may be subsequently deleted. This is logically equivalent to CreateMutableBinding followed by a SetMutableBinding but it allows function declarations to receive special treatment.</td>
</tr>
</tbody>
</table>

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

10.2.1.4.1 HasBinding(N)

The concrete environment record method HasBinding for global environment records simply determines if the argument identifier is one of the identifiers bound by the record.
1. Let \( envRec \) be the global environment record for which the method was invoked.
2. Let \( DclRec \) be \( envRec \)'s DeclarativeEnvironment.
3. If the result of calling \( DclRec \)'s HasBinding concrete method with argument \( N \) is \texttt{true}, return \texttt{true}.
4. Let \( ObjRec \) be \( envRec \)'s ObjectEnvironment.
5. Return the result of calling \( ObjRec \)'s HasBinding concrete method with argument \( N \).

10.2.1.4.2 \texttt{CreateMutableBinding} (\( N, D \))

The concrete environment record method \texttt{CreateMutableBinding} for global environment records creates a new mutable binding for the name \( N \) that is uninitialised. The binding is created in the associated DeclarativeEnvironment. A binding for \( N \) must not already exist in the DeclarativeEnvironment. If Boolean argument \( D \) is provided and has the value \texttt{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 \( envRec \)'s DeclarativeEnvironment.
3. Assert: \( DclRec \) does not already have a binding for \( N \).
4. Create a mutable binding in \( DclRec \) for \( N \) and record that it is uninitialised. If \( D \) is \texttt{true} record that the newly created binding may be deleted by a subsequent \texttt{DeleteBinding} call.
5. Return NormalCompletion(\texttt{empty})

10.2.1.4.3 \texttt{CreateImmutableBinding} [\( N \)]

The concrete Environment Record method \texttt{CreateImmutableBinding} for declarative environment records creates a new immutable binding for the name \( N \) that is uninitialised. A binding must not already exist in this environment record for \( N \).

1. Let \( envRec \) be the global environment record for which the method was invoked.
2. Let \( envRec \) does not already have a binding for \( N \).
3. Create an immutable binding in \( envRec \) for \( N \) and record that it is uninitialised.

10.2.1.4.4 \texttt{InitialiseBinding} (\( N, V \))

The concrete Environment Record method \texttt{InitialiseBinding} for global environment records is used to set the bound value of the current binding of the identifier whose name is the value of the argument \( N \) to the value of argument \( V \). An uninitialised binding for \( N \) must already exist.

1. Let \( envRec \) be the global environment record for which the method was invoked.
2. Let \( DclRec \) be \( envRec \)'s DeclarativeEnvironment.
3. If the result of calling \( DclRec \)'s HasBinding concrete method with argument \( N \) is \texttt{true}, then
   a. Return the result of calling \( DclRec \)'s InitialiseBinding concrete method with arguments \( N \) and \( V \).
4. Let \( ObjRec \) be \( envRec \)'s ObjectEnvironment.
5. If the result of calling \( ObjRec \)'s HasBinding concrete method with argument \( N \) is \texttt{true}, then
   a. Set the bound value for \( N \) in \( envRec \) to \( V \).
   b. Record that the binding for \( N \) in \( envRec \) has been initialised.

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

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

1. Let \( envRec \) be the declarative environment record for which the method was invoked.
2. Let \( DclRec \) be \( envRec \)'s DeclarativeEnvironment.
3. If the result of calling \( DclRec \)'s HasBinding concrete method with argument \( N \) is \texttt{true}, then
   a. Return the result of calling the \texttt{SetMutableBinding} concrete method of \( DclRec \) with arguments \( N \), \( V \), and \( S \).
4. Let \( ObjRec \) be \( envRec \)'s ObjectEnvironment.
5. Return the result of calling the \texttt{SetMutableBinding} concrete method of \( ObjRec \) with arguments \( N \), \( V \), and \( S \).
10.2.1.4.6 GetBindingValue(N,S)

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

1. Let envRec be the declarative environment record for which the method was invoked.
2. Let DclRec be envRec’s DeclarativeEnvironment.
3. If the result of calling DclRec’s HasBinding concrete method with argument N is true, then
   a. Return the result of calling the GetBindingValue concrete method of DclRec with arguments N, and S.
4. Let ObjRec be envRec’s ObjectEnvironment.
5. Return the result of calling the GetBindingValue concrete method of ObjRec with arguments N, and S.

10.2.1.4.7 DeleteBinding (N)

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

1. Let envRec be the declarative environment record for which the method was invoked.
2. Let DclRec be envRec’s DeclarativeEnvironment.
3. If the result of calling DclRec’s HasBinding concrete method with argument N is true, then
   a. Return the result of calling the DeleteBinding concrete method of DclRec with argument N.
4. Let ObjRec be envRec’s ObjectEnvironment.
5. If the result of calling ObjRec’s HasBinding concrete method with argument N is true, then
   a. Let status be the result of calling the DeleteBinding concrete method of ObjRec with argument N.
   b. ReturnIfAbrupt(status).
   c. If status is true, then
      i. Let varNames be envRec’s VarNames List.
      ii. If N is an element of varNames, then remove that element from the varNames.
   d. Return status.
6. Return true.

10.2.1.4.8 HasThisBinding ()

Global Environment Records always provide a this binding whose value is the associated global object.

1. Return true.

10.2.1.4.9 HasSuperBinding ()

1. Return false.

10.2.1.4.10 WithBaseObject()()

Global Environment Records always return undefined as their WithBaseObject.

1. Return undefined.

10.2.1.4.11 GetThisBinding ()

2. Let envRec be the global environment record for which the method was invoked.
3. Let ObjRec be envRec’s ObjectEnvironment.
4. Let bindings be the binding object for ObjRec.
5. Return bindings.
10.2.1.12 HasVarDeclaration (N)

The concrete environment record method HasVarDeclaration for global environment records determines if the argument identifier has a binding in this record that was created using a VariableStatement or a FunctionDeclaration:

1. Let envRec be the global environment record for which the method was invoked.
2. Let varDeclaredNames be envRec’s VarNames List.
3. If varDeclaredNames contains the value of N, return true.
4. Return false.

10.2.1.13 HasLexicalDeclaration (N)

The concrete environment record method HasLexicalDeclaration for global environment records determines if the argument identifier has a binding in this record that was created using a lexical declaration such as a LexicalDeclaration or a ClassDeclaration:

1. Let envRec be the global environment record for which the method was invoked.
2. Let DeclRec be envRec’s DeclarativeEnvironment.
3. Return the result of calling DeclRec’s HasBinding concrete method with argument N.

10.2.1.14 CanDeclareGlobalVar (N)

The concrete environment record method CanDeclareGlobalVar for global environment records determines if a corresponding CreateGlobalVarBinding call would succeed if called for the same argument N. Redundant var declarations and var declarations for pre-existing global object properties are allowed.

1. Let envRec be the global environment record for which the method was invoked.
2. Let ObjRec be envRec’s ObjectEnvironment.
3. If the result of calling ObjRec’s HasBinding concrete method with argument N is false, then return extensible.
4. Let bindings be the binding object for ObjRec.
5. Let extensible be the result of IsExtensible(bindings).
6. Return extensible.

10.2.1.15 CanDeclareGlobalFunction (N)

The concrete environment record method CanDeclareGlobalVar for global environment records determines if a corresponding CreateGlobalFunctionBinding call would succeed if called for the same argument N.

1. Let envRec be the global environment record for which the method was invoked.
2. Let ObjRec be envRec’s ObjectEnvironment.
3. Let globalObject be the binding object for ObjRec.
4. Let extensible be the result of IsExtensible(globalObject).
5. ReturnIfAbrupt(extensible).
6. If the result of calling ObjRec’s HasBinding concrete method with argument N is false, then return extensible.
7. Let existingProp be the result of calling the [[GetOwnProperty]] internal method of globalObject with argument N.
8. If existingProp is undefined, then return extensible.
9. If existingProp[[Configurable]] is true, then return true.
10. If IsDataDescription(existingProp) is true and existingProp has attribute values {[[Writable]]: true, [[Enumerable]]: true}, then return true.
11. Return false.

10.2.1.16 CreateGlobalVarBinding (N, D)

The concrete Environment Record method CreateGlobalVarBinding for global environment records creates a mutable binding in the associated object environment record and records the bound name in the associated VarNames List. If a binding already exists, it is reused.
1. Let envRec be the declarative environment record for which the method was invoked.
2. Let ObjRec be envRec’s ObjectEnvironment.
3. Assert: The result of calling envRec’s CanDeclareGlobalVar concrete method with argument N is true.
4. If the result of calling ObjRec’s HasBinding concrete method with argument N is false, then
   a. Call the CreateMutableBinding concrete method of ObjRec with arguments N and D.
5. Let varDeclaredNames be envRec’s VarNames List.
6. If varDeclaredNames does not contain the value of N, then
   a. Append N to varDeclaredNames.
7. Return.

10.2.1.4.17 CreateGlobalFunctionBinding (N, V, D)

The concrete Environment Record method CreateFunctionBinding for global environment records creates a mutable binding in the associated object environment record and records the bound name in the associated VarNames List. If a binding already exists, it is replaced.

1. Let envRec be the declarative environment record for which the method was invoked.
2. Let ObjRec be envRec’s ObjectEnvironment.
3. Assert: The result of calling envRec’s CanDeclareGlobalFunction concrete method with argument N is true.
4. Let globalObject be the binding object for ObjRec.
5. Let existingProp be the result of calling the [GetOwnProperty] internal method of globalObject with argument N.
6. If existingProp is undefined or existingProp.[[Configurable]] is true, then
   a. Call the [[DefineOwnProperty]] internal method of globalObject passing N and Property Descriptor 
      {[[Value]]: V, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: D} as arguments.
7. Else,
   a. Call the [[DefineOwnProperty]] internal method of globalObject passing N and Property Descriptor 
      {[[Value]]: V} as arguments.
8. NOTE The assertion in step 3 means that the above [[DefineOwnProperty]] calls will never return false or an abrupt completion.
9. Let varDeclaredNames be envRec’s VarNames List.
10. If varDeclaredNames does not contain the value of N, then
    a. Append N to varDeclaredNames.
11. Return.

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

10.2.2 Lexical Environment Operations

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

10.2.2.1 GetIdentifierReference (lex, name, strict)

The abstract operation GetIdentifierReference is called with a Lexical Environment lex, a String name, and a Boolean flag strict. The value of lex may be null. When called, the following steps are performed:

1. If lex is the value null, then
   a. Return a value of type Reference whose base value is undefined, whose referenced name is name, 
      and whose strict reference flag is strict.
2. Let envRec be lex’s environment record.
3. Let exists be the result of calling the HasBinding(N) concrete method of envRec passing name as the argument N.
4. If exists is true, then
   a. Return a value of type Reference whose base value is envRec, whose referenced name is name, 
      and whose strict reference flag is strict.
5. Else
   a. Let outer be the value of lex’s outer environment reference.
   b. Return the result of calling GetIdentifierReference passing outer, name, and strict as arguments.
10.2.2.2 NewDeclarativeEnvironment (E)

When the abstract operation NewDeclarativeEnvironment is called with either a Lexical Environment or null as argument E the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let envRec be a new declarative environment record containing no bindings.
3. Set env's environment record to be envRec.
4. Set the outer lexical environment reference of env to E.
5. Return env.

10.2.2.3 NewObjectEnvironment (O, E)

When the abstract operation NewObjectEnvironment is called with an Object O and a Lexical Environment E (or null) as arguments, the following steps are performed:

1. Let env be a new Lexical Environment.
2. Let envRec be a new object environment record containing O as the binding object.
3. Set env's environment record to be envRec.
4. Set the outer lexical environment reference of env to E.
5. Return env.

10.2.2.4 NewFunctionEnvironment (F, T)

When the abstract operation NewFunctionEnvironment is called with an ECMAScript function Object F and a ECMAScript value T as arguments, the following steps are performed:

1. Assert: The value of F's [[ThisMode]] internal data property is not lexical.
2. Let env be a new Lexical Environment.
3. Let envRec be a new Function environment record containing no bindings.
4. Set envRec's thisValue to T.
5. If F has a [[HomeObject]] internal data property, then
   a. Set envRec's HomeObject to the value of F's [[HomeObject]] internal data property.
   b. Set envRec's MethodName to the value of F's [[MethodName]] internal data property.
6. Else,
   a. Set envRec's HomeObject to Empty.
7. Set env's environment record to be envRec.
8. Set the outer lexical environment reference of env to the value of F's [[Scope]] internal data property.

10.3 Code Realms

Before it is evaluated, all ECMAScript code must be associated with a Realm. Conceptually, a realm consists of a set of intrinsic objects, an ECMAScript global environment, all of the ECMAScript code that is loaded within the scope of that global environment, a Loader object that can associate new ECMAScript code with the realm, and other associated state and resources.

A Realm is specified as a Record with the fields specified in Table 26:

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[intrinsics]]</td>
<td>A record whose field names are intrinsic keys and whose values are objects</td>
<td>These are the intrinsic values used by code associated with this Realm</td>
</tr>
<tr>
<td>[[globalThis]]</td>
<td>An ECMAScript object</td>
<td>The global object for this Realm</td>
</tr>
<tr>
<td>[[globalEnv]]</td>
<td>An ECMAScript environment</td>
<td>The global environment for this Realm</td>
</tr>
<tr>
<td>[[loader]]</td>
<td>any ECMAScript identifier or empty</td>
<td>The Loader object that can associate ECMAScript code with this Realm</td>
</tr>
</tbody>
</table>

Commented [AWB858]: Other possible terms that have been discussed are “Home” and “Island”. We still need to get final agreement on terminology.
The intrinsic objects associated with a code Realm include the well-known intrinsics listed in Table 11 and additional intrinsics specified by Table 27.

<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>ECMAScript Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>??</td>
<td>??</td>
</tr>
<tr>
<td>??</td>
<td>??</td>
</tr>
</tbody>
</table>

### Table 27 — Additional Intrinsic Objects with Realm Specific Bindings

### 10.4 Execution Contexts

An execution context is a specification device that is used to track the runtime evaluation of code by an ECMAScript implementation. At any point in time, there is at most one execution context that is actually executing code. This is known as the running execution context. A stack is used to track execution contexts. The running execution context is always the top element of this stack. A new execution context is created whenever control is transferred from the executable code associated with the currently running execution context to executable code that is not associated with that execution context. The newly created execution context is pushed onto the stack and becomes the running execution context.

An execution context contains whatever implementation specific state is necessary to track the execution progress of its associated code. Each execution context has the state components listed in Table 28.

### Table 28 — State Components for All Execution Contexts

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>code evaluation state</td>
<td>Any state needed to perform, suspend, and resume evaluation of the code associated with this execution context.</td>
</tr>
<tr>
<td>Realm</td>
<td>The Realm from which associated code accesses ECMAScript resources.</td>
</tr>
</tbody>
</table>

Evaluation of code by the running execution context may be suspended at various points defined within this specification. Once the running execution context has been suspended a different execution context may become the running execution context and commence evaluating its code. At some latter time a suspended execution context may again become the running execution context and continue evaluating its code at the point where it had previously been suspended. Transition of the running execution context status among execution contexts usually occurs in stack-like last-in/first-out manner. However, some ECMAScript features require non-LIFO transitions of the running execution context.

The value of the Realm component of the running execution context is also called the current Realm.

Execution contexts for ECMAScript code have the additional state components listed in Table 29.

### Table 29 — Additional State Components for ECMAScript Code Execution Contexts

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

The LexicalEnvironment and VariableEnvironment components of an execution context are always Lexical Environments. When an execution context is created its LexicalEnvironment and VariableEnvironment components initially have the same value. The value of the VariableEnvironment component never changes while the value of the LexicalEnvironment component may change during execution of code within an execution context.
Execution contexts representing the evaluation of generator objects have the additional state components listed in Table 30.

Table 30 — Additional State Components for Generator Execution Contexts

<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 an ECMAScript program to directly access or observe an execution context.

10.4.1 Identifier Resolution

Identifier resolution is the process of determining the binding of an IdentifierName using the LexicalEnvironment of the running execution context. During execution of ECMAScript code, Identifier Resolution is performed using the following algorithm:

1. Let env be the running execution context’s LexicalEnvironment.
2. If the syntactic production that is being evaluated is contained in strict mode code, then let strict be true, else let strict be false.
3. Return the result of calling GetIdentifierReference abstract operation passing env, the StringValue of IdentifierName, and strict as arguments.

The result of evaluating an identifier is always a value of type Reference with its referenced name component equal to the IdentifierName String.

10.4.2 GetThisEnvironment

The abstract operation GetThisEnvironment finds the lexical environment that currently supplies the binding of the keyword this. GetThisEnvironment performs the following steps:

1. Let lex be the running execution context’s LexicalEnvironment.
2. Repeat
   a. Let envRec be lex’s environment record.
   b. Let exists be the result of calling the HasThisBinding concrete method of envRec.
   c. If exists is true, then return envRec.
   d. Let outer be the value of lex’s outer environment reference.
   e. Let lex be outer.

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

10.4.3 This Resolution

The abstract operation ThisResolution is the process of determining the binding of the keyword this using the LexicalEnvironment of the running execution context. ThisResolution performs the following steps:

1. Let env be the result of performing the GetThisEnvironment abstract operation.
2. Return the result of calling the GetThisBinding concrete method of env.
10.4.4 GetGlobalObject

The abstract operation GetGlobalObject returns the global object used by the currently running execution context. GetGlobalObject performs the following steps:

1. Let ctx be the running execution context.
2. Let currentRealm be ctx’s Realm.
3. Return currentRealm.[[globalThis]].

10.5 Declaration Binding Instantiation

10.5.1 Global Declaration Instantiation

NOTE When an execution context is established for evaluating scripts, declarations are instantiated in the current global environment. Each global binding declared in the code is instantiated.

Global Declaration Instantiation is performed as follows using arguments `script`, `env`, and `deletableBindings`. `script` is the `ScriptBody` that for which the execution context is being established. `env` is the global environment record in which bindings are to be created. `deletableBindings` is `true` if the bindings that are created should be deletable.

1. Let `strict` be IsStrict of `script`.
2. Let `lexNames` be the LexicallyDeclaredNames of `script`.
3. Let `varNames` be the VarDeclaredNames of `script`.
4. For each `name` in `lexNames`, do
   a. If the result of calling `env`’s `HasVarDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
   b. If the result of calling `env`’s `HasLexicalDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
5. For each `name` in `varNames`, do
   a. If the result of calling `env`’s `HasLexicalDeclaration` concrete method passing `name` as the argument is `true`, throw a `SyntaxError` exception.
6. Let `varDeclarations` be the VarScopedDeclarations of `script`.
7. Let `functionsToInitialize` be an empty List.
8. Let `declaredFunctionNames` be an empty List.
9. For each `d` in `varDeclarations`, in reverse list order do
   a. If `d` is a `FunctionDeclaration` then
      i. NOTE If there are multiple `FunctionDeclarations` for the same name, the last declaration is used.
   ii. Let `fn` be the sole element of the BoundNames of `d`.
   iii. If `fn` is not an element of `declaredFunctionNames`, then
      1. Let `fnIsDefinable` be the result of calling `env`’s `CanDeclareGlobalFunction` concrete method passing `fn` as the argument.
      2. If `fnIsDefinable` is false, throw `TypeError` exception.
      3. Append `fn` to `declaredFunctionNames`.
      4. Append `fn` to `functionsToInitialize`.
10. Let `declaredVarNames` be an empty List.
11. For each `d` in `varDeclarations`, do
   a. If `d` is a `VariableStatement` then
      i. For each String `vn` in the BoundNames of `d`, do
         1. If `vn` is not an element of `declaredFunctionNames`, then
            a. Let `vnIsDefinable` be the result of calling `env`’s `CanDeclareGlobalVar` concrete method passing `vn` and `deletableBindings` as the arguments.
            b. If `vnIsDefinable` is false, throw `TypeError` exception.
            c. If `vn` is not an element of `declaredVarNames`, then
               i. Append `vn` to `declaredVarNames`.
12. NOTE No abnormal terminations occur after this algorithm step.
13. For each `FunctionDeclaration` `f` in `functionsToInitialize`, do
   a. Let `fo` be the sole element of the BoundNames of `f`.
   b. Let `fo` be the result of performing `InstantiateFunctionObject` for `f` with argument `env`.

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c. Call env's CreateGlobalFunctionBinding concrete method passing fn, fo, and deletableBindings as the arguments.

14. For each String vn in declaredVarNames, in list order do
   a. Call env's CreateGlobalVarBinding concrete method passing vn and deletableBindings as the argument.

15. Let lexDeclarations be the LexicallyScopedDeclarations of script.

16. For each element d in lexDeclarations do
   a. NOTE Lexically declared names are only instantiated here but not initialized.
   b. For each element dn of the BoundNames of d do
      i. If IsConstantDeclaration of d is true, then
         1. Call env's CreateImmutableBinding concrete method passing dn as the argument.
      ii. Else,
         1. Call env's CreateMutableBinding concrete method passing dn and false as the arguments.
   c. If d is a GeneratorDeclaration production, then
      i. Let fn be the sole element of the BoundNames of d.
      ii. Let fo be the result of performing InstantiateFunctionObject for d with argument env.
      iii. Call env's SetMutableBinding concrete method passing fn, fo, and false as the arguments.

17. Return NormalCompletion(\emptyset)

NOTE Early errors specified in 14.1 prevent name conflicts between function/var declarations and let/const/class/module bindings for declaration contained within a single Script. However, such conflicts and redeclarations that span more than one Script are detected as runtime errors during Global Declaration Instantiation. If any such errors are detected, no bindings are instantiated for the script.

Unlike explicit var or function declarations, properties that are directly created on the global object result in global bindings that may be shadowed by let, const, class, and module declarations.

10.5.2 Module Declaration Instantiation

10.5.3 Function Declaration Instantiation

This version reflects the consensus as of the Sept. 2012 TC39 meeting. However, it now appears that the binding semantics of formal parameters is like to change again.

NOTE When an execution context is established for evaluating function code a new Declarative Environment Record is created and bindings for each formal parameter, and each function level variable, constant, or function declared in the function are instantiated in the environment record. Formal parameters and functions are initialized as part of this process. All other bindings are initialized during execution of the function code.

Function Declaration Instantiation is performed as follows using arguments func, argumentsList, and env. func is the function object that for which the execution context is being established. env is the declarative environment record in which bindings are to be created.

1. Let code be the value of the [[Code]] internal data property of func.
2. Let strict be the value of the [[Strict]] internal data property of func.
3. Let formals be the value of the [[FormalParameters]] internal data property of func.
4. Let parameterNames be the BoundNames of formals.
5. Let varDeclarations be the VarScopedDeclarations of code.
6. Let functionsToInitialize be an empty List.
7. Let argumentsObjectNotNeeded be false.
8. For each d in varDeclarations, in reverse list order do
   a. If d is a FunctionDeclaration then

Commented [AWB61]: The exact details of declaration instantiation for module code still need to be worked out.
NOTE If there are multiple FunctionDeclarations for the same name, the last declaration is used.
ii. Let fn be the sole element of the BoundNames of d.
iii. If fn is "arguments", then let argumentsObjectNotNeeded be true.
iv. Let alreadyDeclared be the result of calling env's HasBinding concrete method passing fn as the argument.
v. If alreadyDeclared is false, then
   1. Let status be the result of calling env's CreateMutableBinding concrete method passing fn as the argument.
   2. Assert: status is never an Abrupt Completion.
   3. Append d to functionsToInitialize.
9. For each String paramName in parameterNames, do
   a. Let alreadyDeclared be the result of calling env's HasBinding concrete method passing paramName as the argument.
   b. NOTE Duplicate parameter names can only occur in non-strict functions. Parameter names that are the same as function declaration names do not get initialized to undefined.
   c. If alreadyDeclared is false, then
      i. If paramName is "arguments", then let argumentsObjectNotNeeded be true.
      ii. Let status be the result of calling env's CreateMutableBinding concrete method passing paramName as the argument.
      iii. Assert: status is never an Abrupt Completion.
      iv. Call env's InitialiseBinding concrete method passing paramName, and undefined as the arguments.
10. NOTE If there is a function declaration or formal parameter with the name "arguments" then an argument object is not created.
11. If argumentsObjectNotNeeded is false, then
    a. If strict is true, then
       i. Call env's CreateImmutableBinding concrete method passing the String "arguments" as the argument.
    b. Else, i. Call env's CreateMutableBinding concrete method passing the String "arguments" as the argument.
12. Let varNames be the VarDeclaredNames of code.
13. For each String varName in varNames, in list order do
    a. Let alreadyDeclared be the result of calling env's HasBinding concrete method passing varName as the argument.
    b. NOTE A VarDeclaredName is only instantiated and initialized here if it is not also the name of a formal parameter or a FunctionDeclarations.
    c. If alreadyDeclared is false, then
       i. Call env's CreateMutableBinding concrete method passing varName as the argument.
14. Let lexDeclarations be the LexicalDeclarations of code.
15. For each element d in lexDeclarations do
    a. NOTE A lexically declared name cannot be the same as a function declaration, formal parameter, or a var name. Lexically declared names are only instantiated here but not initialized.
    b. For each element dn of the BoundNames of d do
       i. If isConstantDeclaration of d is true, then
          1. Call env's CreateImmutableBinding concrete method passing dn as the argument.
       ii. Else, i. Call env's CreateMutableBinding concrete method passing dn and false as the arguments.
    c. If d is a GeneratorDeclaration production, then
       i. Append d to functionsToInitialize.
16. For each production f in functionsToInitialize, do
    a. Let fn be the sole element of the BoundNames of f.
    b. Let fo be the result of performing InstantiateFunctionObject for f with argument env.
    c. Call env's SetMutableBinding concrete method passing fn, fo, and false as the arguments.
17. NOTE Function declaration are initialized prior to parameter initialization so that default value expressions may reference them. "arguments" is not initialized until after parameter initialization.
18. Let ao be the result of InstantiateArgumentsObject with argument argumentsList.
19. **NOTE** If `argumentsObjectNotNeeded` is `true` then the value of `aa` is not directly observable to ECMAScript code and need not actually exist. In that case, its use in the above steps is strictly as a device for specifying formal parameter initialisation semantics.

20. Let `formalStatus` be the result of performing Binding Initialisation for `formals` with `aa` and `undefined` as arguments.

21. ReturnIfAbrupt(`formalStatus`).

22. If `argumentsObjectNotNeeded` is `false`, then
   a. If `strict` is `true`, then
      i. Perform the abstract operation CompleteStrictArgumentsObject with argument `aa`.
   b. Else,
      i. Perform the abstract operation CompleteMappedArgumentsObject with arguments `aa`, `func`, `formals`, and `env`.
   c. Call env’s InitialiseBinding concrete method passing `arguments` and `aa` as arguments.

23. Return NormalCompletion(`empty`).

### 10.5.4 Block Declaration Instantiation

**NOTE** When a Block or CaseBlock production is evaluated a new Declarative Environment Record is created and bindings for each block scoped variable, constant, or function declared in the block are instantiated in the environment record.

Block Declaration Instantiation is performed as follows using arguments `code` and `env`. `code` is the grammar production corresponding to the body of the block. `env` is the declarative environment record in which bindings are to be created.

1. Let `declarations` be the LexicalDeclarations of `code`.
2. Let `functionsToInitialize` be an emptyList.
3. For each element `d` in `declarations` do
   a. For each element `dn` of the BoundNames of `d` do
      i. If `IsConstantDeclaration of d` is `true`, then
         1. Call env’s CreateImmutableBinding concrete method passing `dn` as the argument.
      ii. Else,
         1. Call env’s CreateMutableBinding concrete method passing `dn` and `false` as the arguments.
   b. If `d` is a GeneratorDeclaration production or a FunctionDeclaration production, then
      i. Append `d` to `functionsToInitialize`.
4. For each production `f` in `declarations`, in list order do
   a. Let `fn` be the sole element of the BoundNames of `f`.
   b. Let `fo` be the result of performing InstantiateFunctionObject for `f` with argument `env`.
   c. Call env’s InitialiseBinding concrete method passing `fn`, and `fo` as the arguments.

### 10.5.5 Eval Declaration Instantiation

#### 10.6 Arguments Object

When function code is evaluated, an arguments object is created unless (as specified in 10.5) the identifier `arguments` occurs as an Identifier in the function’s `FormalParameters` or occurs as the BindingIdentifier of a FunctionDeclaration contained in the outermost `StatementList` of the function code.

The abstract operation InstantiateArgumentsObject called with an argument `args` performs the following steps:

1. Let `len` be the number of elements in `args`.
2. Let `obj` be the result of the abstract operation ObjectCreate with the intrinsic object `%ObjectPrototype%` as its argument.
3. Call the `[[DefineOwnProperty]]` internal method on `obj` passing “`length`” and the Property Descriptor `[[Value]]: len`, `[Writable]: true`, `[Enumerable]: false`, `[Configurable]: true` as arguments.
4. Let `indx = len - 1`.
5. Repeat while `indx ≥ 0`.
   a. Let `val` be the element of `args` at 0-origined list position `indx`.

Commented [AWB764]: TODO: don’t create an arguments binding for arrow functions (and perhaps for concise methods)

Commented [AWB765]: Jan 19 meeting notes: Current tentative decision is to support let, const, and local functions in nonstrict ES5 in the same way as in strict ES5. Fall back to either specifying limited cases or doing the ES5 nonstrict status quo (i.e. syntax error + Clause 16) if experiments show this to not be viable. We won’t resolve this discussion without running some experiments.

Commented [AWB 266]: Additional modification to this text will probably be needed to account for the new declaration statements.
b. Call the [[DefineOwnProperty]] internal method on obj passing ToString(indxs) and the Property Descriptor {
   [[Value]]: val, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true} as arguments.

   c. Let indx = indx - 1

6. Return obj

The abstract operation CompleteStrictArgumentsObject is called with argument obj which must have been previously created by the abstract operation InstantiateArgumentsObject. The following steps are performed:

1. Perform the AddRestrictedFunctionProperties abstract operation with argument obj.
2. Return.

The abstract operation CompleteMappedArgumentObject is called with object obj, object func, grammar production formals, and environment record env. obj must have been previously created by the abstract operation InstantiateArgumentsObject. The following steps are performed:

1. Let len be the result of Get(obj, "length").
2. Let mappedNames be an empty List.
3. Let numberOfNonRestFormals be NumberOfParameters of formals.
4. Let map be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
5. Let indx = len - 1.
6. Repeat while indx ≥ 0,
   a. If indx is less than the numberOfNonRestFormals, then
      i. Let param be getParameter of formals with argument indx.
      ii. If param is a BindingIdentifier, then
          1. Let name be the sole element of BoundNames of param.
          2. If name is not an element of mappedNames, then
             a. Add name as an element of the list mappedNames.
             b. Let g be the result of calling the MakeArgGetter abstract operation with arguments name and env.
             c. Let p be the result of calling the MakeArgSetter abstract operation with arguments name and env.
             d. Call the [[DefineOwnProperty]] internal method of map passing ToString(indxs) and the Property Descriptor {
                  [[Set]]: g, [[Get]]: p, [[Configurable]]: true} as arguments.
   b. Let indx = indx - 1.
7. If mappedNames is not empty, then
   a. Set the [[ParameterMap]] internal data property of obj to map.
   b. Set the [[GetOwnProperty]], [[DefineOwnProperty]], and [[Delete]] internal methods of obj to the definitions provided below.
8. Call the [[DefineOwnProperty]] internal method on obj passing callee and the Property Descriptor {
      [[Value]]: func, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true} as arguments.

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

1. Let bodyText be the result of concatenating the Strings "return" , name, and ";".
2. Let body be the result of parsing bodyText using FunctionBody as the goal symbol.
3. Let parameters be a FormalParameters z [empty] production.
4. Return the result of calling the abstract operation FunctionCreate using Normal as the kind, parameters as FormalParameterList, body for FunctionBody, env as Scope, and true for Strict.

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

1. Let paramText be the String name concatenated with the String "arg".
2. Let parameters be the result of parsing paramText using FormalParameters as the goal symbol.
3. Let bodyText be the String "<name> = <param>"; with <name> replaced by the value of name and <param> replaced by the value of paramText.
4. Let body be the result of parsing bodyText using FunctionBody as the goal symbol.
5. Return the result of calling the abstract operation FunctionCreate using Normal as the kind, parameters as FormalParameterList, body for FunctionBody, env as Scope, and true for Strict.

The [[Get]] internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name `P` performs the following steps:

1. Let `args` be the arguments object.
2. Let `map` be the value of the `[[ParameterMap]]` internal data property of the arguments object.
3. Let `isMapped` be the result of calling the `[[GetOwnProperty]]` internal method of `map` passing `P` as the argument.
4. If the value of `isMapped` is undefined, then
   a. Let `v` be the result of calling the default ordinary object `[[Get]]` internal method (8.12.3) on `args` passing `P` and `args` as the arguments.
   b. If `P` is `"caller"` and `v` is a strict mode `Function` object, throw a `TypeError` exception.
   c. Return `v`.
5. Else `map` contains a formal parameter mapping for `P`,
   a. Return the result of calling Get(map, `P`).

The `[[GetOwnProperty]]` internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name `P` performs the following steps:

1. Let `desc` be the result of calling the default `[[GetOwnProperty]]` internal method (8.12.1) on the arguments object passing `P` as the argument.
2. If `desc` is undefined then return `desc`.
3. Let `map` be the value of the `[[ParameterMap]]` internal data property of the arguments object.
4. Let `isMapped` be the result of calling the `[[GetOwnProperty]]` internal method of `map` passing `P` as the argument.
5. If the value of `isMapped` is not undefined, then
   a. Set `desc.[[Value]]` to the result of calling `Get(map, `P`).
   b. Return `desc`.

The `[[DefineOwnProperty]]` internal method of an arguments object for a non-strict mode function with formal parameters when called with a property name `P` and Property Descriptor `Desc` performs the following steps:

1. Let `map` be the value of the `[[ParameterMap]]` internal data property of the arguments object.
2. Let `isMapped` be the result of calling the `[[DefineOwnProperty]]` internal method of `map` passing `P` as the argument.
3. Let `allowed` be the result of calling the `[[DefineOwnProperty]]` internal method (8.3.9) on the arguments object passing `P` and `Desc` as the arguments.
4. Return IfAbrupt(allowed).
5. If `allowed` is false, then return false.
6. If the value of `isMapped` is not undefined, then
   a. If IsAccessorDescriptor(Desc) is true, then
      i. Call the `[[Delete]]` internal method of `map` passing `P` as the argument.
   b. Else
      i. If Desc.[[Value]] is present, then
         1. Assert: the follow Put call will always succeed because formal parameters mapped by argument objects are always writable.
         2. Call Put(map, `P`, Desc.[[Value]], false).
      ii. If Desc.[[Writable]] is present and its value is false, then
          1. Call the `[[Delete]]` internal method of `map` passing `P` as the argument.
   7. Return true.

The `[[Delete]]` internal method of an arguments object for a non-strict mode function with formal parameters when called with a property key `P` performs the following steps:

1. Let `map` be the value of the `[[ParameterMap]]` internal data property of the arguments object.
2. Let `isMapped` be the result of calling the `[[GetOwnProperty]]` internal method of `map` passing `P` as the argument.
3. Let result be the result of calling the default \([\text{Delete}]\) internal method for ordinary objects (8.3.10) on the arguments object passing \(P\) as the argument.

4. If result is true and the value of isMapped is not undefined, then
   a. Call the \([\text{Delete}]\) internal method of map passing \(P\) as the argument.

5. Return result.

NOTE 1 For non-strict mode functions the array index (defined in 15.4) data properties of an arguments object whose numeric name values are less than the number of formal parameters of the corresponding function object initially share their values with the corresponding argument bindings in the function’s execution context. This means that changing the property changes the corresponding value of the argument binding and vice-versa. This correspondence is broken if such a property is deleted and then redefined or if the property is changed into an accessor property. For strict mode functions, the values of the arguments object’s properties are simply a copy of the arguments passed to the function and there is no dynamic linkage between the property values and the formal parameter values.

NOTE 2 The ParameterMap object and its property values are used as a device for specifying the arguments object correspondence to argument bindings. The ParameterMap object and the objects that are the values of its properties are not directly accessible from ECMAScript code. An ECMAScript implementation does not need to actually create or use such objects to implement the specified semantics.

NOTE 3 Arguments objects for strict mode functions define non-configurable accessor properties named “callee” and “caller” which throw a TypeError exception on access. The “callee” property has a more specific meaning for non-strict mode functions and a “caller” property has historically been provided as an implementation-defined extension by some ECMAScript implementations. The strict mode definition of these properties exists to ensure that neither of them is defined in any other manner by conforming ECMAScript implementations.
CoverParenthesisedExpressionAndArrowParameterList : { Expression }

1. Return the result of parsing the lexical token stream matched by
   CoverParenthesisedExpressionAndArrowParameterList using ParenthesisedExpression as the goal symbol.

**Static Semantics: IsValidSimpleAssignmentTarget**

**PrimaryExpression :**

- this
- Literal
- ArrayInitialiser
- ObjectLiteral
- FunctionExpression
- ClassExpression
- GeneratorExpression
- GeneratorComprehension
- RegularExpressionLiteral
- TemplateLiteral

1. Return false.

PrimaryExpression : Identifier

1. If this PrimaryExpression is contained in strict code and StringValue of Identifier is "eval" or
   "arguments", then return false.
2. Return true.

PrimaryExpression : CoverParenthesisedExpressionAndArrowParameterList

1. Let expr be CoverParenthesisedExpression of CoverParenthesisedExpressionAndArrowParameterList.
2. Return IsValidSimpleAssignmentTarget of expr.

**11.1.1 The this Keyword**

**Runtime Semantics: Evaluation**

PrimaryExpression : this

1. Return the result of calling the ThisResolution abstract operation.

**11.1.2 Identifier Reference**

**Runtime Semantics: Evaluation**

PrimaryExpression : Identifier

1. Let ref be the result of performing Identifier Resolution as specified in 10.4.1 using the IdentifierName
   corresponding to Identifier.
2. Return ref.

NOTE: The result of evaluating an Identifier is always a value of type Reference.

**11.1.3 Literals**

**Syntax**

Literal :

NullLiteral
ValueLiteral

Commented [AWB868]: It may make sense to define some of the static semantic rules related static name resolution
ValueLiteral:
  BooleanLiteral
  NumericLiteral
  StringLiteral

Runtime Semantics

Runtime Semantics: Evaluation

Literal : NullLiteral
  1. Return null.

ValueLiteral : BooleanLiteral
  1. Return false if BooleanLiteral is the token BooleanLiteral :: false
  2. Return true if BooleanLiteral is the token BooleanLiteral :: true.

ValueLiteral : NumericLiteral
  1. Return the number whose value is MV of NumericLiteral as defined in 7.8.3.

ValueLiteral : StringLiteral
  1. Return the string whose elements are the SV of StringLiteral as defined in 7.8.4.

11.1.4 Array Initialiser

Syntax

ArrayInitialiser :
  ArrayLiteral
  ArrayComprehension

11.1.4.1 Array Literal

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

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

Syntax

ArrayLiteral :
  [ Elisionopt ]
  [ ElementList ]
  [ ElementList , Elisionopt ]

ElementList :
  Elisionopt AssignmentExpression
  Elisionopt SpreadElement
  ElementList , Elisionopt AssignmentExpression
  ElementList , Elisionopt SpreadElement
Static Semantics

static semantics: elision width

Elision : ,
  Elision ,
  SpreadElement :
    . . AssignmentExpression

static semantics: array accumulation

With parameters array and nextIndex.

ElementList : Elisionopt AssignmentExpression
  1. Let padding be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
  2. Let initResult be the result of evaluating AssignmentExpression.
  3. ReturnIfAbrupt(initResult).
  4. Return the result of performing Array Accumulation for SpreadElement with arguments array and nextIndex+padding.

ElementList : Elisionopt SpreadElement
  1. Let padding be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
  2. Return the result of performing Array Accumulation for SpreadElement with arguments array and nextIndex+padding.

ElementList : ElementList , Elisionopt AssignmentExpression
  1. Let postIndex be the result of performing Array Accumulation for ElementList with arguments array and nextIndex.
  2. ReturnIfAbrupt(postIndex).
  3. Let padding be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
  4. Let initResult be the result of evaluating AssignmentExpression.
  5. ReturnIfAbrupt(initResult).
  6. ReturnIfAbrupt(initValue).
  7. Call the [[DefineOwnProperty]] internal method of array with arguments
     ToString(String(nextIndex+padding)) and the Property Descriptor { [[Value]]: initValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true }.
  8. Assert: the above call to [[DefineOwnProperty]] will never return false or an abrupt completion value.
  9. Return postIndex+padding+1.

ElementList : ElementList , Elisionopt SpreadElement
1. Let `postIndex` be the result of performing Array Accumulation for `ElementList` with arguments `array` and `nextIndex`.
2. ReturnIfAbrupt(`postIndex`).
3. Let `padding` be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
4. Return the result of performing Array Accumulation for `SpreadElement` with arguments `array` and `postIndex+padding`.

`SpreadElement` : ... AssignmentExpression

1. Let `spreadRef` be the result of evaluating AssignmentExpression.
2. Let `spreadValue` be GetValue(`spreadRef`).
3. Let `spreadObj` be ToObject(`spreadValue`).
4. ReturnIfAbrupt(`spreadObj`).
5. Let `lenVal` be the result of calling Get(`spreadObj`, "length").
6. Let `spreadLen` be ToUint32(`lenVal`).
7. ReturnIfAbrupt(`spreadLen`).
8. Let `n=0`;
9. Repeat, while `n < spreadLen`
   a. Let `exists` be the result of HasProperty(`spreadObj`, ToString(`n`)).
   b. ReturnIfAbrupt(`exists`).
   c. If `exists` is true then,
      i. Let `v` be the result of calling the `[[Get]]` internal method of `spreadObj` passing ToString(`n`) as the argument.
      ii. Call the `[[DefineOwnProperty]]` internal method of `array` with arguments ToString(ToUint32(`nextIndex`)) and Property Descriptor `[[Value]]: v, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
      iv. Assert: the above call to `[[DefineOwnProperty]]` will never return `false` or an abrupt completion value.
   d. Let `n = n+1`.
10. Return `nextIndex`.

NOTE  `[[DefineOwnProperty]]` is used to ensure that own properties are defined for the array even if the standard built-in Array prototype object has been modified in a manner that would preclude the creation of new own properties using `[[Set]]`.

Runtime Semantics: Evaluation

`ArrayLiteral` : [ Elision?, ... ]

1. Let `array` be the result of the abstract operation `ArrayCreate` with argument 0.
2. Let `pad` be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
3. Call Put(`array`, "length", pad, false).
4. Return `array`.

`ArrayLiteral` : [ `ElementList` ]

1. Let `array` be the result of the abstract operation `ArrayCreate` with argument 0.
2. Let `len` be the result of performing Array Accumulation for `ElementList` with arguments `array` and 0.
3. ReturnIfAbrupt(`len`).
5. Return `array`.

`ArrayLiteral` : [ `ElementList`, Elision?, ... ]

1. Let `array` be the result of the abstract operation `ArrayCreate` with argument 0.
2. Let `len` be the result of performing Array Accumulation for `ElementList` with arguments `array` and 0.
3. ReturnIfAbrupt(`len`).

Commented [AW69]: Note that the value the spread operator is applied to is coerced to an Object.

Commented [AW70]: Note that indices wrap. For example consider:

```javascript
[... { 4294967293: "x", length: Math.pow(2,32)-2}]
```
4. Let \( \text{padding} \) be the Elision Width of \( \text{Elision} \); if \( \text{Elision} \) is not present, use the numeric value zero.
5. Call \( \text{Put}(\text{array}, \"\text{length}\", \text{ToUint32}(\text{padding}+\text{len}), \text{false}) \).
6. Return \( \text{array} \).

11.1.4.2 Array Comprehension

Syntax

\[
\text{ArrayComprehension} : \begin{align*}
\text{Comprehension} : & \quad \text{ComprehensionFor} \; \text{ComprehensionQualifierTail} \\
\text{ComprehensionQualifierTail} : & \quad \text{AssignmentExpression} \\
& \quad \text{ComprehensionQualifier} \; \text{ComprehensionQualifierTail} \\
\text{ComprehensionQualifier} : & \quad \text{ComprehensionFor} \\
& \quad \text{ComprehensionIf} \\
\text{ComprehensionFor} : & \quad \text{for} ( \text{ForBinding} \; \text{of} \; \text{AssignmentExpression} ) \\
\text{ComprehensionIf} : & \quad \text{if} ( \text{AssignmentExpression} ) \\
\text{ForBinding} : & \quad \text{Binding} \; \text{Identifier} \\
& \quad \text{BindingPattern} \\
\end{align*}
\]

Static Semantics

Static Semantics: Early Errors

- It is a Syntax Error if the BoundNames of \( \text{ForBinding} \) contains any duplicate entries.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments \( \text{value} \) and \( \text{environment} \).

NOTE: \( \text{undefined} \) is passed for \( \text{environment} \) to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for var statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initializer.

ForBinding : BindingPattern

1. Let \( \text{obj} \) be ToObject(\( \text{value} \)).
2. ReturnIfAbrupt(\( \text{obj} \)).
3. Return the result of performing Binding Initialisation for BindingPattern passing \( \text{obj} \) and \( \text{environment} \) as the arguments.

Runtime Semantics: ComprehensionEvaluation

With argument \( \text{accumulator} \).
NOTE  **undefined** is passed for `accumulator` to indicate that a comprehension component is being evaluated as part of a generator comprehension. Otherwise, the value of `accumulator` is the array object into the elements of an array comprehension are to be accumulated.

Comprehension : ComprehensionFor ComprehensionQualifierTail

1. Return the result of performing QualifierEvaluation for `ComprehensionFor` with arguments `ComprehensionQualifierTail` and `accumulator`.

ComprehensionQualifierTail: ComprehensionQualifier ComprehensionQualifierTail

1. Return the result of performing QualifierEvaluation for `ComprehensionQualifier` with arguments `ComprehensionQualifierTail` and `accumulator`.

ComprehensionQualifierTail: AssignmentExpression

1. Let `valueRef` be the result of evaluating AssignmentExpression.
2. Let `value` be GetValue(`valueRef`).
3. ReturnIfAbrupt(`value`).
4. If `accumulator` is not undefined, then
   a. Assert: this is part of an array comprehension.
   b. Assert: `accumulator` is an exotic array object so access to its `length` property should never fail.
   c. Let `len` be the result of Get(`accumulator`, "length").
   d. If `len >= 2^{32} - 1`, then throw a **RangeError** exception.
   e. Let `putStatus` be the result of Put(O, ToString(`len`), `value`, true).
   f. ReturnIfAbrupt(`putStatus`).
   g. Increase `len` by 1.
   h. Let `putStatus` be the result of Put(O, "length", `len`, true).
   i. ReturnIfAbrupt(`putStatus`).
   j. Return `NormalCompletion(undefined)`.
5. Assert: `accumulator` is undefined, so this is part of a generator comprehension.
6. Let `yieldStatus` be the result of GeneratorYield(CreateIterResultObject(`value`, false)).
7. ReturnIfAbrupt(`yieldStatus`).
8. Return `NormalCompletion(undefined)`.

Runtime Semantics: QualifierEvaluation

With arguments `tail` and `accumulator`.

NOTE  **undefined** is passed for `accumulator` to indicate that a comprehension component is being evaluated as part of a generator comprehension. Otherwise, the value of `accumulator` is the array object into the elements of an array comprehension are to be accumulated.

ComprehensionFor : for ( ForBinding of AssignmentExpression )

1. Let `exprRef` be the result of evaluating AssignmentExpression.
2. Let `exprValue` be GetValue(`exprRef`).
3. Let `obj` beToObject(`exprValue`).
4. ReturnIfAbrupt(`obj`).
5. Let `iterator` be the result of performing Invoke with arguments `obj`, @@iterator, and an empty List.
6. Let `keys` be ToObject(`iterator`).
7. ReturnIfAbrupt(`keys`).
8. Let `oldEnv` be the running execution context’s LexicalEnvironment.
9. Let `noArgs` be an empty List.
10. Repeat
    a. Let `nextResult` be the result of Invoke(`keys`, "next").
    b. ReturnIfAbrupt(`nextResult`).
    c. If Type(`nextResult`) is not Object, then throw a **TypeError** exception.
    d. Let `done` be IteratorComplete(`nextResult`).

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e. `ReturnIfAbrupt(done)`.

f. If `done` is `true`, then return `true`.

g. Let `nextValue` be `IteratorValue(nextResult)`.

h. `ReturnIfAbrupt(nextValue)`.

i. Let `forEnv` be the result of calling `NewDeclarativeEnvironment` passing `oldEnv` as the argument.

j. For each element name of the `BoundNames` of `ForBinding` do
   - Call `forEnv`'s `CreateMutableBinding` concrete method with argument `name`.

k. Let `status` be the result of performing `Binding Initialisation` for `ForBinding` passing `value` and `environment` as the arguments.

l. `ReturnIfAbrupt(status)`.

m. Set the running execution context's `LexicalEnvironment` to `forEnv`.

n. Let `continue` be the result of performing `ComprehensionEvaluation` for `tail` with argument `accumulator`.

o. Set the running execution context's `LexicalEnvironment` to `oldEnv`.

p. `ReturnIfAbrupt(continue)`.

ComprehensionFor : if (AssignmentExpression )

1. Let `valueRef` be the result of evaluating `AssignmentExpression`.

2. Let `value` be `GetValue(valueRef)`.

3. Let `boolValue` be `ToBoolean(value)`.

4. `ReturnIfAbrupt(boolValue)`.

5. If `exprValue` is `true`, then
   a. Return the result of performing `ComprehensionEvaluation` for `tail` with argument `accumulator`.

6. Else,
   a. Return `NormalCompletion(undefined)`.

Runtime Semantics: Evaluation

ArrayComprehension : [ Comprehension ]

1. Let `array` be the result of the abstract operation `ArrayCreate` with argument 0.

2. Let `status` be the result of performing `ComprehensionEvaluation` for `Compression` with argument `array`.

3. `ReturnIfAbrupt(status)`.

4. Return `array`.

11.1.5 Object Initialiser

NOTE 1 An object initialiser is an expression describing the initialisation of an Object, written in a form resembling a literal. It is a list of zero or more pairs of property names and associated values, enclosed in curly braces. The values need not be literals; they are evaluated each time the object initialiser is evaluated.

Syntax

ObjectLiteral : { }

{ PropertyDefinitionList }

{ PropertyDefinitionList , }

PropertyDefinitionList : PropertyDefinition

PropertyDefinitionList , PropertyDefinition

PropertyDefinition : IdentifierName

CoverInitialisedName

PropertyName : AssignmentExpression

MethodDefinition
Property Name:
  IdentifierName
  StringLiteral
  NumericLiteral

Cover Initialised Name:
  IdentifierName Initialiser

Initialiser:
  = AssignmentExpression

NOTE 2  Method Definition is defined in 13.3.

NOTE 3  In certain contexts, Object Literal is used as a cover grammar for a more restricted secondary grammar. The Cover Initialised Name 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 Object Literal is expected.

Static Semantics

Static Semantics: Early Errors

In addition to describing an actual object initialiser the Object Literal productions are also used as a cover grammar for Object Assignment Pattern (11.13.1). When Object Literal appears in a context where Object Assignment Pattern is required, the following Early Error rules are not applied.

Object Literal: { Property Definition List }
and
Object Literal: { Property Definition List , }

- It is a Syntax Error if Property Name List of Property Definition List contains any duplicate entries, unless one of the following conditions are true for each duplicate entry:
  1. The source code corresponding to Property Definition List is not strict code and all occurrences in the list of the duplicated entry were obtained from productions of the form Property Definition : Property Name : Assignment Expression.
  2. The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor Method Definition and the other occurrence was obtained from a set accessor Method Definition.

Property Definition : Method Definition

- It is a Syntax Error if References Super of Method Definition is true.

Property Definition : Identifier Name

- It is a Syntax Error if Identifier Name is a Reserved Word.

Property Definition : Cover Initialised Name

- Always throw a Syntax Error if this production is present

NOTE  This production exists so that Object Literal can serve as a cover grammar for Object Assignment Pattern (11.13.1). It cannot occur in an actual object initialiser.

Static Semantics: Contains

  1st parameter symbol.

Property Definition : Method Definition

Commented [AW8871]: The currently prevailing position in TC39 is that use of super should not be allowed in object literals. This restriction is arbitrary in the sense that the runtime semantics would work.
1. If `symbol` is `MethodDefinition`, return `true`.
2. Return `false`.

NOTE  Static semantic rules that depend upon substructure generally do not look into function definitions.

**PropertyName**: `IdentifierName`

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

**Static Semantics**: `IsValidSimpleAssignmentTarget`

**PrimaryExpression**: `Literal`

1. Return `false`.

**Static Semantics**: `PropName`

**PropertyDefinition**: `IdentifierName`

1. Return `StringValue of IdentifierName`.

**PropertyDefinition**: `PropertyName : AssignmentExpression`

1. Return `PropName of PropertyName`.

**PropertyName**: `StringLiteral`

1. Return a `String value` whose characters are the `SV of the StringLiteral`.

**PropertyName**: `NumericLiteral`

1. Let `nbr` be the result of forming the `value of the NumericLiteral`.
2. Return `ToString(nbr)`.

**Static Semantics**: `PropertyNameList`

**PropertyDefinitionList**: `PropertyDefinition`

1. Return a new `List containing PropName of PropertyDefinition`.

**PropertyDefinitionList**: `PropertyDefinitionList , PropertyDefinition`

1. Let `list` be `PropertyNameList of PropertyDefinitionList`.
2. Append `PropName of PropertyDefinition` to the end of `list`.
3. Return `list`.

**Runtime Semantics**

**Runtime Semantics**: `Evaluation`

**ObjectLiteral**

1. Return a new object created as if by the expression `new Object()` where `Object` is the standard built-in constructor with that name.

Commented [AWB1072]: Issue: static semantic rules probably should call `ToString` (a runtime operation).
ObjectLiteral :
  { PropertyDefinitionList }
  { PropertyDefinitionList , }

  1. Let obj be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
  2. Let status be the result of performing Property Definition Evaluation of PropertyDefinitionList with argument obj.
  3. ReturnIfAbrupt(status).
  4. Return obj.

Runtime Semantics: Property Definition Evaluation

With parameter object and optional parameter functionPrototype.

PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition

  1. Let status be the result of performing Property Definition Evaluation of PropertyDefinitionList with argument object.
  2. ReturnIfAbrupt(status).
  3. Return the result of performing Property Definition Evaluation of PropertyDefinition with argument object.

PropertyDefinition : IdentifierName

  1. Let propName be StringValue of IdentifierName.
  2. Let exprValue be the result of performing Identifier Resolution as specified in 10.3.1 using IdentifierName.
  3. Let propValue be GetValue(exprValue).
  4. ReturnIfAbrupt(propValue).
  5. Let desc be the Property Descriptor{[[Value]]: propValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
  6. Return the result of DefinePropertyOrThrow(object, propName, desc).

PropertyDefinition : PropertyName : AssignmentExpression

  1. Let propName be PropName of PropertyName.
  2. Let exprValue be the result of evaluating AssignmentExpression.
  3. Let propValue be GetValue(exprValue).
  4. ReturnIfAbrupt(propValue).
  5. Let desc be the Property Descriptor{[[Value]]: propValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
  6. Return the result of DefinePropertyOrThrow(object, propName, desc).

11.1.6 Function Defining Expressions

See 13.1 for PrimaryExpression : FunctionExpression.

See 13.4 for PrimaryExpression : GeneratorExpression.

See 13.5 for PrimaryExpression : ClassExpression.

11.1.7 Generator Comprehensions

Syntax

  GeneratorComprehension :
    ( Comprehension )

Static Semantics

Static Semantics: Early Errors
GeneratorComprehension : ( Comprehension )

- It is a Syntax Error if Comprehension Contains YieldExpression is true.

Runtime Semantics

Runtime Semantics: Evaluation

GeneratorComprehension : ( Comprehension )
1. If GeneratorComprehension is contained in strict mode code, then let strict be true; otherwise let strict be false.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let parameters be the production: FormalParameters : [empty].
4. Using Comprehension from the production that is being evaluated, let body be the supplemental syntactic grammar production: GeneratorBody : Comprehension.
5. Let closure be the result of performing the GeneratorFunctionCreate abstract operation with arguments Arrow, parameters, body, scope, and strict.
6. Let prototype be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
7. Perform the abstract operation MakeConstructor with arguments closure, true, and prototype.
8. Let iterator be the result of calling the [[Call]] internal method of closure with undefined as this Argument and an empty List as argumentsList.
9. Return iterator.

NOTE The GeneratorFunction object created in step 5 is not observable from ECMAScript code so an implementation may choose to avoid its allocation and initialization. In that case use other semantically equivalent means must be used to allocate and initialize the iterator object in step 8. In either case, the prototype object created in step 6 must be created because it is potentially observable as the value of the iterator object's [[Prototype]] internal data property.

11.1.8 Regular Expression Literals

Syntax

See 7.8.4.

Static Semantics

Static Semantics: Early Errors

PrimaryExpression : RegularExpressionLiteral

- It is a Syntax Error if BodyText of RegularExpressionLiteral cannot be recognised using the goal symbol Pattern of the ECMAScript RegExp grammar specified in 15.10.
- It is a Syntax Error if FlagText of RegularExpressionLiteral contains any character other than "g", "i", "m", "u", or "y", or if it contains the same character more than once.

Runtime Semantics: Evaluation

PrimaryExpression : RegularExpressionLiteral

1. A regular expression literal evaluates to a value of the Object type that is an instance of the standard built-in constructor RegExp. This value is determined in two steps: first, the characters comprising the regular expression's RegularExpressionBody and RegularExpressionFlags production expansions are collected uninterpreted into two Strings Pattern and Flags, respectively. Then each time the literal is evaluated, a new object is created as if by the expression new RegExp(Pattern, Flags) where RegExp is the standard built-in constructor with that name. The newly constructed object becomes the value of the RegularExpressionLiteral.
11.1.9 Template Literals

Syntax

TemplateLiteral :  
   NoSubstitutionTemplate 
   TemplateHead Expression [Lexical goal InputElementTemplateTail] TemplateSpans

TemplateSpans :  
   TemplateTail 
   TemplateMiddleList [Lexical goal InputElementTemplateTail]TemplateTail

TemplateMiddleList :  
   TemplateMiddle Expression 
   TemplateMiddleList [Lexical goal InputElementTemplateTail]TemplateMiddle Expression

Static Semantics

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 [Lexical goal InputElementTemplateTail] TemplateSpans

1. If raw is false, then
   a. Let head be the TV of TemplateHead.
2. Else,
   a. Let head be the TRV of TemplateHead.
3. Let tail be TemplateStrings of TemplateSpans with argument raw.
4. Return a List containing head followed by the element, in order of tail.

TemplateSpans : TemplateTail

1. If raw is false, then
   a. Let tail be the TV of TemplateTail.
2. Else,
   a. Let tail be the TRV of TemplateTail.
3. Return a List containing the single element, tail.

TemplateSpans : TemplateMiddleList [Lexical goal InputElementTemplateTail] 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 [LastTailInputElementTemplateTail] 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.

Runtime Semantics

Runtime Semantics: ArgumentListEvaluation

TemplateLiteral : NoSubstitutionTemplate
1. Let siteObj be the result of the abstract operation GetTemplateCallSite passing this TemplateLiteral production as the argument.
2. Return a List containing the one element which is siteObj.

TemplateLiteral : TemplateHead Expression [LexicalGoalInputElementTemplateTail] TemplateSpans
1. Let siteObj be the result of the abstract operation GetTemplateCallSite passing this TemplateLiteral production as the argument.
2. Let firstSub be the result of evaluating Expression.
3. ReturnIfAbrupt(firstSub).
4. Let restSub be SubstitutionEvaluation of TemplateSpans.
5. ReturnIfAbrupt(restSub).
6. Assert, restSub is a List.
7. Return a List whose first element is siteObj, whose second elements is firstSub, and whose subsequent elements are the elements of restSub, in order. restSub may contain no elements.

Runtime Semantics: GetTemplateCallSite Abstract Operation

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

1. If a call site object for the source code corresponding to templateLiteral has already been created by a previous call to this abstract operation, then return that call site object.
2. Let cookedStrings be TemplateStrings of templateLiteral with argument false.
3. Let rawStrings be TemplateStrings of templateLiteral with argument true.
4. Let count be the number of elements in the List cookedStrings.
5. Let siteObj be the result of the abstract operation ArrayCreate with argument count.
6. Let rawObj be the result of the abstract operation ArrayCreate with argument count.
7. Let index be 0.
8. Repeat while index < count
   a. Let prop be ToString(index).
   b. Let cookedValue be the string value at 0-based position index of the List cookedStrings.
   c. Call the [[DefineOwnProperty]] internal method of siteObj with arguments prop and Property Descriptor {[[Value]]: cookedValue, [[Writable]]: false, [[Configurable]]: false}.
   d. Let rawValue be the string value at 0-based position index of the List rawStrings.
   e. Call the [[DefineOwnProperty]] internal method of rawObj with arguments prop and Property Descriptor {[[Value]]: rawValue, [[Writable]]: false, [[Configurable]]: false}.
   f. Let index be index+1.
9. Call the [[Freeze]] internal method of rawObj.
10. Call the `[[DefineOwnProperty]]` internal method of `siteObj` with arguments "raw" and Property Descriptor `{{[Value]: rawObj, [Writable]: false, [Enumerable]: false, [Configurable]: false}}`.

11. Call the `[[Freeze]]` internal method of `siteObj`.

12. Remember an association between the source code corresponding to `templateLiteral` and `siteObj` such that `siteObj` can be retrieve in subsequent calls to this abstract operation.

13. Return `siteObj`.

NOTE 1 The creation of a call site object cannot result in an abrupt completion.

NOTE 2 Each `TemplateLiteral` in the program code is associated with a unique `Template call site object` that is used in the evaluation of tagged Templates (11.2.6). The same call site object is used each time a specific tagged Template is evaluated. Whether call site objects are created lazily upon first evaluation of the `TemplateLiteral` or eagerly prior to first evaluation is an implementation choice that is not observable to ECMAScript code.

Runtime Semantics: SubstitutionEvaluation

```
TemplateSpans : TemplateTail
1. Return an empty List.
```

```
TemplateSpans : TemplateMiddleList [lexical goal InputElementTemplateTail] TemplateTail
1. Return the result of SubstitutionEvaluation of TemplateMiddleList.
```

```
TemplateMiddleList : TemplateMiddleExpression
1. Let `head` be the TV of `TemplateHead` as defined in 7.8.5.
2. Let `sub` be the result of evaluating `Expression`.
3. Let `middle` be `ToString(sub)`.
4. ReturnIfAbrupt(`middle`).
5. Let `tail` be the result of evaluating `TemplateSpans`.
6. ReturnIfAbrupt(`tail`).
7. Return the string value whose elements are the code units of `head` followed by the code units of `tail`.
```

```
TemplateSpans : TemplateTail
1. Let `tail` be the TV of `TemplateTail` as defined in 7.8.5.
2. Return the string whose elements are the code units of `tail`.
```

Commented [AW8975]: Note that the conversion semantics are like `String.prototype.concat` rather than the `+` operator.
TemplateSpans : TemplateMiddleList [Lexical goal InputElementTemplateTail] TemplateTail

1. Let head be the result of evaluating TemplateMiddleList.
2. ReturnIfAbrupt(head).
3. Let tail be the TV of TemplateTail as defined in 7.8.5.
4. Return the string whose elements are the elements of head followed by the elements of tail.

TemplateMiddleList : TemplateMiddle Expression

1. Let head be the TV of TemplateMiddle as defined in 7.8.5.
2. Let sub be the result of evaluating Expression.
3. Let middle be ToString(sub).
4. ReturnIfAbrupt(middle).
5. Return the sequence of characters consisting of the code units of head followed by the elements of middle.

TemplateMiddleList : TemplateMiddleList [Lexical goal InputElementTemplateTail] TemplateMiddle Expression

1. Let rest be the result of evaluating TemplateMiddleList.
2. ReturnIfAbrupt(rest).
3. Let middle be the TV of TemplateMiddle as defined in 7.8.5.
4. Let sub be the result of evaluating Expression.
5. Let last be ToString(sub).
6. ReturnIfAbrupt(last).
7. Return the sequence of characters consisting of the elements of rest followed by the code units of middle followed by the elements of last.

11.1.10 The Grouping Operator

Static Semantics: Early Errors

PrimaryExpression : 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 the CoverParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.

Static Semantics: IsValidSimpleAssignmentTarget

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList
1. Let expr be CoverParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return IsValidSimpleAssignmentTarget of expr.

ParenthesizedExpression : ( Expression )

1. Return IsValidSimpleAssignmentTarget of Expression.

Runtime Semantics: Evaluation

PrimaryExpression : CoverParenthesizedExpressionAndArrowParameterList
1. Let expr be CoverParenthesizedExpression of CoverParenthesizedExpressionAndArrowParameterList.
2. Return the result of evaluating expr.

ParenthesizedExpression : ( Expression )
1. Return the result of evaluating Expression. This may be of type Reference.

Commented [AWB977]: Note that the conversion semantics are like String.prototype.concat rather than the + operator.

Commented [AWB978]: Note that the conversion semantics are like String.prototype.concat rather than the + operator.
NOTE  This algorithm does not apply GetValue to the result of evaluating Expression. The principal motivation for this is so that operators such as delete and typeof may be applied to parenthesised expressions.

11.2 Left-Hand-Side Expressions

Syntax

MemberExpression :
  [ Lexical goal InputElementRegExp PrimaryExpression
  MemberExpression [ Expression ]
  MemberExpression . IdentifierName
  MemberExpression TemplateLiteral
  super [ Expression ]
  super . IdentifierName
  new super Argumentsopt
  new MemberExpression Arguments

NewExpression :
  MemberExpression
  new NewExpression

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

Arguments :
  ( )
  ( ArgumentList )

ArgumentList :
  AssignmentExpression
  . . . AssignmentExpression
  ArgumentList , AssignmentExpression
  ArgumentList , . . . AssignmentExpression

LeftHandSideExpression :
  NewExpression
  CallExpression

Static Semantics

Static Semantics: Contains

With parameter symbol,

MemberExpression : MemberExpression . IdentifierName

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

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

**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`.

**MemberExpression**: `new super`

1. If `symbol` is the `ReservedWord` `super`, return `true`.
2. If `symbol` is the `ReservedWord` `new`, return `true`.
3. Return `false`.

**MemberExpression**: `new super Arguments`

1. If `symbol` is the `ReservedWord` `super`, return `true`.
2. If `symbol` is the `ReservedWord` `new`, return `true`.
3. Return the result of `Arguments Contains symbol`.

**Static Semantics**: `IsValidSimpleAssignmentTarget`

**CallExpression**:

- `CallExpression [ Expression ]`
- `CallExpression . IdentifierName`

**MemberExpression**:

- `MemberExpression [ Expression ]`
- `MemberExpression . IdentifierName`
  - `super [ Expression ]`
  - `super . IdentifierName`

   1. Return `true`.

**CallExpression**:

- `MemberExpression Arguments`
  - `super Arguments`
  - `CallExpression Arguments`
  - `CallExpression TemplateLiteral`

**NewExpression**: `new NewExpression`

**MemberExpression**:

- `new super Arguments`
- `new MemberExpression Arguments`

1. Return `false`.

### 11.2.1 Property Accessors

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

```javascript
Commented [AWB1079]: These are false, because we disallow host functions returning reference values.
```
The dot notation is explained by the following syntactic conversion:

MemberExpression . IdentifierName

or the bracket notation:

MemberExpression [ Expression ]
CallExpression [ Expression ]

The dot notation is identical in its behaviour to

MemberExpression [ <identifier-name-string> ]

and similarly

CallExpression . IdentifierName
is identical in its behaviour to

CallExpression [ <identifier-name-string> ]

where <identifier-name-string> is a string literal containing the same sequence of characters after processing of Unicode escape sequences as the IdentifierName.

Runtime Semantics: Evaluation

MemberExpression : MemberExpression [ Expression ]

1. Let baseReference be the result of evaluating MemberExpression.
2. Let baseValue be GetValue(baseReference).
3. ReturnIfAbrupt(baseValue).
4. Let propertyNameReference be the result of evaluating Expression.
5. Let propertyNameValue be GetValue(propertyNameReference).
6. ReturnIfAbrupt(propertyNameValue).
7. Let bv be CheckObjectCoercible(baseValue).
8. ReturnIfAbrupt(bv).
9. Let propertyNameString be ToString(propertyNameValue).
10. If the code matched by the syntactic production that is being evaluated is strict mode code, let strict be true, else let strict be false.
11. Return a value of type Reference whose base value is bv and whose referenced name is propertyNameString, and whose strict reference flag is strict.

CallExpression : CallExpression [ Expression ]
Is evaluated in exactly the same manner as MemberExpression : MemberExpression [ Expression ] except that the contained CallExpression is evaluated in step 1.

11.2.2 The new Operator

Runtime Semantics: Evaluation

NewExpression : new NewExpression

1. Let ref be the result of evaluating NewExpression.
2. Let constructor be GetValue(ref).
3. ReturnIfAbrupt(constructor).
4. If Type(constructor) is not Object, throw a TypeError exception.
5. If constructor does not implement the [[Construct]] internal method, throw a TypeError exception.
6. Return the result of calling the [[Construct]] internal method on constructor with an empty List as the argument.

Commented [AWB980]: TODO probably need to do something about new operators in tail position.
MemberExpression : new MemberExpression Arguments

1. Let ref be the result of evaluating MemberExpression.
2. Let constructor be GetValue(ref).
3. ReturnIfAbrupt(constructor).
4. Let argList be the result of evaluating Arguments, producing an internal List of argument values (11.2.4).
5. ReturnIfAbrupt(argList).
6. If Type(constructor) is not Object, throw a TypeError exception.
7. If constructor does not implement the [[Construct]] internal method, throw a TypeError exception.
8. Return the result of calling the [[Construct]] internal method on constructor, passing argList as the argument.

11.2.3 Function Calls

Runtime Semantics: Evaluation

CallExpression : MemberExpression Arguments

1. Let ref be the result of evaluating MemberExpression.
2. If this CallExpression is in a tail position (13.6) then let tailCall be true, otherwise let tailCall be false.
3. Return the result of the abstract operation EvaluateCall with arguments ref, Arguments, and tailCall.

CallExpression : CallExpression Arguments

1. Let ref be the result of evaluating CallExpression.
2. If this CallExpression is in a tail position (13.6) then let tailCall be true, otherwise let tailCall be false.
3. Return the result of the abstract operation EvaluateCall with arguments ref, Arguments, and tailCall.

A tail position call must either release any transient internal resources associated with the currently executing function execution context before invoking the target function or reuse those resources in support of the target function.

NOTE 1 For example, a tail position call should only grow an implementation's activation record stack by the amount that the size of the target function's activation record exceeds the size of the calling function's activation record. If the target function's activation record is smaller, then the total size of the stack should decrease.

Runtime Semantics: EvaluateCall Abstract Operation

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

1. Let func be GetValue(ref).
2. ReturnIfAbrupt(func).
3. Let argList be the result of performing ArgumentListEvaluation of arguments.
4. ReturnIfAbrupt(argList).
5. If Type(func) is not Object, throw a TypeError exception.
6. If IsCallable(func) is false, throw a TypeError exception.
7. If Type(ref) is Reference, then
   a. If IsPropertyReference(ref) is true, then
      i. Let thisValue be GetThisValue(ref).
   b. Else, the base of ref is an Environment Record
      i. Let thisValue be the result of calling the WithBaseObject concrete method of GetBase(ref).
8. Else Type(ref) is not Reference,
   a. Let thisValue be undefined.
9. If tailPosition is true, then
   a. Let leafContext be the running execution context.
   b. Suspend leafContext.
   c. Pop leafContext from the execution context stack. The execution context now on the top of the stack becomes the running execution context, however it remains in its suspended state.
   d. Assert: leafContext has no further use. It will never be activated as the running execution context.
10. Let result be the result of calling the [[Call]] internal method on func, passing thisValue as the thisArgument and argList as the argumentsList.
11. Assert: If tailPosition is true, the above call will not return here, but instead evaluation will continue with the resumption of leafCallerContext as the running execution context.
12. Assert: Type(result) is an ECMAScript language type
13. Return result.

11.2.4 The super Keyword

Static Semantics

Static Semantics: Early Errors

MemberExpression: `super [ Expression ]`
MemberExpression: `super . IdentifierName`
MemberExpression: `new super Arguments`

CallExpression: `super Arguments`
  • It is a Syntax Error if the source code parsed with this production is global code that is not eval code.
  • It is a Syntax Error if the source code parsed with this production is eval code and the source code is not being processed by a direct call to eval that is contained in function code.

Runtime Semantics: Evaluation

MemberExpression: `super [ Expression ]`
1. Let propertyNameReference be the result of evaluating Expression.
2. Let propertyNameValue be GetValue(propertyNameReference).
3. Let propertyKey be ToPropertyKey(propertyNameValue).
4. If the code matched by the syntactic production that is being evaluated is strict mode code, let strict be true, else let strict be false.
5. Return the result of MakeSuperReference(propertyKey, strict).

MemberExpression: `super . IdentifierName`
1. Let propertyKey be StringValue of IdentifierName.
2. If the code matched by the syntactic production that is being evaluated is strict mode code, let strict be true, else let strict be false.
3. Return the result of MakeSuperReference(propertyKey, strict).

MemberExpression: `new super Arguments`
1. If the code matched by the syntactic production that is being evaluated is strict mode code, let strict be true, else let strict be false.
2. Let ref be the result of MakeSuperReference(undefined, strict).
3. Let constructor be GetValue(ref).
4. ReturnIfAbrupt(constructor).
5. If Arguments is present, then
   a. Let argList be the result of evaluating Arguments, producing an internal List of argument values (11.2.4).
   b. ReturnIfAbrupt(argList).
6. Else,
   a. Let argList be a new empty List.
7. If Type(constructor) is not Object, throw a TypeError exception.
8. If constructor does not implement the [[Construct]] internal method, throw a TypeError exception.
9. Return the result of calling the [[Construct]] internal method on constructor, passing argList as the argument.
CallExpression: super Arguments

1. If the code matched by the syntactic production that is being evaluated is strict mode code, let strict be true, else let strict be false.
2. Let ref be the result of MakeSuperReference(undefined, strict).
3. ReturnIfAbrupt(ref).
4. If this CallExpression is in a tail position (13.7) then let tailCall be true, otherwise let tailCall be false.
5. Return the result of the abstract operation EvaluateCall with arguments ref, Arguments, and tailCall.

Runtime Semantics: Abstract Operation MakeSuperReference(propertyKey, strict)

1. Let env be the result of performing the GetThisEnvironment abstract operation.
2. If the result of calling the HasSuperBinding concrete method of env is false, then throw a ReferenceError exception.
3. Let actualThis be the result of calling the GetThisBinding concrete method of env.
4. Let baseValue be the result of calling the GetSuperBase concrete method of env.
5. Let bv be CheckObjectCoercible(baseValue).
6. ReturnIfAbrupt(bv).
7. If propertyKey is undefined, then
   a. Let propertyKey be the result of calling the GetMethodName concrete method of env.
8. Return a value of type Reference that is a Super Reference whose base value is bv, whose referenced name is propertyKey, whose thisValue is actualThis, and whose strict reference flag is strict.

11.2.5 Argument Lists

The evaluation of an argument list produces a List of values (see 8.7).

Runtime Semantics

Runtime Semantics: ArgumentListEvaluation

Arguments: {}

1. Return an empty List.

ArgumentList: AssignmentExpression

1. Let ref be the result of evaluating AssignmentExpression.
2. Let arg be GetValue(ref).
3. ReturnIfAbrupt(arg).
4. Return a List whose sole item is arg.

ArgumentList: . . . . AssignmentExpression

1. Let list be an empty List.
2. Let spreadRef be the result of evaluating AssignmentExpression.
3. Let spreadValue be GetValue(spreadRef).
4. Let spreadObj be ToObject(spreadValue).
5. ReturnIfAbrupt(spreadObj).
6. Let lenVal be the result of calling Get(spreadObj, "length").
7. Let spreadLen be ToUint32(lenVal).
8. ReturnIfAbrupt(spreadLen).
9. Let n = 0.
10. Repeat, while n < spreadLen
    a. Let nextArg be the result of calling Get(spreadObj, ToString(n)).
    b. ReturnIfAbrupt(nextArg).
    c. Append nextArg as the last element of list.
    d. Let n = n+1.
11. Return list.
ArgumentList : ArgumentList , AssignmentExpression

1. Let precedingArgs be the result of evaluating ArgumentList.
2. ReturnIfAbrupt(precedingArgs).
3. Let ref be the result of evaluating AssignmentExpression.
4. Let arg be GetValue(ref).
5. ReturnIfAbrupt(arg).
6. Return a List whose length is one greater than the length of precedingArgs and whose items are the items of precedingArgs, in order, followed at the end by arg which is the last item of the new list.

ArgumentList : ArgumentList , ... AssignmentExpression

1. Let precedingArgs be an empty List.
2. Let spreadRef be the result of evaluating AssignmentExpression.
3. Let spreadValue be GetValue(spreadRef).
4. Let spreadObj be ToObject(spreadValue).
5. ReturnIfAbrupt(spreadObj).
6. Let lenVal be the result of calling Get(spreadObj, "length").
7. Let spreadLen be ToUint32(lenVal).
8. ReturnIfAbrupt(spreadLen).
9. Let n = 0.
10. Repeat, while n < spreadLen
    a. Let nextArg be the result of calling Get(spreadObj, ToString(n)).
    b. ReturnIfAbrupt(nextArg).
    c. Append nextArg as the last element of precedingArgs.
    d. Let n = n+1.

11.2.6 Tagged Templates

Runtime Semantics

Runtime Semantics: Evaluation

MemberExpression : MemberExpression TemplateLiteral

1. Let tagRef be the result of evaluating MemberExpression.
2. If this MemberExpression is in a tail position (13.7) then let tailCall be true, otherwise let tailCall be false.
3. Return the result of the abstract operation EvaluateCall with arguments tagRef, TemplateLiteral, and tailCall.

CallExpression : CallExpression TemplateLiteral

1. Let tagRef be the result of evaluating CallExpression.
2. If this CallExpression is in a tail position (13.7) then let tailCall be true, otherwise let tailCall be false.
3. Return the result of the abstract operation EvaluateCall with arguments tagRef, TemplateLiteral, and tailCall.

11.3 Postfix Expressions

Syntax

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

Static Semantics

Commented [AW84]: Note that the value the spread operator is applied to is coerced to an Object.
Static Semantics: Early Errors

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

- It is an early Reference Error if IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

11.3.1 Postfix Increment Operator

Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression [no LineTerminator here] ++

1. Let lhs be the result of evaluating LeftHandSideExpression.
2. Let oldValue be ToNumber(GetValue(lhs)).
3. ReturnIfAbrupt(oldValue).
4. Let newValue be the result of adding the value 1 to oldValue, using the same rules as for the + operator (see 11.6.3).
5. Let status be PutValue(lhs, newValue).
6. ReturnIfAbrupt(status).
7. Return oldValue.

11.3.2 Postfix Decrement Operator

Runtime Semantics: Evaluation

PostfixExpression : LeftHandSideExpression [no LineTerminator here] --

1. Let lhs be the result of evaluating LeftHandSideExpression.
2. Let oldValue be ToNumber(GetValue(lhs)).
3. Let newValue be the result of subtracting the value 1 from oldValue, using the same rules as for the - operator (11.6.3).
4. Let status be PutValue(lhs, newValue).
5. ReturnIfAbrupt(status).
6. Return oldValue.
11.4 Unary Operators

Syntax

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

Static Semantics

Static Semantics: Early Errors

UnaryExpression :
    ++ UnaryExpression
    -- UnaryExpression

- It is an early Reference Error if IsValidSimpleAssignmentTarget of UnaryExpression is false.

11.4.1 The delete Operator

Static Semantics: Early Errors

UnaryExpression : delete UnaryExpression

- It is a Syntax Error if the UnaryExpression is contained in strict code and the derived UnaryExpression is
  PrimaryExpression : Identifier.
- It is a Syntax Error if the derived UnaryExpression is
  PrimaryExpression : ParenthesizedExpressionAndArrowParameterList
  and derives a production that is used in place of UnaryExpression would produce a Syntax Error
  according to these rules. This rule is recursively applied.

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. If IsStrictReference(`ref`) is `true`, then throw a `SyntaxError` exception.
   b. Return `true`.
5. If IsPropertyReference(`ref`) is `true`, then,
   a. If IsSuperReference(`ref`), then throw a `ReferenceError` exception.
   b. Let `deleteStatus` be the result of calling the `[[Delete]]` internal method on `ToObject(GetBase(ref))`, providing `GetReferencedName(ref)` as the argument.
   c. ReturnIfAbrupt(`deleteStatus`).
   d. If `deleteStatus` is `false` and IsStrictReference(`ref`) is `true`, then throw a `TypeError` exception.
   e. Return `deleteStatus`.
6. Else `ref` is a Reference to an Environment Record binding,
   a. Let `bindings` be `GetBase(ref)`.
   b. Return the result of calling the `DeleteBinding` concrete method of `bindings`, providing `GetReferencedName(ref)` as the argument.

**NOTE** When a `delete` operator occurs within strict mode code, a `SyntaxError` exception is thrown if its `UnaryExpression` is a direct reference to a variable, function argument, or function name. In addition, if a `delete` operator occurs within strict mode code and the property to be deleted has the attribute `[[Configurable]]: false`, a `TypeError` exception is thrown.

### 11.4.2 The `void` Operator

**Runtime Semantics: Evaluation**

`UnaryExpression` : `void UnaryExpression`

1. Let `expr` be the result of evaluating `UnaryExpression`.
2. Let `status` be `GetValue(expr)`.
3. ReturnIfAbrupt(`status`).
4. Return `undefined`.

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

### 11.4.3 The `typeof` Operator

**Runtime Semantics: Evaluation**

`UnaryExpression` : `typeof UnaryExpression`

1. Let `val` be the result of evaluating `UnaryExpression`.
2. If Type(`val`) is Reference, then,
   a. If IsUnresolvableReference(`val`) is `true`, return "undefined".
   b. Let `val` be `GetValue(val)`.
3. ReturnIfAbrupt(`val`).
4. Return a String determined by Type(`val`) according to Table 31.

**Table 31 — typeof Operator Results**
<table>
<thead>
<tr>
<th>Type of val</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. May not be &quot;undefined&quot;, &quot;boolean&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.

11.4.4 Prefix Increment Operator

Runtime Semantics: Evaluation

UnaryExpression : ++ UnaryExpression

1. Let expr be the result of evaluating UnaryExpression.
2. Let oldValue be ToNumber(GetValue(expr)).
3. ReturnIfAbrupt(oldValue).
4. Let newValue be the result of adding the value 1 to oldValue, using the same rules as for the + operator (see 11.6.3).
5. Let status be PutValue(expr, newValue).
6. ReturnIfAbrupt(status).
7. Return newValue.

11.4.5 Prefix Decrement Operator

Runtime Semantics: Evaluation

UnaryExpression : -- UnaryExpression

1. Let expr be the result of evaluating UnaryExpression.
2. Let oldValue be ToNumber(GetValue(expr)).
3. ReturnIfAbrupt(oldValue).
4. Let newValue be the result of subtracting the value 1 from oldValue, using the same rules as for the - operator (see 11.6.3).
5. Let status be PutValue(expr, newValue).
6. ReturnIfAbrupt(status).
7. Return newValue.

11.4.6 Unary + Operator

NOTE The unary + operator converts its operand to Number type.
**Runtime Semantics: Evaluation**

UnaryExpression : + UnaryExpression

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

### 11.4.7 Unary – Operator

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

**Runtime Semantics: Evaluation**

UnaryExpression : – UnaryExpression

1. Let expr be the result of evaluating UnaryExpression.
2. Let oldValue be ToNumber(GetValue(expr)).
3. ReturnIfAbrupt(oldValue).
4. If oldValue is NaN, return NaN.
5. Return the result of negating oldValue; that is, compute a Number with the same magnitude but opposite sign.

### 11.4.8 Bitwise NOT Operator (~)

**Runtime Semantics: Evaluation**

UnaryExpression : ~ UnaryExpression

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

### 11.4.9 Logical NOT Operator (!)

**Runtime Semantics: Evaluation**

UnaryExpression : ! UnaryExpression

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

### 11.5 Multiplicative Operators

**Syntax**

MultiplicativeExpression :

  - UnaryExpression
  - MultiplicativeExpression * UnaryExpression
  - MultiplicativeExpression / UnaryExpression
  - MultiplicativeExpression % UnaryExpression

**Static Semantics: IsValidSimpleAssignmentTarget**
MultiplicativeExpression:
  MultiplicativeExpression • UnaryExpression
  MultiplicativeExpression / UnaryExpression
  MultiplicativeExpression % UnaryExpression

1. Return false.

Runtime Semantics: Evaluation

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

1. Let `left` be the result of evaluating `MultiplicativeExpression`.
2. Let `leftValue` be `GetValue(left)`.
3. ReturnIfAbrupt(leftValue).
4. Let `right` be the result of evaluating `UnaryExpression`.
5. Let `rightValue` be `GetValue(right)`.
6. Let `lnum` be `ToNumber(leftValue)`.
7. ReturnIfAbrupt(lnum).
8. Let `rnum` be `ToNumber(rightValue)`.
9. ReturnIfAbrupt(rnum).
10. Return the result of applying the specified operation (*, /, or %) to `lnum` and `rnum`. See the Notes below 11.5.1, 11.5.2, 11.5.3.

11.5.1 Applying the * Operator

The * operator performs multiplication, producing the product of its operands. Multiplication is commutative. Multiplication is not always associative in ECMAScript, because of finite precision.

The result of a floating-point multiplication is governed by the rules of IEEE 754 binary double-precision arithmetic:

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

11.5.2 Applying the / Operator

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

- If either operand is NaN, the result is NaN.
- The sign of the result is positive if both operands have the same sign, negative if the operands have different signs.
- Division of an infinity by an infinity results in NaN.
- Division of an infinity by a zero results in an infinity. The sign is determined by the rule already stated above.
Division of an infinity by a nonzero finite value results in a signed infinity. The sign is determined by the rule already stated above.

Division of a finite value by an infinity results in zero. The sign is determined by the rule already stated above.

Division of a zero by a zero results in NaN; division of zero by any other finite value results in zero, with the sign determined by the rule already stated above.

Division of a nonzero finite value by a zero results in a signed infinity. The sign is determined by the rule already stated above.

In the remaining cases, where neither an infinity, nor a zero, nor NaN is involved, the quotient is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode. If the magnitude is too large to represent, the operation overflows; the result is then an infinity of appropriate sign. If the magnitude is too small to represent, the operation underflows and the result is a zero of the appropriate sign. The ECMAScript language requires support of gradual underflow as defined by IEEE 754.

### 11.5.3 Applying the % Operator

The % operator yields the remainder of its operands from an implied division; the left operand is the dividend and the right operand is the divisor.

NOTE In C and C++, the remainder operator accepts only integral operands; in ECMAScript, it also accepts floating-point operands.

The result of a floating-point remainder operation as computed by the % operator is not the same as the "remainder" operation defined by IEEE 754. The IEEE 754 "remainder" operation computes the remainder from a rounding division, not a truncating division, and so its behaviour is not analogous to that of the usual integer remainder operator. Instead the ECMAScript language defines % on floating-point operations to behave in a manner analogous to that of the Java integer remainder operator; this may be compared with the C library function fmod.

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

- If either operand is NaN, the result is NaN.
- The sign of the result equals the sign of the dividend.
- If the dividend is a zero, or the divisor is a zero, or both, the result is NaN.
- If the dividend is an infinity, the result equals the dividend.
- If the dividend is a zero and the divisor is nonzero and finite, the result is the same as the dividend.
- In the remaining cases, where neither an infinity, nor a zero, nor NaN is involved, the floating-point remainder r from a dividend n and a divisor d is defined by the mathematical relation r = n - (d × q) where q is an integer that is negative only if n/d is negative and positive only if n/d is positive, and whose magnitude is as large as possible without exceeding the magnitude of the true mathematical quotient of n and d. r is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode.

### 11.6 Additive Operators

**Syntax**

```
AdditiveExpression : 
   AdditiveExpression + MultiplicativeExpression
   AdditiveExpression - MultiplicativeExpression
```

**Static Semantics:** IsValidSimpleAssignmentTarget

```
AdditiveExpression : 
   AdditiveExpression + MultiplicativeExpression
   AdditiveExpression - MultiplicativeExpression
```
1. Return false.

11.6.1 The Addition operator (+)

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

Runtime Semantics: Evaluation

AdditiveExpression : AdditiveExpression + MultiplicativeExpression

1. Let lref be the result of evaluating AdditiveExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating MultiplicativeExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let lprim be ToPrimitive(lval).
8. ReturnIfAbrupt(lprim).
9. Let rprim be ToPrimitive(rval).
10. ReturnIfAbrupt(rprim).
11. If Type(lprim) is String or Type(rprim) is String, then
   a. Return the String that is the result of concatenating ToString(lprim) followed by ToString(rprim)
12. Return the result of applying the addition operation to ToNumber(lprim) and ToNumber(rprim). See the Note below 11.6.3.

NOTE 1 No hint is provided in the calls to ToPrimitive in steps 5 and 6. All standard ECMAScript objects except Date objects handle the absence of a hint as if the hint Number were given; Date objects handle the absence of a hint as if the hint String were given. Exotic objects may handle the absence of a hint in some other manner.

NOTE 2 Step 7 differs from step 3 of the comparison algorithm for the relational operators (11.8.1), by using the logical-or operation instead of the logical-and operation.

11.6.2 The Subtraction Operator (−)

Runtime Semantics: Evaluation

AdditiveExpression : AdditiveExpression − MultiplicativeExpression

1. Let lref be the result of evaluating AdditiveExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating MultiplicativeExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Let lnum be ToNumber(lval).
8. ReturnIfAbrupt(lnum).
9. Let rnum be ToNumber(rval).
10. ReturnIfAbrupt(rnum).
11. Return the result of applying the subtraction operation to lnum and rnum. See the note below 11.6.3.

11.6.3 Applying the Additive Operators to Numbers

The + operator performs addition when applied to two operands of numeric type, producing the sum of the operands. The − operator performs subtraction, producing the difference of two numeric operands.

Addition is a commutative operation, but not always associative.

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

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

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

### 11.7 Bitwise Shift Operators

#### Syntax

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

#### Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return `false`.

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

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

#### Runtime Semantics: Evaluation

```
ShiftExpression : ShiftExpression << AdditiveExpression
1. Let `lref` be the result of evaluating `ShiftExpression`.
2. Let `lval` be GetValue(`lref`).
3. ReturnIfAbrupt(`lval`).
4. Let `rref` be the result of evaluating `AdditiveExpression`.
5. Let `rval` be GetValue(`rref`).
6. ReturnIfAbrupt(`rval`).
7. Let `lnum` be ToInt32(`lval`).
8. ReturnIfAbrupt(`lnum`).
9. Let `rnum` be ToUint32(`rval`).
10. ReturnIfAbrupt(`rnum`).
11. Let `shiftCount` be the result of masking out all but the least significant 5 bits of `rnum`, that is, compute `rnum & 0x1F`.
12. Return the result of left shifting `lnum` by `shiftCount` bits. The result is a signed 32-bit integer.
```
11.7.2 The Signed Right Shift Operator (\(\gg\))

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

Runtime Semantics: Evaluation

\[\text{ShiftExpression : ShiftExpression} \gg \text{AdditiveExpression}\]

1. Let \(lref\) be the result of evaluating \(\text{ShiftExpression}\).
2. Let \(lval\) be GetValue\((lref)\).
3. ReturnIfAbrupt\((lval)\).
4. Let \(rref\) be the result of evaluating \(\text{AdditiveExpression}\).
5. Let \(rval\) be GetValue\((rref)\).
6. ReturnIfAbrupt\((rval)\).
7. Let \(lnum\) be ToInt32\((lval)\).
8. ReturnIfAbrupt\((lnum)\).
9. Let \(rnum\) be ToUint32\((rval)\).
10. ReturnIfAbrupt\((rnum)\).
11. Let \(\text{shiftCount}\) be the result of masking out all but the least significant 5 bits of \(rnum\), that is, compute \(rnum \& 0x1F\).
12. Return the result of performing a sign-extending right shift of \(\text{lnum}\) by \(\text{shiftCount}\) bits. The most significant bit is propagated. The result is a signed 32-bit integer.

11.7.3 The Unsigned Right Shift Operator (\(\gg\))

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

Runtime Semantics: Evaluation

\[\text{ShiftExpression : ShiftExpression} \gg\gg \text{AdditiveExpression}\]

1. Let \(lref\) be the result of evaluating \(\text{ShiftExpression}\).
2. Let \(lval\) be GetValue\((lref)\).
3. ReturnIfAbrupt\((lval)\).
4. Let \(rref\) be the result of evaluating \(\text{AdditiveExpression}\).
5. Let \(rval\) be GetValue\((rref)\).
6. ReturnIfAbrupt\((rval)\).
7. Let \(lnum\) be ToUint32\((lval)\).
8. ReturnIfAbrupt\((lnum)\).
9. Let \(rnum\) be ToUint32\((rval)\).
10. ReturnIfAbrupt\((rnum)\).
11. Let \(\text{shiftCount}\) be the result of masking out all but the least significant 5 bits of \(rnum\), that is, compute \(rnum \& 0x1F\).
12. Return the result of performing a zero-filling right shift of \(\text{lnum}\) by \(\text{shiftCount}\) bits. Vacated bits are filled with zero. The result is an unsigned 32-bit integer.

11.8 Relational Operators

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

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

RelationalExpressionNoIn :
  ShiftExpression
  RelationalExpressionNoIn < ShiftExpression
  RelationalExpressionNoIn > ShiftExpression
  RelationalExpressionNoIn <= ShiftExpression
  RelationalExpressionNoIn >= ShiftExpression
  RelationalExpressionNoIn instanceof ShiftExpression

The semantics of the RelationalExpressionNoIn productions are the same as the RelationalExpression productions except that the contained RelationalExpressionNoIn is used in place of the contained RelationalExpression.

NOTE The ‘NoIn’ variants are needed to avoid confusing the in operator in a relational expression with the in operator in a for statement.

Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

11.8.1 Runtime Semantics

Runtime Semantics: The Abstract Relational Comparison Algorithm

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

1. ReturnIfAbrupt(x).
2. ReturnIfAbrupt(y).
3. If the LeftFirst flag is true, then
   a. Let px be the result of calling ToPrimitive(x, hint Number).
   b. ReturnIfAbrupt(px).
   c. Let py be the result of calling ToPrimitive(y, hint Number).
   d. ReturnIfAbrupt(py).
4. Else the order of evaluation needs to be reversed to preserve left to right evaluation
   a. Let py be the result of calling ToPrimitive(y, hint Number).
5. If both `px` and `py` are Strings, then
   a. If `py` is a prefix of `px`, return `false`. (A String value `p` is a prefix of String value `q` if `q` can be the result of concatenating `p` and some other String `r`. Note that any String is a prefix of itself, because `r` may be the empty String.)
   b. If `px` is a prefix of `py`, return `true`.
   c. Let `k` be the smallest nonnegative integer such that the character at position `k` within `px` is different from the character at position `k` within `py`. (There must be such a `k`, for neither String is a prefix of the other.)
   d. Let `m` be the integer that is the code unit value for the character at position `k` within `px`.
   e. Let `n` be the integer that is the code unit value for the character at position `k` within `py`.
   f. If `m < n`, return `true`. Otherwise, return `false`.

6. Else,
   a. Let `nx` be the result of calling `ToNumber(px)`. Because `px` and `py` are primitive values evaluation order is not important.
   b. Let `ny` be the result of calling `ToNumber(py)`.
   c. If `nx` is `NaN`, return `undefined`.
   d. If `nx` is not `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`.
   g. If `nx` is `−0` and `ny` is `+0`, return `false`.
   h. If `nx` is `+∞`, return `false`.
   i. If `nx` is `−∞`, return `true`.
   j. If `nx` is `−∞`, return `false`.
   k. If `ny` is `−∞`, return `true`.
   l. If the mathematical value of `nx` is less than the mathematical value of `ny`—note that these mathematical values are both finite and not both zero—return `true`. Otherwise, return `false`.

NOTE 1 Step 3 differs from step 7 in the algorithm for the addition operator `+` (11.6.1) in using and instead of or.

NOTE 2 The comparison of Strings uses a simple lexicographic ordering on sequences of code unit values. There is no attempt to use the more complex, semantically oriented definitions of character or string equality and collating order defined in the Unicode specification. Therefore `String` values that are canonically equal according to the Unicode standard could test as unequal. In effect, this algorithm assumes that both Strings are already in normalised form. Also, note that for strings containing supplementary characters, lexicographic ordering on sequences of UTF-16 code unit values differs from that on sequences of code point values.

Runtime Semantics: Evaluation

RelationalExpression : RelationalExpression < ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. Return `false`.
4. Let `rref` be the result of evaluating `ShiftExpression`.
5. Let `rval` be `GetValue(rref)`.
6. Let `r` be the result of performing abstract relational comparison `lval < rval`. (see 11.8.5)
7. Return `false`.

RelationalExpression : RelationalExpression > ShiftExpression

1. Let `lref` be the result of evaluating `RelationalExpression`.
2. Let `lval` be `GetValue(lref)`.
3. Return `false`.
4. Let `rref` be the result of evaluating `ShiftExpression`.
5. Let `rval` be `GetValue(rref)`.
6. Let `r` be the result of performing abstract relational comparison `lval > rval` with `LeftFirst` equal to `false`.

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7. ReturnIfAbrupt(r).
8. If r is undefined, return false. Otherwise, return r.

RelationalExpression : RelationalExpression <= ShiftExpression
1. Let lref be the result of evaluating RelationalExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating ShiftExpression.
5. Let rval be GetValue(rref).
6. Let r be the result of performing abstract relational comparison \( rval < lval \) with LeftFirst equal to false.
7. ReturnIfAbrupt(r).
8. If r is true or undefined, return false. Otherwise, return true.

RelationalExpression : RelationalExpression => ShiftExpression
1. Let lref be the result of evaluating RelationalExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating ShiftExpression.
5. Let rval be GetValue(rref).
6. Let r be the result of performing abstract relational comparison \( lval < rval \).
7. ReturnIfAbrupt(r).
8. If r is true or undefined, return false. Otherwise, return true.

RelationalExpression : RelationalExpression instanceof ShiftExpression
1. Let lref be the result of evaluating RelationalExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating ShiftExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. Return the result of instanceof Operator(lval, rval).

The abstract operation instanceof Operator(O, C) implements the generic algorithm for determining if an object O inherits from the inheritance path defined by constructor C. This abstract operation performs the following steps:

1. If Type(C) is not Object, throw a TypeError exception.
2. Let instOfHandler be the result of GetMethod(C, @@hasInstance).
3. ReturnIfAbrupt(instOfHandler).
4. If instOfHandler is not undefined, then
   a. Let result be the result of calling the [[Call]] internal method of instOfHandler passing C as thisArgument and a new List containing O as argumentsList.
   b. Return ToBoolean(result).
5. If IsCallable(C) is false, then throw a TypeError exception.
6. Return the result of OrdinaryHasInstance(C, O).

NOTE Steps 5 and 6 provide compatibility with previous editions of ECMAScript that did not use a @@hasInstance method to define the instanceof operator semantics. If a function object does not define or inherit @@hasInstance it uses the default instanceof semantics.

RelationalExpression : RelationalExpression in ShiftExpression
1. Let lref be the result of evaluating RelationalExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let rref be the result of evaluating ShiftExpression.
5. Let rval be GetValue(rref).
6. ReturnIfAbrupt(rval).
7. If Type(rval) is not Object, throw a TypeError exception.
8. Return the result of HasProperty(rval, ToPropertyKey(lval)).

11.9 Equality Operators

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

Syntax

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

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

The semantics of the EqualityExpressionNoIn productions are the same as the EqualityExpression productions except that the contained EqualityExpressionNoIn and RelationalExpressionNoIn are used in place of the contained EqualityExpression and RelationalExpression, respectively.

Static Semantics: IsValidSimpleAssignmentTarget

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

1. Return false.

11.9.1 Runtime Semantics

Runtime Semantics: The Abstract Equality Comparison Algorithm

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

1. If Type(x) is the same as Type(y), then
   a. Return the result of performing strict equality comparison algorithm \( x === y \).
2. If \( x \) is null and \( y \) is undefined, return true.
3. If \( x \) is undefined and \( y \) is null, return true.
4. If Type(x) is Number and Type(y) is String, return the result of the comparison ToNumber(x) == y.
5. If Type(x) is String and Type(y) is Number, return the result of the comparison ToNumber(x) == y.
6. If Type(x) is Boolean, return the result of the comparison ToNumber(x) == y.
7. If Type(x) is Boolean, return the result of the comparison x == ToNumber(y).
8. If Type(x) is either String or Number and Type(y) is Object, return the result of the comparison x == ToPrimitive(y).
9. If Type(x) is Object and Type(y) is either String or Number, return the result of the comparison ToPrimitive(x) == y.

10. Return false.

NOTE 1 Given the above definition of equality:
- String comparison can be forced by: "" + a == "" + b.
- Numeric comparison can be forced by: +a == +b.
- Boolean comparison can be forced by: a == !b.

NOTE 2 The equality operators maintain the following invariants:
- A != B is equivalent to !(A == B).
- A == B is equivalent to B == A, except in the order of evaluation of A and B.

NOTE 3 The equality operator is not always transitive. For example, there might be two distinct String objects, each representing the same String value; each String object would be considered equal to the String value by the == operator, but the two String objects would not be equal to each other. For Example:
- new String("a") == "a" and "a" == new String("a") are both true.
- new String("a") == new String("a") is false.

NOTE 4 Comparison of Strings uses a simple equality test on sequences of code unit values. There is no attempt to use the more complex, semantically oriented definitions of character or string equality and collating order defined in the Unicode specification. Therefore Strings values that are canonically equal according to the Unicode standard could test as unequal. In effect this algorithm assumes that both Strings are already in normalised form.

Runtime Semantics: The Strict Equality Comparison Algorithm

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

1. If Type(x) is different from Type(y), return false.
2. If Type(x) is Undefined, return true.
3. If Type(x) is Null, return true.
4. If Type(x) is Number, then
   a. If x is NaN, return false.
   b. If y is NaN, return false.
   c. If x is the same Number value as y, return true.
   d. If x is +0 and y is −0, return true.
   e. If x is −0 and y is +0, return true.
   f. Return false.
5. If Type(x) is String, then
   a. If x and y are exactly the same sequence of characters (same length and same characters in corresponding positions), return true.
   b. Else, return false.
6. If Type(x) is Boolean, then
   a. If x and y are both true or both false, return true.
   b. Else, return false.
7. If x and y are the same Symbol value, return true.
8. If x and y are the same Object value, return true.
9. Return false.

NOTE This algorithm differs from the SameValue Algorithm (9.12) in its treatment of signed zeroes and NaNs.

Runtime Semantics: Evaluation

EqualityExpression : EqualityExpression == RelationalExpression

1. Let lref be the result of evaluating EqualityExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let `lref` be the result of evaluating `RelationalExpression`.
5. Let `lval` be `GetValue(lref)`.
6. ReturnIfAbrupt(`lval`).
7. Return the result of performing abstract equality comparison algorithm `lval == rval`.

EqualityExpression : EqualityExpression != RelationalExpression
1. Let `lref` be the result of evaluating `EqualityExpression`.
2. Let `lval` be `GetValue(lref)`.
3. ReturnIfAbrupt(`lval`).
4. Let `rref` be the result of evaluating `RelationalExpression`.
5. Let `rval` be `GetValue(rref)`.
6. ReturnIfAbrupt(`rval`).
7. Let `r` be the result of performing abstract equality comparison algorithm `rval == lval`.
8. If `r` is `true`, return `false`. Otherwise, return `true`.

EqualityExpression : EqualityExpression !== RelationalExpression
1. Let `lref` be the result of evaluating `EqualityExpression`.
2. Let `lval` be `GetValue(lref)`.
3. ReturnIfAbrupt(`lval`).
4. Let `rref` be the result of evaluating `RelationalExpression`.
5. Let `rval` be `GetValue(rref)`.
6. ReturnIfAbrupt(`rval`).
7. Return the result of performing the strict equality comparison algorithm `rval === lval`.
8. If `r` is `true`, return `false`. Otherwise, return `true`.

11.10 Binary Bitwise Operators

Syntax

**BitwiseANDExpression** :

```
EqualityExpression & EqualityExpression
```

**BitwiseANDExpressionNoIn** :

```
EqualityExpressionNoIn & EqualityExpressionNoIn
```

**BitwiseXORExpression** :

```
BitwiseXORExpression
```

```
BitwiseXORExpression
```

```
BitwiseXORExpressionNoIn
```

**BitwiseORExpression** :

```
BitwiseANDExpressionNoIn ^ BitwiseANDExpression
```

```
BitwiseXORExpressionNoIn
```

```
BitwiseXORExpressionNoIn
```

```
BitwiseORExpression | BitwiseXORExpression
```

```
BitwiseORExpression | BitwiseXORExpression
```

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BitwiseORExpression
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BitwiseORExpression
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BitwiseORExpression
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```
BitwiseORExpressionNoIn:
  BitwiseORExpressionNoIn
  BitwiseORExpressionNoIn | BitwiseXORExpressionNoIn

Static Semantics: IsValidSimpleAssignmentTarget

BitwiseANDExpression : BitwiseORExpression & EqualityExpression
BitwiseXORExpression : BitwiseXORExpression * BitwiseANDExpression
BitwiseORExpression : BitwiseORExpression | BitwiseXORExpression

1. Return false.

Runtime Semantics: Evaluation

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

1. Let $lref$ be the result of evaluating $A$.
2. Let $lval$ be GetValue($lref$).
3. ReturnIfAbrupt($lval$).
4. Let $rval$ be the result of evaluating $B$.
5. Let $rval$ be GetValue($rval$).
6. ReturnIfAbrupt($rval$).
7. Let $lnum$ be ToInt32($lval$).
8. ReturnIfAbrupt($lnum$).
9. Let $rnum$ be ToInt32($rval$).
10. Return If Abrupt ($rnum$).
11. Return the result of applying the bitwise operator $@$ to $lnum$ and $rnum$. The result is a signed 32 bit integer.

11.11 Binary Logical Operators

Syntax

LogicalANDExpression:
  LogicalORExpression
  LogicalANDExpression & LogicalORExpression

LogicalANDExpressionNoIn:
  LogicalORExpressionNoIn
  LogicalANDExpressionNoIn & LogicalORExpressionNoIn

LogicalORExpression:
  LogicalANDExpression
  LogicalORExpression || LogicalANDExpression

LogicalORExpressionNoIn:
  LogicalORExpressionNoIn
  LogicalORExpressionNoIn || LogicalANDExpressionNoIn

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

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

Static Semantics: IsValidSimpleAssignmentTarget
LogicalANDExpression : LogicalANDExpression && BitwiseORExpression

LogicalORExpression : LogicalORExpression || LogicalANDExpression

1. Return false.

Runtime Semantics: Evaluation

LogicalANDExpression : LogicalANDExpression && BitwiseORExpression

1. Let lref be the result of evaluating LogicalANDExpression.
2. Let lval be GetValue(lref).
3. Let lbool be ToBoolean(lval).
4. ReturnIfAbrupt(lbool).
5. If lbool is false, return lval.
6. Let rref be the result of evaluating BitwiseORExpression.
7. Return GetValue(rref).

LogicalORExpression : LogicalORExpression || LogicalANDExpression

1. Let lref be the result of evaluating LogicalORExpression.
2. Let lval be GetValue(lref).
3. Let lbool be ToBoolean(lval).
4. ReturnIfAbrupt(lbool).
5. If lbool is true, return lval.
6. Let rref be the result of evaluating LogicalANDExpression.
7. Return GetValue(rref).

11.12 Conditional Operator ( ? : )

Syntax

ConditionalExpression :
  LogicalORExpression
  LogicalORExpression ? AssignmentExpression : AssignmentExpression

ConditionalExpressionNoIn :
  LogicalORExpressionNoIn
  LogicalORExpressionNoIn ? AssignmentExpressionNoIn : AssignmentExpressionNoIn

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

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

Static Semantics: IsValidSimpleAssignmentTarget

ConditionalExpression : LogicalORExpression ? AssignmentExpression : AssignmentExpression

1. Return false.

Runtime Semantics: Evaluation

ConditionalExpression : LogicalORExpression ? AssignmentExpression : AssignmentExpression

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

11.13 Assignment Operators

Syntax

AssignmentExpression : ConditionalExpression
                      YieldExpression
                      ArrowFunction
                      LeftHandSideExpression = AssignmentExpression
                      LeftHandSideExpression AssignmentOperator AssignmentExpression

AssignmentExpressionNoIn : ConditionalExpressionNoIn
                          YieldExpression
                          ArrowFunction
                          LeftHandSideExpression = AssignmentExpressionNoIn
                          LeftHandSideExpression AssignmentOperator AssignmentExpressionNoIn

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

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

Static Semantics

Static Semantics: Early Errors

AssignmentExpression : LeftHandSideExpression = AssignmentExpression
   • It is a Syntax Error if LeftHandSideExpression is either an ObjectLiteral or an ArrayLiteral and if the
     lexical token sequence matched by LeftHandSideExpression cannot be parsed with no tokens left over
     using AssignmentPattern as the goal symbol.
   • If LeftHandSideExpression is either an ObjectLiteral or an ArrayLiteral and if the lexical token sequence
     matched by LeftHandSideExpression can be parsed with no tokens left over using AssignmentPattern as
     the goal symbol then the following rules are not applied. Instead, the Early Error rules for AssignmentPattern
     are used.
   • It is a Syntax Error if LeftHandSideExpression is an Identifier that can be statically determined to always
     resolve to a declarative environment record binding and the resolved binding is an immutable binding.
   • It is an early Reference Error if LeftHandSideExpression is neither an ObjectLiteral nor an ArrayLiteral
     and IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

AssignmentExpression : LeftHandSideExpression AssignmentOperator AssignmentExpression
   • It is a Syntax Error if the LeftHandSideExpression is an Identifier that can be statically determined to
     always resolve to a declarative environment record binding and the resolved binding is an immutable
     binding.
   • It is an early Reference Error if IsValidSimpleAssignmentTarget of LeftHandSideExpression is false.

Static Semantics: IsValidSimpleAssignmentTarget
AssignmentExpression:
  YieldExpression
  ArrowFunction
  LeftHandSideExpression = AssignmentExpression
  LeftHandSideExpression AssignmentOperator AssignmentExpression

1. Return false.

Runtime Semantics

Runtime Semantics: Evaluation

AssignmentExpression: LeftHandSideExpression = AssignmentExpression

1. If LeftHandSideExpression is neither an ObjectLiteral nor an ArrayLiteral then
   a. Let lref be the result of evaluating LeftHandSideExpression.
   b. ReturnIfAbrupt(lref).
   c. Let ref be the result of evaluating AssignmentExpression.
   d. Let rval be GetValue(ref).
   e. Let status be PutValue(lref, rval).
   f. ReturnIfAbrupt(status).
   g. Return rval.
2. Let AssignmentPattern be the parse of the source code corresponding to LeftHandSideExpression using AssignmentPattern as the goal symbol.
3. Let ref be the result of evaluating AssignmentExpression.
4. Let rval be ToObject(GetValue(ref)).
5. ReturnIfAbrupt(rval).
6. Let status be the result of performing Destructuring Assignment Evaluation of AssignmentPattern using rval as the argument.
7. ReturnIfAbrupt(status).
8. Return rval.

AssignmentExpression: LeftHandSideExpression AssignmentOperator AssignmentExpression

1. Let lref be the result of evaluating LeftHandSideExpression.
2. Let lval be GetValue(lref).
3. ReturnIfAbrupt(lval).
4. Let ref be the result of evaluating AssignmentExpression.
5. Let rval be GetValue(ref).
6. ReturnIfAbrupt(rval).
7. Let operator be the @ where AssignmentOperator is @=
8. Let r be the result of applying operator @ to lval and rval.
9. Let status be PutValue(lref, r).
10. ReturnIfAbrupt(status).
11. Return r.

NOTE When an assignment occurs within strict mode code, it is a runtime error if lref in step 1.e of the first algorithm or step 8 of the second algorithm it is an unresolvable reference. If it is, a ReferenceError exception is thrown. The LeftHandSide also may not be a reference to a data property with the attribute value {[[Writable]]:false}, to an accessor property with the attribute value {[[Set]]:undefined}, nor to a non-existent property of an object for which the IsExtensible predicate returns the value false. In these cases a TypeError exception is thrown.

11.13.1 Destructuring Assignment

Supplemental Syntax

In certain circumstances when processing the production AssignmentExpression: LeftHandSideExpression = AssignmentExpression the following grammar is used to refine the interpretation of LeftHandSideExpression.

Formatted: Note
AssignmentPattern :
  ObjectAssignmentPattern
  ArrayAssignmentPattern

ObjectAssignmentPattern :
  { }
  { AssignmentPropertyList } { AssignmentPropertyList , }

ArrayAssignmentPattern :
  [ Elision opt AssignmentRestElementopt ]
  [ AssignmentElementList ]
  [ AssignmentElementList , Elision opt AssignmentRestElementopt ]

AssignmentPropertyList :
  AssignmentProperty
  AssignmentPropertyList , AssignmentProperty

AssignmentElementList :
  Elision opt AssignmentElement
  AssignmentElementList , Elision opt AssignmentElement

AssignmentProperty :
  Identifier Initialiseropt
  PropertyName : AssignmentElement

AssignmentElement :
  DestructuringAssignmentTarget Initialiseropt

AssignmentRestElement :
  . . . DestructuringAssignmentTarget

DestructuringAssignmentTarget :
  LeftHandSideExpression

Static Semantics

Static Semantics: Early Errors

AssignmentProperty : Identifier Initialiseropt

- It is a Syntax Error if Identifier is the Identifier eval or the Identifier arguments.
- It is a Syntax Error if Identifier does not statically resolve to a declarative environment record binding or if the resolved binding is an immutable binding.

AssignmentRestElement : . . . DestructuringAssignmentTarget

- It is a Syntax Error if IsValidSimpleAssignmentTarget of DestructuringAssignmentTarget is false.

DestructuringAssignmentTarget : LeftHandSideExpression

- It is a Syntax Error 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 of LeftHandSideExpression is false.
• It is a Syntax Error if the LeftHandSideExpression is an Identifier that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
• It is a Syntax Error if LeftHandSideExpression is the Identifier eval or the Identifier arguments.
• It is a Syntax Error if InvalidAssignmentPattern of LeftHandSideExpression is true.
• It is a Syntax Error if the LeftHandSideExpression is CoverParenthesisedExpressionAndArrowParameterList : ( Expression ) and Expression derived a production that would produce a Syntax Error according to these rules. This rule is recursively applied.

Runtime Semantics

Runtime Semantics: Destructuring Assignment Evaluation

with parameter obj

ObjectAssignmentPattern : { } and ArrayAssignmentPattern : []

1. Return NormalCompletion(empty).

AssignmentPropertyList : AssignmentPropertyList , AssignmentProperty

1. Let status be the result of performing Destructuring Assignment Evaluation for AssignmentPropertyList using obj as the argument.
2. ReturnIfAbrupt(status).
3. Return the result of performing Destructuring Assignment Evaluation for AssignmentProperty using obj as the argument.

AssignmentProperty : Identifier Initialiser

1. Let P be StringValue of Identifier.
2. Let v be the result of calling Get(obj, P).
3. ReturnIfAbrupt(v).
4. If Initialiseropt is present and v is undefined, then
   a. Let defaultValue be the result of evaluating Initialiser.
   b. Let v be ToObject(GetValue(defaultValue)).
5. ReturnIfAbrupt(v).
6. Let ref be the result of performing Identifier Resolution(10.3.1) with the IdentifierName corresponding to Identifier.
7. Return PutValue(ref, v).

AssignmentProperty : PropertyName AssignmentElement

1. Let name be PropName of PropertyName.
2. Return the result of performing Keyed Destructuring Assignment Evaluation of AssignmentElement with obj and name as the arguments.

ArrayAssignmentPattern : [ Elisionopt AssignmentRestElement ]

1. Let skip be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
2. Return the result of performing Indexed Destructuring Assignment Evaluation of AssignmentRestElement with obj and skip as the arguments.
1. Return the result of performing Indexed Destructuring Assignment Evaluation of AssignmentElementList using obj and 0 as the arguments.

ArrayAssignmentPattern : [ AssignmentElementList , Elisionopt AssignmentRestElementopt ]

1. Let lastIndex be the result of performing Indexed Destructuring Assignment Evaluation of AssignmentElementList using obj and 0 as the arguments.
2. ReturnIfAbrupt(lastIndex).
3. Let skip be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
4. If AssignmentRestElement is present, then return the result of performing Indexed Destructuring Assignment Evaluation of AssignmentRestElement with obj and lastIndex+skip as the arguments.
5. Return lastIndex.

Runtime Semantics: Indexed Destructuring Assignment Evaluation with parameters obj and index

AssignmentElementList : AssignmentElement

1. Let listNext be the result of performing Indexed Destructuring Assignment Evaluation of AssignmentElementList using obj as the obj parameter and index as the index parameter
2. Let name be ToString(index+skip).
3. Let status be the result of performing Keyed Destructuring Assignment Evaluation of AssignmentElement with obj and name as the arguments.
4. ReturnIfAbrupt(status).
5. Return lastIndex+skip+1.

AssignmentRestElement : ... DestructuringAssignmentTarget

1. Let lref be the result of evaluating DestructuringAssignmentTarget.
2. ReturnIfAbrupt(lref).
3. Let lenVal be the result of Get(obj, "length").
4. Let len be ToUint32(lenVal).
5. ReturnIfAbrupt(len).
6. Let A be the result of the abstract operation ArrayCreate with argument 0.
7. Let n=0;
8. Repeat, while index < len
   a. Let P be ToString(index).
   b. Let exists be the result of HasProperty(obj, P).
   c. ReturnIfAbrupt(exists).
   d. If exists is true, then
      i. Let v be the result of Get(obj, ToString(index)).
      ii. ReturnIfAbrupt(v).
      iii. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(n) and Property Descriptor {[[Value]]: v, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
   e. Let n = n+1.
   f. Let index = index+1.
Runtime Semantics: Keyed Destructuring Assignment Evaluation

with parameters `obj` and `propertyName`

AssignmentElement : DestructuringAssignmentTarget Initialiser

1. Let `v` be the result of Get(`obj`, `propertyName`).
2. ReturnIfAbrupt(`v`).
3. If InitialiserOpt is present and `v` is `undefined`, then
   a. Let defaultValue be the result of evaluating Initialiser.
      b. Let `v` be GetValue(defaultValue)
4. If DestructuringAssignmentTarget is an ObjectLiteral or an ArrayLiteral then
   a. Let AssignmentPattern be the parse of the source code corresponding to
      DestructuringAssignmentTarget using AssignmentPattern as the goal symbol
   b. Let `v` be ToObject(`v`).
   c. ReturnIfAbrupt(`v`).
   d. Return the result of performing Destructuring Assignment Evaluation of AssignmentPattern with
      `v` as the argument.
5. ReturnIfAbrupt(`v`).
6. Let `lref` be the result of evaluating DestructuringAssignmentTarget.

11.14 Comma Operator ( , )

Syntax

Expression : AssignmentExpression
Expression , AssignmentExpression

ExpressionNoIn : AssignmentExpressionNoIn
ExpressionNoIn , AssignmentExpressionNoIn

The semantics of the ExpressionNoIn production is the same manner as the Expression production except that
the contained ExpressionNoIn and AssignmentExpressionNoIn are used in place of the contained Expression and
AssignmentExpression, respectively.

Static Semantics: IsValidSimpleAssignmentTarget

Expression : Expression , AssignmentExpression

1. Return false.

Runtime Semantics: Evaluation

Expression : Expression , AssignmentExpression

1. Let `lref` be the result of evaluating Expression.
2. ReturnIfAbrupt(GetValue(lref))
3. Let `rref` be the result of evaluating AssignmentExpression.
4. Return GetValue(rref).

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

Syntax
Statement:
  BlockStatement
  VariableStatement
  EmptyStatement
  ExpressionStatement
  IfStatement
  BreakableStatement
  ContinueStatement
  BreakStatement
  ReturnStatement
  WithStatement
  LabelledStatement
  ThrowStatement
  TryStatement
  DebuggerStatement

Declaration:
  FunctionDeclaration
  GeneratorDeclaration
  ClassDeclaration
  LexicalDeclaration

BreakableStatement:
  IterationStatement
  SwitchStatement

Static Semantics

Static Semantics: VarDeclaredNames
Statement:
  EmptyStatement
  ExpressionStatement
  ContinueStatement
  BreakStatement
  ReturnStatement
  ThrowStatement
  DebuggerStatement
1. Return a new empty List.

Runtime Semantics

Runtime Semantics: Labelled Evaluation
With argument labelSet.
BreakableStatement : IterationStatement
1. Let stmtResult be the result of performing Labelled Evaluation of IterationStatement with argument labelSet.
2. If stmtResult.[[type]] is break and stmtResult.[[target]] is empty, then
   a. If stmtResult.[[value]] is empty, then let stmtResult be NormalCompletion(undefi ned).
   b. Else, let stmtResult be NormalCompletion(stmtResult.[[value]])
3. Return stmtResult.
BreakableStatement : SwitchStatement

1. Let stmtResult be the result of evaluating SwitchStatement.
2. If stmtResult.[[type]] is break and stmtResult.[[target]] is empty, then
   a. If stmtResult.[[value]] is empty, then let stmtResult be NormalCompletion(undefined).
   b. Else, let stmtResult be NormalCompletion(stmtResult.[[value]])
3. Return stmtResult.

NOTE  A BreakableStatement is one that can be exited via an unlabelled BreakStatement.

Runtime Semantics: Evaluation

BreakableStatement : IterationStatement
SwitchStatement

1. Let newLabelSet be a new empty List.
2. Return the result of performing Labelled Evaluation of this BreakableStatement with argument newLabelSet.

12.1 Block

Syntax
BlockStatement : Block

Block : ( StatementListopt )

StatementList : StatementList Item
StatementList StatementList Item

StatementList Item : Statement
Declaration

Static Semantics

Static Semantics: Early Errors

Block : ( StatementList )

- It is a Syntax Error if the LexicallyDeclaredNames of StatementList contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of StatementList also occurs in the VarDeclaredNames of StatementList.

Static Semantics: LexicalDeclarations

StatementList : StatementList Item
StatementList Item : Statement
StatementList Item : Declaration
1. Return a new List containing `Declaration`.

**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. Return a new empty List.

**StatementListItem**: `Declaration`

- 1. If `Declaration` is `Declaration : FunctionDeclaration`, then return a new empty List.
- 2. Return the `BoundNames` of `Declaration`.

**NOTE** At the top level of a function or script, function declarations are treated like var declarations rather than like lexical declarations.

**Static Semantics: TopLevelLexicallyScopedDeclarations**

**StatementList**: `StatementList StatementListItem`

- 1. Let `declarations` be `TopLevelLexicallyScopedDeclarations` of `StatementList`.
- 2. Append to `declarations` the elements of the `TopLevelLexicallyScopedDeclarations` of `StatementListItem`.
- 3. Return `declarations`.

**StatementListItem**: `Statement`

- 1. Return a new empty List.

**StatementListItem**: `Declaration`

- 1. If `Declaration` is `Declaration : FunctionDeclaration`, then return a new empty List.
- 2. Return a new List containing `Declaration`.

**Static Semantics: TopLevelVarDeclaredNames**
StatementList : StatementList StatementListItem

1. Let names be TopLevelVarDeclaredNames of StatementList.
2. Append to names the elements of the TopLevelVarDeclaredNames of StatementListItem.
3. Return names.

StatementListItem : Declaration

1. If Declaration is Declaration : FunctionDeclaration, then return the LexicallyDeclaredNames of Declaration.
2. Return a new empty List.

NOTE At the top level of a function or script, inner function declarations are treated like var declarations.

Static Semantics: TopLevelVarScopedDeclarations

StatementList : StatementList StatementListItem

1. Let declarations be TopLevelVarScopedDeclarations of StatementList.
2. Append to declarations the elements of the TopLevelVarScopedDeclarations of StatementListItem.
3. Return declarations.

StatementListItem : Statement

1. If Statement is Statement : VariableStatement, then return a new List containing VariableStatement.
2. Return a new empty List.

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. If Declaration is Declaration : FunctionDeclaration, then return a new List containing Declaration.
2. Return a new empty List.

Static Semantics: VarDeclaredNames

Block : { }

1. Return NormalCompletion(undefi ned);
Block: \{ StatementList \}

1. Let oldEnv be the running execution context’s LexicalEnvironment.
2. Let blockEnv be the result of calling NewDeclarativeEnvironment passing oldEnv as the argument.
3. Perform Block Declaration Instantiation using StatementList and blockEnv.
4. Set the running execution context’s LexicalEnvironment to blockEnv.
5. Let blockValue be the result of evaluating StatementList.
6. Set the running execution context’s LexicalEnvironment to oldEnv.
7. If blockValue.[[type]] is *normal* and blockValue.[[value]] is *empty*, then
   a. Return NormalCompletion(\undefined\).
8. Return blockValue.

**NOTE** No matter how control leaves the block the LexicalEnvironment is always restored to its former state.

StatementList : StatementList StatementListItem

1. Let sl be the result of evaluating StatementList.
2. ReturnIfAbrupt(sl).
3. Let s be the result of evaluating StatementListItem.
4. If s.[[type]] is *throw*, return s.
5. If s.[[value]] is *empty*, let V = sl.[[value]]; otherwise let V = s.[[value]].
6. Return Completion {[[type]]: s.[[type]], [[value]]: V, [[target]]: s.[[target]]}.

**NOTE** Steps 4 and 5 of the above algorithm ensure that the value of a StatementList is the value of the last value producing Statement in the StatementList. For example, the following calls to the eval function all return the value 1:

```javascript
eval("1;;;");
```

12.2 Declarations and the Variable Statement

12.2.1 Let and Const Declarations

**NOTE** A let and const declarations define variables that are scoped to the running execution context’s LexicalEnvironment. The variables are created when the containing Lexical Environment is instantiated but may not be accessed in any way until the variables’ LexicalBinding is evaluated. A variable defined by a LexicalBinding with an Initialiser is assigned the value of its Initialiser’s AssignmentExpression when the LexicalBinding is evaluated, not when the variable is created. If a LexicalBinding in a let declaration does not have an an Initialiser the variable is assigned the value \undefined\ when the LexicalBinding is evaluated.

**Syntax**

```
LexicalDeclaration : LetOrConst BindingList ;
```

```
LexicalDeclarationNoIn : LetOrConst BindingListNoIn
```

```
LetOrConst : let const
```

```
BindingList : LexicalBinding BindingList , LexicalBinding
```

```
BindingListNoIn : LexicalBindingNoIn BindingListNoIn , LexicalBindingNoIn
```

Commented [AWB1390]: Breaking change: completion reform

Commented [AWB1392]: Issue: above changes to completion reform will mean this evaluates to \undefined\ rather than 1 is
LexicalBinding : BindingIdentifier Initialiser opt
    BindingPattern Initialiser

LexicalBindingNoIn : BindingIdentifierNoIn InitialiserNoIn opt
    BindingPattern InitialiserNoIn

BindingIdentifier : Identifier

InitialiserNoIn : = AssignmentExpressionNoIn

The semantics of the LexicalDeclarationNoIn, BindingListNoIn, LexicalBindingNoIn and InitialiserNoIn productions are the same as the LexicalDeclaration, BindingList, LexicalBinding and Initialiser productions except that the contained BindingListNoIn, LexicalBindingNoIn, InitialiserNoIn and AssignmentExpressionNoIn are used in place of the contained BindingList, LexicalBinding, Initialiser and AssignmentExpression, respectively.

Static Semantics

Static Semantics: Early Errors

LexicalBinding : BindingIdentifier
• It is a Syntax Error if IsConstantDeclaration of the LexicalDeclaration containing this production is true.

BindingIdentifier : Identifier
• It is a Syntax Error if the BindingIdentifier is contained in strict code and if the Identifier is eval or arguments.

Static Semantics: BoundNames

LexicalDeclaration : LetOrConst BindingList ;
1. Return the BoundNames of BindingList.

BindingList : BindingList , LexicalBinding
1. Let names be the BoundNames of BindingList.
2. Append to names the elements of the BoundNames of LexicalBinding.
3. Return names.

LexicalBinding : BindingIdentifier Initialiser opt
1. Return the BoundNames of BindingIdentifier.

LexicalBinding : BindingPattern Initialiser
1. Return the BoundNames of BindingPattern.

BindingIdentifier : Identifier
1. Return a new List containing the StringValue of Identifier.

Static Semantics: IsConstantDeclaration

LexicalDeclaration : LetOrConst BindingList ;
1. Return `IsConstantDeclaration of LetOrConst`.

LetOrConst: `let`
1. Return `false`.

LetOrConst: `const`
1. Return `true`.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments `value` and `environment`.

NOTE `undefined` is passed for `environment` to indicate that a `PutValue` operation should be used to assign the initialisation value. This is the case for `var` statements formal parameter lists of non-strict functions, in those cases a lexical binding is hosted and preinitialised prior to evaluation of its initialiser.

`BindingIdentifier : Identifier`
1. If `environment` is not `undefined`, then
   a. Let `name` be `StringValue of Identifier`.
   b. Let `env` be the environment record component of `environment`.
   c. Call the `InitialiseBinding` concrete method of `.env` passing `name` and `value` as the arguments.
   d. Return NormalCompletion(`undefined`).
2. Else
   a. Let `lhs` be the result of evaluating `Identifier` as described in 11.1.2.
   b. Return `PutValue(lhs, value)`.

Runtime Semantics: Evaluation

`LexicalDeclaration : LetOrConst BindingList`:
1. Let `next` be the result of evaluating `BindingList`.
2. ReturnIfAbrupt(`next`).
3. Return NormalCompletion(`empty`).

`BindingList : BindingList , LexicalBinding`
1. Let `next` be the result of evaluating `BindingList`.
2. ReturnIfAbrupt(`next`).
3. Return the result of evaluating `LexicalBinding`.

`LexicalBinding : BindingIdentifier Initialiser`
1. Let `env` be the running execution context’s `LexicalEnvironment`.
2. Return the result of performing `Binding Initialisation` for `BindingIdentifier` passing `undefined` and `env` as the arguments.

NOTE A static semantics rule ensures that this form of `LexicalBinding` never occurs in a `const` declaration.

`LexicalBinding : BindingIdentifier Initialiser`
1. Let `rhs` be the result of evaluating `Initialiser`.
2. Let `value` be `GetValue(rhs)`.
3. ReturnIfAbrupt(`value`).
4. Let `env` be the running execution context’s `LexicalEnvironment`.
5. Return the result of performing Binding Initialisation for BindingIdentifier passing value and env as the arguments.

LexicalBinding : BindingPattern Initialiser

1. Let rhs be the result of evaluating Initialiser.
2. Let value be ToObject(GetValue(rhs)).
3. ReturnIfAbrupt(value).
4. Let env be the running execution context’s LexicalEnvironment.
5. Return the result of performing Binding Initialisation for BindingPattern using value and env as the arguments.

12.2.2 Variable Statement

Note A var statement declares variables that are scoped to the running execution context’s VariableEnvironment. Var variables are created when their containing Lexical Environment is instantiated and are initialised to undefined when created. Within the scope of any VariableEnvironment a common Identifier may appear in more than one VariableDeclaration but those declarations collective define only one variable. A variable defined by a VariableDeclaration with an Initialiser is assigned the value of its Initialiser’s AssignmentExpression when the VariableDeclaration is executed, not when the variable is created.

Syntax

VariableStatement : 
  var VariableDeclarationList ;

VariableDeclarationList : 
  VariableDeclaration
  VariableDeclarationList ;

VariableDeclarationListNoIn : 
  VariableDeclarationNoIn
  VariableDeclarationListNoIn ;

VariableDeclaration : 
  BindingIdentifier Initialiser
  BindingPattern Initialiser

VariableDeclarationNoIn : 
  BindingIdentifier InitialiserNoIn
  BindingPattern InitialiserNoIn

The semantics of the VariableDeclarationListNoIn, VariableDeclarationNoIn and InitialiserNoIn productions are the same as the VariableDeclarationList, VariableDeclaration and Initialiser productions except that the contained VariableDeclarationListNoIn, VariableDeclarationNoIn, InitialiserNoIn and AssignmentExpressionNoIn are used in of the contained VariableDeclarationList, VariableDeclaration, Initialiser and AssignmentExpression, respectively.

Static Semantics

VariableDeclarationList : VariableNames, VariableDeclaration

1. Let names be VariableNames of VariableDeclarationList.
2. Append to names the elements of VariableNames of VariableDeclaration.
3. Return names.

VariableDeclaration : BindingIdentifier Initialiser
1. Return the BoundNames of BindingIdentifier.

VariableDeclaration : BindingPattern Initialiser

1. Return the BoundNames of BindingPattern.

### Runtime Semantics

#### Runtime Semantics: Binding Initialisation

**With arguments** value and environment.

**NOTE** undefined is passed for environment to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for var statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initializer.

**VariableDeclaration : BindingIdentifier**

1. Return the result of performing Binding Initialisation for BindingIdentifier passing value and undefined as the arguments.

**VariableDeclaration : BindingIdentifier Initialiser**

1. Return the result of performing Binding Initialisation for BindingIdentifier passing value and undefined as the arguments.

**VariableDeclaration : BindingPattern Initialiser**

1. Return the result of performing Binding Initialisation for BindingPattern passing value and undefined as the arguments.

#### Runtime Semantics: Evaluation

**VariableStatement : var VariableDeclarationList ;**

1. Let next be the result of evaluating VariableDeclarationList.
2. ReturnIfAbrupt(next).
3. Return NormalCompletion(empty).

**VariableDeclarationList : VariableDeclarationList , VariableDeclaration**

1. Let next be the result of evaluating VariableDeclarationList.
2. ReturnIfAbrupt(next).
3. Return the result of evaluating VariableDeclaration.

**VariableDeclaration : BindingIdentifier**

1. Return NormalCompletion(empty).

**VariableDeclaration : BindingIdentifier Initialiser**

1. Let rhs be the result of evaluating Initialiser.
2. Let value be GetValue(rhs).
3. ReturnIfAbrupt(value).
4. Return the result of performing Binding Initialisation for BindingIdentifier passing value and undefined as the arguments.

**NOTE** If a VariableDeclaration is nested within a with statement and the Identifier in the VariableDeclaration is the same as a property name of the binding object of the with statement's object environment record, then step 3 will assign value to the property instead of to the VariableEnvironment binding of the Identifier.
VariableDeclaration : BindingPattern Initialiser

2. Let rhs be the result of evaluating Initialiser.
3. Let rval be ToObject(GetValue(rhs)).
4. ReturnIfAbrupt(rval).
5. Return the result of performing Binding Initialisation for BindingPattern passing rval and undefined as arguments.

12.2.4 Destructuring Binding Patterns

Syntax

BindingPattern :
  ObjectBindingPattern
  ArrayBindingPattern

ObjectBindingPattern :
  { BindingPropertyList }
  { BindingPropertyList , }

ArrayBindingPattern :
  [ Elisionopt BindingRestElementopt }
  [ BindingElementList ]
  [ BindingElementList , Elisionopt BindingRestElementopt ]

BindingPropertyList :
  BindingProperty
  BindingPropertyList , BindingProperty

BindingElementList :
  Elisionopt BindingElement
  BindingElementList , Elisionopt BindingElement

BindingProperty :
  SingleNameBinding
  PropertyName : BindingElement

BindingElement :
  SingleNameBinding
  BindingPattern Initialiseropt

SingleNameBinding :
  BindingIdentifier Initialiseropt

BindingRestElement :
  ... BindingIdentifier

Static Semantics

Static Semantics: Early Errors

BindingPattern : ObjectBindingPattern

- It is a Syntax Error if the BoundNames of ObjectBindingPattern contains the string “eval” or the string “arguments”.

BindingPattern : ArrayBindingPattern
It is a Syntax Error if the BoundNames of `ArrayBindingPattern` contains the string "eval" or the string "arguments".

**Static Semantics: BoundNames**

ObjectBindingPattern : { }

1. Return an empty List.

ArrayBindingPattern : [ Elisionopt ]

1. Return an empty List.

ArrayBindingPattern : [ Elisionopt BindingRestElement ]

1. Return the BoundNames of BindingRestElement.

ArrayBindingPattern : [ BindingElementList , Elisionopt ]

1. Return the BoundNames of BindingElementList.

ArrayBindingPattern : [ BindingElementList , Elisionopt BindingRestElement ]

1. Let names be BoundNames of BindingElementList.
2. Append to names the elements of BoundNames of BindingRestElement.
3. Return names.

BindingPropertyList : BindingPropertyList , BindingProperty

1. Let names be BoundNames of BindingPropertyList.
2. Append to names the elements of BoundNames of BindingProperty.
3. Return names.

BindingElementList : Elisionopt BindingElement

1. Return BoundNames of BindingElement.

BindingElementList : BindingElementList , Elisionopt BindingElement

1. Let names be BoundNames of BindingElementList.
2. Append to names the elements of BoundNames of BindingElement.
3. Return names.

BindingProperty : PropertyName : BindingElement

1. Return the BoundNames of BindingElement.

SingleNameBinding : BindingIdentifier Initialiseropt

1. Return the BoundNames of BindingIdentifier.

BindingElement : BindingPattern Initialiseropt

1. Return the BoundNames of BindingPattern.

**Static Semantics: HasInitialiser**

BindingElement : BindingPattern
1. Return false.

**BindingElement**: BindingPattern Initialiser

1. Return true.

**SingleNameBinding**: BindingIdentifier

1. Return false.

**SingleNameBinding**: BindingIdentifier Initialiser

1. Return true.

**Runtime Semantics**

**Runtime Semantics: Binding Initialisation**

With parameters value and environment.

**NOTE** When **undefined** is passed for **environment** it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

**BindingPattern**: ObjectBindingPattern

1. Assert: Type(value) is Object
2. Return the result of performing Binding Initialisation for ObjectBindingPattern using value and environment as arguments.

**BindingPattern**: ArrayBindingPattern

1. Assert: Type(value) is Object
2. Return the result of performing Indexed Binding Initialisation for ArrayBindingPattern using value, 0, and environment as arguments.

**ObjectBindingPattern**: { }

1. Return NormalCompletion(EMPTY).

**BindingPropertyList**: BindingPropertyList , BindingProperty

1. Let status be the result of performing Binding Initialisation for BindingPropertyList using value and environment as arguments.
2. ReturnIfAbrupt(status).
3. Return the result of performing Binding Initialisation for BindingProperty using value and environment as arguments.

**BindingProperty**: SingleNameBinding

1. Let name be the string that is the only element of BoundNames of SingleNameBinding.
2. Return the result of performing Keyed Binding Initialisation for SingleNameBinding using value, environment, and name as the arguments.

**BindingProperty**: PropertyName : BindingElement

1. Let P be the PropName of PropertyName
2. Return the result of performing Keyed Binding Initialisation for BindingElement using value, environment, and P as arguments.
Runtime Semantics: Indexed Binding Initialisation

With parameters array, nextIndex, and environment.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

ArrayBindingPattern : [ Elisionopt ]

1. Return NormalCompletion(empty).

ArrayBindingPattern : [ Elisionopt BindingRestElement ]

1. Let nextIndex be the Elision Width of Elision; if Elision is not present, use the numeric value zero.
2. Return the result of performing Indexed Binding Initialisation for BindingRestElement using array, nextIndex, and environment as arguments.

ArrayBindingPattern : [ BindingElementList ]

1. Return the result of performing Indexed Binding Initialisation for BindingElementList using array, nextIndex, and environment as arguments.

ArrayBindingPattern : [ BindingElementList , Elisionopt ]

1. Return the result of performing Indexed Binding Initialisation for BindingElementList using array, nextIndex, and environment as arguments.

ArrayBindingPattern : [ BindingElementList , Elisionopt BindingRestElement ]

1. Let next be the result of performing Indexed Binding Initialisation for BindingElementList using array, nextIndex, and environment as arguments.
2. ReturnIfAbrupt(next).
3. Let skip be the Elision Width of Elision, if Elision is not present, use the numeric value zero.
4. Return the result of performing Indexed Binding Initialisation for BindingRestElement using array, next+skip , and environment as arguments.

BindingElementList : Elisionopt BindingElement

1. Let skip be the Elision Width of Elision, if Elision is not present, use the numeric value zero.
2. Let status be the result of performing Indexed Binding Initialisation for BindingElement using array, nextIndex+skip , and environment as arguments.
3. ReturnIfAbrupt(status).
4. Return nextIndex+skip+1.

BindingElementList : BindingElementList , Elisionopt BindingElement

1. Let listNext be the result of performing Indexed Binding Initialisation for BindingElementList using array, nextIndex, and environment as arguments.
2. ReturnIfAbrupt(listNext).
3. Let skip be the Elision Width of Elision, if Elision is not present, use the numeric value zero.
4. Let status be the result of performing Indexed Binding Initialisation for BindingElement using array, listNext+skip , and environment as arguments.
5. ReturnIfAbrupt(status).
6. Return listNext+skip+1.

BindingElement : SimpleNameBinding
1. Return the result of performing Keyed Binding Initialisation for SingleNameBinding using array, environment, and ToString(nextIndex) as the arguments.

BindingElement : BindingPattern InitialiserOpt

Let P be ToString(nextIndex).
Let v be the result of Get(array, P).
ReturnIfAbrupt(v).
If InitialiserOpt present and v is undefined, then
a. Let defaultValue be the result of evaluating Initialiser.
b. Let v be ToObject(GetValue(defaultValue)).
5. ReturnIfAbrupt(v).
6. Return the result of performing Binding Initialisation for BindingPattern passing v and environment as arguments.

BindingRestElement : . . . BindingIdentifier

Let A be the result of the abstract operation ArrayCreate with argument 0.
Let lenVal be the result of Get(array, "length").
Let arrayLength be ToUint32(lenVal).
Let n=0.
Let index = nextIndex.
Repeat, while index < arrayLength
a. Let P be ToString(index).
b. Let exists be the result of HasProperty(array, P).
c. ReturnIfAbrupt(exists).
d. If exists is true, then
i. Let v be the result of Get(array, P).
ii. ReturnIfAbrupt(v).
iii. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(n) and Property Descriptor {
"[[Value]]": v, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
e. Let n = n+1.
9. Return the result of performing Binding Initialisation for BindingIdentifier using A and environment as arguments.

Runtime Semantics: Keyed Binding Initialisation
With parameters obj, environment, and propertyName.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

BindingElement : BindingPattern InitialiserOpt

Let v be the result of Get(obj, propertyName).
ReturnIfAbrupt(v).
If InitialiserOpt present and v is undefined, then
a. Let defaultValue be the result of evaluating Initialiser.
b. Let v be ToObject(GetValue(defaultValue)).
4. ReturnIfAbrupt(v).
5. Return the result of performing Binding Initialisation for BindingPattern passing v and environment as arguments.

SingleNameBinding : BindingIdentifier InitialiserOpt

Let v be the result of Get(obj, propertyName).
2. ReturnIfAbrupt(v).
3. If Initialiser is present and v is undefined, then
   a. Let defaultValue be the result of evaluating Initialiser.
   b. Let v be GetValue(defaultValue).
4. ReturnIfAbrupt(v).
5. Return the result of performing Binding Initialisation for BindingIdentifier passing v and environment as arguments.

12.3 Empty Statement

Syntax
EmptyStatement : ;

Runtime Semantics
Runtime Semantics: Evaluation
EmptyStatement : ;
1. Return NormalCompletion(empty).

12.4 Expression Statement

Syntax
ExpressionStatement : [lookahead \{, function, class\}] Expression ;

NOTE An ExpressionStatement cannot start with an opening curly brace because that might make it ambiguous with a Block. Also, an ExpressionStatement cannot start with the function or class keywords because that would make it ambiguous with a FunctionDeclaration, a GeneratorDeclaration, or a ClassDeclaration.

Runtime Semantics
Runtime Semantics: Evaluation
ExpressionStatement : [lookahead \{, function, class\}] Expression ;
1. Let exprRef be the result of evaluating Expression.
2. Let value be GetValue(exprRef).
3. ReturnIfAbrupt(value).
4. Return NormalCompletion(value).

12.5 The if Statement

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

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

Static Semantics: VarDeclaredNames
IfStatement : if ( Expression ) Statement else Statement
1. Let names be VarDeclaredNames of the first Statement.
2. Append to names the elements of the VarDeclaredNames of the second Statement.
3. Return names.

**IfStatement : if ( Expression ) Statement**

1. Return the VarDeclaredNames of Statement.

**Runtime Semantics**

**Runtime Semantics: Evaluation**

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

1. Let exprRef be the result of evaluating Expression.
2. Let exprValue be ToBoolean(GetValue(exprRef)).
3. ReturnIfAbrupt(exprValue).
4. If exprValue is **true**, then
   a. Let stmtValue be the result of evaluating the first Statement.
5. Else,
   a. Let stmtValue be the result of evaluating the second Statement.
6. If stmtValue [[type]] is normal and stmtValue [[value]] is empty, then
   a. Return NormalCompletion(undefined).
7. Return stmtValue.

12.6 **Iteration Statements**

**Syntax**

**IterationStatement**:

- `do Statement while ( Expression )` Statement
- `while ( Expression ) Statement`
- `for ( ExpressionNoInopt ; Expressionopt ; Expressionopt ) Statement`
- `for ( LexicalDeclarationNoInopt ; Expressionopt ; Expressionopt ) Statement`
- `for ( LeftHandSideExpression in Expression ) Statement`
- `for ( var VariableDeclarationListNoInopt ; Expressionopt ; Expressionopt ) 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`

**ForDeclaration**:

- `LetOrConst ForBinding`

NOTE 1  * ForBinding is defined in 11.1.4.2.
NOTE 2  A semicolon is not required after a do-while statement.

Runtime Semantics

Runtime Semantics: LoopContinues Abstract Operation

The abstract operation LoopContinues with arguments completion and labelSet is defined by the following step:

1. If completion.[[type]] is normal, then return true.
2. If completion.[[type]] is not continue, then return false.
3. If completion.[[target]] is empty, then return true.
4. If completion.[[target]] is an element of labelSet, then return true.
5. Return false.

NOTE  Within the Statement part of an IterationStatement a ContinueStatement may be used to begin a new iteration.

12.6.1 The do-while Statement

Static Semantics: VarDeclaredNames

IterationStatement: do Statement while ( Expression )

1. Return the VarDeclaredNames of Statement.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument labelSet.

IterationStatement: do Statement while ( Expression )

1. Let V = undefined
2. Repeat
   a. Let stmt be the result of evaluating Statement.
   b. If stmt.[[value]] is not empty, let V = stmt.[[value]].
   c. If stmt is an abrupt completion and LoopContinues(stmt, labelSet) is false, return stmt.
   d. Let exprRef be the result of evaluating Expression.
   e. Let exprValue be ToBoolean(GetValue(exprRef)).
   f. If exprValue is false, Return NormalCompletion(V).
   g. Else if exprValue is not true, then
      i. Assert: exprValue is an abrupt completion.
      ii. If LoopContinues(exprValue, labelSet) is false, return exprValue.

Commented [AWB6103]: Note that this is technically a breaking change from ES5, however it is made to match web reality.

Commented [AWB6104]: Breaking change: completion reform

Commented [AWB6105]: Break/continue/return in the expression works normally (future for do {} or block lambda expressions)

12.6.2 The while Statement

Static Semantics: VarDeclaredNames

IterationStatement: while ( Expression ) Statement

1. Return the VarDeclaredNames of Statement.

Runtime Semantics

Runtime Semantics: Labelled Evaluation

With argument labelSet.

IterationStatement: while ( Expression ) Statement
1. Let \( V = \text{undefined} \)
2. Repeat
   a. Let \( \text{exprRef} \) be the result of evaluating \( \text{Expression} \).
   b. Let \( \text{exprValue} \) be \( \text{ToBoolean(GetValue(\text{exprRef})} \).
   c. If \( \text{exprValue} \) is false, return \( \text{NormalCompletion(V)} \).
   d. If \( \text{exprValue} \) is not true, then
      i. Assert: \( \text{exprValue} \) is an abrupt completion.
      ii. If \( \text{LoopContinues(\text{exprValue}, \text{labelSet})} \) is false, return \( \text{exprValue} \).
   e. Let \( \text{stmt} \) be the result of evaluating \( \text{Statement} \).
   f. If \( \text{stmt}[[\text{value}]] \) is not empty, let \( V = \text{stmt}[[\text{value}]] \).
   g. If \( \text{LoopContinues(\text{stmt}, \text{labelSet})} \) is false, return \( \text{stmt} \).

### 12.6.3 The for Statement

#### Static Semantics

**IterationStatement**: \( \text{for (ExpressionNoInopt; Expressionopt; Expressionopt) Statement} \)

1. Return the VarDeclaredNames of \( \text{Statement} \).

**IterationStatement**: \( \text{for(\ var \ VariableDeclarationListNoIn; Expressionopt; Expressionopt) Statement} \)

1. Let \( \text{names} \) be BoundNames of \( \text{VariableDeclarationListNoIn} \).
2. Append to \( \text{names} \) the elements of the VarDeclaredNames of \( \text{Statement} \).
3. Return \( \text{names} \).

**IterationStatement**: \( \text{for (LexicalDeclarationNoIn; Expressionopt; Expressionopt) Statement} \)

1. Return the VarDeclaredNames of \( \text{Statement} \).

#### Runtime Semantics

**Labelled Evaluation**

With argument \( \text{labelSet} \).

**IterationStatement**: \( \text{for (ExpressionNoInopt; Expressionopt; Expressionopt) Statement} \)

1. If \( \text{ExpressionNoIn} \) is present, then
   a. Let \( \text{exprRef} \) be the result of evaluating \( \text{ExpressionNoIn} \).
   b. Let \( \text{exprValue} \) be \( \text{GetValue(\text{exprRef})} \).
   c. If \( \text{LoopContinues(\text{exprValue}, \text{labelSet})} \) is false, return \( \text{exprValue} \).
2. Return the result of performing For Body Evaluation with the first \( \text{Expression} \) as the testExpr argument, the second \( \text{Expression} \) as the incrementExpr argument, \( \text{Statement} \) as the stmt argument, and with \( \text{labelSet} \).

**IterationStatement**: \( \text{for (\ var \ VariableDeclarationListNoIn; Expressionopt; Expressionopt) Statement} \)

1. Let \( \text{varDcl} \) be the result of evaluating \( \text{VariableDeclarationListNoIn} \).
2. If \( \text{LoopContinues(\text{varDcl}, \text{labelSet})} \) is false, return \( \text{varDcl} \).
3. Return the result of performing For Body Evaluation with the first \( \text{Expression} \) as the testExpr argument, the second \( \text{Expression} \) as the incrementExpr argument, \( \text{Statement} \) as the stmt argument, and with \( \text{labelSet} \).

**IterationStatement**: \( \text{for ( \ LexicalDeclarationNoIn; Expressionopt; Expressionopt) Statement} \)

1. Let \( \text{oldEnv} \) be the running execution context’s LexicalEnvironment.
2. Let \( \text{loopEnv} \) be the result of calling NewDeclarativeEnvironment passing \( \text{oldEnv} \) as the argument.
3. Let \( \text{isConst} \) be the result of performing IsConstantDeclaration of \( \text{LexicalDeclarationNoIn} \).
4. For each element \( dn \) of the BoundNames of \( \text{LexicalDeclarationNoIn} \) do
   a. If \( \text{isConst} \) is \text{true}, then
      i. Call \( \text{loopEnv}'s \) \( \text{CreateImmutableBinding} \) concrete method passing \( dn \) as the argument.
   b. Else,
      i. Call \( \text{loopEnv}'s \) \( \text{CreateMutableBinding} \) concrete method passing \( dn \) and \text{false} as the arguments.
5. Set the running execution context’s \( \text{LexicalEnvironment} \) to \( \text{loopEnv} \).
6. Let \( \text{forDcl} \) be the result of evaluating \( \text{LexicalDeclarationNoIn} \).
7. If \( \text{LoopContinues}(\text{forDcl}, \text{labelSet}) \) is \text{false}, then
   a. Set the running execution context’s \( \text{LexicalEnvironment} \) to \( \text{oldEnv} \).
   b. Return \( \text{forDcl} \).
8. Let \( \text{bodyResult} \) be the result of performing For Body Evaluation with the first \( \text{Expression} \) as the \( \text{testExpr} \) argument, the second \( \text{Expression} \) as the \( \text{incrementExpr} \) argument, Statement as the \( \text{stmt} \) argument, and with \( \text{labelSet} \).
9. Set the running execution context’s \( \text{LexicalEnvironment} \) to \( \text{oldEnv} \).
10. Return \( \text{bodyResult} \).

Runtime Semantics: For Body Evaluation Abstract Operation

The abstract operation For Body Evaluation with arguments \( \text{testExpr} \), \( \text{incrementExpr} \), \( \text{stmt} \), and \( \text{labelSet} \) is performed as follows:

1. Let \( V = \text{undefined} \)
2. Repeat
   a. If \( \text{testExpr} \) is not \{empty\}, then
      i. Let \( \text{testExprRef} \) be the result of evaluating \( \text{testExpr} \).
      ii. Let \( \text{testExprValue} \) be \( \text{ToBoolean(GetValue(\text{testExprRef}))} \).
      iii. If \( \text{testExprValue} \) is \text{false}, return \( \text{NormalCompletion}(V, \text{false}) \).
      iv. Else if \( \text{LoopContinues}(\text{testExprValue}, \text{labelSet}) \) is \text{false}, return \( \text{testExprValue} \).
   b. Let \( \text{result} \) be the result of evaluating \( \text{stmt} \).
   c. If \( \text{result} \) is either an \( \text{ObjectLiteral} \) or an \( \text{ArrayLiteral} \), then
      i. Let \( \text{incExprRef} \) be the result of evaluating \( \text{incrementExpr} \).
      ii. Let \( \text{incExprValue} \) be \( \text{GetValue(\text{incExprRef})} \).
      iii. If \( \text{LoopContinues}(\text{incExprValue}, \text{labelSet}) \) is \text{false}, return \( \text{incExprValue} \).

12.6.4 The for-in and for-of Statements

Static Semantics

Static Semantics: Early Errors

\[ \text{IterationStatement} : \]
\[ \text{for (LeftHandSideExpression in Expression) Statement} \]
\[ \text{for (LeftHandSideExpression of AssignmentExpression) Statement} \]

- It is a Syntax Error if \( \text{LeftHandSideExpression} \) is either an \( \text{ObjectLiteral} \) or an \( \text{ArrayLiteral} \) and if the lexical token sequence matched by \( \text{LeftHandSideExpression} \) cannot be parsed with no tokens left over using \( \text{AssignmentPattern} \) as the goal symbol.
- If \( \text{LeftHandSideExpression} \) is either an \( \text{ObjectLiteral} \) or an \( \text{ArrayLiteral} \) and if the lexical token sequence matched by \( \text{LeftHandSideExpression} \) can be parsed with no tokens left over using \( \text{AssignmentPattern} \) as the goal symbol then the following rules are not applied. Instead, the Early Error rules for \( \text{AssignmentPattern} \) are used.
- It is a Syntax Error if the \( \text{LeftHandSideExpression} \) is an \( \text{Identifier} \) that can be statically determined to always resolve to a declarative environment record binding and the resolved binding is an immutable binding.
- It is a Syntax Error if \( \text{LeftHandSideExpression} \) is neither an \( \text{ObjectLiteral} \) nor an \( \text{ArrayLiteral} \) and IsValidSimpleAssignmentTarget of \( \text{LeftHandSideExpression} \) is \text{false}.
• It is a Syntax Error if the `LeftHandSideExpression` is a `CoverParenthesisedExpressionAndArrowParameterList : { Expression }` and `Expression` derived a production that would produce a Syntax Error according to these rules. This rule is recursively applied.

```
IterationStatement :
  for ( ForDeclaration in Expression ) Statement
  for ( ForDeclaration of AssignmentExpression ) Statement

• It is a Syntax Error if any element of the `BoundNames` of `ForDeclaration` also occurs in the `VarDeclaredNames` of `Statement`.
```

**Static Semantics: `BoundNames`**

ForDeclaration : LetOrConst ForBinding
1. Return the `BoundNames` of `ForBinding`.

**Static Semantics: `VarDeclaredNames`**

```
IterationStatement : for ( LeftHandSideExpression in Expression ) Statement
1. Return the `VarDeclaredNames` of `Statement`.

IterationStatement : for ( var ForBinding in Expression ) Statement
1. Let `names` be the `BoundNames` of `ForBinding`.
2. Append to `names` the elements of the `VarDeclaredNames` of `Statement`.
3. Return `names`.

IterationStatement : for ( ForDeclaration in Expression ) Statement
1. Return the `VarDeclaredNames` of `Statement`.

IterationStatement : for ( LeftHandSideExpression of AssignmentExpression ) Statement
1. Return the `VarDeclaredNames` of `Statement`.

IterationStatement : for ( var ForBinding of AssignmentExpression ) Statement
1. Let `names` be the `BoundNames` of `ForBinding`.
2. Append to `names` the elements of the `VarDeclaredNames` of `Statement`.
3. Return `names`.

IterationStatement : for ( ForDeclaration of AssignmentExpression ) Statement
1. Return the `VarDeclaredNames` of `Statement`.
```

**Runtime Semantics**

**Runtime Semantics: `Binding Instantiation`**

With arguments `value` and `environment`.

ForDeclaration : LetOrConst ForBinding
1. For each element `name` of the `BoundNames` of `ForBinding` do
   a. If `IsConstantDeclaration` of `LetOrConst` is `false`, then
      i. Call `environment`’s `CreateMutableBinding` concrete method with argument `name`.
b. Else,
   i. Call environment's CreateImmutableBinding concrete method with argument name.
2. Return the result of performing Binding Initialisation for ForBinding passing value and environment as the arguments.

Runtime Semantics: Labelled Evaluation

With argument labelSet.

IterationStatement: for ( LeftHandSideExpression in Expression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with Expression, enumerate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with LeftHandSideExpression, Statement, keyResult, assignment, and labelSet.

IterationStatement: for ( var ForBinding in Expression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with Expression, enumerate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with ForBinding, Statement, keyResult, varBinding, and labelSet.

IterationStatement: for ( ForDeclaration in Expression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with Expression, enumerate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with ForDeclaration, Statement, keyResult, lexicalBinding, and labelSet.

IterationStatement: for ( LeftHandSideExpression of AssignmentExpression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with AssignmentExpression, iterate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with LeftHandSideExpression, Statement, keyResult, assignment, and labelSet.

IterationStatement: for ( var ForBinding of AssignmentExpression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with AssignmentExpression, iterate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with ForBinding, Statement, keyResult, varBinding, and labelSet.

IterationStatement: for ( ForDeclaration of AssignmentExpression ) Statement

1. Let keyResult be the result of performing For In/Of Expression Evaluation with AssignmentExpression, iterate, and labelSet.
2. ReturnIfAbrupt(keyResult).
3. Return the result of performing For In/Of Body Evaluation with ForDeclaration, Statement, keyResult, lexicalBinding, and labelSet.
Runtime Semantics: For In/Of Expression Evaluation Abstract Operation

The abstract operation For In/Of Expression Evaluation is called with arguments `expr`, `iterationKind`, and `labelSet`. The value of `iterationKind` is either `enumerate` or `iterate`.

1. `let exprRef` be the result of evaluating the production that is `expr`.
2. `let exprValue` be `GetValue(exprRef)`.
3. If `exprValue` is an abrupt completion,
   a. If `LoopContinues(exprValue,labelSet)` is `false`, then return `exprValue`.
   b. Else, return `Completion` `[[type]]: break, [[value]]: empty, [[target]]: empty`.
4. If `exprValue` `[[value]]` is `null` or `undefined`, return `Completion` `[[type]]: break, [[value]]: empty, [[target]]: empty`.
5. Let `obj` be `ToObject(exprValue)`.
6. If `iterationKind` is `enumerate`, then
   a. Let `keys` be the result of calling the `[[Enumerate]]` internal method of `obj` with no arguments.
   b. Assert `iterationKind` is `iterate`.
   c. Let `iterator` be the result of performing `Invoke` with arguments `obj`, `@iterator` and an empty List.
   d. Let `keys` be `ToObject(iterator)`.
7. Else,
   a. Assert `iterationKind` is `iterate`.
   b. Let `iterator` be the result of performing `Invoke` with arguments `obj`, `@iterator` and an empty List.
   c. Let `keys` be `ToObject(iterator)`.
8. If `keys` is an abrupt completion, then
   a. If `LoopContinues(exprValue,labelSet)` is `false`, then return `exprValue`.
   b. Assert: `keys` `[[type]]` is `continue`.
   c. Return `Completion` `[[type]]: break, [[value]]: empty, [[target]]: empty`.
9. Return `keys`.

Runtime Semantics: For In/Of Body Evaluation Abstract Operation

The abstract operation For In/Of Body Evaluation is called with arguments `lhs`, `stmt`, `keys`, `lhsKind`, and `labelSet`. The value of `lhsKind` is either `assignment`, `varBinding` or `lexicalBinding`.

1. Let `oldEnv` be the running execution context’s `LexicalEnvironment`.
2. Let `noKeys` be an empty List.
3. Let `V = undefined`.
4. Repeat
   a. Let `nextResult` be the result of `Invoke(keys, "next")`.
   b. ReturnAbrupt(`nextResult`).
   c. If `Type(nextResult)` is `Object`, then throw a `TypeError` exception.
   d. Let `done` be `IteratorComplete(innerResult)`.
   e. `ReturnIfAbrupt(done)`.
   f. If `done` is `true` then return `NormalCompletion(V)`.
   g. Let `nextValue` be the result of `IteratorValue(nextResult)`.
   h. ReturnAbrupt(`nextValue`).
   i. If `lhsKind` is `assignment`, then
      i. Assert: `lhs` is a `LeftHandSideExpression`.
      ii. If `lhs` is neither an `ObjectLiteral` nor an `ArrayLiteral` then
          1. `let lhsRef` be the result of evaluating `lhs` (it may be evaluated repeatedly).
          2. Let `status` be the result of performing `PutValue(lhsRef, nextValue)`.
      iii. Else
          1. Let `AssignmentPattern` be the parse of the source code corresponding to `lhs` using `AssignmentPattern` as the goal symbol.
          2. Let `rval` be `ToObject(nextValue)`.
          3. If `rval` is an abrupt completion, then let `status` be `rval`.
          4. Else, let `status` be the result of performing `Destructuring Assignment Evaluation` of `AssignmentPattern` using `rval` as the argument.
   j. Else if `lhsKind` is `varBinding`, then
      i. Assert: `lhs` is a `ForBinding`.
      ii. Let `status` be the result of performing `Binding Initialisation` for `lhs` passing `nextValue` and `undefined` as the arguments.
   k. Else,
i. Assert lhsKind is lexicalBinding.
ii. Assert: lhs is a ForDeclaration.
iii. Let iterationEnv be the result of calling NewDeclarativeEnvironment passing oldEnv as the argument.
iv. Perform Binding Instantiation for lhs passing nextValue and iterationEnv as arguments.
v. Let status be NormalCompletion(empty)
vi. Set the running execution context’s LexicalEnvironment to iterationEnv.

1. If status.[[type]] is normal, then
   i. Let status be the result of evaluating stmt.
   ii. If status.[[type]] is normal and status.[[value]] is not empty, then
      1. Let V = status.[[value]].
m. Set the running execution context’s LexicalEnvironment to oldEnv.

12.7 The continue Statement

Syntax
ContinueStatement :
  continue ;
  continue [no LineTerminator here] Identifier ;

Static Semantics
Static Semantics: Early Errors
ContinueStatement : continue :
  • It is a Syntax Error if this production is not nested, directly or indirectly (but not crossing function boundaries), within an IterationStatement.

ContinueStatement : continue [no LineTerminator here] Identifier :
  • It is a Syntax Error if Identifier does not appear in the CurrentLabelSet of an enclosing (but not crossing function boundaries) IterationStatement.

Runtime Semantics
Runtime Semantics: Evaluation
ContinueStatement : continue :
1. Return Completion {[[type]]: continue, [[value]]: empty, [[target]]: empty}.

ContinueStatement : continue [no LineTerminator here] Identifier :
1. Return Completion {[[type]]: continue, [[value]]: empty, [[target]]: Identifier}.

12.8 The break Statement

Syntax
BreakStatement :
  break ;
  break [no LineTerminator here] Identifier ;

Static Semantics
Static Semantics: Early Errors
BreakStatement: `break`;

- It is a Syntax Error if this production is not nested, directly or indirectly (but not crossing function boundaries), within an `IterationStatement` or a `SwitchStatement`.

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

- It is a Syntax Error if `Identifier` does not appear in the `CurrentLabelSet` of an enclosing (but not crossing function boundaries) Statement.

Runtime Semantics

Runtime Semantics: Evaluation

BreakStatement: `break`;

1. Return Completion `[[type]]: break, [[value]]: empty, [[target]]: empty`.

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

1. Return Completion `[[type]]: break, [[value]]: empty, [[target]]: Identifier`.

12.9 The `return` Statement

Syntax

ReturnStatement:

- `return`  
- `return` [no LineTerminator here] `Expression`;

NOTE A `return` statement causes a function to cease execution and return a value to the caller. If `Expression` is omitted, the return value is `undefined`. Otherwise, the return value is the value of `Expression`.

Static Semantics

Static Semantics: Early Errors

- It is a Syntax Error if a `return` statement is not within a `FunctionBody` or a `GeneratorBody`.

Runtime Semantics

Runtime Semantics: Evaluation

ReturnStatement: `return`;

1. Return Completion `[[type]]: return, [[value]]: undefined, [[target]]: empty`.


1. Let `exprRef` be the result of evaluating `Expression`.
2. Let `exprValue` be `GetValue(exprRef)`.
3. ReturnIfAbrupt(`exprValue`).
4. Return Completion `[[type]]: return, [[value]]: exprValue, [[target]]: empty`.

12.10 The `with` Statement

Syntax

WithStatement:

- `with` (`Expression`) `Statement`
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.

Static Semantics

Static Semantics: Early Errors

WithStatement : with ( Expression ) Statement

- It is a Syntax Error if the code that matches this production is contained in strict code.

Static Semantics: VarDeclaredNames

WithStatement : with ( Expression ) Statement

1. Return the VarDeclaredNames of Statement.

Runtime Semantics

Runtime Semantics: Evaluation

WithStatement : with ( Expression ) Statement

1. Let val be the result of evaluating Expression.
2. Let obj be ToObject(GetValue(val)).
3. ReturnIfAbrupt(obj).
4. Let oldEnv be the running execution context’s LexicalEnvironment.
5. Let newEnv be the result of calling NewObjectEnvironment passing obj and oldEnv as the arguments.
6. Set the withEnvironment flag of newEnv to true.
7. Set the running execution context’s LexicalEnvironment to newEnv.
8. Let C be the result of evaluating Statement.
9. Set the running execution context’s LexicalEnvironment to oldEnv.
10. Return C.

NOTE No matter how control leaves the embedded Statement, whether normally or by some form of abrupt completion or exception, the lexicalEnvironment is always restored to its former state.

12.11 The switch Statement

Syntax

SwitchStatement : switches CaseBlock

CaseBlock : { CaseClauses opt } { CaseClauses opt DefaultClause CaseClauses opt }

CaseClauses : CaseClause CaseClauses CaseClause

CaseClause : case Expression : StatementList opt

DefaultClause : default : StatementList opt
Static Semantics

Static Semantics: Early Errors

CaseBlock : { CaseClauses }

- It is a Syntax Error if the LexicallyDeclaredNames of CaseClauses contains any duplicate entries.
- It is a Syntax Error if any element of the LexicallyDeclaredNames of CaseClauses also occurs in the VarDeclaredNames of CaseClauses.

Static Semantics: LexicalDeclarations

CaseBlock : { }

1. Return a new empty List.

CaseBlock : { CaseClauses DefaultClause CaseClauses } opt

1. If the first CaseClauses is present, let declarations be the LexicalDeclarations of the first CaseClauses.
2. Else let declarations be a new empty List.
3. Append to declarations the elements of the LexicalDeclarations of the DefaultClause.
4. If the second CaseClauses is not present, return declarations.
5. Else return the result of appending to declarations the elements of the LexicalDeclarations of the second CaseClauses.

CaseClauses : CaseClauses CaseClause

1. Let declarations be LexicalDeclarations of CaseClauses.
2. Append to declarations the elements of the LexicalDeclarations of CaseClause.
3. Return declarations.

CaseClause : case Expression : StatementList

1. If the StatementList is present, return the LexicalDeclarations of StatementList.
2. Else return a new empty List.

DefaultClause : default : StatementList opt

1. If the StatementList is present, return the LexicalDeclarations of StatementList.
2. Else return a new empty List.

Static Semantics: LexicallyDeclaredNames

CaseBlock : { }

1. Return a new empty List.

CaseBlock : { CaseClauses DefaultClause CaseClauses } opt

1. If the first CaseClauses is present, let names be the LexicallyDeclaredNames of the first CaseClauses.
2. Else let names be a new empty List.
3. Append to names the elements of the LexicallyDeclaredNames of the DefaultClause.
4. If the second CaseClauses is not present, return names.
5. Else return the result of appending to names the elements of the LexicallyDeclaredNames of the second CaseClauses.

CaseClauses : CaseClauses CaseClause

1. Let names be LexicallyDeclaredNames of CaseClauses.
2. Append to `names` the elements of the `LexicallyDeclaredNames` of `CaseClause`.
3. Return `names`.

`CaseClause` : `case` `Expression` : `StatementListopt`

1. If the `StatementList` is present, return the `LexicallyDeclaredNames` of `StatementList`.
2. Else return a new empty List.

`DefaultClause` : `default` : `StatementListopt`

1. If the `StatementList` is present, return the `LexicallyDeclaredNames` of `StatementList`.
2. Else return a new empty List.

**Static Semantics: VarDeclaredNames**

`SwitchStatement` : `switch` `{ ` `Expression` `} ` `CaseBlock`

1. Return the `VarDeclaredNames` of `CaseBlock`.

`CaseBlock` : `{ ` `}

1. Return a new empty List.

`CaseBlock` : `{ ` `CaseClausesopt ` `DefaultClause` `CaseClauses`opt ` `}

1. If the first `CaseClauses` is present, let `names` be the `VarDeclaredNames` of the first `CaseClauses`.
2. Else let `names` be a new empty List.
3. Append to `names` the elements of the `VarDeclaredNames` of the `DefaultClause`.
4. If the second `CaseClauses` is not present, return `names`.
5. Else return the result of appending to `names` the elements of the `VarDeclaredNames` of the second `CaseClauses`.

`CaseClauses` : `CaseClauses` `CaseClause`

1. Let `names` be `VarDeclaredNames` of `CaseClauses`.
2. Append to `names` the elements of the `VarDeclaredNames` of `CaseClause`.
3. Return `names`.

`CaseClause` : `case` `Expression` : `StatementListopt`

1. If the `StatementList` is present, return the `VarDeclaredNames` of `StatementList`.
2. Else return a new empty List.

`DefaultClause` : `default` : `StatementListopt`

1. If the `StatementList` is present, return the `VarDeclaredNames` of `StatementList`.
2. Else return a new empty List.

**Runtime Semantics**

**Runtime Semantics: Case Block Evaluation**

   With argument `input`.

`CaseBlock` : `{ ` `CaseClausesopt ` `}

1. Let `V = undefined`.
2. Let `A` be the list of `CaseClause` items in source text order.
3. Let `searching` be `true`. 

Commented [AWB6124]: ES5 breaking change: completion reform
4. Repeat, while searching is true
   a. Let C be the next CaseClause in A. If there is no such CaseClause, return NormalCompletion(V).
   b. Let clauseSelector be the result of evaluating C.
   c. ReturnIfAbrupt(clauseSelector).
   d. If input is equal to clauseSelector as defined by the Strict Equality Comparison Algorithm (11.9.1), then
      i. Set searching to false.
      ii. If C has a StatementList, then
          1. Evaluate C’s StatementList and let R be the result.
          2. ReturnIfAbrupt(R).
          3. Let V = R.[[value]].
   5. Repeat
      a. Let C be the next CaseClause in A. If there is no such CaseClause, return NormalCompletion(V).
      b. If C has a StatementList, then
         i. Evaluate C’s StatementList and let R be the result.
         ii. If R.[[value]] is not empty, then let \( V = R.[[value]] \).
         iii. If R is an abrupt completion, then return Completion ([[type]]: R.[[type]], [[value]]: V, [[target]]: R.[[target]]).

CaseBlock : ( CaseClauses\_opt DefaultClause CaseClauses\_opt )

1. Let V = undefined.
2. Let A be the list of CaseClause items in the first CaseClauses, in source text order.
3. Let found be false.
4. Repeat letting C be in order each CaseClause in A
   a. If found is false, then
      i. Let clauseSelector be the result of Case Selector Evaluation of C.
      ii. If clauseSelector is an abrupt completion, then
         1. If clauseSelector.[[value]] is empty then return Completion ([[type]]: clauseSelector.[[type]], [[value]]: undefined, [[target]]: clauseSelector.[[target]]).
         2. Else, return clauseSelector.
      iii. If input is equal to clauseSelector as defined by the Strict Equality Comparison Algorithm (11.9.1), then set found to true.
   b. If found is true, then
      i. Evaluate CaseClause C and let R be the result.
      ii. If R.[[value]] is not empty, then let \( V = R.[[value]] \).
      iii. If R is an abrupt completion, then return Completion ([[type]]: R.[[type]], [[value]]: V, [[target]]: R.[[target]])
5. Let found\_B be false.
6. If found\_B is false, then
   a. Let B be a new list of the CaseClause items in the second CaseClauses, in source text order.
   b. Repeat, letting C be in order each CaseClause in B
      i. If found\_B is false, then
         1. Let clauseSelector be the result of Case Selector Evaluation of C.
         2. If clauseSelector is an abrupt completion, then
            a. If clauseSelector.[[value]] is empty, then return Completion ([[type]]: clauseSelector.[[type]], [[value]]: undefined, [[target]]: clauseSelector.[[target]]).
            b. Else, return clauseSelector.
         3. If input is equal to clauseSelector as defined by the Strict Equality Comparison Algorithm (11.9.1), then set found\_B to true.
      ii. If found\_B is true, then
          1. Evaluate CaseClause C and let R be the result.
          2. If R.[[value]] is not empty, then let \( V = R.[[value]] \).
          3. If R is an abrupt completion, then return Completion ([[type]]: R.[[type]], [[value]]: V, [[target]]: R.[[target]]).
6. If found\_B is true, then return NormalCompletion(V).
8. Evaluate DefaultClause and let R be the result.
9. If R.[[value]] is not empty, then let \( V = R.[[value]] \).
10. If R is an abrupt completion, then return Completion ([[type]]: R.[[type]], [[value]]: V, [[target]]: R.[[target]])
11. Let B be a new list of the CaseClause items in the second CaseClauses, in source text order.
12. Repeat, letting C be in order each CaseClause in B (NOTE: this is another complete iteration of the second CaseClauses)
   a. Evaluate CaseClause C and let R be the result.
   b. If R.[[value]] is not empty, then let V = R.[[value]].
   c. If R is an abrupt completion, then return Completion {[[type]]: R.[[type]], [[value]]: V, [[target]]: R.[[target]].
13. Return NormalCompletion(V).

**Runtime Semantics: Case Selector Evaluation**

CaseClause : case Expression : StatementList

1. Let exprRef be the result of evaluating Expression.
2. Return GetValue(exprRef).

**NOTE** Case Selector Evaluation does not execute the associated StatementList. It simply evaluates the Expression and returns the value, which the CaseBlock algorithm uses to determine which StatementList to start executing.

**Runtime Semantics: Evaluation**

SwitchStatement : switch (Expression) CaseBlock

1. Let exprRef be the result of evaluating Expression.
2. Let switchValue be GetValue(exprRef).
3. ReturnIfAbrupt(switchValue).
4. Let oldEnv be the running execution context’s LexicalEnvironment.
5. Let blockEnv be the result of calling NewDeclarativeEnvironment passing oldEnv as the argument.
6. Perform Block Declaration Instantiation using CaseBlock and blockEnv.
7. Let R be the result of performing Case Block Evaluation of CaseBlock with argument switchValue.
8. Set the running execution context’s LexicalEnvironment to oldEnv.
9. Return R.

**NOTE** No matter how control leaves the SwitchStatement the LexicalEnvironment is always restored to its former state.

CaseClause : case Expression :

1. Return NormalCompletion(empty).

CaseClause : case Expression : StatementList

1. Return the result of evaluating StatementList.

DefaultClause : default:

1. Return NormalCompletion(empty).

DefaultClause : default : StatementList

1. Return the result of evaluating StatementList.

12.12 Labelled Statements

**Syntax**

LabelledStatement : Identifier : Statement

**NOTE** A Statement may be prefixed by a label. Labelled statements are only used in conjunction with labelled break and continue statements. ECMAScript has no goto statement. A Statement can be part of a LabelledStatement, which itself can be part of a LabelledStatement, and so on. The labels introduced this way are collectively referred to as the "current label set" when describing the semantics of individual statements. A LabelledStatement has no semantic meaning.
other than the introduction of a label to a label set. The label set of an *IterationStatement* or a *SwitchStatement* initially contains the single element *empty*. The label set of any other statement is initially empty.

**Static Semantics**

**Static Semantics: Early Errors**

- It is a Syntax Error if a *LabelledStatement* is enclosed by a *LabelledStatement* with the same *Identifier* as the enclosed *LabelledStatement*. This does not apply to a *LabelledStatement* appearing within the body of a *FunctionDeclaration* and a *LabelledStatement* that encloses, directly or indirectly the *FunctionDeclaration*.

**Static Semantics: VarDeclaredNames**

*LabelledStatement* : *Identifier* : Statement

1. Return the VarDeclaredNames of Statement.

**Runtime Semantics**

**Runtime Semantics: Labelled Evaluation**

With argument *labelSet*.

*LabelledStatement* : *Identifier* : Statement

1. Let *label* be the StringValue of *Identifier*.
2. Let *newLabelSet* be a new List containing *label* and the elements of *labelSet*.
3. If *Statement* is either *LabelledStatement* or *BreakableStatement*, then
   a. Let *stmtResult* be the result of performing Labelled Evaluation of *Statement* with argument *newLabelSet*.
4. Else,
   a. Let *stmtResult* be the result of evaluating *Statement*.
5. If *stmtResult* [*type*] is *break* and *stmtResult* [*target*] is the same value as *label*, then
   a. Let *result* be NormalCompletion(*stmtResult* [*value]*)
6. Else,
   a. Let *result* be *stmtResult*.
7. Return *result*.

**Runtime Semantics: Evaluation**

*LabelledStatement* : *Identifier* : Statement

3. Let *newLabelSet* be a new empty List.
4. Return the result of performing Labelled Evaluation of this *LabelledStatement* with argument *newLabelSet*.

**12.13 The throw Statement**

**Syntax**

*ThrowStatement* : 

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

**Runtime Semantics: Evaluation**

The production *ThrowStatement* : 

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

is evaluated as follows:
1. Let exprRef be the result of evaluating Expression.
2. Let exprValue be GetValue(exprRef).
3. ReturnIfAbrupt(exprValue).
4. Return Completion {[[type]]: throw, [[value]]: GetValue(exprRef), [[target]]: empty}.

12.14 The try Statement

Syntax

TryStatement : try Block Catch
try Block Finally
try Block Catch Finally

Catch : catch { CatchParameter } Block

Finally : finally Block

CatchParameter :
  BindingIdentifier
  BindingPattern

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

Static Semantics

Static Semantics: Early Errors

Catch : catch { CatchParameter } Block
- It is a Syntax Error if any element of the BoundNames of CatchParameter also occurs in the LexicallyDeclaredNames of Block.
- It is a Syntax Error if any element of the BoundNames of CatchParameter also occurs in the VarDeclaredNames of Block.

Static Semantics: VarDeclaredNames

TryStatement : try Block Catch
1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Catch.
3. Return names.

TryStatement : try Block Finally
1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Finally.
3. Return names.

TryStatement : try Block Catch Finally
1. Let names be VarDeclaredNames of Block.
2. Append to names the elements of the VarDeclaredNames of Catch.
3. Append to names the elements of the VarDeclaredNames of Finally.
4. Return names.
Catch: `catch (CatchParameter) Block`

1. Return the VarDeclaredNames of Block.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With arguments `value` and `environment`.

NOTE undefined is passed for `environment` to indicate that a PutValue operation should be used to assign the initialisation value. This is the case for var statements formal parameter lists of non-strict functions. In those cases a lexical binding is hosted and preinitialised prior to evaluation of its initialiser.

CatchParameter: BindingPattern

1. Let `exceptionObj` be ToObject(`value`).
2. ReturnIfAbrupt(`exceptionObj`).
3. Return the result of performing Binding Initialisation for `bindingPattern` passing `exceptionObj` and `environment` as the arguments.

Runtime Semantics: Catch Clause Evaluation

with parameter `thrownValue`

Catch: `catch (CatchParameter) Block`

1. Let `oldEnv` be the running execution context’s LexicalEnvironment.
2. Let `catchEnv` be the result of calling NewDeclarativeEnvironment passing `oldEnv` as the argument.
3. For each element `argName` of the BoundNames of `CatchParameter`, do
   a. Call the CreateMutableBinding concrete method of `catchEnv` passing `argName` as the argument.
4. Let `status` be the result of performing Binding Initialisation for `CatchParameter` passing `thrownValue` and `catchEnv` as arguments.
5. ReturnIfAbrupt(`status`).
6. Set the running execution context’s LexicalEnvironment to `catchEnv`.
7. Let `B` be the result of evaluating `Block`.
8. Set the running execution context’s LexicalEnvironment to `oldEnv`.

NOTE No matter how control leaves the `Block` the LexicalEnvironment is always restored to its former state.

Runtime Semantics: Evaluation

TryStatement: `try Block Catch`

1. Let `B` be the result of evaluating `Block`.
2. If `B`.[[type]] is not `throw`, return `B`.
3. Return the result of performing Catch Clause Evaluation of `Catch` with parameter `B`.[[value]].

TryStatement: `try Block Finally`

1. Let `B` be the result of evaluating `Block`.
2. Let `F` be the result of evaluating `Finally`.
3. If `F`.[[type]] is `normal`, return `B`.
4. Return `F`.

TryStatement: `try Block Catch Finally`

1. Let `B` be the result of evaluating `Block`.

Commented [AWB10127]: Catching a thrown null or undefined with a destructuring parameter rethrows a TypeError. Does this make sense?
2. If \( B.\text{[[type]]} \) is \texttt{throw}, then
   a. Let \( C \) be the result of performing Catch Clause Evaluation of \texttt{Catch} with parameter \( B \).
3. Else \( B.\text{[[type]]} \) is \texttt{not throw},
   a. Let \( C \) be \( B \).
4. Let \( F \) be the result of evaluating \texttt{Finally}.
5. If \( F.\text{[[type]]} \) is \texttt{normal}, return \( C \).
6. Return \( F \).

### 12.15 The \texttt{debugger} statement

**Syntax**

\[
\text{DebuggerStatement : } \texttt{debugger ;}
\]

**Runtime Semantics: Evaluation**

\[\]

**NOTE** Evaluating the \texttt{DebuggerStatement} production may allow an implementation to cause a breakpoint when run under a debugger. If a debugger is not present or active this statement has no observable effect.

The production \texttt{DebuggerStatement : debugger ;} is evaluated as follows:

1. If an implementation defined debugging facility is available and enabled, then
   a. Perform an implementation defined debugging action.
   b. Let \( \text{result} \) be an implementation defined Completion value.
2. Else
   a. Let \( \text{result} \) be \texttt{NormalCompletion(\texttt{empty})}.
3. Return \( \text{result} \).

### 13 Functions and Generators

#### 13.1 Function Definitions

**Syntax**

\[
\text{FunctionDeclaration : } \texttt{function BindingIdentifier ( FormalParameters ) { FunctionBody }}
\]

\[
\text{FunctionExpression : } \texttt{function BindingIdentifierforall ( FormalParameters ) { FunctionBody }}
\]

\[
\text{StrictFormalParameters : } \texttt{FormalParameters}
\]

\[
\text{FormalParameters : } \texttt{[empty]}
\]

\[
\text{FormalParameterList : } \texttt{FunctionRestParameter FormalList FormalList , FunctionRestParameter}
\]

\[
\text{FormalList : } \texttt{FormalParameter FormalList , FormalParameter}
\]

\[
\text{FunctionRestParameter : } \texttt{... BindingIdentifier}
\]
FormalParameter : BindingElement
FunctionBody : FunctionStatementList
FunctionStatementList : StatementList opt

Supplemental Syntax
The following productions are used as an aid in specifying the semantics of certain ECMAScript language features. They are not used when parsing ECMAScript source code.
FunctionBody : ThrowTypeError
ThrowTypeError : [empty]

Static Semantics
Static Semantics: Early Errors
FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }
and
FunctionExpression : function BindingIdentifier opt ( FormalParameters ) { FunctionBody }

• It is a Syntax Error if FunctionBody Contains YieldExpression is true.
• It is a Syntax Error if IsSimpleParameterList of FormalParameters is false and any element of the BoundNames of FormalParameters also occurs in the VarDeclaredNames of FunctionBody.
• It is a Syntax Error if any element of the BoundNames of FormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

NOTE The LexicallyDeclaredNames of a FunctionBody does not include identifiers bound using var or function declarations. Simple parameter lists bind identifiers as VarDeclaredNames. Parameter lists that contain destructuring patterns, default value initialisers, or a rest parameter bind identifiers as LexicallyDeclaredNames.

StrictFormalParameters : FormalParameters

• It is a Syntax Error if BoundNames of FormalParameterList contains any duplicate elements.
• It is a Syntax Error if BoundNames of FormalParameterList contains either "eval" or "arguments".

FormalParameters : FormalParameterList

• It is a Syntax Error if FormalParameters Contains YieldExpression is true.
• It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains any duplicate elements.
• It is a Syntax Error if IsSimpleParameterList of FormalParameterList is false and BoundNames of FormalParameterList contains either "eval" or "arguments".
• It is a Syntax Error if the source code matching this production is strict code and BoundNames of FormalParameterList contains any duplicate elements.

NOTE Multiple occurrences of the same Identifier in a FormalParameterList is only allowed for non-strict functions and generator functions that have simple parameter lists.

FunctionStatementList : StatementList

• It is a Syntax Error if the LexicallyDeclaredNames of StatementList contains any duplicate entries.
• It is a Syntax Error if any element of the LexicallyDeclaredNames of StatementList also occurs in the VarDeclaredNames of StatementList.

FormalParameter : BindingElement

• It is a Syntax Error if BindingElement Contains YieldExpression.

Static Semantics: BoundNames

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return the BoundNames of BindingIdentifier.

FormalParameters : [empty]

1. Return an empty List.

FormalParameterList : FormalsList , FunctionRestParameter

1. Let names be BoundNames of FormalsList.
2. Append to names the BoundNames of FunctionRestParameter.
3. Return names.

FormalsList : FormalsList , FormalParameter

1. Let names be BoundNames of FormalsList.
2. Append to names the elements of BoundNames of FormalParameter.
3. Return names.

Static Semantics: Contains

With parameter symbol,

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return false.

FunctionExpression : function BindingIdentifieropt ( FormalParameters ) { FunctionBody }

1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

Static Semantics: ExpectedArgumentCount

FormalParameters : [empty]

1. Return 0.

FormalParameterList : FunctionRestParameter

1. Return 0.

FormalParameterList : FormalsList , FunctionRestParameter

1. Return the ExpectedArgumentCount of FormalsList.

NOTE The ExpectedArgumentCount of a FormalParametersList is the number of FormalParameters to the left of either the rest parameter or the first FormalParameter with an Initialiser. A FormalParameter without an initializer is allowed after the first parameter with an initializer but such parameters are considered to be optional with undefined as their default value.
FormalsList : FormalParameter
1. If HasInitialiser of FormalParameter is false return 0
2. Return 1.

FormalsList : FormalsList , FormalParameter
1. Let count be the ExpectedArgumentCount of FormalsList.
2. If HasInitialiser of FormalsList is true or HasInitialiser of FormalParameter is true, then return count.

Static Semantics: HasInitialiser
FormalsList : FormalsList , FormalParameter
1. If HasInitialiser of FormalsList is true, then return true.
2. Return HasInitialiser of FormalParameter.

Static Semantics: IsConstantDeclaration
FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }
1. Return false.

Static Semantics: IsSimpleParameterList
FormalParameters : [empty]
1. Return true.

FormalParameterList : FunctionRestParameter
1. Return false.

FormalParameterList : FormalsList , FunctionRestParameter
1. Return false.

FormalsList : FormalsList , FormalParameter
1. If IsSimpleParameterList of FormalsList is false, return false.

FormalParameter : BindingElement
1. If HasInitialiser of BindingElement is true, return false.
2. If FormalParameter Contains BindingPattern is true, return false.
3. Return true.

Static Semantics: IsStrict
FunctionStatementList : StatementListopt
1. If this FunctionStatementList is contained in strict code or if StatementList is strict code, then return true. Otherwise, return false.

Static Semantics: LexicallyDeclaredNames
FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

Commented [AWB10128]: Need a better definition
1. Return the BoundNames of BindingIdentifier.

FunctionStatementList : [empty]

1. Return an empty List.

FunctionStatementList : StatementList

1. Return TopLevelLexicallyDeclaredNames of StatementList.

Static Semantics: VarDeclaredNames

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return an empty List.

FunctionBody : [empty]

1. Return an empty List.

FunctionBody : StatementList

1. Return TopLevelVarDeclaredNames of StatementList.

Runtime Semantics

Runtime Semantics: Binding Initialisation

With parameters value and environment.

NOTE When undefined is passed for environment it indicates that a PutValue operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.

FormalParameters : [empty]

1. Return NormalCompletion( empty ).

FormalParameterList : FunctionRestParameter

1. Return the result of performing Indexed Binding Initialisation for FunctionRestParameter using value, 0, and environment as the arguments.

FormalParameterList : FormalsList

1. Return the result of performing Indexed Binding Initialisation for FormalsList using value, 0, and environment as the arguments.

FormalParameterList : FormalsList , FunctionRestParameter

1. Let restIndex be the result of performing Indexed Binding Initialisation for FormalsList using value, 0, and environment as the arguments.
2. ReturnIfAbrupt( restIndex ).
3. Return the result of performing Indexed Binding Initialisation for FunctionRestParameter using value, restIndex, and environment as the arguments.

Runtime Semantics EvaluateBody

With parameter functionObject.
FunctionBody : FunctionStatementListopt

1. The code of this FunctionBody is strict mode code if it is contained in strict mode code or if the Directive Prologue (14.1) of its FunctionStatementList contains a Use Strict Directive or if any of the conditions in 10.1.1 apply. If the code of this FunctionBody is strict mode code, FunctionStatementList is evaluated in the following steps as strict mode code; otherwise, StatementList is evaluated in the following steps as non-strict mode code.
2. If FunctionStatementList is not present, then return NormalCompletion(undefined).
3. Let result be the result of evaluating FunctionStatementList.
4. If result.[[type]] is return then return NormalCompletion(result.[[value]])
5. ReturnIfAbrupt(result).
6. Return NormalCompletion(undefined).

FunctionBody : ThrowTypeError

1. Throw a TypeError exception.

Runtime Semantics: Indexed Binding Initialisation

With parameters array, nextIndex, and environment.

FormalsList : FormalParameter

1. Let status be the result of performing Indexed Binding Initialisation for FormalParameter using array, nextIndex, and environment as the arguments.
2. ReturnIfAbrupt(status).
3. Return nextIndex + 1.

FormalsList : FormalsList, FormalParameter

1. Let lastIndex be the result of performing Indexed Binding Initialisation for FormalsList using array, nextIndex, and environment as the arguments.
2. ReturnIfAbrupt(lastIndex).
3. Let status be the result of performing Indexed Binding Initialisation for FormalParameter using array, lastIndex, and environment as the arguments.
4. ReturnIfAbrupt(status).
5. Return lastIndex + 1.

FunctionRestParameter : . . . BindingIdentifier

1. Asser: array is a well formed arguments object and hence it has a valid integer valued "length" property.
2. Let status be the result of Get(array, "length").
3. Let argumentsLength be status.[[value]].
4. Let A be the result of the abstract operation ArrayCreate with argument 0.
5. Let n=0;
6. Repeat, while nextIndex < argumentsLength
   a. Let P be ToString(nextIndex).
   b. Asser: array is a well formed arguments object, hence it must have a property P.
   c. Let v be the result of Get(array, P).
   d. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(n) and Property Descriptor {[[Value]]: v.[[value]], [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true.
   e. Let n = n+1.
   f. Let nextIndex = nextIndex + 1.
7. Return the result of performing Binding Initialisation for BindingIdentifier using A and environment as arguments.

Runtime Semantics: InstantiateFunctionObject

With parameter scope.
FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. If the FunctionDeclaration is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Let F be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, scope, and strict.
3. Perform the abstract operation MakeConstructor with argument F.
4. Return F.

Runtime Semantics: Evaluation

FunctionDeclaration : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return NormalCompletion(empty)

FunctionExpression : function ( FormalParameters ) { FunctionBody }

1. If the FunctionExpression is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let closure be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, scope, and strict.
4. Perform the abstract operation MakeConstructor with argument closure.
5. Return closure.

FunctionExpression : function BindingIdentifier ( FormalParameters ) { FunctionBody }

1. If the FunctionExpression is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Let funcEnv be the result of calling NewDeclarativeEnvironment passing the running execution context’s Lexical Environment as the argument.
3. Let envRec be funcEnv’s environment record.
4. Let name be StringValue of BindingIdentifier.
5. Call the CreateImmutableBinding concrete method of envRec passing name as the argument.
6. Let closure be the result of performing the FunctionCreate abstract operation with arguments Normal, FormalParameters, FunctionBody, funcEnv, and strict.
7. Perform the abstract operation MakeConstructor with argument closure.
8. Call the InitializeBinding concrete method of envRec passing name and closure as the arguments.
9. Return NormalCompletion(closure).

NOTE 1 The BindingIdentifier in a FunctionExpression can be referenced from inside the FunctionExpression's FunctionBody to allow the function to call itself recursively. However, unlike in a FunctionDeclaration, the BindingIdentifier in a FunctionExpression cannot be referenced from and does not affect the scope enclosing the FunctionExpression.

NOTE 2 A prototype property is automatically created for every function defined using a FunctionDeclaration or FunctionExpression, to allow for the possibility that the function will be used as a constructor.

13.2 Arrow Function Definitions

Syntax

ArrowFunction : ArrowParameters => ConciseBody

ArrowParameters :
  BindingIdentifier
  CoverParensTheadExpressionAndArrowParameterList
ConciseBody:
  [lookahead ≠ { }])AssignmentExpression
  { FunctionBody }

Supplemental Syntax

When processing the production ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList the following grammar is used to refine the interpretation of CoverParenthesisedExpressionAndArrowParameterList.

ArrowFormalParameters:
  ( StrictFormalParameters )

Static Semantics

Static Semantics: Early Errors

ArrowFunction: ArrowParameters => ConciseBody

• It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the VarDeclaredNames of ConciseBody.
• It is a Syntax Error if any element of the BoundNames of ArrowParameters also occurs in the LexicallyDeclaredNames of ConciseBody.

ArrowParameters: BindingIdentifier

• It is a Syntax Error if the StringValue of the sole element of the BoundNames of BindingIdentifier is eval
  of arguments.

ArrowParameters: [lookahead ≠ { }])CoverParenthesisedExpressionAndArrowParameterList

• It is a Syntax Error if the lexical token sequence matched by CoverParenthesisedExpressionAndArrowParameterList cannot be parsed with no tokens left over using ArrowFormalParameters as the goal symbol.
• It is a Syntax Error if any early errors are present for CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList.

ConciseBody: [lookahead ≠ { }])AssignmentExpression

• It is a Syntax Error if AssignmentExpression Contains YieldExpression.

Static Semantics: BoundNames

ArrowParameters: CoverParenthesisedExpressionAndArrowParameterList

1. Let formals be CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList.
2. Return the BoundNames of formals.

Static Semantics: Contains

With parameter symbol.

ArrowFunction: ArrowParameters => ConciseBody

1. If symbol is neither super or this, then return false.
2. If ArrowParameters Contains symbol is true, return true;
3. Return ConciseBody Contains symbol.
NOTE: Normally, `Contains` does not look inside most function forms. However, `Contains` is used to detect `this` and `super` usage within an `ArrowFunction`.

`ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList`

1. Let `formals` be `CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList`.
2. Return `formals` `Contains symbol`.

**Static Semantics:** `CoveredFormalsList` 

`ArrowParameters : BindingIdentifier`

1. Return `BindingIdentifier`.

`CoverParenthesisedExpressionAndArrowParameterList :  
  ( Expression )  
  ( . . . Identifier )  
  ( Expression , . . . Identifier )`

1. Return the result of parsing the lexical token stream matched by `CoverParenthesisedExpressionAndArrowParameterList` using `ArrowFormalParameters` as the goal symbol.

**Static Semantics:** `ExpectedArgumentCount` 

`ArrowParameters : BindingIdentifier`

2. Return 1.

`ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList`

1. Let `formals` be `CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList`.
2. Return the `ExpectedArgumentCount of formals`.

**Static Semantics:** `IsSimpleParameterList` 

`ArrowParameters : BindingIdentifier`

1. Return `true`.

`ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList`

1. Let `formals` be `CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList`.
2. Return the `IsSimpleParameterList of formals`.

**Static Semantics:** `LexicallyDeclaredNames` 

`ConciseBody : [lookahead ꞏ{[]} AssignmentExpression`

1. Return an empty List.

**Runtime Semantics** 

**Runtime Semantics:** `Binding Initialisation`

With `parameters value and environment`.

NOTE: When `undefined` is passed for `environment` it indicates that a `PutValue` operation should be used to assign the initialisation value. This is the case for formal parameter lists of non-strict functions. In that case the formal parameter bindings are preinitialised in order to deal with the possibility of multiple parameters with the same name.
ArrowParameters : BindingIdentifier

1. Return the result of performing Binding Initialisation for BindingIdentifier using value and environment as the arguments.

ArrowParameters : CoverParenthesisedExpressionAndArrowParameterList

1. Let formals be CoveredFormalsList of CoverParenthesisedExpressionAndArrowParameterList.
2. Return the result of performing Binding Initialisation of formals with arguments value and environment.

Runtime Semantics EvaluateBody

With parameter functionObject.

ConciseBody : [lookahead = [ ]] AssignmentExpression

1. The code of this ConciseBody is strict mode code if it is contained in strict mode code or if any of the conditions in 10.1.1 apply. If the code of this ConciseBody is strict mode code, AssignmentExpression is evaluated in the following steps as strict mode code. Otherwise, AssignmentExpression is evaluated in the following steps as non-strict mode code.
2. Let exprRef be the result of evaluating AssignmentExpression.
3. Let exprValue be GetValue(exprRef).
4. If exprValue.[[type]] is return then return NormalCompletion(exprValue.[[value]]).
5. ReturnIfAbrupt(exprValue).
6. Return NormalCompletion(exprValue).

NOTE In the absence of extensions to this specification, the test is step 4 will never be true.

Runtime Semantics: Evaluation

ArrowFunction : ArrowParameters => ConciseBody

1. Let strict be true.
2. Let scope be the LexicalEnvironment of the running execution context.
3. Let parameters be CoveredFormalsList of ArrowParameters.
4. Let closure be the result of performing the FunctionCreate abstract operation with arguments Arrow, parameters, ConciseBody, scope, and strict.
5. Return closure.

NOTE Even though an ArrowFunction may contain references to super, the FunctionCreate call in step 3 is not passed the optional homeObject and methodName parameters. An ArrowFunction that references super is always contained within a non-ArrowFunction and the necessary state to implement super is accessible via the scope that is captured by the function object of the ArrowFunction.

13.3 Method Definitions

Syntax

MethodDefinition : 

PropertySetParameterList : BindingIdentifier BindingPattern

NOTE The single element of a PropertySetParameterList may not have a default value Initialiser because set accessor are always called with an implicitly provided argument.
Static Semantics

Static Semantics: Early Errors

MethodDefinition : PropertyName ( StrictFormalParameters ) { FunctionBody }

- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

MethodDefinition : set PropertyName ( PropertySetParameterList ) { FunctionBody }

- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and any element of the BoundNames of PropertySetParameterList also occurs in the VarDeclaredNames of FunctionBody.
- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and BoundNames of PropertySetParameterList contains any duplicate elements.
- It is a Syntax Error if IsSimpleParameterList of PropertySetParameterList is false and BoundNames of PropertySetParameterList contains either "eval" or "arguments".
- It is a Syntax Error if BoundNames of PropertySetParameterList contains any duplicate elements.
- It is a Syntax Error if any element of the BoundNames of PropertySetParameterList also occurs in the LexicallyDeclaredNames of FunctionBody.
- It is a Syntax Error if PropertySetParameterList Contains YieldExpression.

Static Semantics: ExpectedArgumentCount

PropertySetParameterList : BindingIdentifier
1. Return 1.

PropertySetParameterList : BindingPattern
1. Return 1.

Static Semantics: IsSimpleParameterList

PropertySetParameterList : BindingIdentifier
1. Return true.

PropertySetParameterList : BindingPattern
1. Return false.

Static Semantics: PropName

MethodDefinition :
  PropertyName ( FormalParameters ) { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }
1. Return PropName of PropertyName.

Static Semantics: ReferencesSuper

MethodDefinition : PropertyName ( FormalParameters ) { FunctionBody }
1. If FormalParameters Contains super is true, then return true.
2. Return `FunctionBody` Contains `super`.

**MethodDefinition**: `get PropertyName ( ) { FunctionBody }

1. Return `FunctionBody` Contains `super`.

**MethodDefinition**: `set PropertyName ( PropertySetParameterList ) { FunctionBody }

1. If `PropertySetParameterList` Contains `super` is `true`, then return `true`.
2. Return `FunctionBody` Contains `super`.

**Static Semantics**: `SpecialMethod`

**MethodDefinition**: `PropertyName (StrictFormalParameters ) { FunctionBody }

1. Return `false`.

**MethodDefinition**: `GeneratorMethod` `get PropertyName ( ) { FunctionBody }

1. Return `true`.

**Runtime Semantics**

**Runtime Semantics: Property Definition Evaluation**

With parameter `object` and optional parameter `functionPrototype`.

**MethodDefinition**: `PropertyName (StrictFormalParameters ) { FunctionBody }

1. Let `propName` be `PropName` of `PropertyName`.
2. Let `strict` be `IsStrict` of `FunctionBody`.
3. Let `scope` be the running execution context’s LexicalEnvironment.
4. If ReferencesSuper of `MethodDefinition` is `true`, then
   a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `StrictFormalParameters`, `FunctionBody`, `scope`, and `strict` and with `object` as the `homeObject` optional argument and `propName` as the `methodName` optional argument. If `functionPrototype` was passed as a parameter then also pass its value as the `functionPrototype` optional argument of `FunctionCreate`.
5. Else
   a. Let `closure` be the result of performing the `FunctionCreate` abstract operation with arguments `Method`, `StrictFormalParameters`, `FunctionBody`, `scope`, and `strict`. If `functionPrototype` was passed as a parameter then also pass its value as the `functionPrototype` optional argument of `FunctionCreate`.
6. Let `desc` be the Property Descriptor `{[[Value]]: closure, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}`.
7. Let `status` be the result of `DefinePropertyOrThrow(object, propName desc)`.
8. ReturnIfAbrupt(`status`).
9. `NormalCompletion(closure)`.

**MethodDefinition**: `GeneratorMethod` See 13.4.

**MethodDefinition**: `get PropertyName ( ) { FunctionBody }

1. Let `propName` be `PropName` of `PropertyName`.
2. Let `strict` be `IsStrict` of `FunctionBody`.
3. Let `scope` be the running execution context’s LexicalEnvironment.
4. Let formalParameterList be the production `FormalParameters` [empty]
5. If ReferencesSuper of MethodDefinition is `true`, then
   a. Let closure be the result of performing the FunctionCreate abstract operation with arguments Method, formalParameterList, FunctionBody, scope, and strict and with object as the `homeObject` optional argument and propName as the `methodName` optional argument.
6. Else
   a. Let closure be the result of performing the FunctionCreate abstract operation with arguments Method, formalParameterList, FunctionBody, scope, and strict.
7. Let desc be the Property Descriptor `[[Get]]: closure, [[Enumerable]]: true, [[Configurable]]: true`
8. Let status be the result of calling the `[[DefineOwnProperty]]` internal method of object with arguments propName and desc.
9. ReturnIfAbrupt(status).
10. Return NormalCompletion(closure).

MethodDefinition : `set` PropertyName `{ PropertySetParameterList } { FunctionBody }
1. Let propName be PropName of PropertyName.
2. Let strict be IsStrict of FunctionBody.
3. Let scope be the running execution context’s LexicalEnvironment.
4. If ReferencesSuper of MethodDefinition is `true`, then
   a. Let closure be the result of performing the FunctionCreate abstract operation with arguments Method, PropertySetParameterList, FunctionBody, scope, and strict and with object as the `homeObject` optional argument and propName as the `methodName` optional argument.
5. Else
   a. Let closure be the result of performing the FunctionCreate abstract operation with arguments Method, PropertySetParameterList, FunctionBody, scope, and strict.
6. Let desc be the Property Descriptor `[[Set]]: closure, [[Enumerable]]: true, [[Configurable]]: true`
7. Let status be the result of DefinePropertyOrThrow(object, propName, desc).
8. ReturnIfAbrupt(status).
9. Return NormalCompletion(closure).

13.4 Generator Function Definitions

Syntax

GeneratorMethod :
   * PropertyName `StrictFormalParameters` { FunctionBody }

GeneratorDeclaration :
   function * BindingIdentifier `FormalParameters` { FunctionBody }

GeneratorExpression :
   function * BindingIdentifieropt `FormalParameters` { FunctionBody }

YieldExpression :
   yield YieldDelegatoropt [Lexical goal InputElementRegExp] AssignmentExpression

YieldDelegator :
   *

Supplemental Syntax

The following productions are used as an aid in specifying the semantics of certain ECMAScript language features. They are not used when parsing ECMAScript source code.

GeneratorBody :
   FunctionBody
   Comprehension

Commented [AWB10136]: This actually doesn’t accomplish anything because a similar annotation within MemberExpression takes care of the possibility of a leading RegExp here.
Static Semantics

Static Semantics: Early Errors

GeneratorMethod: * PropertyName (StrictFormalParameters) { FunctionBody }

and

GeneratorDeclaration: function * BindingIdentifier (FormalParameters) { FunctionBody }

and

GeneratorExpression: function * BindingIdentifieropt (FormalParameters) { FunctionBody }

• It is a Syntax Error if FunctionBody Contains YieldExpression is false.

GeneratorMethod: * PropertyName (StrictFormalParameters) { FunctionBody }

• It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the VarDeclaredNames of FunctionBody.

• It is a Syntax Error if any element of the BoundNames of StrictFormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

GeneratorDeclaration: function * BindingIdentifier (FormalParameters) { FunctionBody }

and

GeneratorExpression: function * BindingIdentifieropt (FormalParameters) { FunctionBody }

• It is a Syntax Error if IsSimpleParameterList of FormalParameters is false and any element of the BoundNames of FormalParameters also occurs in the VarDeclaredNames of FunctionBody.

• It is a Syntax Error if any element of the BoundNames of FormalParameters also occurs in the LexicallyDeclaredNames of FunctionBody.

YieldExpression: yield YieldDelegatoropt AssignmentExpression

• It is a Syntax Error if AssignmentExpression Contains YieldExpression.

Static Semantics: BoundNames

GeneratorDeclaration: function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return the BoundNames of BindingIdentifier.

Static Semantics: Contains

With parameter symbol.

GeneratorDeclaration: function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return false.

GeneratorExpression: function * BindingIdentifieropt (FormalParameters) { FunctionBody }

1. Return false.

NOTE Static semantic rules that depend upon substructure generally do not look into function definitions.

Static Semantics: IsConstantDeclaration

GeneratorDeclaration: function * BindingIdentifier (FormalParameters) { FunctionBody }

1. Return false.
**Static Semantics: LexicallyDeclaredNames**

GeneratorDeclaration: `function * BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return the BoundNames of BindingIdentifier.

**Static Semantics: PropName**

GeneratorMethod: `* PropertyName ( FormalParameters ) { FunctionBody }

1. Return PropName of PropertyName.

**Static Semantics: ReferencesSuper**

GeneratorMethod: `* PropertyName ( FormalParameters ) { FunctionBody }

1. If FormalParameters Contains `super` is true, then return `true`.
2. Return FunctionBody Contains `super`.

**Static Semantics: VarDeclaredNames**

GeneratorDeclaration: `function * BindingIdentifier ( FormalParameters ) { FunctionBody }

1. Return an empty List.

**Runtime Semantics**

NOTE: Abstract operations relating to generator objects are defined in 15.19.4.3.3.

**Runtime Semantics EvaluateBody**

With parameter `functionObject`.

GeneratorBody: `FunctionBody`

1. Let `G` be the `this` value.
2. If `Type(G)` is not `Object` or if `Type(G)` is `Object` and `G` does not have a `[[GeneratorState]]` internal data property, then
   a. Let `G` be the result of calling `OrdinaryCreateFromConstructor(functionObject, "%GeneratorPrototype", [[GeneratorState]], [[GeneratorContext]])`.
   b. ReturnIfAbrupt(`G`).
3. Return the result of `GeneratorStart(G, FunctionBody)`.

**Runtime Semantics: InstantiateFunctionObject**

With parameter `scope`.

GeneratorDeclaration: `function * BindingIdentifier ( FormalParameters ) { FunctionBody }`
1. If the GeneratorDeclaration is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Using FunctionBody from the production that is being evaluated, let body be the supplemental syntactic grammar production: GeneratorBody : FunctionBody.
3. Let F be the result of performing the GeneratorFunctionCreate abstract operation with arguments Normal, FormalParameters, body, scope, and strict.
4. Let prototype be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
5. Perform the abstract operation MakeConstructor with arguments F, true, and prototype.
6. Return F.

Runtime Semantics: Property Definition Evaluation

With parameter object and optional parameter functionPrototype.

GeneratorMethod : • PropertyName ( StrictFormalParameters ) { FunctionBody }
1. Let propName be PropName ofPropertyName.
2. Let strict be IsStrict of FunctionBody.
3. Let scope be the running execution context’s LexicalEnvironment.
4. Using FunctionBody from the production that is being evaluated, let body be the supplemental syntactic grammar production: GeneratorBody : FunctionBody.
5. If ReferencesSuper of GeneratorMethod is true, then
   a. Let closure be the result of performing the GeneratorFunctionCreate abstract operation with arguments Method, StrictFormalParameters, body, scope, and strict and with object as the homeObject optional argument and propName as the methodName optional argument.
6. Else
   a. Let closure be the result of performing the GeneratorFunctionCreate abstract operation with arguments Method, StrictFormalParameters, body, scope, and strict.
7. Let prototype be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
8. Perform the abstract operation MakeConstructor with arguments closure, true, and prototype.
9. Let desc be the Property Descriptor{[[Value]]: closure, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}.
10. Let status be the result of DefinePropertyOrThrow(object, propName desc).
11. Return NormalCompletion(status).
12. Return NormalCompletion(closure).

Runtime Semantics: Evaluation

GeneratorDeclaration : function • BindingIdentifier ( FormalParameters ) { FunctionBody }
1. Return NormalCompletion(empty)

GeneratorExpression : function • ( FormalParameters ) { FunctionBody }
1. If the GeneratorExpression is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Using FunctionBody from the production that is being evaluated, let body be the supplemental syntactic grammar production: GeneratorBody : FunctionBody.
3. Let scope be the LexicalEnvironment of the running execution context.
4. Let closure be the result of performing the GeneratorFunctionCreate abstract operation with arguments Normal, FormalParameters, body, scope, and strict.
5. Let prototype be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
6. Perform the abstract operation MakeConstructor with arguments closure, true, and prototype.
7. Return closure.

GeneratorExpression : function • BindingIdentifier ( FormalParameters) { FunctionBody }
1. If the GeneratorExpression is contained in strict code or if its FunctionBody is strict code, then let strict be true. Otherwise let strict be false.
2. Using FunctionBody from the production that is being evaluated, let body be the supplemental syntactic grammar production: GeneratorBody : FunctionBody.
3. Let funcEnv be the result of calling NewDeclarativeEnvironment passing the running execution context’s Lexical Environment as the argument.
4. Let envRec be funcEnv's environment record.
5. Let name be StringValue of BindingIdentifier.
6. Call the CreateImmutableBinding concrete method of envRec passing name as the argument.
7. Let closure be the result of performing the GeneratorFunctionCreate abstract operation with arguments Normal, FormalParameters, body, funcEnv, and strict.
8. Let prototype be the result of the abstract operation ObjectCreate with the intrinsic object %GeneratorPrototype% as its argument.
9. Perform the abstract operation MakeConstructor with arguments closure, true, and prototype.
10. Call the InitialiseBinding concrete method of envRec passing name and closure as the arguments.
11. Return NormalCompletion(closure).

NOTE 1 The BindingIdentifier in a GeneratorExpression can be referenced from inside the GeneratorExpression's FunctionBody to allow the generator code to call itself recursively. However, unlike in a GeneratorDeclaration, the BindingIdentifier in a GeneratorExpression cannot be referenced from and does not affect the scope enclosing the GeneratorExpression.

YieldExpression : yield YieldDelegatoropt AssignmentExpression

1. Let exprRef be the result of evaluating AssignmentExpression.
2. Let value be GetValue(exprRef).
3. ReturnIfAbrupt(value).
4. If YieldDelegator is present, then
   a. If Type(value) is not then throw a TypeError exception.
   b. Let iterator be the result of performing Invoke with arguments value, @@iterator and an empty List.
   c. ReturnIfAbrupt(iterator).
   d. If Type(iterator) is not then throw a TypeError exception.
   e. Let received be undefined.
   f. Repeat
      i. Let innerResult be the result of Invoke(iterator, "value", (received)).
      ii. ReturnIfAbrupt(innerResult).
      iii. If Type(innerResult) is not Object, then throw a TypeError exception.
      iv. Let done be IteratorComplete(innerResult).
      v. ReturnIfAbrupt(done).
      vi. If done is true, then
         1. Let innerValue be the result of Get (innerResult, "value").
         2. Return innerValue.
      vii. Let yieldCompletion be the result of GeneratorYield(innerResult).
      viii. Let received be yieldCompletion.[[value]].
      ix. If yieldCompletion.[[type]] is THROW, then
         1. If HasProperty(iterator, "throw") is true, then
            a. Let innerResult be the result of Invoke(iterator, "throw", (received)).
            b. ReturnIfAbrupt(innerResult).
         2. Return yieldCompletion.
5. Return the result of GeneratorYield(CreateIterResultObject(value, false)).

13.5 Class Definitions

Syntax

ClassDeclaration :
   class BindingIdentifier ClassTail

ClassExpression :
   class BindingIdentifieropt ClassTail
ClassTail :
  ClassHeritage opt { ClassBody opt }

ClassHeritage :
  extends AssignmentExpression

ClassBody :
  ClassElementList

ClassElementList :
  ClassElement
  ClassElementList ClassElement

ClassElement :
  MethodDefinition
  static MethodDefinition ;

NOTE A ClassBody is always strict code.

Static Semantics

Static Semantics: Early Errors

ClassBody : ClassElementList
  • It is a Syntax Error if PrototypePropertyNameList of ClassElementList contains any duplicate entries, unless the following condition is true for each duplicate entry: The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor MethodDefinition and the other occurrence was obtained from a set accessor MethodDefinition.
  • It is a Syntax Error if StaticPropertyNameList of ClassElementList contains any duplicate entries, unless the following condition is true for each duplicate entry: The duplicated entry occurs exactly twice in the list and one occurrence was obtained from a get accessor MethodDefinition and the other occurrence was obtained from a set accessor MethodDefinition.

ClassElement : MethodDefinition
  • It is a Syntax Error if PropName of MethodDefinition is "constructor" and SpecialMethod of MethodDefinition is true.

ClassElement : static MethodDefinition
  • It is a Syntax Error if PropName of MethodDefinition is "prototype".

Static Semantics: BoundNames

ClassDeclaration: class BindingIdentifier ClassTail
  1. Return the BoundNames of BindingIdentifier.

Static Semantics: ConstructorMethod

ClassBody : ClassElementList
  1. Let list be PrototypeMethodDefinitions of ClassElementList.
  2. For each MethodDefinition m in list, do
     1. If PropName of m is "constructor", return m.
  3. Return empty.
NOTE Early Error rules ensure that there is only one method definition named "constructor" and that it isn't an accessor property or generator definition.

Static Semantics: \( \text{Contains} \)

With parameter symbol.

\[
\text{ClassTail : ClassHeritage}_\text{opt} \{ \text{ClassBody} \}
\]

1. If symbol is ClassBody, return true.
2. If ClassHeritage is not present, return false.
3. If symbol is ClassHeritage, return true.
4. Return the result of Contains for ClassHeritage with argument symbol.

NOTE Static semantic rules that depend upon substructure generally do not look into class bodies.

Static Semantics: \( \text{IsConstantDeclaration} \)

\[
\text{ClassDeclaration: class BindingIdentifier ClassTail}
\]

1. Return false.

Static Semantics: \( \text{IsStatic} \)

\[
\text{ClassElement : MethodDefinition}
\]

1. Return false.

\[
\text{ClassElement : static MethodDefinition}
\]

1. Return true.

\[
\text{ClassElement : ;}
\]

1. Return false.

Static Semantics: \( \text{LexicallyDeclaredNames} \)

\[
\text{ClassDeclaration: class BindingIdentifier ClassTail}
\]

1. Return the BoundNames of BindingIdentifier.

Static Semantics: \( \text{PrototypeMethodDefinitions} \)

\[
\text{ClassElementList : ClassElement}
\]

1. If PropName of ClassElement is empty or "constructor", return a new empty List.
2. If IsStatic of ClassElement is true, return a new empty List.
3. Return a List containing ClassElement.

\[
\text{ClassElementList : ClassElementList ClassElement}
\]

1. Let list be PrototypeMethodDefinitions of ClassElementList.
2. If PropName of ClassElement is empty or "constructor", return list.
3. If IsStatic of ClassElement is true, return list.
4. Append ClassElement to the end of list.
5. Return list.

Static Semantics: \( \text{PrototypePropertyNameList} \)
ClassElementList : ClassElement
1. If PropName of ClassElement is empty, return a new empty List.
2. If IsStatic of ClassElement is true, return a new empty List.
3. Return a List containing PropName of ClassElement.

ClassElementList : ClassElementList ClassElement
1. Let list be PrototypePropertyNameList of ClassElementList.
2. If PropName of ClassElement is empty, return list.
3. If IsStatic of ClassElement is true, return list.
4. Append PropName of ClassElement to the end of list.
5. Return list.

Static Semantics: PropName
ClassElement : ;
1. Return empty.

Static Semantics: StaticPropertyNameList
ClassElementList : ClassElement
1. If PropName of ClassElement is empty, return a new empty List.
2. If IsStatic of ClassElement is false, return a new empty List.
3. Return a List containing PropName of ClassElement.

ClassElementList : ClassElementList ClassElement
1. Let list be StaticPropertyNameList of ClassElementList.
2. If PropName of ClassElement is empty, return list.
3. If IsStatic of ClassElement is false, return list.
4. Append PropName of ClassElement to the end of list.
5. Return list.

Static Semantics: StaticMethodDefinitions
ClassElementList : ClassElement
1. If PropName of ClassElement is empty, return a new empty List.
2. If IsStatic of ClassElement is false, return a new empty List.
3. Return a List containing ClassElement.

ClassElementList : ClassElementList ClassElement
1. Let list be StaticMethodDefinitions of ClassElementList.
2. If PropName of ClassElement is empty, return list.
3. If IsStatic of ClassElement is false, return list.
4. Append ClassElement to the end of list.
5. Return list.

Static Semantics: VarDeclaredNames
ClassDeclaration: class BindingIdentifier ClassTail
1. Return an empty List.
Runtime Semantics

Runtime Semantics: ClassDefinitionEvaluation

With parameter className.

ClassTail : ClassHeritageopt ( ClassBody )

1. If ClassHeritageopt is not present, then
   a. let protoParent be the intrinsic object %ObjectPrototype%.
   b. Let constructorParent be the intrinsic object %FunctionPrototype%.
2. Else
   a. Let superclass be the result of evaluating ClassHeritage.
   b. ReturnIfAbrupt(superclass).
   c. If superclass is null, then
      i. Let protoParent be null.
      ii. Let constructorParent be the intrinsic object %FunctionPrototype%.
   d. Else if Type(superclass) is not Object, throw a TypeError exception.
   e. Else if IsConstructor(superclass) is false, then throw a TypeError exception.
   f. Else
      i. Let protoParent be the result of Get(superclass, "prototype").
      ii. ReturnIfAbrupt(protoParent).
      iii. If Type(protoParent) is neither Object or Null, throw a TypeError exception.
      iv. Let constructorParent be superclass.
3. Let proto be the result of the abstract operation ObjectCreate with argument protoParent.
4. Let lex be the LexicalEnvironment of the running execution context.
5. If className is not undefined, then
   a. Let scope be the result of calling NewDeclarativeEnvironment passing lex as the argument
   b. Let envRec be scope’s environment record.
   c. Call the CreateImmutableBinding concrete method of envRec passing className as the argument.
   d. Set the running execution context’s LexicalEnvironment to scope.
7. If constructor is empty, then
   a. If ClassHeritageopt is present, then
      i. Let constructor be the result of parsing the String “constructor( ... args) { }" using the syntactic grammar with the goal symbol MethodDefinition.
   b. Else
      i. Let constructor be the result of parsing the String “constructor( ) { }" using the syntactic grammar with the goal symbol MethodDefinition.
8. Let isEra be true.
9. Let F be the result of performing Property Definition Evaluation for constructor with argument proto and constructorParent as the optional functionPrototype argument.
10. Perform the abstract operation MakeConstructor with argument F and false as the optional writablePrototype argument and proto as the optional prototype argument.
11. If className is not undefined, then
    a. Call the InitialiseBinding concrete method of envRec passing className and F as the arguments.
12. Let desc be the PropertyDescriptor [[Enumerable]], false, [[Writable]], true, [[Configurable]], true.
13. Call the [[DefineOwnProperty]] internal method of proto with arguments “constructor” and desc
15. For each MethodDefinition m in order from protoMethods
    a. Perform Property Definition Evaluation for m with argument proto.
16. Let staticMethods be StaticMethodDefinitions of ClassBody.
17. For each MethodDefinition s in order from staticMethods
    a. Perform Property Definition Evaluation for s with argument F.
18. Set the running execution context’s LexicalEnvironment to lex.
19. Return F.
Runtime Semantics: Evaluation

ClassDeclaration: \texttt{class} BindingIdentifier ClassTail

1. Let value be the result of ClassDefinitionEvaluation of ClassTail with argument \texttt{undefined}.
2. ReturnIfAbrupt(value).
3. Let env be the running execution context’s LexicalEnvironment.
4. Let status be the result of performing Binding Initialisation for BindingIdentifier passing value and env as the arguments.
5. ReturnIfAbrupt(status).
6. Return NormalCompletion(\texttt{empty}).

NOTE The argument to ClassDefinitionEvaluation controls whether or not the class that is defined with a BindingIdentifier has a local binding to the identifier. Only a ClassExpression gets a local name binding of its name. A ClassDeclaration never has such a binding. This maintains the parallel with FunctionExpression and FunctionDeclaration.

ClassExpression: \texttt{class} BindingIdentifier\_opt ClassTail

1. If BindingIdentifier\_opt is not present, then let className be \texttt{undefined}.
2. Else, let className be StringValue of BindingIdentifier.
3. Let value be the result of ClassDefinitionEvaluation of ClassTail with argument className.
4. ReturnIfAbrupt(value).
5. Return NormalCompletion(value).

13.6 Tail Position Calls

The wiki proposal has a preliminary attempt at defining tail position. See http://wiki.ecmascript.org/doku.php?id=harmony:proper_tail_calls. This material still needs to be reviewed and updated for incorporation here.

14 Scripts and Modules

14.1 Script

Syntax

Script : ScriptBody\_opt

ScriptBody : OuterStatementList

OuterStatementList : OuterItem OuterStatementList OuterItem

OuterItem : ModuleDeclaration ImportDeclaration StatementList Item

Static Semantics

Static Semantics: Early Errors

ScriptBody : OuterStatementList
• It is a Syntax Error if the LexicallyDeclaredNames of OuterStatementList contains any duplicate entries.
• It is a Syntax Error if any element of the LexicallyDeclaredNames of OuterStatementList also occurs in the VarDeclaredNames of OuterStatementList.
• It is a Syntax Error if OuterStatementList Contains ReturnStatement.
• It is a Syntax Error if OuterStatementList Contains super.
• It is a Syntax Error if OuterStatementList Contains YieldExpression.

NOTE Additional error conditions relating to conflicting or duplicate declarations are checked during module linking prior to evaluation of a Script. If any such errors are detected the Script is not evaluated.

Static Semantics: IsStrict

ScriptBody : OuterStatementList

1. If this ScriptBody is contained in strict code or if OuterStatementList is strict code, then return true.
   Otherwise, return false.

Static Semantics: LexicallyDeclaredNames

OuterStatementList : OuterStatementList OuterItem

1. Let names be LexicallyDeclaredNames of OuterStatementList.
2. Append to names the elements of the LexicallyDeclaredNames of OuterItem.
3. Return names.

OuterItem : ModuleDeclaration

1. Return the BoundNames of ModuleDeclaration.

OuterItem : ImportDeclaration

1. Return the BoundNames of ImportDeclaration.

OuterItem : StatementListItem

1. Return TopLevelLexicallyDeclaredNames of StatementListItem.

NOTE At the top level of a Script, function declarations are treated like var declarations rather than like lexical declarations.

Static Semantics: LexicallyScopedDeclarations

OuterStatementList : OuterStatementList OuterItem

1. Let declarations be LexicallyScopedDeclarations of OuterStatementList.
2. Append to declarations the elements of the LexicallyScopedDeclarations of OuterItem.
3. Return declarations.

OuterItem : ModuleDeclaration

1. Return a new List containing ModuleDeclaration.

OuterItem : ImportDeclaration

1. Return a new List containing ImportDeclaration.

OuterItem : StatementListItem

1. Return TopLevelLexicallyScopedDeclarations of StatementListItem.
**Static Semantics: VarDeclaredNames**

OuterStatementList : OuterStatementList OuterItem
1. Let names be VarDeclaredNames of OuterStatementList.
2. Append to names the elements of the VarDeclaredNames of OuterItem.
3. Return names.

OuterItem : ModuleDeclaration
2. Return an empty List.

OuterItem : ImportDeclaration
2. Return an empty List.

OuterItem : StatementListItem
2. Return TopLevelVarDeclaredNames of StatementListItem.

**Static Semantics: VarScopedDeclarations**

OuterStatementList : OuterStatementList OuterItem
1. Let declarations be VarScopedDeclarations of OuterStatementList.
2. Append to declarations the elements of the VarScopedDeclarations of OuterItem.
3. Return declarations.

OuterItem : ModuleDeclaration
1. Return a new empty List.

OuterItem : ImportDeclaration
1. Return a new empty List.

OuterItem : StatementListItem
1. Return the TopLevelVarScopedDeclarations of StatementListItem.

**Runtime Semantics**

**Runtime Semantics: Script Evaluation**

With arguments realm and deletableBindings.

Script : ScriptBody
1. The code of this Script is strict mode code if the Directive Prologue (14.1) of its ScriptBody contains a Use Strict Directive or if any of the conditions of 10.1.1 apply. If the code of this Script is strict mode code, ScriptBody is evaluated in the following steps as strict mode code. Otherwise ScriptBody is evaluated in the following steps as non-strict mode code.
2. If ScriptBody is not present, return NormalCompletion(empty).
3. Let globalEnv be realm.([globalEnv]).
4. Let status be the result of performing Global Declaration Instantiation as described in 10.5.1 using ScriptBody, globalEnv, and deletableBindings as arguments.
5. ReturnIfAbrupt(status).
6. Let progCxt be a new ECMAScript code execution context.
7. Set the progCxt's Realm to realm.
8. Set the progCxt's VariableEnvironment to globalEnv.
9. Set the `progCxt`'s `LexicalEnvironment` to `globalEnv`.
10. If there is a currently running execution context, suspend it.
11. Push `progCxt` on to the execution context stack; `progCxt` is now the running execution context.
12. Let `result` be the result of evaluating `ScriptBody`.
13. Suspend `progCxt` and remove it from the execution context stack.
14. If the execution context stack is not empty, resume the context that is now on the top of the execution context stack as the running execution context. Otherwise, the execution context stack is now empty and there is no running execution context.
15. Return `result`.

NOTE The processes for initiating the evaluation of a `Script` and for dealing with the result of such an evaluation are defined by an ECMAScript implementation and not by this specification.

Runtime Semantics: Evaluation

```
OuterStatementList : OuterStatementList OuterItem
1. Let `sl` be the result of evaluating `OuterStatementList`.
2. ReturnIfAbrupt(`sl`).
3. Let `s` be the result of evaluating `OuterItem`.
4. If `s.[[type]]` is `throw`, return `s`.
5. If `s.[[value]]` is empty, let `V = sl.[[value]]`, otherwise let `V = s.[[value]]`.
6. Return Completion `[[type]]: s.[[type]], [[value]]: V, [[target]]: s.[[target]]`.
```

NOTE See the 12.1 NOTE regarding evaluation of `StatementList : StatementList StatementListItem`.


A Directive Prologue is the longest sequence of `ExpressionStatement` productions occurring as the initial `StatementListItem` productions of a `ScriptBody` or `FunctionBody`, and where each `ExpressionStatement` in the sequence consists entirely of a `StringLiteral` token followed by a semicolon. The semicolon may appear explicitly or may be inserted by automatic semicolon insertion. A Directive Prologue may be an empty sequence.

A Use Strict Directive is an `ExpressionStatement` in a Directive Prologue whose `StringLiteral` is either the exact character sequences "use strict" or 'use strict'. A Use Strict Directive may not contain an `EscapeSequence` or `LineContinuation`.

A Directive Prologue may contain more than one Use Strict Directive. However, an implementation may issue a warning if this occurs.

NOTE The `ExpressionStatement` productions of a Directive Prologue are evaluated normally during evaluation of the containing production. Implementations may define implementation specific meanings for `ExpressionStatement` productions which are not a Use Strict Directive and which occur in a Directive Prologue. If an appropriate notification mechanism exists, an implementation should issue a warning if it encounters in a Directive Prologue an `ExpressionStatement` that is not a Use Strict Directive or which does not have a meaning defined by the implementation.

14.2 Modules

15 Standard Built-in ECMAScript Objects

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

Unless specified otherwise, a built-in object that is callable as a function is a Build-in Function object with the characteristics described in 8.4.7. Unless specified otherwise, the `[[Extensible]]` internal data property of a built-in object initially has the value `true`. 
Many built-in objects are functions: they can be invoked with arguments. Some of them furthermore are constructors: they are functions intended for use with the `new` operator. For each built-in function, this specification describes the arguments required by that function and properties of the Function object. For each built-in constructor, this specification furthermore describes properties of the prototype object of that constructor and properties of specific object instances returned by a `new` expression that invokes that constructor.

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

Unless otherwise specified in the description of a particular function, if a function or constructor described in this clause is given more arguments than the function is specified to allow, the extra arguments are evaluated by the call and then ignored by the function. However, an implementation may define implementation specific behaviour relating to such arguments as long as the behaviour is not the throwing of a `TypeError` exception that is predicated simply on the presence of an extra argument.

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

Every built-in function and every built-in constructor has the Function prototype object, which is the initial value of the expression `Function.prototype` (15.3.3), as the value of its `[[Prototype]]` internal data property. Unless otherwise specified every built-in prototype object has the Object prototype object, which is the initial value of the expression `Object.prototype` (15.2.4), as the value of its `[[Prototype]]` internal data property, except the Object prototype object itself.

None of the built-in functions described in this clause that are not constructors shall implement the `[[Construct]]` internal method unless otherwise specified in the description of a particular function. The behaviour specified in this clause for each built-in function is the specification of the `[[Call]]` internal method behaviour for that function with `[[Call]]` thisArgument providing the `this` value and `[[Call]]` argumentsList providing the named parameters for each built-in function. None of the built-in functions described in this clause shall have a `prototype` property unless otherwise specified in the description of a particular function.

This clause generally describes distinct behaviours for when a constructor is "called as a function" and for when it is "called as part of a new expression". The "called as a function" behaviour corresponds to the invocation of the constructor's `[[Call]]` internal method and the "called as part of a new expression" behaviour corresponds to the invocation of the constructor's `[[Construct]]` internal method.

Every built-in Function object, `F`, described in this clause—whether as a constructor, an ordinary function, or both—has the properties that are defined by performing the following step when the function object is created:

1. Perform the `AddRestrictedFunctionProperties` (13.6.3) abstract operation with argument `F`.

Every built-in Function object described in this clause—whether as a constructor, an ordinary function, or both—has a `length` property whose value is an integer. Unless otherwise specified, this value is equal to the largest number of named arguments shown in the subclause headings for the function description, including optional parameters.

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

In every case, the `length` property of a built-in Function object described in this clause has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

Every other data property described in this clause has the attributes `{ [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true } unless otherwise specified.
Every accessor property described in this clause has the attributes {[[Enumerable]]: false, [[Configurable]]: true} unless otherwise specified. If only a get accessor function is described, the set accessor function is the default value, undefined. If only a set accessor is function is described the get accessor is the default value, undefined.

15.1 The Global Object

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

Unless otherwise specified, the standard built-in properties of the global object have attributes {[[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}.

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

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 data property of the global object is implementation-dependent.

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

15.1.1 Value Properties of the Global Object

15.1.1.1 NaN

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

15.1.1.2 Infinity

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

15.1.1.3 undefined

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

15.1.2 Function Properties of the Global Object

15.1.2.1 eval(x)

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

1. If Type(x) is not String, return x.
2. Let script be the ECMAScript code that is the result of parsing x, interpreted as UTF-16 encoded Unicode text as described in 8.4, for the goal symbol Script. If the parse fails or any early errors are detected, throw a SyntaxError exception (but see also clause 16).
3. If script Contains ScriptBody is false, return undefined.
4. Let strictScript be IsStrict of script.
5. If this is a direct call to eval (15.1.2.1.1), let direct be true, otherwise let direct be false.
6. If direct is true and the code that made the direct call to eval is strict code, then let strictCaller be true. Otherwise, let strictCaller be false.

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7. Let ctx be the running execution context. If direct is true, ctx will be the execution context that performed the direct eval. If direct is false, ctx will be the execution context for the invocation of the eval function.

8. Let evalRealm be ctx’s Realm.
9. If direct is false and strictScript is false, then
   a. Return the result of Script Evaluation for script with arguments evalRealm and true.
10. If direct is true, strictScript is false, strictCaller is false, and ctx’s LexicalEnvironment is the same as evalRealm.[[globalEnv]], then
    a. Return the result of Script Evaluation for script with arguments evalRealm and true.
11. If direct is true, then
    a. If the code that made the direct call to eval is function code and ValidInFunction of script is false, then throw a SyntaxError exception.
    b. If the code that made the direct call to eval is module code and ValidInModule of script is false, then throw a SyntaxError exception.
12. If direct is true, then
    a. Let lexEnv be ctx’s LexicalEnvironment.
    b. Let varEnv be ctx’s VariableEnvironment.
13. Else,
    a. Let lexEnv be evalRealm.[[globalEnv]].
    b. Let varEnv be evalRealm.[[globalEnv]].
14. If strictScript is true or if direct is true and strictCaller is true, then
    a. Let strictVarEnv be the result of calling NewDeclarativeEnvironment passing the lexEnv as the argument.
    b. Let lexEnv be strictVarEnv.
    c. Let varEnv be strictVarEnv.
15. Let status be the result of performing Eval Declaration Instantiation as described in 10.5.5 with script, varEnv, and lexEnv.
16. ReturnIfAbrupt(status).
17. Let evalCtx be a new ECMAScript code execution context.
18. Set the evalCtx’s Realm to evalRealm.
19. Set the evalCtx’s VariableEnvironment to varEnv.
20. Set the evalCtx’s LexicalEnvironment to lexEnv.
21. If there is a currently running execution context, suspend it.
22. Push evalCtx on to the execution context stack; evalCtx is now the running execution context.
23. Let result be the result of evaluating script.
24. Suspends evalCtx and remove it from the execution context stack.
25. Resume the context that is now on top of the execution context stack as the running execution context.
26. Return result.

NOTE The eval code cannot instantiate variable or function bindings in the variable environment of the calling context that invoked the eval if either the code of the calling context or the eval code is strict code. Instead such bindings are instantiated in a new VariableEnvironment that is only accessible to the eval code.

### 15.1.2.1 Direct Call to Eval

A direct call to the eval function is one that is expressed as a `CallExpression` that meets the following two conditions:

The Reference that is the result of evaluating the MemberExpression in the `CallExpression` has an environment record as its base value and its reference name is “eval”.

The result of calling the abstract operation GetValue with that Reference as the argument is the standard built-in function defined in 15.1.2.2.

### 15.1.2.2 parseInt

The `parseInt` function produces an integer value dictated by interpretation of the contents of the string argument according to the specified radix. Leading white space in string is ignored. If radix is `undefined` or 0, it is assumed to be 10 except when the number begins with the character pairs `0x` or `0X`, in which case a radix of 16 is assumed. If radix is 16, the number may also optionally begin with the character pairs `0x` or `0X`. 

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

1. Let `inputString` be `ToString(string)`.
2. ReturnIfAbrupt(`string`).
3. Let `S` be a newly created substring of `inputString` consisting of the first character that is not a `StrWhiteSpaceChar` and all characters following that character. (In other words, removing leading white space.) If `inputString` does not contain any such characters, let `S` be the empty string.
4. Let `sign` be 1.
5. If `S` is not empty and the first character of `S` is a minus sign `-`, let `sign` be \(-\)1.
6. If `S` is not empty and the first character of `S` is a plus sign `+` or a minus sign `-`, then remove the first character from `S`.
7. Let `R = ToInt32(radix)`.
8. ReturnIfAbrupt(`R`).
9. Let `stripPrefix` be `true`.
10. If `R \neq 0`, then
    a. If `R < 2` or `R > 36`, then return `NaN`.
    b. If `R \neq 16`, let `stripPrefix` be `false`.
11. Else `R = 0`,
    a. Let `R = 10`.
12. If `stripPrefix` is `true`, then
    a. If the length of `S` is at least 2 and the first two characters of `S` are either “0x” or “0X”, then remove the first two characters from `S` and let `R = 16`.
13. If `S` contains any character that is not a radix-`R` digit, then let `Z` be the substring of `S` consisting of all characters before the first such character; otherwise, let `Z` be `S`.
14. 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 \(\neq 10\) 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.)
15. Let `number` be the Number value for `mathInt`.
16. Return `sign \times number`.

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

### 15.1.2.3 `parseFloat (string)`

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

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

1. Let `inputString` be `ToString(string)`.
2. ReturnIfAbrupt(`string`).
3. Let `trimmedString` be a substring of `inputString` consisting of the leftmost character that is not a `StrWhiteSpaceChar` and all characters to the right of that character. (In other words, remove leading white space.) If `inputString` does not contain any such characters, let `trimmedString` be the empty string.
4. If neither `trimmedString` nor any prefix of `trimmedString` satisfies the syntax of a `StrDecimalLiteral` (see 9.3.1), return `NaN`.
5. Let `numberString` be the longest prefix of `trimmedString`, which might be `trimmedString` itself, that satisfies the syntax of a `StrDecimalLiteral`.
6. Return the Number value for the MV of `numberString`.

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

Returns true if the argument coerces to NaN, and otherwise returns false.

1. Let num be ToNumber(number).
2. ReturnIfAbrupt(num).
3. If num is NaN, return true.
4. Otherwise, return false.

NOTE A reliable way for ECMAScript code to test if a value \( x \) is a NaN is an expression of the form \( x \neq x \). The result will be true if and only if \( x \) is a NaN.

15.1.2.5 isFinite (number)

Returns false if the argument coerces to NaN, +\( \infty \), or -\( \infty \), and otherwise returns true.

1. Let num be ToNumber(number).
2. ReturnIfAbrupt(num).
3. If ToNumber(num) is NaN, +\( \infty \), or -\( \infty \), return false.
4. Otherwise, return true.

15.1.3 URI Handling Function Properties

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

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

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

```
Scheme : First / Second ; Third ? Fourth
```

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

The following lexical grammar specifies the form of encoded URIs.

Syntax

```
uri ::=
  uriCharactersopt
uriCharacters ::=
  uriCharacter uriCharactersopt
uriCharacter ::=
  uriReserved
  uriUnescaped
  uriEscaped
uriReserved ::=
  one of
  ; / ? : @ & = + $ ,
```

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uriUnescaped ::= uriAlpha decimalDigit uriMark

uriEscaped ::= % HexDigit HexDigit

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

uriMark ::= one of
        - _ . ! ~ * ' ( )

NOTE: The above syntax is based upon RFC 2396 and does not reflect changes introduced by the more recent RFC 3986.

Runtime Semantics

When a character to be included in a URI is not listed above or is not intended to have the special meaning sometimes given to the reserved characters, that character must be encoded. The character is transformed into its UTF-8 encoding, with surrogates pairs first converted from UTF-16 to the corresponding code point value. (Note that for code units in the range [0,127] this results in a single octet with the same value.) The resulting sequence of octets is then transformed into a String with each octet represented by an escape sequence of the form "%xx".

Runtime Semantics: Encode Abstract Operation

The encoding and escaping process is described by the abstract operation Encode taking two String arguments string and unescapedSet.

1. Let strLen be the number of characters in string.
2. Let R be the empty string.
3. Let k be 0.
4. Repeat
   a. If k equals strLen, return R.
   b. Let C be the character at position k within string.
   c. If C is in unescapedSet, then
      i. Let S be a String containing only the character C.
      ii. Let R be a new String value computed by concatenating the previous value of R and S.
   d. Else C is not in unescapedSet, then
      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. If k equals strLen, throw a URIError exception.
            3. Let kChar be the code unit value of the character at position k within string.
            4. If kChar is less than 0xDC00 or greater than 0xDFFF, throw a URIError exception.
            5. Let V be (((the code unit value of C) – 0xDC00) × 0x400 + (kChar – 0xDC00) + 0x10000).
      iv. Let Octets be the array of octets resulting by applying the UTF-8 transformation to V, and let L be the array size.
      v. Let j be 0.
      vi. Repeat, while j < L
          1. Let jOctet be the value at position j within Octets.
2. Let $S$ be a String containing three characters “%XY” where $XY$ are two uppercase hexadecimal digits encoding the value of $j$Octet.
3. Let $R$ be a new String value computed by concatenating the previous value of $R$ and $S$.
4. Increase $j$ by 1.
5. Increase $k$ by 1.

Runtime Semantics: Decode Abstract Operation

The unescaping and decoding process is described by the abstract operation Decode taking two String arguments string and reservedSet.

1. Let $strLen$ be the number of characters in string.
2. Let $R$ be the empty String.
3. Let $k$ be 0.
4. Repeat
   a. If $k$ equals $strLen$, return $R$.
   b. Let $C$ be the character at position $k$ within string.
   c. If $C$ is not ‘%’, then
      i. Let $S$ be the String containing only the character $C$.
   d. Else $C$ is ‘%’.
      i. Let start be $k$.
      ii. If $k + 2$ is greater than or equal to $strLen$, throw a URIError exception.
      iii. If the characters at position $(k+1)$ and $(k+2)$ within string do not represent hexadecimal digits, throw a URIError exception.
      iv. Let $B$ be the 8-bit value represented by the two hexadecimal digits at position $(k+1)$ and $(k+2)$.
      v. Increment $k$ by 2.
      vi. If the most significant bit in $B$ is 1, then
         a. Let $n$ be the smallest non-negative number such that $(B << n) & 0x80$ is equal to 0.
         b. If $n$ equals 1 or $n$ is greater than 4, throw a URIError exception.
         c. Let Octets be an array of 8-bit integers of size $n$.
         d. Put $B$ into Octets at position 0.
         e. If $k + (3 \times (n - 1))$ is greater than or equal to $strLen$, throw a URIError exception.
         f. Let $j$ be 1.
         g. Repeat, while $j < n$
            a. Increment $k$ by 1.
            b. If the character at position $k$ within string is not ‘%’, throw a URIError exception.
            c. If the characters at position $(k+1)$ and $(k+2)$ within string do not represent hexadecimal digits, throw a URIError exception.
            d. Let $B$ be the 8-bit value represented by the two hexadecimal digits at position $(k+1)$ and $(k+2)$.
            e. If the two most significant bits in $B$ are not 10, throw a URIError exception.
            f. Increment $k$ by 2.
            g. Put $B$ into Octets at position $j$.
            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 an URIError exception.
9. If $V \leq 0x10000$, then
   a. Let $C$ be the character with code unit value $V$.
   b. If $C$ is not in reservedSet, then
Let \( S \) be the string containing only the character \( C \).

Else \( C \) is in reservedSet,

Let \( S \) be the substring of string from position \( start \) to position \( k \) included.

10. Else \( V \geq 0x10000 \),

a. Let \( L \) be \(((V - 0x10000) & 0x3FF) + 0xDC00)\).

b. Let \( H \) be \(((V - 0x10000) >> 10) & 0x3FF) + 0xD800\).

c. Let \( S \) be the string containing the two characters with code unit values \( H \) and \( L \).

Else \( k \) by 1.

**NOTE**

This syntax of Uniform Resource Identifiers is based upon RFC 2396 and does not reflect the more recent RFC 3986 which replaces RFC 2396. A formal description and implementation of UTF-8 is given in RFC 3629.

In UTF-8, characters are encoded using sequences of 1 to 6 octets. The only octet of a "sequence" of one has the higher-order bit set to 0, the remaining 7 bits being used to encode the character value. In a sequence of \( n \) octets, \( n \geq 1 \), the initial octet has the \( n \) higher-order bits set to 1, followed by a bit set to 0. The remaining bits of that octet contain bits from the value of the character to be encoded. The following octets all have the higher-order bit set to 1 and the following bit set to 0, leaving 6 bits in each to contain bits from the character to be encoded. The possible UTF-8 encodings of ECMAScript characters are specified in Table 32.

<table>
<thead>
<tr>
<th>Code Unit Value</th>
<th>Representation</th>
<th>1st Octet</th>
<th>2nd Octet</th>
<th>3rd Octet</th>
<th>4th Octet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0000 – 0x007F</td>
<td>00000000 0zzzzzz</td>
<td>0zzzzzz</td>
<td>0zzzz</td>
<td>0zzzz</td>
<td>0zzzz</td>
</tr>
<tr>
<td>0x0080 – 0x00FF</td>
<td>00000 yyy yyyyzzzzzz</td>
<td>110 yyyy</td>
<td>10 yyyy</td>
<td>10 yyyy</td>
<td>10 zzzzz</td>
</tr>
<tr>
<td>0x0100 – 0x01FF</td>
<td>01111 yyyy yyyyzzzzzz</td>
<td>111 yyyy</td>
<td>10 yyyy</td>
<td>10 yyyy</td>
<td>10 zzzzz</td>
</tr>
</tbody>
</table>

Where 

\[ uuuuu = vvvv + 1 \]

to account for the addition of 0x10000 as in Surrogates, section 3.7, of the Unicode Standard.

The range of code unit values 0x0000-0x00FF is used to encode surrogate pairs; the above transformation combines a UTF-16 surrogate pair into a UTF-32 representation and encodes the resulting 21-bit value in UTF-8. Decoding reconstructs the surrogate pair.

RFC 3629 prohibits the decoding of invalid UTF-8 octet sequences. For example, the invalid sequence C0 80 must not decode into the character U+0000. Implementations of the Decode algorithm are required to throw a URIError when encountering such invalid sequences.

15.1.3.1 decodeURI(encodedURI)

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

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

1. Let uriString be ToString(encodedURI).
2. ReturnIfAbrupt(uriString).
3. Let reservedURISet be a String containing one instance of each character valid in uriReserved plus "#".
4. Return the result of calling Decode(uriString, reservedURISet)

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

15.1.3.2 decodeURIComponent (encodedURIComponent)

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

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

1. Let componentString be ToString(encodedURIComponent).
2. ReturnIfAbrupt(componentString).
3. Let reservedURIComponentSet be the empty String.
4. Return the result of calling Decode(componentString, reservedURIComponentSet)

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

15.1.3.3 encodeURIComponent (uriComponent)

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

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

1. Let componentString be ToString(uriComponent).
2. ReturnIfAbrupt(componentString).
3. Let unescapedURIComponentSet be a String containing one instance of each character valid in uriUnescaped.
4. Return the result of calling Encode(componentString, unescapedURIComponentSet)

NOTE The character "#" is not encoded to an escape sequence even though it is not a reserved or unescaped URI character.

15.1.4 Constructor Properties of the Global Object

15.1.4.1 Object ( . . . )

See 15.2.1 and 15.2.2.

15.1.4.2 Function ( . . . )

See 15.3.1.
15.1.4.3 Array ( ... )  
See 15.4.1.
15.1.4.4 String ( ... )  
See 15.5.1 and 15.5.2.
15.1.4.5 Boolean ( ... )  
See 15.6.1 and 15.6.2.
15.1.4.6 Number ( ... )  
See 15.7.1 and 15.7.2.
15.1.4.7 Date ( ... )  
See 15.9.2.
15.1.4.8 RegExp ( ... )  
See 15.10.3 and 15.10.4.
15.1.4.9 Error ( ... )  
See 15.11.1 and 15.11.2.
15.1.4.10 EvalError ( ... )  
See 15.11.6.1.
15.1.4.11 RangeError ( ... )  
See 15.11.6.2.
15.1.4.12 ReferenceError ( ... )  
See 15.11.6.3.
15.1.4.13 SyntaxError ( ... )  
See 15.11.6.4.
15.1.4.14 TypeError ( ... )  
See 15.11.6.5.
15.1.4.15 URIError ( ... )  
See 15.11.6.6.
15.1.4.16 Map ( ... )  
See 15.14.3.
15.1.4.17 WeakMap ( ... )  
See 15.15.3.
15.1.4.18 `Set(...)`
See 15.16.3.

15.1.5 Other Properties of the Global Object

15.1.5.1 Math
See 15.8.

15.1.5.2 JSON
See 15.12.

15.2 Object Objects

15.2.1 The Object Constructor Called as a Function

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

15.2.1.1 `Object([value])`

When the `Object` function is called with no arguments or with one argument `value`, the following steps are taken:

1. If `value` is `null`, `undefined` or not supplied, return the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.
2. Return `ToObject(value)`.

15.2.2 The Object Constructor

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

15.2.2.1 `new Object([value])`

When the `Object` constructor is called with no arguments or with one argument `value`, the following steps are taken:

1. If `value` is supplied, then
   a. If `Type(value)` is `Object`, then return `value`.
   b. If `Type(value)` is `String`, return `ToObject(value)`.
   c. If `Type(value)` is `Boolean`, return `ToObject(value)`.
   d. If `Type(value)` is `Number`, return `ToObject(value)`.
2. Assert: The argument `value` was not supplied or its type was `null` or `Undefined`.
3. Return the result of the abstract operation `ObjectCreate` with the intrinsic object `%ObjectPrototype%` as its argument.

15.2.3 Properties of the Object Constructor

The value of the `[Prototype]` internal data property of the Object constructor is the standard built-in Function prototype object.

Besides the `length` property (whose value is 1), the Object constructor has the following properties:

15.2.3.1 `Object.prototype`

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

### 15.2.3.2 Object.getPrototypeOf (O)

When the `getPrototypeOf` function is called with argument `O`, the following steps are taken:

1. If `Type(O)` is not Object throw a `TypeError` exception.
2. Return the result of calling the [[Inheritance]] internal method of `O`.

### 15.2.3.3 Object.getOwnPropertyDescriptor (O, P)

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

1. If `Type(O)` is not Object throw a `TypeError` exception.
2. Let `key` be `ToPropertyKey(P)`.
3. ReturnIfAbrupt(`key`).
4. Let `desc` be the result of calling the [[GetOwnProperty]] internal method of `O` with argument `key`.
5. ReturnIfAbrupt(`desc`).
6. Return the result of calling FromPropertyDescriptor(`desc`) (8.2.5.4).

### 15.2.3.4 Object.getOwnPropertyNames (O)

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

1. If `Type(O)` is not Object, throw a `TypeError` exception.
2. Let `keys` be the result of calling the [[OwnPropertyKeys]] internal method of `O`.
3. ReturnIfAbrupt(`keys`).
4. Let `nameList` be a new empty List.
5. Let `getAllNames` be false.
6. Repeat while `getAllNames` is false
   a. Let `next` be the result of `invoke(keys, "next")`.
   b. ReturnIfAbrupt(`next`).
   c. If `Type(`next`)` is not Object, then throw a `TypeError` exception.
   d. Let `done` be `IteratorComplete(`next`).
   e. ReturnIfAbrupt(`done`).
   f. If `done` is true, then let `getAllNames` be true.
   g. else
      i. Let `nextKey` be `IteratorValue(`next`).
      ii. ReturnIfAbrupt(`nextKey`).
      iii. If `Type(`nextKey`)` is String, then
         1. Append `nextKey` as the last element of `nameList`.
7. Return `CreateArrayFromList(keys)`.

### 15.2.3.5 Object.create (O [, Properties])

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

1. If `Type(O)` is not Object or Null throw a `TypeError` exception.
2. Let `obj` be the result of the abstract operation `ObjectCreate` with argument `O`.
3. If the argument `Properties` is present and not `undefined`, then
   a. Return the result of the abstract operation `ObjectDefineProperties` with arguments `obj` and `Properties`.
4. Return `obj`.

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

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

1. If `Type(O)` is not Object throw a `TypeError` exception.
2. Let name be ToPropertyKey(P).
3. ReturnIfAbrupt(name).
4. Let desc be the result of calling ToPropertyDescriptor with Attributes as the argument.
5. ReturnIfAbrupt(desc).
6. Let success be the result of DefinePropertyOrThrow(O, name, desc).
7. ReturnIfAbrupt(success).
8. Return O.

15.2.3.7 Object.defineProperties ( O, Properties )

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

1. Return the result of the abstract operation ObjectDefineProperties with arguments O and Properties.

Runtime Semantics: ObjectDefineProperties Abstract Operation

The abstract operation ObjectDefineProperties with arguments O and Properties performs the following steps:

1. If Type(O) is not Object throw a TypeError exception.
2. Let props be ToObject(Properties).
3. Let names be an internal list containing the keys of each enumerable own property of props.
4. Let descriptors be an empty internal List.
5. For each element P of names in list order,
   a. Let descObj be the result of Get(props, P).
   b. ReturnIfAbrupt(descObj).
   c. Let desc be the result of calling ToPropertyDescriptor with descObj as the argument.
   d. ReturnIfAbrupt(desc).
   e. Append the pair (a two element List) consisting of P and desc to the end of descriptors.
6. Let pendingException be undefined.
7. For each pair from descriptors in list order,
   a. Let P be the first element of pair.
   b. Let desc be the second element of pair.
   c. Let status be the result of DefinePropertyOrThrow(O, P, desc).
   d. If status is an Abrupt Completion then
      i. If pendingException is undefined, then set pendingException to status.
8. ReturnIfAbrupt(pendingException).
9. Return O.

If an implementation defines a specific order of enumeration for the for-in statement, that same enumeration order must be used to order the list elements in step 3 of this algorithm.

NOTE An exception in defining an individual property in step 7 does not terminate the process of defining other properties. All valid property definitions are processed.

15.2.3.8 Object.seal ( O )

When the seal function is called, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Let status be the result of calling the [[SetIntegrity]] internal methods of O with argument "sealed".
3. ReturnIfAbrupt(status).
4. If status is false, throw a TypeError exception.
5. Return O.

15.2.3.9 Object.freeze ( O )

When the freeze function is called, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Let status be the result of calling the [[SetIntegrity]] internal methods of O with argument "frozen".
3. ReturnIfAbrupt(status).
4. If status is false, throw a TypeError exception.
5. Return O.

15.2.3.10 Object.preventExtensions (O)

When the preventExtensions function is called, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Let status be the result of calling the [[SetIntegrity]] internal method of O with argument "nonextensible".
3. ReturnIfAbrupt(status).
4. If status is false, throw a TypeError exception.
5. Return O.

15.2.3.11 Object.isSealed (O)

When the isSealed function is called with argument O, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Return the result of calling the [[HasIntegrity]] internal methods of O with argument "sealed".

15.2.3.12 Object.isFrozen (O)

When the isFrozen function is called with argument O, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Return the result of calling the [[HasIntegrity]] internal methods of O with argument "frozen".

15.2.3.13 Object.isExtensible (O)

When the isExtensible function is called with argument O, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Return the result of isExtensible(O).

15.2.3.14 Object.keys (O)

When the keys function is called with argument O, the following steps are taken:

1. If Type(O) is not Object throw a TypeError exception.
2. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of O.
3. ReturnIfAbrupt(keys).
4. Let nameList be a new empty List.
5. Let gotAllNames be false.
6. Repeat while gotAllNames is false,
   a. Let next be the result of Invoke(keys, "next").
   b. ReturnIfAbrupt(next).
   c. If Type(next) is not Object, then throw a TypeError exception.
   d. Let done be IteratorComplete(next).
   e. ReturnIfAbrupt(done).
   f. If done is true, then let gotAllNames be true.
   g. Else,
      i. Let nextKey be IteratorValue(next).
      ii. ReturnIfAbrupt(nextKey).
      iii. If Type(nextKey) is String, then
           1. Let desc be the result of calling the [[GetOwnProperty]] internal method of O with argument nextKey.
           2. ReturnIfAbrupt(desc).
           3. If desc is not undefined and desc [[Enumerable]] is true, then
              a. Append nextKey as the last element of nameList.
7. Return CreateArrayFromList(keys).

If an implementation defines a specific order of enumeration for the for-in statement, the same order must be used for the elements of the array returned in step 7.

15.2.3.15 Object.getOwnPropertyKeys (O)

When the getOwnPropertyKeys function is called with argument O, the following steps are taken:

1. If Type(O) is not Object, throw a TypeError exception.
2. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of O.
3. Return keys.

**TODO:**
- May need to say something about order of enumeration and post call property additions and deletions

15.2.3.16 Object.is (value1, value2)

When the is function is called with arguments value1 and value2 the following steps are taken:

1. Return SameValue(value1, value2).

15.2.3.17 Object.assign (target, source)

**TODO:**
- Only enumerable own properties of source
- Invoke [[Get]] on property list derived from source, for each property in list [[Put]] on target
- private names are not copied
- unique names are copied
- super mechanism (rebind super)
- Returns modified “target”

15.2.3.18 Object.mixin (target, source)

Don’t have TC39 consensus on including this or its name. However, there appears to be strong interest both within TC39 and on es-discuss and reasonable use cases. “mixin” seems to be the favorite name from es-discuss, although concerns have been raised that it might clash with some existing libraries.

**TODO:**
- All non-private properties of source
- Uses [[GetOwnProperty]][[DefineOwnProperty]]
- private symbols are not copied
- non-symbols are copied
super mechanism (rebind super)
Returns modified “target”

15.2.3.2 Object.setPrototypeOf ( O, proto )

When the setPrototypeOf function is called with arguments O and proto, the following steps are taken:

1. If Type(O) is not Object, then throw a TypeError exception.
2. If Type(proto) is neither Object or Null, then throw a TypeError exception.
3. Let status be the result of calling the [[SetInheritance]] internal method of O with argument proto.
4. ReturnIfAbrupt(status).
5. If status is false, then throw a TypeError exception.
6. Return O.

15.2.4 Properties of the Object Prototype Object

The Object prototype object is an ordinary object.

The value of the [[Prototype]] internal data property of the Object prototype object is null and the initial value of the [[Extensible]] internal data property is true.

15.2.4.1 Object.prototype.constructor

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

15.2.4.2 Object.prototype.toString ()

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

1. If the this value is undefined, return "[object Undefined]".
2. If the this value is null, return "[object Null]".
3. If Type(this value) is Symbol, then return "[object Symbol]".
4. Let O be the result of calling ToObject passing this value as the argument.
5. If O is an exotic Array object, then let builtinTag be "Array".
6. Else, if O is an exotic String object, then let builtinTag be "String".
7. Else, if O is an exotic arguments object, then let builtinTag be "Arguments".
8. Else, if O is an ordinary function object, a built-in function object, or a bound function exotic object, then let builtinTag be "Function".
9. Else, if O has a [[ErrorData]] internal data property, then let builtinTag be "Error".
10. Else, if O is a [[BooleanData]] internal data property, then let builtinTag be "Boolean".
11. Else, if O has a [[NumberData]] internal data property, then let builtinTag be "Number".
12. Else, if O has a [[BigIntData]] internal data property, then let builtinTag be "BigInt".
13. Else, if O has a [[RegExpMatcher]] internal data property, then let builtinTag be "RegExp".
14. Else, if O has a [[MathTag]] internal data property, then let builtinTag be "Math".
15. Else, if O has a [[JSONTag]] internal data property, then let builtinTag be "JSON".
16. Else, let builtinTag be "Object".
17. Let hasTag be the result of HasProperty(O, @@toStringTag).
18. ReturnIfAbrupt(hasTag).
19. If hasTag is false, then let tag be builtinTag.
20. Else,
   a. Let tag be the result of Get(O, @@toStringTag).
   b. If tag is an abrupt completion, let tag be NormalCompletion("???").
   c. Let tag be tag.[[value]].
   d. If Type(tag) is not String, let tag be "???".

Commented [AWB14150]: Need to decide how to tag the Math object
Commented [AWB14151]: Need to decide how to tag the JSON object
e. If tag is any of "Arguments", "Array", "Boolean", "Date", "Error", "Function", "JSON", "Math", "Number", "RegExp", or "String" and SameValue(tag, builtinTag) is false, then let tag be the string value "~" concatenated with the current value of tag.

21. Return the String value that is the result of concatenating the three Strings "[object ", tag, and "]".

NOTE Historically, this function was occasionally used to access the string value of the [[Class]] internal data property that was used in previous editions of this specification as a nominal type tag for various built-in objects. The above definition of toString preserves the ability to use it as a reliable test for those specific kinds of built-in objects but it does not provide a reliable type testing mechanism for other kinds of built-in or program defined objects.

15.2.4.3 Object.prototype.toLocaleString ()

When the toLocaleString method is called, the following steps are taken:

1. Let O be the this value.
2. ReturnIfAbrupt(O).
3. Return the result of Invoke(O, "toString").

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

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

15.2.4.4 Object.prototype.valueOf ()

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

1. Let O be the result of calling ToObject passing the this value as the argument.
2. Return O.

15.2.4.5 Object.prototype.hasOwnProperty (V)

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

1. Let P be ToPropertyKey(V).
2. ReturnIfAbrupt(P).
3. Let O be the result of calling ToObject passing the this value as the argument.
4. ReturnIfAbrupt(O).
5. Return the result of calling the [[HasOwnProperty]] internal method of O passing P as the argument.

NOTE The ordering of steps 1 and 3 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the this value is undefined or null.

15.2.4.6 Object.prototype.isPrototypeOf (V)

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

1. If V is not an object, return false.
2. Let O be the result of calling ToObject passing the this value as the argument.
3. ReturnIfAbrupt(O).
4. Repeat
   a. Let V be the result of calling the [[GetInheritance]] internal method of V with no arguments.
   b. if V is null, return false
   c. If O and V refer to the same object, return true.

NOTE The ordering of steps 1 and 2 is chosen to preserve the behaviour specified by previous editions of this specification for the case where V is not an object and the this value is undefined or null.
15.2.4.7 Object.prototype.propertyIsEnumerable (V)

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

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

**NOTE 1** This method does not consider objects in the prototype chain.

**NOTE 2** The ordering of steps 1 and 2 is chosen to ensure that any exception that would have been thrown by step 1 in previous editions of this specification will continue to be thrown even if the this value is `undefined` or `null`.

15.2.5 Properties of Object Instances

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

15.3 Function Objects

15.3.1 The Function Constructor

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. However, if the this value passed in the call is an Object with an `[[Code]]` internal data property whose value is `undefined`, it initializes the this value using the argument values. This permits `Function` to be used both as factory method and to perform constructor instance initialization.

`Function` may be subclassed and subclass constructors may perform a super invocation of the `Function` constructor to initialize subclass instances. However, all syntactic forms for defining function objects create instances of `Function`. There is no syntactic means to create instances of `Function` subclasses except for the built-in `Generator Function` subclass.

15.3.1.1 Function (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 argCount be the total number of arguments passed to this function invocation.
2. Let P be the empty String.
3. If argCount = 0, let bodyText be the empty String.
4. Else if argCount = 1, let bodyText be that argument.
5. Else argCount > 1, 
   a. Let firstArg be the first argument.
   b. Let P be ToString(firstArg).
   c. ReturnIfAbrupt(P).
   d. Let k be 2.
   e. Repeat, while k < argCount
      i. Let nextArg be the k’th argument.
      ii. Let nextArgString be ToString(nextArg).
      iii. ReturnIfAbrupt(nextArgString).
iv. Let P be the result of concatenating the previous value of P, the String "," (a comma), and nextArgString.

v. Increase k by 1.

f. Let bodyText be the k'th argument.

6. Let bodyText be ToString(bodyText).

7. ReturnIfAbrupt(bodyText).

8. Let parameters be the result of parsing P, interpreted as UTF-16 encoded Unicode text as described in 8.4, using FormalParameters as the goal symbol. Throw a SyntaxError exception if the parse fails.

9. Let body be the result of parsing bodyText, interpreted as UTF-16 encoded Unicode text as described in 8.4, using FunctionBody as the goal symbol. Throw a SyntaxError exception if the parse fails or if any static semantics errors are detected.

10. If funcBodyContainsYieldExpression is true, then throw a SyntaxError exception.

11. If IsSimpleParameterList of parameters is false and any element of the BoundNames of body also occurs in the VarDeclaredNames of body, then throw a SyntaxError exception.

12. If any element of the BoundNames of parameters also occurs in the LexicallyDeclaredNames of body, then throw a SyntaxError exception.

13. If bodyText is strict mode code (see 10.1.1) then let strict be true, else let strict be false.

14. Let scope be the Global Environment.

15. Let F be the this value.

16. If Type(F) is not Object or if F does not have a [[Code]] internal data property or if the value of [[Code]] is not undefined, then

   a. Let F be the result of calling FunctionAllocate with argument %FunctionPrototype%.

17. If the value of F's [[FunctionKind]] internal data property is not "normal", then throw a TypeError exception.

18. Perform the FunctionInitialize abstract operation with arguments F, Normal, parameters, body, scope, and strict.

19. Perform the abstract operation MakeConstructor with argument F.

20. Return F.

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

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

```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")
```

### 15.3.1.2 new Function (... argumentsList)

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

1. Let F be the Function function object on which the new operator was applied.

2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.

3. Return the result of OrdinaryConstruct (F, argumentsList).

If Function is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

### 15.3.2 Properties of the Function Constructor

The Function constructor is itself a built-in Function object. The value of the [[Prototype]] internal data property of the Function constructor is %FunctionPrototype%, the intrinsic Function prototype object (15.3.3).

The value of the [[Extensible]] internal data property of the Function constructor is true.

The Function constructor has the following properties:
15.3.2 Function.prototype

The value of `Function.prototype` is the `%FunctionPrototype%`, the intrinsic Function prototype object (15.3.3).

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

15.3.2.1 Function.prototype

15.3.2.2 Function.length

This is a data property with a value of 1. This property has the attributes { `[[Writable]]: false, `[[Enumerable]]: false, `[[Configurable]]: false }.

15.3.2.3 Function @@create ()

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the this value.
2. Let `proto` be the result of `GetPrototypeFromConstructor(F, "%FunctionPrototype%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `FunctionAllocate` with argument `proto`.
5. Return `obj`.

This property has the attributes { `[[Writable]]: false, `[[Enumerable]]: false, `[[Configurable]]: true }.

NOTE The `Function` `@@create` function is intentionally generic; it does not require that its this value be the `Function` constructor object. It can be transferred to other constructor functions for use as a `@@create` method. When used with other constructors, this function will create a exotic function object whose `[[Prototype]]` value is obtained from the associated constructor.

15.3.3 Properties of the Function Prototype Object

The Function prototype object is itself a Built-in Function object. When invoked, it accepts any arguments and returns `undefined`.

NOTE The Function prototype object is specified to be a function object to ensure compatibility with ECMAScript code that was created prior to the 6th Edition of this specification.

The value of the `[[Prototype]]` internal data property of the Function prototype object is the intrinsic object `%ObjectPrototype%` (15.2.4). The initial value of the `[[Extensible]]` internal data property of the Function prototype object is `true`.

The function prototype object does not have a `prototype` property.

The `length` property of the Function prototype object is 0.

15.3.3.1 Function.prototype.constructor

The initial value of `Function.prototype.constructor` is the intrinsic object `%Function%`.

15.3.3.2 Function.prototype.toString ()

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

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

When the apply method is called on an object func with arguments thisArg and argArray, the following steps are taken:

1. If IsCallable(func) is false, then throw a TypeError exception.
2. If argArray is null or undefined, then
   a. Return the result of calling the [[Call]] internal method of func, providing thisArg as thisArgument and an empty List of arguments as argumentsList.
3. If Type(argArray) is not Object, then throw a TypeError exception.
4. Let len be the result of Get(argArray, "length").
5. Let n be ToUint32(len).
6. ReturnIfAbrupt(n).
7. Let argList be an empty List.
8. Let index be 0.
9. Repeat while index < n
   a. Let indexName be ToString(index).
   b. Let nextArg be the result of Get(argArray, indexName).
   c. ReturnIfAbrupt(nextArg).
   d. Append nextArg as the last element of argList.
   e. Set index to index + 1.
10. Return the result of calling the [[Call]] internal method of func, providing thisArg as thisArgument and argList as argumentsList.

The length property of the apply method is 2.

NOTE The thisArg value is passed without modification as the this value. This is a change from Edition 3, where a undefined or null thisArg is replaced with the global object and ToObject is applied to all other values and that result is passed as the this value.

15.3.3.4 Function.prototype.call (thisArg [, arg1 [, arg2, …]])

When the call method is called on an object func with argument thisArg and optional arguments arg1, arg2 etc, the following steps are taken:

1. If IsCallable(func) is false, then throw a TypeError exception.
2. Let argList be an empty List.
3. If this method was called with more than one argument then in left to right order starting with arg1 append each argument as the last element of argList.
4. Return the result of calling the [[Call]] internal method of func, providing thisArg as thisArgument and argList as argumentsList.

The length property of the call method is 1.

NOTE The thisArg value is passed without modification as the this value. This is a change from Edition 3, where a undefined or null thisArg is replaced with the global object and ToObject is applied to all other values and that result is passed as the this value.

15.3.3.5 Function.prototype.bind (thisArg [, arg1 [, arg2, ...]])

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

1. Let Target be the this value.
2. If IsCallable(Target) is false, throw a TypeError exception.
3. Let A be a new (possibly empty) internal list consisting of all of the argument values provided after thisArg (arg1, arg2 etc), in order.
4. Let F be the result of the abstract operation BoundFunctionCreate with arguments Target, thisArg, and A.
5. If Target has a [[BoundTargetFunction]] internal data property, then
   a. Let targetLen be the result of GetTarget("length").
b. ReturnIfAbrupt(targetLen).

c. Let L be the larger of 0 and the result of \( \text{targetLen} \) minus the number of elements of A.

6. Else let \( L \) be 0.

7. Call the [[DefineOwnProperty]] internal method of \( F \) with arguments "\( \text{length} \)" and PropertyDescriptor
   \( {{\text{[[value]]}}: L, {\text{[[Writable]]}}: \text{false}, {\text{[[Enumerable]]}}: \text{false}, {\text{[[Configurable]]}}: \text{false}})\).

8. Perform the AddRestrictedFunctionProperties abstract operation with argument \( F \).

9. Return \( F \).

The \( \text{length} \) property of the bind method is 1.

NOTE Function objects created using Function.prototype.bind are exotic objects. They also do not have a
prototype property.

15.3.3.6 Function.prototype[@@create]()

The @@create method of an object \( F \) performs the following steps:

1. Return the result of calling OrdinaryCreateFromConstructor(\( F, "\%\text{ObjectPrototype}\%" \)).

NOTE This is default @@create method that is inherited by all ordinary constructor functions that do not explicitly
over-ride it.

15.3.3.7 Function.prototype[@@hasInstance](V)

When the @@hasInstance method of an object \( F \) is called with value \( V \), the following steps are taken:

1. Let \( F \) be the this value.
2. Return the result of OrdinaryHasInstance(\( F, V \)).

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

NOTE This is the default implementation of @@hasInstance that most functions inherit. @@hasInstance is called
by the instanceof operator to determine whether a value is an instance of a specific constructor. An expression such as
\( v \text{ instanceof } f \) evaluates as

\( F[@@hasInstance](v) \).

A constructor function can control which objects are recognize as its instances by instanceof by exposing a different
@@hasInstance method on the function.

This property is non-writable and non-configurable to prevent tampering that could be used to globally expose the target
function of a bound function.

15.3.4 Function Instances

Every function instance is an ordinary function object and has the internal data properties listed in Table 13.

Function instances that correspond to strict mode functions and function instances created using the
Function.prototype.bind method (15.3.3.5) have properties named caller and arguments that throw a
TypeError exception. An ECMAScript implementation must not associate any implementation specific
behaviour with accesses of these properties from strict mode function code.

The Function instances have the following properties:

15.3.4.1 length

The value of the \( \text{length} \) 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
15.3.4.2 prototype

Function instances that can be used used as a constructor have a prototype property. Whenever such a function instance is created another ordinary object is also created and is the initial value of the function’s prototype property. Unless otherwise specified, the value of the prototype property is used to initialise the [[Prototype]] internal data property of a newly created ordinary object before the Function object is invoked as a constructor for that newly created object.

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

NOTE Function objects created using Function.prototype.bind, or by evaluating a MethodDefinition (that is not a GeneratorMethod) or an ArrowFunction grammar production do not have a prototype property.

15.4 Array Objects

Array objects are exotic objects that give special treatment to a certain class of property names. See 8.4.3 for a definition of this special treatment.

An array object, O, is said to be sparse if the following algorithm returns true:

1. Let len be the result of Get(O, "length").
2. For each integer i in the range 0 ≤ i < ToUint32(len):
   a. Let elem be the result of calling the [[GetOwnProperty]] internal method of O with argument ToString(i).
   b. If elem is undefined, return true.
3. Return false.

15.4.1 The Array Constructor

The Array constructor is the %Array% intrinsic object and the initial value of the Array property of the global object. When Array is called as a function rather than as a constructor, it creates and initialises a new Array object. Thus the function call Array() is equivalent to the object creation expression new Array() with the same arguments. However, if the this value passed in the call is an Object with an [[ArrayInitialisationState]] internal data property whose value is undefined, it initializes the this value using the argument values. This permits Array to be used both as factory method and to perform constructor instance initialization.

Array may be subclassed and subclass constructors may perform a super invocation of the Array constructor to initialize subclass instances.

15.4.1.1 Array([item1, item2, …])

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

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

1. Let numberOfArgs be the number of arguments passed to this constructor call.
3. Let O be the this value.
4. If Type(O) is Object and O has a [[ArrayInitialisationState]] internal data property and the value of [[ArrayInitialisationState]] is false, then
   a. Set the value of O’s [[ArrayInitialisationState]] internal data property to true.
   b. Let array be O.
5. Else,
   a. Let F be this function.
   b. Let proto be the result of GetPrototypeFromConstructor(F, "%ArrayPrototype").
c. ReturnIfAbrupt(proto).
d. Let array be the result of the abstract operation ArrayCreate with arguments numberOfArgs and proto.
6. ReturnIfAbrupt(array).
7. Let \( k \) be 0.
8. Let items be a zero-originated List contain the argument items in order.
9. Repeat, while \( k < \) numberOfArgs
   a. Let \( P_k \) be ToString(\( k \)).
   b. Let item\( k \) be \( k \)th element of items.
   c. Let defineStatus be the result of DefinePropertyOrThrow(array, \( P_k \), Property Descriptor {[[Value]]: item\( k \), [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}).
   d. ReturnIfAbrupt(defineStatus).
   e. Increase \( k \) by 1.
10. Let putStatus be the result of Put(array, "length", numberOfArgs, true).
11. ReturnIfAbrupt(putStatus).
12. Return array.

15.4.1.2 Array (\( len \))

This description applies if and only if the Array constructor is given exactly one argument.

1. Let numberOfArgs be the number of arguments passed to this constructor call.
3. Let \( O \) be the this value.
4. If Type(\( O \)) is Object and \( O \) has a [[ArrayInitialisationState]] internal data property and the value of [[ArrayInitialisationState]] is false, then
   a. Set the value of \( O \)’s [[ArrayInitialisationState]] internal data property to true.
   b. Let array be \( O \).
5. Else,
   a. Let \( F \) be this function.
   b. Let proto be the result of GetPrototypeFromConstructor(\( F \), "ArrayPrototype").
   c. ReturnIfAbrupt(proto).
   d. Let array be the result of the abstract operation ArrayCreate with argument 0 and proto.
6. ReturnIfAbrupt(array).
7. If Type(\( len \)) is not Number, then
   a. Let defineStatus be the result of DefinePropertyOrThrow(array, "0", Property Descriptor {[[Value]]: \( len \), [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}).
   b. ReturnIfAbrupt(defineStatus).
   c. Let intLen be 1.
8. Else,
   a. Let intLen be ToUint32(\( len \)).
   b. If intLen ≠ \( len \), then throw a RangeError exception.
9. Let putStatus be the result of Put(array, "length", intLen, true).
10. ReturnIfAbrupt(putStatus).
11. Return array.

15.4.1.3 new Array (\( \ldots \) argumentsList)

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

1. Let \( F \) be the Array function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (\( F \), argumentsList).

If Array is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.
15.4.2 Properties of the Array Constructor

The value of the [[Prototype]] internal data property of the Array constructor is the Function prototype object (15.3.3).

Besides and the length property (whose value is 1), the Array constructor has the following properties:

15.4.2.1 Array.prototype

The value of Array.prototype is %ArrayPrototype% the intrinsic Array prototype object (15.4.3).

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false).

15.4.2.2 Array.isArray ( arg )

The isArray function takes one argument arg, and performs the following steps are taken:

1. If Type(arg) is not Object, return false.
2. If arg is an exotic Array object, then return true.
3. Return false.

15.4.2.3 Array.of ( ...items )

When the of method is called with any number of arguments, the following steps are taken:

1. Let lenValue be the result of Get(items, "length").
2. Let len be ToInteger(lenValue).
3. Let C be the this value.
4. If IsConstructor(C) is true, then
   a. Let newObj be the result of calling the [[Construct]] internal method of C with an argument list containing the single item len.
   b. Let A be ToObject(newObj).
5. Else,
   a. Let A be the result of the abstract operation ArrayCreate with argument len.
6. ReturnIfAbrupt(A).
7. Let k be 0.
8. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kValue be the result of Get(items, Pk).
   c. Let defineStatus be the result of DefinePropertyOrThrow(A, Pk, Property Descriptor ( [[Value]]: kValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true)).
   d. ReturnIfAbrupt(defineStatus).
   e. Increase k by 1.
9. Let putStatus be the result of Put(A, "length", len, true).
10. ReturnIfAbrupt(putStatus).
11. Return A.

The length property of the of method is 0.

NOTE 1 The items argument is assume to be a well-formed rest argument value.

NOTE 2 The of function is an intentionally generic factory method; it does not require that its this value be the Array constructor. Therefore it can be transferred to or inherited by other constructors that may be called with a single numeric argument.

15.4.2.4 Array.from ( arrayLike, mapFn=undefined, thisArg=undefined )

When the from method is called with argument arrayLike, the following steps are taken:

1. Let items be ToObject(arrayLike).

Commented [AWB7154]: It would be nice to have a more explicit way to create a collection with a pre-specified number of elements.
2. ReturnIfAbrupt(items).
3. Let lenValue be the result of Get(items, "length").
4. Let len be ToInteger(lenValue).
5. ReturnIfAbrupt(len).
6. Let C be the this value.
7. If IsConstructor(C) is true, then
   a. Let newObj be the result of calling the [[Construct]] internal method of C with an argument list containing the single item len.
   b. Let A be ToObject(newObj).
8. Else,
   a. Let A be the result of the abstract operation ArrayCreate with argument len.
9. ReturnIfAbrupt(A).
10. Let k be 0.
11. Repeat, while k < len
    a. Let Pk be ToString(k).
    b. Let kPresent be the result of HasProperty(items, Pk).
    c. ReturnIfAbrupt(kPresent).
    d. If kPresent is true, then
       i. Let kValue be the result of Get(items, Pk).
       ii. ReturnIfAbrupt(kValue).
       iii. Let defineStatus be the result of DefinePropertyOrThrow(A, Pk Property Descriptor
           { [[Value]]: kValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true
           }).
       iv. ReturnIfAbrupt(defineStatus).
    e. Increase k by 1.
12. Let putStatus be the result of Put(A, "length", len, true).
13. ReturnIfAbrupt(putStatus).
14. Return A.

NOTE The from function is an intentionally generic factory method; it does not require that its this value be the Array constructor. Therefore it can be transferred to or inherited by any other constructors that may be called with a single numeric argument.

15.4.2.5 Array( @@create ] ( )
The @@create method of an object F performs the following steps:
1. Let F be the this value.
2. Let proto be the result of GetPrototypeFromConstructor(F, "%ArrayPrototype%").
3. ReturnIfAbrupt(proto).
4. Let obj be the result of calling ArrayCreate with arguments undefined and proto.
5. Return obj.

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

NOTE 1 Passing undefined as the first argument to ArrayCreate causes the [[ArrayInitialisationState]] internal data property of the array to be initially assigned the value false. This is a flag used to indicate that the instance has not yet been initialized by the Array constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in any unobservable manner.

NOTE 2 The Array @@create function is intentionally generic; it does not require that its this value be the Array constructor object. It can be transferred to other constructor functions for use as a @@create method. When used with other constructors, this function will create an exotic Array object whose [[Prototype]] value is obtained from the associated constructor.

15.4.3 Properties of the Array Prototype Object
The value of the [[Prototype]] internal data property of the Array prototype object is the intrinsic object %ObjectPrototype%.
The Array prototype object is itself an ordinary object. It is not an Array instance and does not have a `length` property.

In following descriptions of functions that are properties of the Array prototype object, the phrase “this object” refers to the object that is the this value for the invocation of the function. It is permitted for the this object to be an object which is not an exotic Array object.

NOTE The Array prototype object does not have a `valueOf` property of its own; however, it inherits the `valueOf` property from the standard built-in `Object` prototype `Object`.

15.4.3.1 Array.prototype.constructor

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

15.4.3.2 Array.prototype.toString ()

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

1. Let `array` be the result of calling `ToObject` on the this value.
2. ReturnIfAbrupt(`array`).
3. Let `func` be the result of `Get(array, "join")`.
4. ReturnIfAbrupt(`func`).
5. If `IsCallable(func)` is false, then let `func` be the standard built-in method `Object.prototype.toString (15.2.4.2)`.
6. Return the result of calling the `[[Call]]` internal method of `func` providing `array` as thisArgument and an empty List as argumentsList.

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

15.4.3.3 Array.prototype.toLocaleString ()

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

The result is calculated as follows:

1. Let `array` be the result of calling `ToObject` passing the this value as the argument.
2. ReturnIfAbrupt(`array`).
3. Let `arrayLen` be the result of `Get(array, "length")`.
4. Let `len` be `ToUint32(arrayLen)`. ReturnIfAbrupt(`len`).
5. Let `separator` be the String value for the list-separator String appropriate for the host environment’s current locale (this is derived in an implementation-defined way).
6. If `len` is zero, return the empty String.
7. Let `firstElement` be the result of `Get(array, "0")`.
8. Let `nextElement` be the result of `Get(array, "\"\"`)`.
9. Let `noArgs` be an empty List.
10. ReturnIfAbrupt(`firstElement`).
11. If `firstElement` is undefined or null, then
   a. Let `R` be the empty String.
12. Else
   a. Let `R` be the result of `Invoke(firstElement, "toLocaleString")`.
   b. Let `R` be `ToString(R)`.
   c. ReturnIfAbrupt(`R`).
13. Let `k` be 1.
14. Repeat, while `k < len`
   a. Let `S` be a String value produced by concatenating `R` and `separator`.
b. Let nextElement be the result of Get(array, ToString(k)).

c. ReturnIfAbrupt(nextElement).

d. If nextElement is undefined or null, then
   i. Let R be the empty String.
   
   e. Else
      i. Let R be the result of Invoke(nextElement, "toLocaleString").
      ii. Let R be ToString(R).
   
   f. Let R be a String value produced by concatenating S and R.

g. Increase k by 1.

15. Return R.

NOTE 1 The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

NOTE 2 The toLocaleString function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the toLocaleString function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.4 Array.prototype.concat ([item1 [, item2 [, ...]]])

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

The following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let A be the result of the abstract operation ArrayCreate with argument 0.
4. Let n be 0.
5. Let items be an internal List whose first element is O and whose subsequent elements are, in left to right order, the arguments that were passed to this function invocation.

6. Repeat, while items is not empty
   a. Remove the first element from items and let E be the value of the element.
   
b. If E is an exotic Array object, then
      i. Let k be 0.
      ii. Let len be the result of Get(E, "length").
      iii. ReturnIfAbrupt(len).
      iv. Repeat, while k < len
          1. Let P be ToString(k).
          2. Let exists be the result of HasProperty(E, P).
          3. ReturnIfAbrupt(exists).
          4. If exists is true, then
             a. Let subElement be the result of Get(E, P).
             b. Call the [[DefineOwnProperty]] internal method of A with arguments
                ToString(n) and Property Descriptor {
                [[Value]]: subElement, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true
                }.
             5. Increase n by 1.
             6. Increase k by 1.
      c. Else E is not an Array,
          i. Call the [[DefineOwnProperty]] internal method of A with arguments
             ToString(n) and Property Descriptor {
             [[Value]]: E, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true
             }.
          ii. Increase n by 1.

7. Let putStatus be the result of Put(A, "length", n, true).
8. ReturnIfAbrupt(putStatus).
9. Return A.

The length property of the concat method is 1.
NOTE 1 The explicit setting of the `length` property in step 7 is necessary to ensure that its value is correct in situations where the trailing elements of the result `Array` are not present.

NOTE 2 The `concat` function is intentionally generic; it does not require that its `this` value be an `Array` object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the `concat` function can be applied successfully to an exotic object that is not an `Array` is implementation-dependent.

15.4.3.5 Array.prototype.join (separator)

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

The `join` method takes one argument, `separator`, and performs the following steps:

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`O`).
3. Let `lenVal` be the result of `Get(O, "length").
4. Let `len` be `ToUint32(lenVal).
5. ReturnIfAbrupt(`len`).
6. If `separator` is `undefined`, let `separator` be the single-character String ",".
7. Let `sep` be `ToString(separator).
8. If `len` is zero, return the empty String.
9. Let `element0` be the result of `Get(O, "0").
10. If `element0` is `undefined` or `null`, let `R` be the empty String; otherwise, let `R` be `ToString(element0).
11. ReturnIfAbrupt(`R`).
12. Let `k` be 1.
13. Repeat, while `k` < `len`:
   a. Let `S` be the String value produced by concatenating `R` and `sep`.
   b. Let `element` be the result of `Get(O, ToString(k)).
   c. If `element` is `undefined` or `null`, then let `next` be the empty String; otherwise, let `next` be `ToString(element).
   d. ReturnIfAbrupt(`next`).
   e. Let `R` be a String value produced by concatenating `S` and `next.
   f. Increase `k` by 1.

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

NOTE The `join` function is intentionally generic; it does not require that its `this` value be an `Array` object. Therefore, it can be transferred to other kinds of objects for use as a method. Whether the `join` function can be applied successfully to an exotic object that is not an `Array` is implementation-dependent.

15.4.3.6 Array.prototype.pop ()

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

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`O`).
3. Let `lenVal` be the result of `Get(O, "length").
4. Let `len` be `ToUint32(lenVal).
5. ReturnIfAbrupt(`len`).
6. If `len` is zero,:
   a. Let `putStatus` be the result of `Put(O, "length", 0, true).
   b. ReturnIfAbrupt(`putStatus`).
   c. Return `undefined`.
7. Else `len > 0`,
   a. Let `newLen` be `len` - 1.
   b. Let `indx` be `ToString(newLen).
   c. Let `element` be the result of `Get(O, indx).`
d. ReturnIfAbrupt(element).

e. Let deleteStatus be the result of DeletePropertyOrThrow(O, index).

f. ReturnIfAbrupt(deleteStatus).

g. Let putStatus be the result of Put(O, "length", newLen, true).

h. ReturnIfAbrupt(putStatus).

i. Return element.

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

15.4.3 Array.prototype.push ([item1 [, item2 [, ... ]]])

The arguments are appended to the end of the array, in the order in which they appear. The new length of the array is returned as the result of the call.

When the push method is called with zero or more arguments item1, item2, etc., the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.

2. ReturnIfAbrupt(O).

3. Let lenVal be the result of Get(O, "length").

4. Let n be ToUint32(lenVal).

5. ReturnIfAbrupt(n).

6. Let items be an internal List whose elements are, in left to right order, the arguments that were passed to this function invocation.

7. Repeat, while items is not empty
   a. Remove the first element from items and let E be the value of the element.
   b. Let putStatus be the result of Put(O, ToString(n), E, true).
   c. ReturnIfAbrupt(putStatus).
   d. Increase n by 1.

8. Let putStatus be the result of Put(O, "length", n, true).

9. ReturnIfAbrupt(putStatus).

10. Return n.

The length property of the push method is 1.

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

15.4.3.8 Array.prototype.reverse ()

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

1. Let O be the result of calling ToObject passing the this value as the argument.

2. ReturnIfAbrupt(O).

3. Let lenVal be the result of Get(O, "length").

4. Let len be ToUint32(lenVal).

5. ReturnIfAbrupt(len).

6. Let middle be floor(len/2).

7. Let lower be 0.

8. Repeat, while lower ≠ middle
   a. Let upper be len−lower−1.
   b. Let upperP be ToString(upper).
   c. Let lowerP be ToString(lower).
   d. Let lowerValue be the result of Get(O, lowerP).
   e. ReturnIfAbrupt(lowerValue).
   f. Let upperValue be the result of Get(O, upper).
11. Let reverse be the result of DeletePropertyOrThrow(O, toString(len–1)).
NOTE The `shift` function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the `shift` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.10 Array.prototype.slice (start, end)

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

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`O`).
3. Let `A` be the result of the abstract operation `ArrayCreate` with argument 0.
4. Let `lenVal` be the result of `Get(O, "length")`.
5. Let `len` be `ToUint32(lenVal)`.
6. ReturnIfAbrupt(`len`).
7. Let `relativeStart` be `ToInteger(start)`.
8. ReturnIfAbrupt(`relativeStart`).
9. If `relativeStart` is negative, let `k` be `max(((len - relativeStart) | 0), 0)`, else let `k` be `min(relativeStart, len)`.
10. If `end` is `undefined`, let `relativeEnd` be `len`, else let `relativeEnd` be `ToInteger(end)`.
11. ReturnIfAbrupt(`relativeEnd`).
12. If `relativeEnd` is negative, let `final` be `max(((len - relativeEnd) | 0), 0)`, else let `final` be `min(relativeEnd, len)`.
13. Let `n` be 0.
14. Repeat, while `k < final`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kPresent` be the result of `HasProperty(O, Pk)`.
   c. ReturnIfAbrupt(`kPresent`).
   d. If `kPresent` is `true`, then
      i. Let `kValue` be the result of `Get(O, Pk)`.
      ii. ReturnIfAbrupt(`kValue`).
      iii. Let `status` be the result of `CreateOwnProperty(A, ToString(n), kValue)`.
      iv. ReturnIfAbrupt(`status`).
      v. If `status` is `false`, throw a `TypeError` exception.
      c. Increase `k` by 1.
   f. Increase `n` by 1.
15. Let `putStatus` be the result of `Put(A, "length", n, true)`
16. ReturnIfAbrupt(`putStatus`).
17. Return `A`.

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

NOTE 1 The explicit setting of the `length` property of the result Array in step 15 is necessary to ensure that its value is correct in situations where the trailing elements of the result Array are not present.

NOTE 2 The `slice` function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the `slice` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.11 Array.prototype.sort (comparefn)

The elements of this array are sorted. The sort is not necessarily stable (that is, elements that compare equal do not necessarily remain in their original order). If `comparefn` is not `undefined`, it should be a function that accepts two arguments `x` and `y` and returns a negative value if `x < y`, zero if `x = y`, or a positive value if `x > y`. 

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Let `obj` be the result of calling `ToObject` passing the `this` value as the argument.

Let `len` be the result of applying `Uint32` to the result of `Get(obj, "length")`.

If `comparefn` is not `undefined` and is not a consistent comparison function for the elements of this array (see below), the behaviour of `sort` is implementation-defined.

Let `proto` be the result of calling the `[[GetInheritance]]` internal method of `obj`. If `proto` is not `null` and there exists an integer `j` such that all of the conditions below are satisfied then the behaviour of `sort` is implementation-defined:

- `obj` is sparse (15.4)
- `0 ≤ j < len`
- The result of `HasProperty(proto, ToString(j))` is `true`.

The behaviour of `sort` is also implementation defined if `obj` is sparse and any of the following conditions are true:

- The result of the predicate `IsExtensible(obj)` is `false`.
- Any array index property of `obj` whose name is a nonnegative integer less than `len` is a data property whose `[[Configurable]]` attribute is `false`.

The behaviour of `sort` is also implementation defined if any array index property of `obj` whose name is a nonnegative integer less than `len` is an accessor property or is a data property whose `[[Writable]]` attribute is `false`.

Otherwise, the following steps are taken.

1. Perform an implementation-dependent sequence of calls to the `[[Get]]` and `[[Set]]` internal methods of `obj`, to the `DeletePropertyOrThrow` abstract operation with `obj` as the first argument, and to `SortCompare` (described below), where the property key argument for each call to `[[Get]]`, `[[Set]]`, or `DeletePropertyOrThrow` is the string representation of a nonnegative integer less than `len` and where the arguments for calls to `SortCompare` are results of previous calls to the `[[Get]]` internal method. If `obj` is not sparse then `DeletePropertyOrThrow` must not be called. If any `[[Set]]` call returns `false`, a `TypeError` exception is thrown. If an abrupt completion is returned from any of these operations, it is immediately returned as the value of this function.

2. Return `obj`.

The returned object must have the following two properties.

- There must be some mathematical permutation `π` of the nonnegative integers less than `len`, such that for every nonnegative integer `j` less than `len`, if property `old[j]` existed, then `new[π(j)]` is exactly the same value as `old[j]`. But if property `old[j]` did not exist, then `new[π(j)]` does not exist.
- Then for all nonnegative integers `j` and `k`, each less than `len`, if `SortCompare(j, k) < 0` (see `SortCompare` below), then `π(j) < π(k)`.

Here the notation `old[j]` is used to refer to the hypothetical result of calling the `[[Get]]` internal method of `obj` with argument `j` before this function is executed, and the notation `new[j]` to refer to the hypothetical result of calling the `[[Get]]` internal method of `obj` with argument `j` after this function has been executed.

A function `comparefn` is a consistent comparison function for a set of values `S` if all of the requirements below are met for all values `a`, `b`, and `c` (possibly the same value) in the set `S`. The notation `a <c b` means `comparefn(a, b) < 0`; `a =c b` means `comparefn(a, b) = 0` (of either sign); and `a >c 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 <c b`, `a =c b`, and `a >c b` will be true for a given pair of `a` and `b`.
- Calling `comparefn(a, b)` does not modify the `this` object.
• \( a =_C a \) (reflexivity)
• If \( a =_C b \), then \( b =_C a \) (symmetry)
• If \( a =_C b \) and \( b =_C c \), then \( a =_C c \) (transitivity of \( =_C \))
• If \( a <_C b \) and \( b <_C c \), then \( a <_C c \) (transitivity of \( <_C \))
• If \( a >_C b \) and \( b >_C c \), then \( a >_C c \) (transitivity of \( >_C \))

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.

Runtime Semantics: SortCompare Abstract Operation

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

1. Let \( xString \) be ToString(\( j \)).
2. Let \( kString \) be ToString(\( k \)).
3. Let \( hasj \) be the result of HasProperty(obj, \( jString \)).
4. ReturnIfAbrupt(\( hasj \)).
5. Let \( hask \) be the result of HasProperty(obj, \( kString \)).
6. ReturnIfAbrupt(\( hask \)).
7. If \( hasj \) and \( hask \) are both \( false \), then return +0.
8. If \( hasj \) is \( false \), then return 1.
9. If \( hask \) is \( false \), then return –1.
10. Let \( x \) be the result of Get(obj, \( xString \)).
11. ReturnIfAbrupt(\( x \)).
12. Let \( y \) be the result of Get(obj, \( kString \)).
13. ReturnIfAbrupt(\( y \)).
14. If \( x \) and \( y \) are both \( undefined \), return +0.
15. If \( x \) is \( undefined \), return 1.
16. If \( y \) is \( undefined \), return –1.
17. If the argument comparefn is not \( undefined \), then
   a. If IsCallable(comparefn) is \( false \), throw a TypeError exception.
   b. Return the result of calling the [[Call]] internal method of comparefn passing undefined as thisArgument and with a List containing the values of \( x \) and \( y \) as the argumentsList.
18. Let \( xString \) be ToString(\( x \)).
19. ReturnIfAbrupt(\( xString \)).
20. Let \( yString \) be ToString(\( y \)).
21. ReturnIfAbrupt(\( yString \)).
22. If \( xString < yString \), return –1.
23. If \( xString > yString \), return 1.
24. Return +0.

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

NOTE 2 The sort function is intentionally generic; it does not require that its this value be an Array object. Therefore, it can be transferred to other kinds of objects for use as a method. Whether the sort function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

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

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

1. Let \( O \) be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(\( O \)).
3. Let \( A \) be the result of the abstract operation ArrayCreate with argument 0.
4. Let lenVal be the result of Get(O, "length")
5. Let len be ToUint32(lenVal).
6. ReturnIfAbrupt(len).
7. Let relativeStart be ToInteger(start).
8. ReturnIfAbrupt(relativeStart).
9. If relativeStart is negative, let actualStart be max((len + relativeStart),0); else let actualStart be min(relativeStart, len).
10. Let actualDeleteCount be min(max(ToInteger(deleteCount),0), len – actualStart).
11. Let k be 0.
12. Repeat, while k < actualDeleteCount
   a. Let from be ToString(actualStart+k).
   b. Let fromPresent be the result of HasProperty(O, from).
   c. ReturnIfAbrupt(fromPresent).
   d. If fromPresent is true, then
      i. Let fromValue be the result of Get(O, from).
      ii. ReturnIfAbrupt(fromValue).
      iii. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(k) and Property Descriptor {
           [[Value]]: fromValue, [[Writable]]: true, [[Enumerable]]: true, 
           [[Configurable]]: true
           }
   e. Increment k by 1.
13. Let putStatus be the result of Put(A, "length", actualDeleteCount, true).
14. ReturnIfAbrupt(putStatus).
15. Let items be an internal List whose elements are, in left to right order, the portion of the actual argument list starting with item1. The list will be empty if no such items are present.
16. Let itemCount be the number of elements in items.
17. If itemCount < actualDeleteCount, then
   a. Let k be actualStart.
   b. Repeat, while k < (len – actualDeleteCount)
      i. Let from be ToString(k+actualDeleteCount).
      ii. Let to be ToString(k+itemCount).
      iii. Let fromPresent be the result of HasProperty(O, from).
      iv. ReturnIfAbrupt(fromPresent).
      v. If fromPresent is true, then
         1. Let fromValue be the result of Get(O, from).
         2. ReturnIfAbrupt(fromValue).
         3. Let putStatus be the result of Put(O, to, fromValue, true).
         4. ReturnIfAbrupt(putStatus).
         v. Else fromPresent is false
            1. Let deleteStatus be the result of DeletePropertyOrThrow(O, to).
            2. ReturnIfAbrupt(deleteStatus).
      vii. Increase k by 1.
   c. Let k be len.
   d. Repeat, while k > (len – actualDeleteCount + itemCount)
      i. Let deleteStatus be the result of DeletePropertyOrThrow(O, ToString(k-1)).
      ii. ReturnIfAbrupt(deleteStatus).
      iii. Decrease k by 1.
18. Else if itemCount > actualDeleteCount, then
   a. Let k be (len – actualDeleteCount).
   b. Repeat, while k > actualStart
      i. Let from be ToString(k + actualDeleteCount – 1).
      ii. Let to be ToString(k + itemCount – 1)
      iii. Let fromPresent be the result of HasProperty(O, from).
      iv. ReturnIfAbrupt(fromPresent).
      v. If fromPresent is true, then
         1. Let fromValue be the result of Get(O, from).
         2. ReturnIfAbrupt(fromValue).
         3. Let putStatus be the result of Put(O, to, fromValue, true).
         4. ReturnIfAbrupt(putStatus).
      vi. Else fromPresent is false
          1. Let deleteStatus be the result of DeletePropertyOrThrow(O, to).
          2. ReturnIfAbrupt(deleteStatus).
      vii. Decrease k by 1.
19. Let \( k \) be actualStart.
20. Repeat, while items is not empty
   a. Remove the first element from items and let \( E \) be the value of that element.
   b. Let putStatus be the result of Put\((O, \text{ToString}(k), E, \text{true})\).
   c. ReturnIfAbrupt\( (\text{putStatus}) \).
   d. Increase \( k \) by 1.
21. Let putStatus be the result of Put\((O, \text{"length"}, len - actualDeleteCount + itemCount, \text{true})\).
22. ReturnIfAbrupt\( (\text{putStatus}) \).
23. Return \( A \).

The length property of the splice method is 2.

NOTE 1 The explicit setting of the length property of the result Array in step 13 is necessary to ensure that its value is correct in situations where its trailing elements are not present.

NOTE 2 The splice function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the splice function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.13 Array.prototype.unshift ([ item1 [ , item2 [ , ... ] ] ])
The arguments are prepended to the start of the array, such that their order within the array is the same as the order in which they appear in the argument list.

When the unshift method is called with zero or more arguments \( \text{item1}, \text{item2}, \text{etc.} \), the following steps are taken:

1. Let \( O \) be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt\( (O) \).
3. Let lenVal be the result of Get\((O, \text{"length"})\).
4. Let \( len \) be ToUint32\( (\text{lenVal}) \).
5. ReturnIfAbrupt\( (len) \).
6. Let \( \text{argCount} \) be the number of actual arguments.
7. Let \( k \) be \( len \).
8. Repeat, while \( k \) > 0
   a. Let from be ToString\((k - 1)\).
   b. Let to be ToString\((\text{argCount} - 1)\).
   c. Let fromPresent be the result of HasProperty\((O, \text{from})\).
   d. ReturnIfAbrupt\( (\text{fromPresent}) \).
   e. If fromPresent is \text{true}, then
      i. Let fromValue be the result of Get\((O, \text{from})\).
      ii. ReturnIfAbrupt\( (\text{fromValue}) \).
      iii. Let putStatus be the result of Put\((O, \text{to, fromValue, true})\).
      iv. ReturnIfAbrupt\( (\text{putStatus}) \).
   f. Else fromPresent is \text{false},
      i. Let deleteStatus be the result of DeletePropertyOrThrow\((O, \text{to})\).
      ii. ReturnIfAbrupt\( (\text{deleteStatus}) \).
   g. Decrease \( k \) by 1.
9. Let \( j \) be 0.
10. Let items be an internal List whose elements are, in left to right order, the arguments that were passed to this function invocation.
11. Repeat, while items is not empty
    a. Remove the first element from items and let \( E \) be the value of that element.
    b. Let putStatus be the result of Put\((O, \text{ToString}(j), E, \text{true})\).
    c. ReturnIfAbrupt\( (\text{putStatus}) \).
    d. Increase \( j \) by 1.
12. Let putStatus be the result of Put\((O, \text{"length"}, len + \text{argCount}, \text{true})\).
13. ReturnIfAbrupt\( (\text{putStatus}) \).
14. Return \( \text{len + argCount} \).
The length property of the unshift method is 1.

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

15.4.3.14 Array.prototype.indexOf ( searchElement [, fromIndex ])

indexOf compares searchElement to the elements of the array, in ascending order, using the internal Strict Equality Comparison Algorithm (11.9.1), and if found at one or more positions, returns the index of the first such position; otherwise, -1 is returned.

The optional second argument fromIndex defaults to 0 (i.e. the whole array is searched). If it is greater than or equal to the length of the array, the array will not be searched. If it is negative, it is used as the offset from the end of the array to compute fromIndex. If the computed index is less than 0, the whole array will be searched.

When the indexOf method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If len is 0, return -1.
7. If argument fromIndex was passed let n be ToInteger(fromIndex); else let n be 0.
8. ReturnIfAbrupt(n).
9. If n ≥ len, return -1.
10. If n ≥ 0, then
    a. Let k be n.
11. Else n<0.
    a. Let k be len - abs(n).
    b. If k < 0, then let k be 0.
12. Repeat, while k<len.
    a. Let kPresent be the result of HasProperty(O, ToString(k)).
    b. ReturnIfAbrupt(kPresent).
    c. If kPresent is true then
        i. Let elementK be the result of Get(O, ToString(k)).
        ii. ReturnIfAbrupt(elementK).
        iii. Let same be the result of performing the Strict Equality Comparison Algorithm searchElement === elementK.
        iv. If same is true, return k.
    d. Increase k by 1.

The length property of the indexOf method is 1.

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

15.4.3.15 Array.prototype.lastIndexOf ( searchElement [, fromIndex ])

lastIndexOf compares searchElement to the elements of the array in descending order using the internal Strict Equality Comparison Algorithm (11.9.1), and if found at one or more positions, returns the index of the last such position; otherwise, -1 is returned.

The optional second argument fromIndex defaults to the array's length minus one (i.e. the whole array is searched). If it is greater than or equal to the length of the array, the whole array will be searched. If it is
negative, it is used as the offset from the end of the array to compute fromIndex. If the computed index is less than 0, -1 is returned.

When the lastIndexOf method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If len is 0, return -1.
7. If argument fromIndex was passed let n be ToInteger(fromIndex); else let n be len - 1.
8. ReturnIfAbrupt(n).
9. If n ≥ 0, then let k be min(n, len - 1).
10. Else n < 0,
   a. Let k be len - abs(n).
   11. Repeat, while k ≥ 0
       a. Let kPresent be the result of HasProperty(O, ToString(k)).
       b. ReturnIfAbrupt(kPresent).
       c. If kPresent is true, then
          i. Let elementK be the result of Get(O, ToString(k)).
          ii. ReturnIfAbrupt(elementK).
          iii. Let same be the result of performing Strict Equality Comparison Algorithm
               searchElement === elementK.
          iv. If same is true, return k.
       d. Decrease k by 1.
   12. Return -1.

The length property of the lastIndexOf method is 1.

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

15.4.3.16 Array.prototype.every (callbackfn [ , thisArg ])

callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value true or false. every calls callbackfn once for each element present in the array, in ascending order, until it finds one where callbackfn returns false. If such an element is found, every immediately returns false. Otherwise, if callbackfn returned true for all elements, every will return true. callbackfn is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a thisArg parameter is provided, it will be used as the this value for each invocation of callbackfn. If it is not provided, undefined is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the object being traversed.

every does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

The range of elements processed by every is set before the first call to callbackfn. Elements which are appended to the array after the call to every begins will not be visited by callbackfn. If existing elements of the array are changed, their value as passed to callbackfn will be the value at the time every visits them; elements that are deleted after the call to every begins and before being visited are not visited. every acts like the "for all" quantifier in mathematics. In particular, for an empty array, it returns true.

When the every method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. If thisArg was supplied, let T be thisArg; else let T be undefined.
8. Let k be 0.
9. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be the result of HasProperty(O, Pk).
      c. If kPresent is true, then
         i. Let kValue be the result of Get(O, Pk).
         ii. ReturnIfAbrupt(kValue).
         iii. Let testResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing kValue, k, and O as argumentsList.
         iv. ReturnIfAbrupt(testResult).
         v. If ToBoolean(testResult) is false, return false.
   d. Increase k by 1.
10. Return true.

The length property of the every method is 1.

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

15.4.3.17 Array.prototype.some (callbackfn [, thisArg])
callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value true or false. some calls callbackfn once for each element present in the array, in ascending order, until it finds one where callbackfn returns true. If such an element is found, some immediately returns true. Otherwise, some returns false. callbackfn is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a thisArg parameter is provided, it will be used as the this value for each invocation of callbackfn. If it is not provided, undefined is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the object being traversed.

some does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

The range of elements processed by some is set before the first call to callbackfn. Elements that are appended to the array after the call to some begins will not be visited by callbackfn. If existing elements of the array are changed, their value as passed to callbackfn will be the value at the time that some visits them; elements that are deleted after the call to some begins and before being visited are not visited. some acts like the “exists” qualifier in mathematics. In particular, for an empty array, it returns false.

When the some method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. If thisArg was supplied, let T be thisArg; else let T be undefined.
8. Let k be 0.
9. Repeat, while k < len
a. Let Pk be ToString(k).
b. Let kPresent be the result of HasProperty(O, Pk).
c. ReturnIfAbrupt(kPresent).
d. If kPresent is true, then
   i. Let kValue be the result of Get(O, Pk).
   ii. ReturnIfAbrupt(kValue).
   iii. Let testResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing kValue, k, and O as argumentsList.
   iv. ReturnIfAbrupt(testResult).
   v. If ToBoolean(testResult) is true, return true.
e. Increase k by 1.

10. Return false.

The length property of the some method is 1.

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

15.4.3.18 Array.prototype.forEach (callbackfn [, thisArg])
callbackfn should be a function that accepts three arguments. forEach calls callbackfn once for each element present in the array, in ascending order. callbackfn is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a thisArg parameter is provided, it will be used as the this value for each invocation of callbackfn. If it is not provided, undefined is used instead.

forEach is called with three arguments: the value of the element, the index of the element, and the object being traversed.

forEach does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

The range of elements processed by forEach is set before the first call to callbackfn. Elements which are appended to the array after the call to forEach begins will not be visited by callbackfn. If existing elements of the array are changed, their value as passed to callback will be the value at the time forEach visits them; elements that are deleted after the call to forEach begins and before being visited are not visited.

When the forEach method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length")
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. If thisArg was supplied, let T be thisArg; else let T be undefined.
8. Let k be 0.
9. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be the result of HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be the result of Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let funcResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing kValue, k, and O as argumentsList.
      iv. ReturnIfAbrupt(funcResult).
   e. Increase k by 1.
10. Return `undefined`.

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

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

15.4.3.19 Array.prototype.map (callbackfn [ , thisArg ])

callbackfn should be a function that accepts three arguments. `map` calls `callbackfn` once for each element in the array, in ascending order, and constructs a new Array from the results. `callbackfn` is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a `thisArg` parameter is provided, it will be used as the `this` value for each invocation of `callbackfn`. If it is not provided, `undefined` is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the object being traversed.

`map` does not directly mutate the object on which it is called but the object may be mutated by the calls to `callbackfn`.

The range of elements processed by `map` is set before the first call to `callbackfn`. Elements which are appended to the array after the call to `map` begins will not be visited by `callbackfn`. If existing elements of the array are changed, their value as passed to `callbackfn` will be the value at the time `map` visits them; elements that are deleted after the call to `map` begins and before being visited are not visited.

When the `map` method is called with one or two arguments, the following steps are taken:

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`O`).
3. Let `lenValue` be the result of `Get(O, "length")`.
4. Let `len` be `ToUint32(lenValue)`.
5. ReturnIfAbrupt(`len`).
6. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
7. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
8. Let `A` be the result of the abstract operation `ArrayCreate` with argument `len`.
9. Let `k` be 0.
10. Repeat, while `k < len`
    a. Let `Pk` be `ToString(k)`.
    b. Let `kPresent` be the result of `HasProperty(O, Pk)`.
    c. ReturnIfAbrupt(`kPresent`).
    d. If `kPresent` is `true`, then
        i. Let `kValue` be the result of `Get(O, Pk)`.
        ii. ReturnIfAbrupt(`kValue`).
        iii. Let `mappedValue` be the result of calling the `[[Call]]` internal method of `callbackfn` with `T` as `thisArgument` and a List containing `kValue`, `k`, and `O` as `argumentsList`.
        iv. ReturnIfAbrupt(`mappedValue`).
        v. Call the `[[DefineOwnProperty]]` internal method of `A` with arguments `Pk` and Property Descriptor {`[[Value]]`: `mappedValue`, `[[Writable]]`: `true`, `[[Enumerable]]`: `true`, `[[Configurable]]`: `true`}.
    e. Increase `k` by 1.
11. Return `A`.

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

NOTE The `map` function is intentionally generic; it does not require that its `this` value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the `map` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.
15.4.3.20 Array.prototype.filter (callbackfn [, thisArg ])

callbackfn should be a function that accepts three arguments and returns a value that is coercible to the Boolean value true or false. 

filter calls callbackfn once for each element in the array, in ascending order, and constructs a new array of all the values for which callbackfn returns true. callbackfn is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a thisArg parameter is provided, it will be used as the this value for each invocation of callbackfn. If it is not provided, undefined is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the object being traversed.

filter does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

The range of elements processed by filter is set before the first call to callbackfn. Elements which are appended to the array after the call to filter begins will not be visited by callbackfn. If existing elements of the array are changed their value as passed to callbackfn will be the value at the time filter visits them; elements that are deleted after the call to filter begins and before being visited are not visited.

When the filter method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. If thisArg was supplied, let T be thisArg; else let T be undefined.
8. Let A be the result of the abstract operation ArrayCreate with argument 0.
9. Let k be 0.
10. Let to be 0.
11. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be the result of HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be the result of Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let selected be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing kValue, k, and O as argumentsList.
      iv. ReturnIfAbrupt(selected).
   e. If ToBoolean(selected) is true, then
      1. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(to)
         and Property Descriptor {[[Value]]: kValue, [[Writable]]: true, [[Enumerable]]: 
         true, [[Configurable]]: true).
      2. Increase to by 1.
   f. Increase k by 1.
12. Return A.

The length property of the filter method is 1.

NOTE The filter function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the filter function can be applied successfully to an exotic object that is not an Array is implementation-dependent.
15.4.3.21 `Array.prototype.reduce ( callbackfn [ , initialValue ] )`

`callbackfn` should be a function that takes four arguments. `reduce` calls the callback, as a function, once for each element present in the array, in ascending order.

`callbackfn` is called with four arguments: the `previousValue` (or value from the previous call to `callbackfn`), the `currentValue` (value of the current element), the `currentIndex`, and the object being traversed. The first time that `callback` is called, the `previousValue` and `currentValue` can be one of two values. If an `initialValue` was provided in the call to `reduce`, then `previousValue` will be equal to `initialValue` and `currentValue` will be equal to the first value in the array and `currentValue` will be equal to the second. It is a `TypeError` if the array contains no elements and `initialValue` is not provided.

`reduce` does not directly mutate the object on which it is called but the object may be mutated by the calls to `callbackfn`.

The range of elements processed by `reduce` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `reduce` begins will not be visited by `callbackfn`. If existing elements of the array are changed, their value as passed to `callbackfn` will be the value at the time `reduce` visits them; elements that are deleted after the call to `reduce` begins and before being visited are not visited.

When the `reduce` method is called with one or two arguments, the following steps are taken:

1. Let `O` be the result of calling `ToObject` passing the `this` value as the argument.
2. ReturnIfAbrupt(`O`).
3. Let `lenValue` be the result of `Get(`O`, "length").
4. Let `len` be `ToUint32(lenValue).
5. ReturnIfAbrupt(`len`).
6. If `IsCallable(callbackFn)` is false, throw a `TypeError` exception.
7. If `len` is 0 and `initialValue` is not present, throw a `TypeError` exception.
8. Let `k` be 0.
9. If `initialValue` is present, then
   a. Set `accumulator` to `initialValue`.
   b. Repeat, while `kPresent` is false and `k` < `len`
      i. Let `Pk` be `ToString(k)`.
      ii. Let `kPresent` be the result of `HasProperty(`O`, Pk).
      iii. ReturnIfAbrupt(`kPresent`).
      iv. If `kPresent` is true, then
         1. Let `accumulator` be the result of `Get(`O`, Pk)
         2. ReturnIfAbrupt(`accumulator`).
      v. Increase `k` by 1.
   c. If `kPresent` is false, throw a `TypeError` exception.
10. Else `initialValue` is not present, then
    a. Let `kPresent` be false.
    b. Repeat, while `k` % `len`< 0
       i. Let `Pk` be `ToString(k)`.
       ii. Let `kPresent` be the result of `HasProperty(`O`, Pk)
       iii. ReturnIfAbrupt(`kPresent`).
       d. If `kPresent` is true, then
          i. Let `kValue` be the result of `Get(`O`, Pk)
          ii. ReturnIfAbrupt(`kValue`).
          iii. Let `accumulator` be the result of calling the `[[Call]]` internal method of `callbackFn` with `undefined` as `thisArgument` and a List containing `accumulator`, `kValue`, `k`, and `O` as `argumentsList`
          iv. ReturnIfAbrupt(`accumulator`).
          e. Increase `k` by 1.
11. Repeat, while `k` % `len`< 0
    a. Let `Pk` be `ToString(k)`.
    b. Let `kPresent` be the result of `HasProperty(`O`, Pk)
    c. ReturnIfAbrupt(`kPresent`).
    d. If `kPresent` is true, then
       i. Let `kValue` be the result of `Get(`O`, Pk)
       ii. ReturnIfAbrupt(`kValue`).
       iii. Let `accumulator` be the result of calling the `[[Call]]` internal method of `callbackFn` with `undefined` as `thisArgument` and a List containing `accumulator`, `kValue`, `k`, and `O` as `argumentsList`
       iv. ReturnIfAbrupt(`accumulator`).
       e. Increase `k` by 1.
12. Return `accumulator`.

The `length` property of the `reduce` method is 1.
NOTE The reduce function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the reduce function can be applied successfully to an exotic object that is not an Array is implementation-dependent.

15.4.3.22 Array.prototype.reduceRight (callbackfn[, initialValue])

callbackfn should be a function that takes four arguments. reduceRight calls the callback, as a function, once for each element present in the array, in descending order.

callbackfn is called with four arguments: the previousValue (or value from the previous call to callbackfn), the currentValue (value of the current element), the currentIndex, and the object being traversed. The first time the function is called, the previousValue and currentValue can be one of two values. If an initialValue was provided in the call to reduceRight, then previousValue will be equal to initialValue and currentValue will be equal to the last value in the array. If no initialValue was provided, then previousValue will be equal to the last value in the array and currentValue will be equal to the second-to-last value. It is a TypeError if the array contains no elements and initialValue is not provided.

reduceRight does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

The range of elements processed by reduceRight is set before the first call to callbackfn. Elements that are appended to the array after the call to reduceRight begins will not be visited by callbackfn. If existing elements of the array are changed by callbackfn, their value as passed to callbackfn will be the value at the time reduceRight visits them; elements that are deleted after the call to reduceRight begins and before being visited are not visited.

When the reduceRight method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToUint32(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. If len is 0 and initialValue is not present, throw a TypeError exception.
8. Let k be len - 1.
9. If initialValue is present, then
   a. Set accumulator to initialValue.
10. Else initialValue is not present,
    a. Let kPresent be false.
    b. Repeat, while kPresent is false and k ≥ 0
      i. Let Pk be ToString(k).
      ii. Let kPresent be the result of HasProperty(O, Pk).
      iii. ReturnIfAbrupt(kPresent).
      iv. If kPresent is true, then
        1. Let accumulator be the result of Get(O, Pk).
        2. ReturnIfAbrupt(accumulator).
      v. Decrease k by 1.
    c. If kPresent is false, throw a TypeError exception.
11. Repeat, while k ≥ 0
    a. Let Pk be ToString(k).
    b. Let kPresent be the result of HasProperty(O, Pk).
    c. ReturnIfAbrupt(kPresent).
    d. If kPresent is true, then
      i. Let kValue be the result of Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let accumulator be the result of calling the [[Call]] internal method of callbackfn with undefined as thisArgument and a List containing accumulator, kValue, k, and O as argumentsList.
ReturnIfAbrupt(accumulator).

e. Decrease \( k \) by 1.

12. Return \( accumulator \).

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

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

15.4.3.23 `Array.prototype.find(predicate, thisArg = undefined)`

`predicate` should be a function that accepts three arguments and returns a value that is coercible to the Boolean value true or false. `find` calls `predicate` once for each element present in the array, in ascending order, until it finds one where `predicate` returns true. If such an element is found, `find` immediately returns that element value. Otherwise, `find` returns `undefined`. `predicate` is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a `thisArg` parameter is provided, it will be used as the this value for each invocation of `predicate`. If it is not provided, `undefined` is used instead.

`predicate` is called with three arguments: the value of the element, the index of the element, and the object being traversed.

`find` does not directly mutate the object on which it is called but the object may be mutated by the calls to `predicate`.

The range of elements processed by `find` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `find` begins will not be visited by `callbackfn`. If existing elements of the array are changed, their value as passed to `predicate` will be the value at the time that `find` visits them; elements that are deleted after the call to `find` begins and before being visited are not visited.

When the `find` method is called with one or two arguments, the following steps are taken:

1. Let \( O \) be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(\( O \)).
3. Let \( lenValue \) be the result of Get(\( O \), "length").
4. Let \( len \) be ToInteger(\( lenValue \)).
5. ReturnIfAbrupt(\( len \)).
6. If IsCallable(\( predicate \)) is false, throw a TypeError exception.
7. If \( thisArg \) was supplied, let \( T \) be \( thisArg \); else let \( T \) be undefined.
8. Let \( k \) be 0.
9. Repeat, while \( k < len \):
   a. Let \( Pk \) be ToString(\( k \)).
   b. Let \( kPresent \) be the result of HasProperty(\( O \), \( Pk \)).
   c. ReturnIfAbrupt(\( kPresent \)).
   d. If \( kPresent \) is true, then
      i. Let \( kValue \) be the result of Get(\( O \), \( Pk \)).
      ii. ReturnIfAbrupt(\( kValue \)).
      iii. Let `testResult` be the result of calling the [[Call]] internal method of `predicate` with \( T \) as thisArgument and a List containing \( kValue \), \( k \), and \( O \) as argumentsList.
      iv. If ToBoolean(`testResult`) is true, return \( kValue \).
   e. Increase \( k \) by 1.
10. Return `undefined`.

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

NOTE The `find` function is intentionally generic; it does not require that its this value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the `find` function can be applied successfully to an exotic object that is not an Array is implementation-dependent.
15.4.3.24 Array.prototype.findIndex ( predicate , thisArg = undefined )

predicate should be a function that accepts three arguments and returns a value that is coercible to the Boolean value true or false. findIndex calls predicate once for each element present in the array, in ascending order, until it finds one where predicate returns true. If such an element is found, findIndex immediately returns the index of that element value. Otherwise, findIndex returns -1. predicate is called only for elements of the array which actually exist; it is not called for missing elements of the array.

If a thisArg parameter is provided, it will be used as the this value for each invocation of predicate. If it is not provided, undefined is used instead.

findIndex 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; elements that are deleted after the call to findIndex begins and before being visited are not visited.

When the findIndex method is called with one or two arguments, the following steps are taken:

1. Let O be the result of calling ToObject passing the this value as the argument.
2. ReturnIfAbrupt(O).
3. Let lenValue be the result of Get(O, "length").
4. Let len be ToInteger(lenValue).
5. ReturnIfAbrupt(len).
6. If IsCallable(predicate) is false, throw a TypeError exception.
7. If thisArg was supplied, let T be thisArg; else let T be undefined.
8. Let k be 0.
9. Repeat, while k < len
   a. Let Pk be ToString(k).
   b. Let kPresent be the result of HasProperty(O, Pk).
   c. ReturnIfAbrupt(kPresent).
   d. If kPresent is true, then
      i. Let kValue be the result of Get(O, Pk).
      ii. ReturnIfAbrupt(kValue).
      iii. Let testResult be the result of calling the [[Call]] internal method of predicate with T as thisArgument and a List containing kValue, k, and O as argumentsList.
      iv. ReturnIfAbrupt(testResult).
   e. Increase k by 1.

The length property of the findIndex method is 1.

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

15.4.3.25 Array.prototype.entries ()

The following steps are taken:

1. Let O be the result of calling ToObject with the this value as its argument.
2. ReturnIfAbrupt(O).
3. Return the result of calling the CreateArrayIterator abstract operation with arguments O and "key+value".
15.4.3.26 Array.prototype.keys ( )

The following steps are taken:

1. Let O be the result of calling ToObject with the this value as its argument.
2. ReturnIfAbrupt(O).
3. Return the result of calling the CreateArrayIterator abstract operation with arguments O and "key".

15.4.3.27 Array.prototype.values ( )

The following steps are taken:

1. Let O be the result of calling ToObject with the this value as its argument.
2. ReturnIfAbrupt(O).
3. Return the result of calling the CreateArrayIterator abstract operation with arguments O and "value".

15.4.3.28 Array.prototype[@@iterator] ( )

The initial value of the @@iterator property is the same function object as the initial value of the Array.prototype.values property.

15.4.4 Properties of Array Instances

Array instances are exotic Array objects and have the internal methods specified for such objects. Array instances inherit properties from the Array prototype object. Array instances also have a [[ArrayInitialisationState]] internal data property.

Array instances have a length property, and a set of enumerable properties with array index names.

15.4.4.1 length

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

The length property initially has the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }.

NOTE Attempting to set the length property of an Array object to a value that is numerically less than or equal to the largest numeric property name of an existing array indexed non-deletable property of the array will result in the length being set to a numeric value that is one greater than that largest numeric property name. See 8.4.2.1.

15.4.5 Array Iterator Object Structure

An Array iterator is an object, with the structure defined below, that represent a specific iteration over some specific Array instance object. There is not a named constructor for Array iterator objects. Instead, Array iterator objects are created by calling certain methods of Array instance objects.

15.4.5.1 CreateArrayIterator Abstract Operation

Several methods of Array objects return iterator objects. The abstract operation CreateArrayIterator with arguments array and kind is used to create and such iterator objects. It performs the following steps:

1. Let O be the result of calling ToObject(array).
2. ReturnIfAbrupt(O).
3. Let itr be the result of the abstract operation ObjectCreate with the intrinsic object %ArrayIteratorPrototype% as its argument.
4. Add a [[IteratedObject]] internal data property to itr with value O.
5. Add a [[ArrayIteratorNextIndex]] internal data property to itr with value 0.
6. Add a [[ArrayIterationKind]] internal data property of itr with value kind.
7. Return itr.

Commented [AWB11161]: Need to decide whether to allow an argument that requests sparse iteration

Commented [AWB11162]: Need to decide whether to allow an argument that requests sparse iteration

Commented [AWB10163]: This is how we identify a property whose key is a built-in Symbol

Commented [AWB10164]: Do we really want to do this sort of method sharing. It has a bad smell.
15.4.5.2 The Array Iterator Prototype

All Array Iterator Objects inherit properties from a common Array Iterator Prototype object. The [[Prototype]] internal data property of the Array Iterator Prototype is the %ObjectPrototype% intrinsic object. In addition, the Array Iterator Prototype as the following properties:

15.4.5.2.1 Array.prototype.constructor

15.4.5.2.2 Array.prototype.next( )

1. Let O be the this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have all of the internal properties of a Array Iterator Instance (15.4.5.1.2), throw a TypeError exception.
4. Let a be the value of the [[IteratedObject]] internal data property of O.
5. Let index be the value of the [[ArrayIteratorNextIndex]] internal data property of O.
6. Let itemKind be the value of the [[ArrayIterationKind]] internal data property of O.
7. Let lenValue be the result of Get(a, "length").
8. Let len be ToUint32(lenValue).
9. ReturnIfAbrupt(len).
10. If itemKind contains the substring "sparse", then
    a. Let found be false.
    b. Repeat, while found is false and index < len
        i. Let elementKey be ToString(index).
        ii. Let found be the result of HasProperty(a, elementKey).
        iii. ReturnIfAbrupt(found).
        iv. If found is false, then
            1. Increase index by 1.
    11. If index ≥ len, then
        a. Set the value of the [[ArrayIteratorNextIndex]] internal data property of O to +∞.
        b. Return CreateItrResultObject(undefined, true).
    12. Let elementKey be ToString(index).
    13. Set the value of the [[ArrayIteratorNextIndex]] internal data property of O to index+1.
    14. If itemKind contains the substring "value", then
        a. Let elementValue be the result of Get(a, elementKey).
        b. ReturnIfAbrupt(elementValue).
    15. If itemKind contains the substring "key+value", then
        a. Let result be the result of the abstract operation ArrayCreate with argument 2.
        b. Assert: result is a new, well-formed Array object so the following operations will never fail.
        c. Call the [[DefineOwnProperty]] internal method of result with arguments "0" and Property Descriptor {
            [[Value]], "elementKey", [[Writable]], true, [[Enumerable]], true, [[Configurable]], true
        }.
        d. Call the [[DefineOwnProperty]] internal method of result with arguments "1" and Property Descriptor {
            [[Value]], "elementValue", [[Writable]], true, [[Enumerable]], true, [[Configurable]], true
        }.
        e. Return CreateItrResultObject(result, false).
    16. Else if itemKind contains the substring "key" then, return CreateItrResultObject(elementKey, false).
    17. Assert: itemKind contains the substring "value".
    18. Return CreateItrResultObject(elementValue, false).

15.4.5.2.3 Array.prototype[@@iterator ]

The following steps are taken:
1. Return the this value.
15.4.5.4  Array Iterator.prototype.@@toStringTag

The initial value of the @@toStringTag property is the string value "Array Iterator".

15.4.5.3 Properties of Array Iterator Instances

Array Iterator instances inherit properties from the Array Iterator prototype (the intrinsic, %ArrayIteratorPrototype%). Array Iterator instances are initially created with the internal properties listed in Table 33.

<table>
<thead>
<tr>
<th>Internal Data Property Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[IteratedObject]]</td>
<td>The object whose array elements are being iterated.</td>
</tr>
<tr>
<td>[[ArrayIteratorNextIndex]]</td>
<td>The integer index of the next array index to be examined by this iteration.</td>
</tr>
<tr>
<td>[[ArrayIterationKind]]</td>
<td>A string value that identifies what is to be returned for each element of the iteration. The possible values are: &quot;key&quot;, &quot;value&quot;, &quot;key+value&quot;, &quot;sparse:key&quot;, &quot;sparse:value&quot;, &quot;sparse:key+value&quot;.</td>
</tr>
</tbody>
</table>

15.5 String Objects

15.5.1 The String Constructor Called as a Function

When String is called as a function rather than as a constructor, it performs a type conversion. However, if the this value passed in the call is an Object with an uninitialized [[StringData]] internal data property, it initializes the this value using the argument value. This permits String to be used both to perform type conversion and to perform constructor instance initialization.

String may be subclassed and subclass constructors may perform a super invocation of the String constructor to initialize the [[StringData]] state of subclass instances.

15.5.1.1 String ( [ value ] )

Returns a String value (not a String object) computed by ToString(value). If value is not supplied, the empty String "" is returned.

When String is called with argument value, the following steps are taken:

1. Let O be the this value.
2. If no arguments were passed to this function invocation, then let s be "".
3. Else, let s be ToString(value).
4. ReturnIfAbrupt(s).
5. If Type(O) is Object and O has a [[StringData]] internal data property and the value of [[StringData]] is undefined, then
   a. Let length be the number of code unit elements in s.
   b. Let status be the result of DefinePropertyOrThrow(O, "length", Property Descriptor:[[Value]: length, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false]).
   c. ReturnIfAbrupt(status).
   d. Set the value of O's [[StringData]] internal data property to s.
   e. Return O.
6. Return s.
15.5.2 The String Constructor

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

15.5.2.1 new String (value)

String called as part of a new expression with optional argument value performs the following steps:

1. Let F be the String function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (F, argumentsList).

If String is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.5.3 Properties of the String Constructor

The value of the [[Prototype]] internal data property of the String constructor is the standard built-in Function prototype object (15.3.3).

Besides the length property (whose value is 1), the String constructor has the following properties:

15.5.3.1 String.prototype

The initial value of String.prototype is the standard built-in String prototype object (15.5.4).

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

15.5.3.2 String.fromCharCode(...codeUnits)

The String.fromCharCode function may be called with a variable number of arguments which form the rest parameter codeUnits. The following steps are taken:

1. Assert: codeUnits is a well-formed rest parameter object.
2. Let length be the result of Get(codeUnits, "length").
3. Let elements be a new List.
4. Let nextIndex be 0.
5. Repeat while nextIndex < length
   a. Let next be the result of Get(codeUnits, ToString(nextIndex)).
   b. Let nextCU be ToUint16(next).
   c. ReturnIfAbrupt(nextCU).
   d. Append nextCU to the end of elements.
   e. Let nextIndex be nextIndex + 1.
6. Return the String value whose elements are, in order, the elements in the List elements. If length is 0, the empty string is returned.

The length property of the fromCharCode function is 1.

15.5.3.3 String.fromCodePoint (...codePoints)

The String.fromCharCode function may be called with a variable number of arguments which form the rest parameter codePoints. The following steps are taken:

1. Assert: codePoints is a well-formed rest parameter object.
2. Let length be the result of Get(codePoints, "length").
3. Let elements be a new List.
4. Let nextIndex be 0.
5. Repeat while nextIndex < length
   a. Let next be the result of Get(codePoints, ToString(nextIndex)).
   b. Let nextCP be ToNumber(next).
   c. ReturnIfAbrupt(nextCP).
   d. If SameValue(nextCP, ToInteger(nextCP)) is false, then throw a RangeError exception.
   e. If nextCP < 0 or nextCP > 0x10FFFF, then throw a RangeError exception.
   f. Append the elements of the UTF-16 Encoding (clause 6) of nextCP to the end of elements.
   g. Let nextIndex be nextIndex + 1.
6. Return the String value whose elements are, in order, the elements in the List elements. If length is 0, the empty string is returned.

The length property of the fromCodePoint function is 0.

15.5.3.4 String.raw (callSite, ...substitutions)

The String.raw function may be called with a variable number of arguments. The first argument is callSite and the remainder of the arguments form the rest parameter substitutions. The following steps are taken:

1. Assert: substitutions is a well-formed rest parameter object.
2. Let cooked be ToObject(callSite).
3. ReturnIfAbrupt(cooked).
4. Let rawValue be the result of Get(cooked, "raw").
5. Let raw be ToObject(rawValue).
6. ReturnIfAbrupt(raw).
7. Let len be the result of Get(raw, "length").
8. Let literalSegments be ToUint(len).
9. ReturnIfAbrupt(literalSegments).
10. If literalSegments = 0, then return the empty string.
11. Let stringElements be a new List.
12. Let nextIndex be 0.
13. Repeat
   a. Let nextKey be ToString(nextIndex).
   b. Let next be the result of Get(rawValue, nextKey).
   c. Let nextSeg be ToString(next).
   d. ReturnIfAbrupt(nextSeg).
   e. Append in order the code unit elements of nextSeg to the end of stringElements.
   f. If nextIndex + 1 = literalSegments, then
      1. Return the string value whose elements are, in order, the elements in the List stringElements. If length is 0, the empty string is returned.
   g. Let next be the result of Get(substitutions, nextKey).
   h. Let nextSub be ToString(next).
   i. ReturnIfAbrupt(nextSub).
   j. Append in order the code unit elements of nextSub to the end of stringElements.
   k. Let nextIndex be nextIndex + 1.

The length property of the raw function is 1.

NOTE String.raw is intended for use as a tag function of a Tagged Template String (11.2.6). When called as such the first argument will be a well formed template call site object and the rest parameter will contain the substitution values.

15.5.3.5 String[@@create]()

The @@create method of an object F performs the following steps:

1. Let F be the this value.
2. Let proto be the result of GetPrototypeFromConstructor(F, "%StringPrototype").
3. ReturnIfAbrupt(proto).
4. Let obj be the result of calling StringCreate(proto).
5. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

NOTE [[StringData]] is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the String constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.5.4 Properties of the String Prototype Object

The String prototype object is itself an ordinary object. It is not a String instance and does not have a [[StringData]] internal data property.

The value of the [[Prototype]] internal data property of the String prototype object is the standard built-in Object prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the String prototype object defined below are not generic and the this value passed to them must be either a String value or an object that has a [[StringData]] internal data property that has been initialized to a String value.

The abstract operation `thisStringValue(value)` performs the following steps:

1. If `Type(value)` is String, return `value`.
2. If `Type(value)` is Object and `value` has a [[StringData]] internal data property, then
   a. Let `s` be the value of `value`'s [[StringData]] internal data property.
   b. If `s` is not `undefined`, then return `s`.
3. Throw a TypeError exception.

The phrase “this String value” within the specification of a method refers to the result returned by calling the abstract operation `thisStringValue` with the this value of the method invocation passed as the argument.

15.5.4.1 `String.prototype.constructor`

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

15.5.4.2 `String.prototype.toString()`

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

1. Let `s` be `thisStringValue(this value)`.
2. Return `s`.

NOTE For a String object, the `toString` method happens to return the same thing as the `valueOf` method.

15.5.4.3 `String.prototype.valueOf()`

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

1. Let `s` be `thisStringValue(this value)`.
2. Return `s`.

15.5.4.4 `String.prototype.charAt(pos)`

NOTE Returns a single element String containing the code unit at element position `pos` in the String value resulting from converting this object to a String. If there is no element at that position, the result is the empty String. The result is a String value, not a String object.

If `pos` is a value of Number type that is an integer, then the result of `x.charAt(pos)` is equal to the result of `x.substring(pos, pos+1)`.
When the `charAt` method is called with one argument `pos`, the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value).
2. Let `S` be `ToString(O).
3. ReturnIfAbrupt(S).
4. Let `position` be `ToInteger(pos).
5. ReturnIfAbrupt(position).
6. Let `size` be the number of elements in `S`.
7. If `pos < 0` or `position ≥ size`, return the empty String.
8. Return a String of length 1, containing one code unit from `S`, namely the code unit at position `position`, where the first (leftmost) code unit in `S` is considered to be at position 0, the next one at position 1, and so on.

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

15.5.4.5 `String.prototype.charAt(pos)`

**NOTE** Returns a Number (a nonnegative integer less than 216) that is the code unit value of the string element at position `pos` in the String resulting from converting this object to a String. If there is no element at that position, the result is NaN.

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

1. Let `O` be `CheckObjectCoercible(this value).
2. Let `S` be `ToString(O).
3. ReturnIfAbrupt(S).
4. Let `position` be `ToInteger(pos).
5. ReturnIfAbrupt(position).
6. Let `size` be the number of elements in `S`.
7. If `pos < 0` or `pos ≥ size`, return NaN.
8. Return a value of Number type, whose value is the code unit value of the element at position `position` in the String `S`, where the first (leftmost) element in `S` is considered to be at position 0, the next one at position 1, and so on.

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

15.5.4.6 `String.prototype.concat(...args)`

**NOTE** When the `concat` method is called with zero or more arguments, it returns a String consisting of the string elements of this object (converted to a String) followed by the string elements of each of the arguments converted to a String. The result is a String value, not a String object.

The following steps are taken:

1. Assert: `args` is a well-formed rest parameter object.
2. Let `O` be `CheckObjectCoercible(this value).
3. Let `S` be `ToString(O).
4. ReturnIfAbrupt(S).
5. Let `args` be an internal list that is a copy of the argument list passed to this function.
7. Repeat, while `args` is not empty
   a. Remove the first element from `args` and let `next` be the value of that element.
   b. Let `nextString` be `ToString(next).
   c. ReturnIfAbrupt(nextString).
   d. Let `#` be the string value consisting of the string elements in the previous value of `R` followed by the string elements of `nextString`.
8. Return `R`. 

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The length property of the concat method is 1.

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

15.5.4.7 String.prototype.indexOf (searchString, position)

If searchString appears as a substring of the result of converting this object to a String, at one or more positions that are greater than or equal to position, then the index of the smallest such position is returned; otherwise, -1 is returned. If position is undefined, 0 is assumed, so as to search all of the String.

The indexOf method takes two arguments, searchString and position, and performs the following steps:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchString be ToString(searchString).
5. ReturnIfAbrupt(searchString).
6. Let pos be ToInteger(position). (If position is undefined, this step produces the value 0).
7. ReturnIfAbrupt(pos).
8. Let len be the number of elements in S.
9. Let start be min(max(pos, 0), len).
10. Let searchLen be the number of elements in searchString.
11. Return the smallest possible integer k not smaller than start such that k + searchLen is not greater than len, and for all nonnegative integers j less than searchLen, the code unit at position k + j of S is the same as the code unit at position j of searchString; but if there is no such integer k, then return the value -1.

The length property of the indexOf method is 1.

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

15.5.4.8 String.prototype.lastIndexOf (searchString, position)

If searchString appears as a substring of the result of converting this object to a String at one or more positions that are smaller than or equal to position, then the index of the greatest such position is returned; otherwise, -1 is returned. If position is undefined, the length of the String value is assumed, so as to search all of the String.

The lastIndexOf method takes two arguments, searchString and position, and performs the following steps:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchString be ToString(searchString).
5. ReturnIfAbrupt(searchString).
6. Let numPos be ToNumber(position). (If position is undefined, this step produces the value NaN).
7. ReturnIfAbrupt(numPos).
8. If numPos is NaN, let pos be +∞; otherwise, let pos be ToInteger(numPos).
9. Let len be the number of elements in S.
10. Let start be min(max(pos, 0), len).
11. Let searchLen be the number of elements in searchString.
12. Return the largest possible nonnegative integer k not larger than start such that k + searchLen is not greater than len, and for all nonnegative integers j less than searchLen, the code unit at position k + j of S is the same as the code unit at position j of searchString; but if there is no such integer k, then return the value -1.

The length property of the lastIndexOf method is 1.
NOTE The lastIndexOf function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.9 String.prototype.localeCompare (that)

When the localeCompare method is called with one argument that, it returns a Number other than NaN that represents the result of a locale-sensitive String comparison of the this value (converted to a String) with that (converted to a String). The two Strings are S and That. The two Strings are compared in an implementation-defined fashion. The result is intended to order String values in the sort order specified by the system default locale, and will be negative, zero, or positive, depending on whether S comes before That in the sort order, the Strings are equal, or S comes after That in the sort order, respectively.

Before performing the comparisons the following steps are performed to prepare the Strings:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let That be ToString(that).
5. ReturnIfAbrupt(That).

The localeCompare method, if considered as a function of two arguments this and that, is a consistent comparison function (as defined in 15.4.3.11) on the set of all Strings.

The actual return values are implementation-defined to permit implementers to encode additional information in the value, but the function is required to define a total ordering on all Strings and to return 0 when comparing Strings that are considered canonically equivalent by the Unicode standard.

If no language-sensitive comparison at all is available from the host environment, this function may perform a bitwise comparison.

NOTE 1 The localeCompare method itself is not directly suitable as an argument to Array.prototype.sort because the latter requires a function of two arguments.

NOTE 2 This function is intended to rely on whatever language-sensitive comparison functionality is available to the ECMAScript environment from the host environment, and to compare according to the rules of the host environment’s current locale. It is strongly recommended that this function treat Strings that are canonically equivalent according to the Unicode standard as identical (in other words, compare the Strings as if they had both been converted to Normalised Form C or D first). It is also recommended that this function not honour Unicode compatibility equivalences or decompositions.

NOTE 3 The second parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

NOTE 4 The localeCompare function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.10 String.prototype.match (regexp)

When the match method is called with argument regexp, the following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. If Type(regexp) is Object and HasProperty(regexp, @@isRegExp) is true, then let rx be regexp;
5. Else, let rx be the result of the abstract operation RegExpCreate (15.10.4.1) with arguments regexp and undefined.
6. ReturnIfAbrupt(rx).
7. Let args be a new List with S as its sole element.
8. Return the result of Invoke(rx, “match”, args).
NOTE  The `replace` function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.11 String.prototype.replace (searchValue, replaceValue)

When the `replace` method is called with arguments `searchValue` and `replaceValue` the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value)`.
2. Let `string` be `ToString(O)`.
3. ReturnIfAbrupt(`string`).
4. If Type(`searchValue`) is Object and HasProperty(`searchValue`, @@isRegExp) is `true`, then
   a. Let `args` be a new List with elements `string` and `replaceValue`.
   b. Return the result of `Invoke(searchValue, "replace", args)`.
5. Let `searchString` be `ToString(searchValue)`.
6. ReturnIfAbrupt(`searchString`).
7. Search `string` for the first occurrence of `searchString` and let `pos` be the index position within `string` of the first code unit of the matched substring and let `matched` be `searchString`. If no occurrences of `searchString` were found, return `string`.
8. If `IsCallable(replaceValue)` is `true`, then
   a. Let `replValue` be the result of calling the [[Call]] internal methods of `replaceValue` passing `undefined` as the this value and a List containing `matched`, `pos`, and `string` as the argument list.
   b. Let `replStr` be `ToString(replValue)`.
   c. ReturnIfAbrupt(`replStr`).
9. Else,
   a. Let `captures` be an empty List.
   b. Let `replStr` be the result of the abstract operation `GetReplaceSubstitution(matched, string, pos, captures)`.
10. Let `tailPos` be `pos + matchLength`.
11. Let `newString` be the String formed by concatenating the first `pos` code units of `string`, `replString`, and the trailing substring of `string` starting at index `tailPos`. If `pos` is `0`, the first element of the concatenation will be the empty String.
12. Return `newString`.

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

Runtime Semantics: `GetReplaceSubstitution` Abstract Operation

The abstract operation `GetReplaceSubstitution(matched, string, position, captures)` performs the following steps:

1. Assert: Type(`matched`) is String.
2. Let `matchLength` be the number of code units in `matched`.
3. Assert: Type(`string`) is String.
4. Let `stringLength` be the number of code units in `string`.
5. Assert: `position` is a non-negative integer.
7. Assert: `captures` is a possibly empty List of Strings.
8. Let `tailPos` be `position + matchLength`.
9. Let `m` be the number of elements in `captures`.
10. Let `result` be a String value derived from `matched` by replacing code unit elements in `matched` by replacement text as specified in Table 34. These $ replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements.
11. Return `result`.
When the search method is called with argument `regexp`, the following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value).`
2. Let `string` be `ToString(O).`
3. ReturnIfAbrupt(`string`).
4. If `Type(regexp)` is `Object` and `HasProperty(regexp, @@isRegExp)` is `true`, then,
   a. Let `rx` be `regexp`.
5. Else,
   a. Let `rx` be the result of the abstract operation `RegExpCreate (15.10.1)` with arguments `regexp` and `undefined`.
6. ReturnIfAbrupt(`cx`).
7. Let `args` be a new List with the single element `string`.
8. Return the result of `Invoke(regexp, "search", args)`.

NOTE: The `search` function is intentionally generic; it does not require that its `this` value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.13 String.prototype.slice (start, end)

The `slice` method takes two arguments, `start` and `end`, and returns a substring of the result of converting this object to a String, starting from element position `start` and running to, but not including, element position `end` (or through the end of the String if `end` is `undefined`). If `start` is negative, it is treated as `sourceLength+start` where `sourceLength` is the length of the String. If `end` is negative, it is treated as `sourceLength+end` where `sourceLength` is the length of the String. The result is a String value, not a String object. The following steps are taken:

1. Let `O` be `CheckObjectCoercible(this value).`
2. Let `S` be `ToString(O).`
3. ReturnIfAbrupt(`S`).
4. Let `len` be the number of elements in `S`.
5. Let `intStart` be `ToInteger(start)`.
6. If `end` is `undefined`, let `intEnd` be `len`; else let `intEnd` be `ToInteger(end)`.
7. If `intStart` is negative, let `from` be `max(len + intStart, 0)`; else let `from` be `min(intStart, len)`.
8. If `intEnd` is negative, let `to` be `max(len + intEnd, 0)`; else let `to` be `min(intEnd, len)`.

Table 34 — Replacement Text Symbol Substitutions

<table>
<thead>
<tr>
<th>Code unit</th>
<th>Unicode Characters</th>
<th>Replacement text</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0024, 0x0026</td>
<td>0</td>
<td>matched</td>
</tr>
<tr>
<td>0x0024, 0x0060</td>
<td>°</td>
<td>If position is 0, the replacement is the empty String. Otherwise the replacement is the substring of string that starts at index 0 and whose last code point is at index position -1.</td>
</tr>
<tr>
<td>0x0024, 0x0027</td>
<td>?</td>
<td>If <code>tailPos</code> ≤ <code>stringLength</code>, the replacement is the empty String. Otherwise the replacement is the substring of string that starts at index <code>tailPos</code> and continues to the end of string.</td>
</tr>
<tr>
<td>0x0024, N where 0x0031 ≤ N ≤ 0x0039</td>
<td>%n</td>
<td>The n° element of captures, where n is a single digit in the range 1 to 9. If n ≤ m and the nth element of captures is <code>undefined</code>, use the empty String instead. [If n &gt; m, the result is implementation-defined].</td>
</tr>
<tr>
<td>0x0024, N where 0x0030 ≤ N ≤ 0x0039</td>
<td>%nn</td>
<td>The nn° element of captures, where nn is a two-digit decimal number in the range 01 to 99. If m ≤ n and the nth element of captures is <code>undefined</code>, use the empty String instead. [If nn is 00 or m &gt; n, the result is implementation-defined].</td>
</tr>
<tr>
<td>0x0024</td>
<td>¥</td>
<td>in any context that does not match on of the above.</td>
</tr>
</tbody>
</table>
9. Let span be max(–to – from,0).
10. Return a String value containing span consecutive elements from S beginning with the element at position from.

The length property of the slice method is 2.

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

15.5.4.14 String.prototype.split (separator, limit)

Returns an Array object into which substrings of the result of converting this object to a String have been stored. The substrings are determined by searching from left to right for occurrences of separator; these occurrences are not part of any substring in the returned array, but serve to divide up the String value. The value of separator may be a String of any length or it may be a RegExp object.

The value of separator may be an empty String, an empty regular expression, or a regular expression that can match an empty String. In this case, separator does not match the empty substring at the beginning or end of the input String, nor does it match the empty substring at the end of the previous separator match. (For example, if separator is the empty String, the String is split up into individual code unit elements, the length of the result array equals the length of the String, and each substring contains one code unit.) If separator is a regular expression, only the first match at a given position of the this String is considered, even if backtracking could yield a non-empty-substring match at that position. (For example, "ab".split(/a*/?) evaluates to the array ["a", "b"], while "ab".split(/a*/) evaluates to the array ["", "b"].)

If the this object is (or converts to) the empty String, the result depends on whether separator can match the empty String. If it can, the result array contains no elements. Otherwise, the result array contains one element, which is the empty String.

If separator is a regular expression that contains capturing parentheses, then each time separator is matched the results (including any undefined results) of the capturing parentheses are spliced into the output array. For example,


If separator is undefined, then the result array contains just one String, which is the this value (converted to a String). If limit is not undefined, then the output array is truncated so that it contains no more than limit elements.

When the split method is called, the following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. ReturnIfAbrupt(O).
3. If Type(separator) is Object and HasProperty(separator, @@isRegExp) is true, then,
   a. Let args be a new List with elements O and limit.
   b. Return the result of Invoke(separator, "split", args)
4. Let S be ToString(O).
5. ReturnIfAbrupt(S).
6. Let A be the result of the abstract operation ArrayCreate with argument 0.
7. Let lengthA be 0.
8. If limit is undefined, let lim = 2^32 – 1; else let lim = ToUint32(limit).
9. Let n be the number of elements in S.
10. Let p = 0.
11. Let R be ToString(separator).
12. ReturnIfAbrupt(R).
13. If lim = 0, return A.
14. If separator is undefined, then
   a. Call the [[DefineOwnProperty]] internal method of A with arguments "0" and Property Descriptor
   b. Assert: the previous step will never result in an abrupt completion.
   c. Return A.
15. If q = 0, then
   a. Let z be the result of SplitMatch(S, 0, R).
   b. If z is not false, return A.
   c. Call the [[DefineOwnProperty]] internal method of A with arguments "0" and Property Descriptor
   d. Assert: the previous step will never result in an abrupt completion.
   e. Return A.
16. Let q = p.
17. Repeat, while q ≠ s
   a. Let e be the result of SplitMatch(S, q, R).
   b. If e is false, then let q = q+1.
   c. Else e is an integer index into S,
      i. If e = p, then let q = q+1.
      ii. Else e ≠ p,
         1. Let T be a String value equal to the substring of S consisting of the code units at
            positions p (inclusive) through e (exclusive).
         2. Call the [[DefineOwnProperty]] internal method of A with arguments
            ToString(lengthA) and Property Descriptor ( [[Value]] : T, [[Writable]] : true, 
            [[Enumerable]] : true, [[Configurable]] : true ).
         3. Assert: the previous step will never result in an abrupt completion.
         4. Increment lengthA by 1.
         5. If lengthA = lim, return A.
         7. Let q = p.
18. Let T be a String value equal to the substring of S consisting of the code units at positions p (inclusive)
    through s (exclusive).
   a. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(lengthA) and Property
   20. Assert: the previous step will never result in an abrupt completion.
21. Return A.

Runtime Semantics: SplitMatch Abstract Operation

The abstract operation SplitMatch takes three parameters, a String S, an integer q, and a String R, and
performs the following in order to return either false or the end index of a match:

1. Type(R) must be String. Let r be the number of code units in R.
2. Let s be the number of code units in S.
3. If q+r > s then return false.
4. If there exists an integer i between 0 (inclusive) and r (exclusive) such that the code unit at position q+i of S
   is different from the code unit at position i of R, then return false.
5. Return q+r.

The length property of the split method is 2.

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

15.5.4.15 String.prototype.substring (start, end)

The substring method takes two arguments, start and end, and returns a substring of the result of converting
this object to a String, starting from element position start and running to, but not including, element position
end of the String (or through the end of the String is end is undefined). The result is a String value, not a String
object.
If either argument is NaN or negative, it is replaced with zero; if either argument is larger than the length of the String, it is replaced with the length of the String.

If start is larger than end, they are swapped.

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let len be the number of elements in S.
5. Let intStart be ToInteger(start).
6. If end is undefined, let intEnd be ToInteger(end).
7. Let finalStart be min(max(intStart, 0), len).
8. Let finalEnd be min(max(intEnd, 0), len).
9. Let from be min(finalStart, finalEnd).
10. Let to be max(finalStart, finalEnd).
11. Return a String whose length is to - from, containing code units from S, namely the code units with indices from through to - 1, in ascending order.

The length property of the substring method is 2.

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

15.5.4.16 String.prototype.toLowerCase ( )

This function interprets a string value as a sequence of code points, as described in 8.4. The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let cpList be a List containing in order the code points as defined in 8.4 of S, starting at the first element of S.
5. For each code point c in cpList, if the Unicode Character Database provides a language insensitive lower case equivalent of c, then replace c in cpList with that equivalent code point(s).
6. Let cuList be a new List.
7. For each code point c in cpList, in order, append to cuList the elements of the UTF-16 Encoding (clause 6) of c.
8. Let L be a String whose elements are, in order, the elements of cuList.
9. Return L.

The result must be derived according to the case mappings in the Unicode character database (this explicitly includes not only the UnicodeData.txt file, but also the SpecialCasings.txt file that accompanies it).

NOTE 1 The case mapping of some code points may produce multiple code points. In this case the result String may not be the same length as the source String. Because both toUpperCase and toLowerCase have context-sensitive behaviour, the functions are not symmetrical. In other words, s.toUpperCase().toLowerCase() is not necessarily equal to s.toLowerCase().

NOTE 2 The toLowerCase function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.17 String.prototype.toLocaleLowerCase ( )

This function interprets a string value as a sequence of code points, as described in 8.4. This function works exactly the same as toLowerCase except that its result is intended to yield the correct result for the host environment’s current locale, rather than a locale-independent result. There will only be a
difference in the few cases (such as Turkish) where the rules for that language conflict with the regular Unicode case mappings.

NOTE 1 The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

NOTE 2 The toLocaleLowerCase function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.18 String.prototype.toUpperCase ( )

This function interprets a string value as a sequence of code points, as described in 8.4.

This function behaves in exactly the same way as String.prototype.toLowerCase, except that code points are mapped to their uppercase equivalents as specified in the Unicode Character Database.

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

15.5.4.19 String.prototype.toLocaleUpperCase ( )

This function interprets a string value as a sequence of code points, as described in 8.4.

This function works exactly the same as toUpperCase except that its result is intended to yield the correct result for the host environment's current locale, rather than a locale-independent result. There will only be a difference in the few cases (such as Turkish) where the rules for that language conflict with the regular Unicode case mappings.

NOTE 1 The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

NOTE 2 The toLocaleUpperCase function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.20 String.prototype.trim ( )

This function interprets a string value as a sequence of code points, as described in 8.4.

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let T be a String value that is a copy of S with both leading and trailing white space removed. The definition of white space is the union of WhiteSpace and LineTerminator. When determining whether a Unicode character is in Unicode general category "Zs", code unit sequences are interpreted as UTF-16 encoded code point sequences as specified in 8.4.
5. Return T.

NOTE The trim function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.21 String.prototype.repeat (count)

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let n be the result of calling ToInteger(count).
5. ReturnIfAbrupt(n).
6. If n < 0, then throw a RangeError exception.
7. If n is +\infty, then throw a RangeError exception.
8. Let T be a String value that is made from n copies of S appended together. If n is 0, T is the empty String.
9. Return T.

NOTE 1 This method creates a String consisting of the string elements of this object (converted to String) repeated count time.

NOTE 2 The repeat function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.22 String.prototype.startsWith (searchString [, position ])

The following steps are taken:
1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchStr be ToString(searchString).
5. ReturnIfAbrupt(searchStr).
6. Let pos be ToInteger(position). (If position is undefined, this step produces the value 0).
7. ReturnIfAbrupt(pos).
8. Let len be the number of elements in S.
9. Let start be min(max(pos, 0), len).
10. Let searchLength be the number of elements in searchString.
11. If searchLength + start is greater than len, return false.
12. If the searchLength sequence of elements of S starting at start is the same as the full element sequence of searchString, return true.
13. Otherwise, return false.

The length property of the startsWith method is 1.

NOTE 1 This method returns true if the sequence of elements of searchString converted to a String is the same as the corresponding elements of this object (converted to a String) starting at position. Otherwise returns false.

NOTE 2 The startsWith function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.23 String.prototype.endsWith (searchString [, endPosition ])

The following steps are taken:
1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchStr be ToString(searchString).
5. ReturnIfAbrupt(searchStr).
6. Let pos be ToInteger(position). (If endPosition is undefined, let pos be len, else let pos be ToInteger(endPosition)).
7. ReturnIfAbrupt(pos).
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 searchLength sequence of elements of S starting at start is the same as the full element sequence of searchString, return true.
13. Otherwise, return false.

The length property of the endsWith method is 1.
NOTE 1  Returns true if the sequence of elements of searchString converted to a String is the same as the corresponding elements of this object (converted to a String) starting at startPosition – length(this). Otherwise returns false.

NOTE 2  The endsWith function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.24 String.prototype.contains (searchString, position = 0 )

The contains method takes two arguments, searchString and position, and performs the following steps:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let searchString be ToString(searchString).
5. ReturnIfAbrupt(searchString).
6. Let pos be ToInteger(position). (If position is undefined, this step produces the value 0).
7. ReturnIfAbrupt(pos).
8. Let len be the number of elements in S.
9. Let start be min(max(pos, 0), len).
10. Let searchLen be the number of characters in searchString.
11. If there exists any integer k not smaller than start such that k + searchLen is not greater than len, and for all nonnegative integers j less than searchLen, the character at position k+j of S is the same as the character at position j of searchString, return true; but if there is no such integer k, return false.

The length property of the contains method is 1.

NOTE 1  If searchString appears as a substring of the result of converting this object to a String, at one or more positions that are greater than or equal to position, then return true; otherwise, returns false. If position is undefined, 0 is assumed, so as to search all of the String.

NOTE 2  The contains function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

15.5.4.25 String.prototype.codePointAt (pos)

NOTE  Returns a Number (a nonnegative integer less than 1114112) that is the UTF-16 encoded code point value starting at the string element at position pos in the String resulting from converting this object to a String, if there is no element at that position, the result is NaN. If a valid UTF-16 surrogate pair does not begin at pos, the result is the code unit at pos.

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

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let position be ToInteger(pos).
5. ReturnIfAbrupt(position).
6. Let size be the number of elements in S.
7. If position < 0 or position ≥ size, return undefined.
8. Let first be the code unit value of the element at index position in the String S.
9. If first < 0xD800 or first > 0xDBFF or position+1 = size, then return first.
10. Let second be the code unit value of the element at index position+1 in the String S.
11. If second < 0xDC00 or second > 0xDFFF, then return first.
12. Return ((first – 0xD800) × 1024) + (second – 0xDC00) + 0x10000.

NOTE  The codePointAt function is intentionally generic; it does not require that its this value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.
15.5.4.26 String.prototype.normalize (form = "NFC")

When the normalize method is called with one argument form, the following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. If form is not provided or undefined let form be "NFC".
5. Let f be ToString(form).
6. ReturnIfAbrupt(f).
7. If f is not one of "NFC", "NFD", "NFKC", or "NFKD", then throw a RangeError Exception.
8. Let ns be the String value is the result of normalizing S into the normalization form named by f as specified in UTR 15 Unicode Normalization Forms.
9. Return ns.

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

15.5.5 Properties of String Instances

String instances are String exotic objects and have the internal methods specified for such objects. String instances inherit properties from the String prototype object. String instances also have a [[StringData]] internal data property.

String instances have a length property, and a set of enumerable properties with array index names.

15.5.5.1 length

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

Once a String object is initialized, this property is unchanging. It has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false ).

15.6 Boolean Objects

15.6.1 The Boolean Constructor Called as a Function

When Boolean is called as a function rather than as a constructor, it performs a type conversion. However, if the this value passed in the call is an Object with an uninitialized [[BooleanData]] internal data property, it initializes the this value using the argument value. This permits Boolean to be used both to perform type conversion and to perform constructor instance initialization.

Boolean may be subclassed and subclass constructors may perform a super invocation of the Boolean constructor to initialize the [[BooleanData]] state of subclass instances.

15.6.1.1 Boolean (value)

When Boolean is called with argument value, the following steps are taken:

1. Let O be the this value.
2. Let b be ToBoolean(value).
3. If Type(O) is Object and O has a [[BooleanData]] internal data property and the value of [[BooleanData]] is undefined, then
   a. Set the value of O’s [[BooleanData]] internal data property to b.
   b. Return O.
4. Return b.
15.6.2 The Boolean Constructor

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

15.6.2.1 new Boolean (value)

Boolean called as part of a new expression with optional argument value performs the following steps:

1. Let F be the Boolean function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (F, argumentsList).

If Boolean is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.6.3 Properties of the Boolean Constructor

The value of the [[Prototype]] internal data property of the Boolean constructor is the Function prototype object (15.3.3).

Besides the length property (whose value is 1), the Boolean constructor has the following property:

15.6.3.1 Boolean.prototype

The initial value of Boolean.prototype is the Boolean prototype object (15.6.4).

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

15.6.3.2 Boolean[@@create] ()

The @@create method of an object F performs the following steps:

1. Let F be the this value.
2. Let obj be the result of calling OrdinaryCreateFromConstructor(F, "%BooleanPrototype", ( [[BooleanData]] )).
3. Return obj.

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

NOTE [[BooleanData]] is initially assigned the value undefined as a flag to indicate that the instance has not yet been initialized by the Boolean constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.6.4 Properties of the Boolean Prototype Object

The Boolean prototype object is an ordinary object. It is not a Boolean instance and does not have a [[BooleanData]] internal data property.

The value of the [[Prototype]] internal data property of the Boolean prototype object is the standard built-in Object prototype object (15.2.4).

The abstract operation thisBooleanValue(value) performs the following steps:

1. If Type(value) is Boolean, return value.
2. If Type(value) is Object and value has a [[BooleanData]] internal data property, then
   a. Let b be the value of value’s [[BooleanData]] internal data property.
   b. If b is not undefined, then return b.
3. Throw a TypeError exception.
15.6.4.1 Boolean.prototype.constructor

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

15.6.4.2 Boolean.prototype.toString ( )

The following steps are taken:

1. Let b be thisBooleanValue(this value).
2. ReturnIfAbrupt(b).
3. If b is true, then return "true"; else return "false".

15.6.4.3 Boolean.prototype.valueOf ( )

The following steps are taken:

1. Return thisBooleanValue(this value).

15.6.5 Properties of Boolean Instances

Boolean instances are ordinary objects that inherit properties from the Boolean prototype object. Boolean instances have a [[BooleanData]] internal data property. The [[BooleanData]] internal data property is the Boolean value represented by this Boolean object.

15.7 Number Objects

15.7.1 The Number Constructor Called as a Function

When Number is called as a function rather than as a constructor, it performs a type conversion. However, if the this value value passed in the call is an Object with an uninitialized [[NumberData]] internal data property, it initializes the this value using the argument value. This permits Number to be used both to perform type conversion and to perform constructor instance initialization.

Number may be subclassed and subclass constructors may perform a super invocation of the Number constructor to initialize the [[NumberData]] state of subclass instances.

15.7.1.1 Number ([value])

When Number is called with argument number, the following steps are taken:

1. Let O be the this value.
2. If no arguments were passed to this function invocation, then let n be +0.
3. Else, let n be ToNumber(value).
4. ReturnIfAbrupt(n).
5. If Type(O) is Object and O has a [[NumberData]] internal data property and the value of [[NumberData]] is undefined, then
   a. Set the value of O's [[NumberData]] internal data property to n.
   b. Return O.
6. Return n.

15.7.2 The Number Constructor

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

15.7.2.1 new Number (...args)

Number called as part of a new expression with argument list args it performs the following steps:
1. Let \( F \) be the \texttt{Number} function object on which the \texttt{new} operator was applied.
2. Let \( argumentsList \) be the \texttt{argumentsList} argument of the [[Construct]] internal method that was invoked by the \texttt{new} operator.
3. Return the result of \texttt{OrdinaryConstruct} (\( F, argumentsList \)).

If \texttt{Number} is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.7.3 Properties of the Number Constructor

The value of the [[Prototype]] internal data property of the \texttt{Number} constructor is the Function prototype object (15.3.3).

Besides the \texttt{length} property (whose value is 1), the \texttt{Number} constructor has the following properties:

15.7.3.1 \texttt{Number.prototype}

The initial value of \texttt{Number.prototype} is the \texttt{Number} prototype object (15.7.4).

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

15.7.3.2 \texttt{Number.MAX_VALUE}

The value of \texttt{Number.MAX_VALUE} is the largest positive finite value of the Number type, which is approximately \( 1.7976931348623157 \times 10^{308} \).

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

15.7.3.3 \texttt{Number.MIN_VALUE}

The value of \texttt{Number.MIN_VALUE} is the smallest positive value of the Number type, which is approximately \( 5 \times 10^{-324} \).

In the IEEE-754 double precision binary representation, the smallest possible value is a denormalized number. If an implementation does not support denormalized values, the value of \texttt{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 \}.

15.7.3.4 \texttt{Number.NaN}

The value of \texttt{Number.NaN} is \texttt{NaN}.

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

15.7.3.5 \texttt{Number.NEGATIVE_INFINITY}

The value of \texttt{Number.NEGATIVE_INFINITY} is \( -\infty \).

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

15.7.3.6 \texttt{Number.POSITIVE_INFINITY}

The value of \texttt{Number.POSITIVE_INFINITY} is \( +\infty \).

This property has the attributes \{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false \}. 
15.7.3.7 Number.EPSILON

The value of Number.EPSILON is the difference between 1 and the smallest value greater than 1 that is representable as a Number value, which is approximately 2.2204460492503130808472633361816 x 10^-16.

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

15.7.3.8 Number.MAX_INTEGER

The value of Number.MAX_INTEGER is the largest integer value that can be represented as a Number value without losing precision, which is 9007199254740991.

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

15.7.3.9 Number.parseInt (string, radix)

Same as 15.1.2.2.

15.7.3.10 Number.parseFloat (string)

Same as 15.1.2.3.

15.7.3.11 Number.isNaN (number)

When the Number.isNaN is called with one argument number, the following steps are taken:

1. If Type(number) is not Number, return false.
2. If number is NaN, return true.
3. Otherwise, return false.

NOTE This function differs from the global isNaN function (15.1.2.4) in that it does not convert its argument to a Number before determining whether it is NaN.

15.7.3.12 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, +\infty, or -\infty, return false.
3. Otherwise, return true.

15.7.3.13 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. Let integer be ToInteger(number).
3. If integer is not equal to number, return false.
4. Otherwise, return true.

15.7.3.14 Number.toInteger (number)

When the Number.toInteger is called with one argument number, the following steps are taken:

1. Return ToInteger(number).

15.7.3.15 Number[@create] ()

The @@create method of an object F performs the following steps:
1. Let \( F \) be the this value.
2. Let \( \text{obj} \) be the result of calling `OrdinaryCreateFromConstructor(\( F \), "%NumberPrototype\%", ([NumberData])).
3. Return \( \text{obj} \).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }

**NOTE**

[NumberData] is initially assigned the value undefined as a flag to indicate that the instance has not yet been initialized by the Number constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

### 15.7.4 Properties of the Number Prototype Object

The Number prototype object is an ordinary object. It is not a Number instance and does not have a [[NumberData]] internal data property.

The value of the [[Prototype]] internal data property of the Number prototype object is the standard built-in Object prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the Number prototype object defined below are not generic and the this value passed to them must be either a Number value or an object that has a [[NumberData]] internal data property that has been initialized to a Number value.

The abstract operation `thisNumberValue(value)` performs the following steps:

1. If `Type(value)` is Number, return `value`.
2. If `Type(value)` is Object and `value` has a [[NumberData]] internal data property, then
   a. Let `n` be the value of `value`'s [[NumberData]] internal data property.
   b. If `n` is not undefined, then return `n`.
3. Throw a TypeError exception.

The phrase “this Number value” within the specification of a method refers to the result returned by calling the abstract operation `thisNumberValue` with the this value of the method invocation passed as the argument.

#### 15.7.4.1 Number.prototype.constructor

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

#### 15.7.4.2 Number.prototype.toString([radix])

The optional radix should be an integer value in the inclusive range 2 to 36. If radix not present or is undefined the Number 10 is used as the value of radix. If ToInteger(radix) is the Number 10 then this Number value is given as an argument to the ToString abstract operation; the resulting String value is returned.

If ToInteger(radix) is not an integer between 2 and 36 inclusive throw a RangeError exception. If ToInteger(radix) is an integer from 2 to 36, but not 10, the result is a String representation of this Number value using the specified radix. Letters \( a-z \) are used for digits with values 10 through 35. The precise algorithm is implementation-dependent if the radix is not 10, however the algorithm should be a generalisation of that specified in 9.1.8.1.

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

#### 15.7.4.3 Number.prototype.toLocaleString()

Produces a String value that represents this Number value formatted according to the conventions of the host environment’s current locale. This function is implementation-dependent, and it is permissible, but not encouraged, for it to return the same thing as toString.
NOTE The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.7.4.4 Number.prototype.valueOf ( )

1. Let x be this Number Value(this value).
2. Return x.

15.7.4.5 Number.prototype.toFixed (fractionDigits)

Note toFixed returns a String containing this Number value represented in decimal fixed-point notation with fractionDigits digits after the decimal point. If fractionDigits is undefined, 0 is assumed.

The following steps are performed:

1. Let x be this Number Value(this value).
2. ReturnIfAbrupt(x).
3. Let f be ToInteger(fractionDigits). (If fractionDigits is undefined, this step produces the value 0).
4. ReturnIfAbrupt(f).
5. If f < 0 or f > 20, throw a RangeError exception.
6. If x is NaN, return the String "NaN".
7. Let s be the empty String.
8. If x < 0, then
   a. Let s be "-".
   b. Let x = –x.
9. If x ≥ 10^{32}, then
   a. Let m = ToString(x).
10. Else x < 10^{32},
    a. Let n be an integer for which the exact mathematical value of n + 10^{-f} – x is as close to zero as possible. If there are two such n, pick the larger n.
    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 ≠ 0, then
       i. Let k be the number of elements in m.
       ii. If k ≤ f, then
          1. Let z be the String consisting of f–1–k occurrences of the code unit 0x0030.
          2. Let m be the concatenation of Strings z and m.
          3. Let k = f + 1.
       iii. Let a be the first k–f elements of m, and let b be the remaining f elements of m.
       iv. Let m be the concatenation of the three Strings a, ".", and b.
11. Return the concatenation of the Strings s and m.

The length property of the toFixed method is 1.

If the toFixed method is called with more than one argument, then the behaviour is undefined (see clause 15).

An implementation is permitted to extend the behaviour of toFixed for values of fractionDigits less than 0 or greater than 20. In this case toFixed would not necessarily throw RangeError for such values.

NOTE The output of toFixed may be more precise than toString for some values because toString only prints enough significant digits to distinguish the number from adjacent number values. For example, (100000000000000128).toString() returns "100000000000000100", while (100000000000000128).toFixed(0) returns "100000000000000128".

15.7.4.6 Number.prototype.toExponential (fractionDigits)

Return a String containing this Number value represented in decimal exponential notation with one digit before the significand’s decimal point and fractionDigits digits after the significand’s decimal point. If fractionDigits is
undefined, include as many significand digits as necessary to uniquely specify the Number (just like in
ToString except that in this case the Number is always output in exponential notation). Specifically, perform
the following steps:

1. Let x be thisNumberValue(this value).
2. ReturnIfAbrupt(x).
3. Let f be ToInteger(fractionDigits).
4. ReturnIfAbrupt(f).
5. If x is NaN, return the String "NaN".
6. Let s be the empty String.
7. If x < 0, then
   a. Let s be "-".
   b. Let x = –x.
8. If x = +∞, then
   a. Return the concatenation of the Strings s and "Infinity".
9. If fractionDigits is not undefined and (f < 0 or f > 20), throw a RangeError exception.
10. If x = 0, then
    a. If fractionDigits is undefined, then let f = 0.
    b. Let m be the String consisting of f+1 occurrences of the code unit 0x0030.
    c. Let e = 0.
11. Else x ≠ 0,
    a. If fractionDigits is not undefined, then
      i. Let e and n be integers such that 10^f ≤ n < 10^{f+1} and for which the exact mathematical value
         of n × 10^{-f} – x is as close to zero as possible. If there are two such sets of e and n, pick the
         e and n for which n × 10^{-f} is larger.
    b. Else fractionDigits is undefined.
      i. Let e, n, and f be integers such that f ≥ 0, 10^f ≤ n < 10^{f+1}, the number value for n × 10^{-f} is x,
         and f is as small as possible. Note that the decimal representation of n has f+1 digits, n is
         not divisible by 10, and the least significant digit of n is not necessarily uniquely
determined by these criteria.
      ii. Let m be the String consisting of the digits of the decimal representation of n (in order, with no
          leading zeroes).
12. If f ≠ 0, 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.
13. If e = 0, then
    a. Let e = "-".
    b. Let d = "0".
14. Else
    a. If e > 0, then let e = "+".
    b. Else e ≤ 0,
       i. Let e = "-".
       ii. Let e = -e.
    c. Let d be the String consisting of the digits of the decimal representation of e (in order, with no
       leading zeroes).
15. Let m be the concatenation of the four Strings m, "e", c, and d.
16. Return the concatenation of the Strings s and m.

The length property of the toExponential method is 1.

If the toExponential method is called with more than one argument, then the behaviour is undefined (see
clause 15).

An implementation is permitted to extend the behaviour of toExponential for values of fractionDigits less
than 0 or greater than 20. In this case toExponential would not necessarily throw RangeError for such
values.
NOTE For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 9.b.i be used as a guideline:

i. Let e, n, and f be integers such that $f \geq 0$, $10^e \leq n < 10^{e+1}$; the number value for $n \times 10^e$ is x, and f is as small as possible. If there are multiple possibilities for n, choose the value of n for which $n \times 10^e$ is closest in value to x. If there are two such possible values of n, choose the one that is even.

15.7.4.7 Number.prototype.toPrecision (precision)

Return a String containing this Number value represented either in decimal exponential notation with one digit before the significand’s decimal point and precision-1 digits after the significand’s decimal point or in decimal fixed notation with precision significant digits. If precision is undefined, call ToString (9.8.1) instead. Specifically, perform the following steps:

1. Let x be thisNumberValue(this value).
2. ReturnIfAbrupt(s).
3. If precision is undefined, return ToString(x).
4. Let p be ToInteger(precision).
5. ReturnIfAbrupt(p).
6. If x is NaN, return the String \"NaN\".
7. Let s be the empty String.
8. If $x < 0$, then
   a. Let s be \"-\".
   b. Let x = -$x$.
9. If $x = \pm \infty$, then
   a. Return the concatenation of the Strings s and \"Infinity\".
10. If $p < 1$ or $p > 21$, throw a RangeError exception.
11. If x = 0, then
    a. Let m be the String consisting of p occurrences of the code unit 0x0030 (the Unicode character \"0\")
    b. Let e = 0.
12. Else x $\neq$ 0,
    a. Let e and n be integers such that $10^{e-1} \leq n < 10^e$ and for which the exact mathematical value of $n \times 10^{e-1}$ is as close to zero as possible. If there are two such sets of e and n, pick the e and n for which $n \times 10^{e-1}$ is larger.
    b. Let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes)
    c. If $e < -6$ or $e \geq p$, then
       i. Let e be the first element of m, and let b be the remaining p-1 elements of m.
       ii. Let a be the concatenation of the three Strings m, \".\", and b.
       iii. If e = 0, then
          1. Let c = \"e\" and d = \"0\".
       iv. Else e $\neq$ 0,
          1. If $e > 0$, then
             a. Let c = \"+e\".
          2. Else e < 0,
             a. Let c = \"-e\".
             b. Let e = -$e$.
          3. Let d be the String consisting of the digits of the decimal representation of e (in order, with no leading zeroes)
       v. Let m be the concatenation of the five Strings $s$, m, \"e\", c, and d.
13. If e = p-1, then return the concatenation of the Strings $s$ and m.
14. If $e \geq 0$, then
    a. Let m be the concatenation of the first e+1 elements of m, the code unit 0x002E (Unicode character \".\"), and the remaining p-$(e+1)$ elements of m.
15. Else e $< 0$.
    a. Let m be the concatenation of the String \"0\", \-(e+1) occurrences of code unit 0x0030 (the Unicode character \"0\"), and the String m.
16. Return the concatenation of the Strings s and m.
The length property of the toPrecision method is 1.

If the toPrecision method is called with more than one argument, then the behaviour is undefined (see clause 15).

An implementation is permitted to extend the behaviour of toPrecision for values of precision less than 1 or greater than 21. In this case toPrecision would not necessarily throw RangeError for such values.

15.7.4.8 Number.prototype.clz()  
When the Number.prototype.clz is called with one argument number, the following steps are taken:
1. Let x be thisNumberValue(this value).
2. Let n be ToInt32(x).
3. ReturnIfAbrupt(n).
4. Let p be the number of leading zero bits in the 32-bit binary representation of n.
5. Return p.

NOTE If n is 0, p will be 32. If the most significant bit of the 32-bit binary encoding of n is 1, p will be 0.

15.7.5 Properties of Number Instances
Number instances are ordinary objects that inherit properties from the Number prototype object. Number instances also have a [[NumberData]] internal data property. The [[NumberData]] internal data property is the Number value represented by this Number object.

15.8 The Math Object
The Math object is a single ordinary object.

The value of the [[Prototype]] internal data property of the Math object is the standard built-in Object prototype object (15.2.4). The Math object has a [[MathTag]] internal data property whose value is true.

The Math 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 8.5.

15.8.1 Value Properties of the Math Object

15.8.1.1 Math.E
The Number value for e, the base of the natural logarithms, which is approximately 2.7182818284590452354.
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.8.1.2 Math.LN10
The Number value for the natural logarithm of 10, which is approximately 2.302585092994046.
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.8.1.3 Math.LN2
The Number value for the natural logarithm of 2, which is approximately 0.6931471805599453.
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.
15.8.1.4 Math.LOG2E

The Number value for the base-2 logarithm of e, the base of the natural logarithms; this value is approximately 1.4426950408889634.

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

NOTE The value of Math.LOG2E is approximately the reciprocal of the value of Math.LN2.

15.8.1.5 Math.LOG10E

The Number value for the base-10 logarithm of e, the base of the natural logarithms; this value is approximately 0.4342944819032518.

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

NOTE The value of Math.LOG10E is approximately the reciprocal of the value of Math.LN10.

15.8.1.6 Math.PI

The Number value for π, the ratio of the circumference of a circle to its diameter, which is approximately 3.1415926535897932.

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

15.8.1.7 Math.SQRT1_2

The Number value for the square root of \( \frac{1}{2} \), which is approximately 0.7071067811865476.

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

NOTE The value of Math.SQRT1_2 is approximately the reciprocal of the value of Math.SQRT2.

15.8.1.8 Math.SQRT2

The Number value for the square root of 2, which is approximately 1.4142135623730951.

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

15.8.2 Function Properties of the Math Object

Each of the following Math object functions applies the ToNumber abstract operation to each of its arguments (in left-to-right order if there is more than one). If ToNumber returns an abrupt completion, that completion record is immediately returned. Otherwise, function performs a computation on the resulting Number value(s).

In the function descriptions below, the symbols NaN, -0, +0, -∞ and +∞ refer to the Number values described in 8.5.

NOTE The behaviour of the functions acos, asin, atan, atan2, cos, exp, log, pow, sin, sqrt, and tan is not precisely specified here except to require specific results for certain argument values that represent boundary cases of interest. For other argument values, these functions are intended to compute approximations to the results of familiar mathematical functions, but some latitude is allowed in the choice of approximation algorithms. The general intent is that an implementer should be able to use the same mathematical library for ECMAScript on a given hardware platform that is available to C programmers on that platform.

Although the choice of algorithms is left to the implementation, it is recommended (but not specified by this standard) that implementations use the approximation algorithms for IEEE 754 arithmetic contained in fdlibm, the freely distributable mathematical library from Sun Microsystems (http://www.netlib.org/fdlibm).
15.8.2.1 Math.abs (x)

Returns the absolute value of x; the result has the same magnitude as x but has positive sign.

- If x is NaN, the result is NaN.
- If x is -0, the result is +0.
- If x is -∞, the result is +∞.

15.8.2.2 Math.acos (x)

Returns an implementation-dependent approximation to the arc cosine of x. The result is expressed in radians and ranges from +0 to +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.

15.8.2.3 Math.asin (x)

Returns an implementation-dependent approximation to the arc sine of x. The result is expressed in radians and ranges from -π/2 to +π/2.

- If x is NaN, the result is NaN.
- If x is greater than 1, the result is NaN.
- If x is less than -1, the result is NaN.
- If x is +0, the result is +0.
- If x is -0, the result is -0.

15.8.2.4 Math.atan (x)

Returns an implementation-dependent approximation to the arc tangent of x. The result is expressed in radians and ranges from -π/2 to +π/2.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is -0, the result is -0.
- If x is +∞, the result is an implementation-dependent approximation to +π/2.
- If x is -∞, the result is an implementation-dependent approximation to -π/2.

15.8.2.5 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 -π to +π.

- 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 +π/2.
- If y > 0 and x is -0, the result is an implementation-dependent approximation to -π/2.
- If y is +0 and x > 0, the result is +0.
- If y is +0 and x < 0, the result is -0.
- If y is -0 and x > 0, the result is an implementation-dependent approximation to +π.
- If y is -0 and x < 0, the result is an implementation-dependent approximation to -π.
- 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 \( y = 0 \) and \( x < 0 \), the result is an implementation-dependent approximation to \(-\pi/2\).
• If \( y > 0 \) and \( x \) is finite and \( x \) is +\( \infty \), the result is +0.
• If \( y > 0 \) and \( x \) is finite and \( x \) is +\( \infty \), the result is an implementation-dependent approximation to +\( \pi/2 \).
• If \( y < 0 \) and \( x \) is finite and \( x \) is +\( \infty \), the result is an implementation-dependent approximation to +\( \pi/4 \).
• If \( y > 0 \) and \( x \) is finite and \( x \) is +\( \infty \), the result is an implementation-dependent approximation to +3\( \pi/4 \).
• If \( y < 0 \) and \( x \) is finite and \( x \) is +\( \infty \), the result is an implementation-dependent approximation to +\( 3\pi/4 \).

15.8.2.6 Math.ceil (x)

Returns the smallest (closest to \(-\infty\)) Number value that is not less than \( x \) and is equal to a mathematical integer. If \( x \) is already an integer, the result is \( x \).

• If \( x \) is NaN, the result is NaN.
• If \( x \) is +0, the result is +0.
• If \( x \) is −0, the result is −0.
• If \( x \) is +\( \infty \), the result is +\( \infty \).
• If \( x \) is −\( \infty \), the result is −\( \infty \).

The value of Math.floor(-x) is the same as the value of −Math.ceil(-x).

15.8.2.7 Math.cos (x)

Returns an implementation-dependent approximation to the cosine of \( x \). The argument is expressed in radians.

• If \( x \) is NaN, the result is NaN.
• If \( x \) is +0, the result is 1.
• If \( x \) is −0, the result is 1.
• If \( x \) is +\( \infty \), the result is NaN.
• If \( x \) is −\( \infty \), the result is NaN.

15.8.2.8 Math.exp (x)

Returns an implementation-dependent approximation to the exponential function of \( x \) (\( e \) raised to the power of \( x \), where \( e \) is the base of the natural logarithms).

• If \( x \) is NaN, the result is NaN.
• If \( x \) is +0, the result is 1.
• If \( x \) is −0, the result is 1.
• If \( x \) is +\( \infty \), the result is +0.

15.8.2.9 Math.floor (x)

Returns the greatest (closest to +\( \infty \)) Number value that is not greater than \( x \) and is equal to a mathematical integer. If \( x \) is already an integer, the result is \( x \).

• If \( x \) is NaN, the result is NaN.
• If \( x \) is +0, the result is +0.
• If \( x \) is −0, the result is −0.
• If \( x \) is \(+\infty\), the result is \(+\infty\).
• If \( x \) is \(-\infty\), the result is \(-\infty\).
• If \( x \) is greater than 0 but less than 1, the result is \(+0\).

NOTE  The value of \( \text{Math.floor}(x) \) is the same as the value of \(-\text{Math.ceil}(-x)\).

15.8.2.10 Math.log ( \( x \) )

• Returns an implementation-dependent approximation to the natural logarithm of \( x \).
• If \( x \) is NaN, the result is NaN.
• If \( x \) is less than 0, the result is NaN.
• If \( x \) is +0 or −0, the result is \(-\infty\).
• If \( x \) is 1, the result is +0.
• If \( x \) is \(+\infty\), the result is \(+\infty\).

15.8.2.11 Math.max ( \{ value1 [, value2 [, … ]] \} )

Given zero or more arguments, calls ToNumber on each of the arguments and returns the largest of the resulting values.

• If no arguments are given, the result is \(-\infty\).
• If any value is NaN, the result is NaN.
• The comparison of values to determine the largest value is done using the Abstract Relational Comparison Algorithm (11.8.1) except that +0 is considered to be larger than −0.

The length property of the max method is 2.

15.8.2.12 Math.min ( \{ value1 [, value2 [, … ]] \} )

Given zero or more arguments, calls ToNumber on each of the arguments and returns the smallest of the resulting values.

• If no arguments are given, the result is \(+\infty\).
• If any value is NaN, the result is NaN.
• The comparison of values to determine the smallest value is done using the Abstract Relational Comparison Algorithm (11.8.1) except that +0 is considered to be larger than −0.

The length property of the min method is 2.

15.8.2.13 Math.pow ( \( x, y \) )

Returns an implementation-dependent approximation to the result of raising \( x \) to the power \( y \).

• If \( y \) is NaN, the result is NaN.
• If \( y \) is +0, the result is 1, even if \( x \) is NaN.
• If \( y \) is −0, the result is 1, even if \( x \) is NaN.
• If \( x \) is NaN and \( y \) is nonzero, the result is NaN.
• If abs(\( x \))>1 and \( y \) is +\( \infty \), the result is +\( \infty \).
• If abs(\( x \))>1 and \( y \) is −\( \infty \), the result is \(+0\).
• If abs(\( x \))<1 and \( y \) is +\( \infty \), the result is +0.
• If abs(\( x \))<1 and \( y \) is −\( \infty \), the result is +\( \infty \).
• If \( x \) is +\( \infty \) and \( y \) is not NaN, the result is +\( \infty \).
• If \( x \) is +0 or −0, the result is +0.
• If \( x \) is −\( \infty \) and \( y \) is an odd integer, the result is −\( \infty \).
• If \( x \) is −\( \infty \) and \( y \) is not an odd integer, the result is +\( \infty \).
• If \( x = -\infty \) and \( y < 0 \) and \( y \) is an odd integer, the result is \(-0\).
• If \( x = -\infty \) and \( y < 0 \) and \( y \) is not an odd integer, the result is \(+0\).
• If \( x = +0 \) and \( y > 0 \), the result is \(+0\).
• If \( x = +0 \) and \( y < 0 \), the result is \(+\infty\).
• If \( x = -0 \) and \( y > 0 \) and \( y \) is an odd integer, the result is \(-0\).
• If \( x = -0 \) and \( y > 0 \) and \( y \) is not an odd integer, the result is \(+0\).
• If \( x = -0 \) and \( y < 0 \) and \( y \) is an odd integer, the result is \(-\infty\).
• If \( x = -0 \) and \( y < 0 \) and \( y \) is not an odd integer, the result is \(+\infty\).
• If \( x < 0 \) and \( x \) is finite and \( y \) is finite and \( y \) is not an integer, the result is NaN.

15.8.2.14 Math.random ( )

Returns a Number value with positive sign, greater than or equal to 0 but less than 1, chosen randomly or pseudo randomly with approximately uniform distribution over that range, using an implementation-dependent algorithm or strategy. This function takes no arguments.

15.8.2.15 Math.round (x)

Returns the Number value that is closest to \( x \) and is equal to a mathematical integer. If two integer Number values are equally close to \( x \), then the result is the Number value that is closer to \(+\infty\). If \( x \) is already an integer, the result is \( x \).

• If \( x \) is NaN, the result is NaN.
• If \( x \) is \(+0\), the result is \(+0\).
• If \( x \) is \(-0\), the result is \(-0\).
• If \( x \) is \(+\infty\) or \(-\infty\), the result is NaN.

NOTE 1  \( \text{Math.round}(3.5) \) returns 4, but \( \text{Math.round}(-3.5) \) returns –3.

NOTE 2  The value of \( \text{Math.round}(x) \) is the same as the value of \( \text{Math.floor}(x+0.5) \), except when \( x \) is \(-0\) or is less than 0 but greater than or equal to \(-0.5\); for these cases \( \text{Math.round}(x) \) returns \(-0\), but \( \text{Math.floor}(x+0.5) \) returns \(+0\).

15.8.2.16 Math.sin (x)

Returns an implementation-dependent approximation to the sine of \( x \). The argument is expressed in radians.

• If \( x \) is NaN, the result is NaN.
• If \( x \) is \(+0\), the result is \(+0\).
• If \( x \) is \(-0\), the result is \(-0\).
• If \( x \) is \(+\infty\) or \(-\infty\), the result is NaN.

15.8.2.17 Math.sqrt (x)

Returns an implementation-dependent approximation to the square root of \( x \).

• If \( x \) is NaN, the result is NaN.
• If \( x \) is less than 0, the result is NaN.
• If \( x \) is \(+0\), the result is \(+0\).
• If \( x \) is \(-0\), the result is \(-0\).
• If \( x \) is \(+\infty\), the result is \(+\infty\).
15.8.2.18 Math.tan (x)

Returns an implementation-dependent approximation to the tangent of \( x \). The argument is expressed in radians.

- If \( x \) is NaN, the result is NaN.
- If \( x \) is +0, the result is +0.
- If \( x \) is −0, the result is −0.
- If \( x \) is +\( \infty \) or −\( \infty \), the result is NaN.

15.8.2.19 Math.log10 (x)

Returns an implementation-dependent approximation to the base 10 logarithm of \( x \).

- If \( x \) is NaN, the result is NaN.
- If \( x \) is less than 0, the result is NaN.
- If \( x \) is +0, the result is −\( \infty \).
- If \( x \) is −0, the result is −\( \infty \).
- If \( x \) is 1, the result is +0.
- If \( x \) is +\( \infty \), the result is +\( \infty \).

15.8.2.20 Math.log2 (x)

Returns an implementation-dependent approximation to the base 2 logarithm of \( x \).

- If \( x \) is NaN, the result is NaN.
- If \( x \) is less than 0, the result is NaN.
- If \( x \) is +0, the result is −\( \infty \).
- If \( x \) is −0, the result is −\( \infty \).
- If \( x \) is 1, the result is +0.
- If \( x \) is +\( \infty \), the result is +\( \infty \).

15.8.2.21 Math.log1p (x)

Returns an implementation-dependent approximation to the natural logarithm of 1 + \( x \). The result is computed in a way that is accurate even when the value of \( x \) is close to zero.

- If \( x \) is NaN, the result is NaN.
- If \( x \) is less than −1, the result is NaN.
- If \( x \) is −1, the result is −\( \infty \).
- If \( x \) is +0, the result is +0.
- If \( x \) is −0, the result is −0.
- If \( x \) is +\( \infty \), the result is +\( \infty \).

15.8.2.22 Math.expm1 (x)

Returns an implementation-dependent approximation to subtracting 1 from the exponential function of \( x \) (\( e \) 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.
15.8.2.23  Math.cosh(x)

Returns an implementation-dependent approximation to the hyperbolic cosine of x.

- If x is NaN, the result is NaN.
- If x is +0, the result is 1.
- If x is −0, the result is 1.
- If x is +∞, the result is +∞.
- If x is −∞, the result is +∞.

**NOTE**  The value of cosh(x) is the same as \((\exp(x) + \exp(-x))/2\).

15.8.2.24  Math.sinh(x)

Returns an implementation-dependent approximation to the hyperbolic sine of x.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.
- If x is +∞, the result is +∞.
- If x is −∞, the result is −∞.

**NOTE**  The value of cosh(x) is the same as \((\exp(x) - \exp(-x))/2\).

15.8.2.25  Math.tanh(x)

Returns an implementation-dependent approximation to the hyperbolic tangent of x.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.
- If x is +∞, the result is +1.
- If x is −∞, the result is −1.

**NOTE**  The value of tanh(x) is the same as \((\exp(x) - \exp(-x))/\exp(x) + \exp(-x))\).

15.8.2.26  Math.acosh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic cosine of x.

- If x is NaN, the result is NaN.
- If x is less than 1, the result is NaN.
- If x is 1, the result is +0.
- If x is +∞, the result is +∞.

15.8.2.27  Math.asinh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic sine of x.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.
- If x is +∞, the result is +∞.
- If x is −∞, the result is −∞.
15.8.2.28 Math.atanh(x)

Returns an implementation-dependent approximation to the inverse hyperbolic tangent of x.

- If x is NaN, the result is NaN.
- If x is less than −1, the result is NaN.
- If x is greater than 1, the result is NaN.
- If x is −1, the result is −∞.
- If x is +1, the result is +∞.
- If x is 0, the result is ±0.
- If x is −0, the result is −0.

15.8.2.29 Math.hypot( value1, value2, value3 = 0 )

Given two or three arguments, hypot returns an implementation-dependent approximation of the square root of the sum of squares of up to three arguments.

- If any argument is +∞, the result is +∞.
- If any argument is −∞, the result is +∞.
- If no argument is +∞ or −∞, and any argument is NaN, the result is NaN.
- If all arguments are either +0 or −0, the result is +0.

The length property of the hypot function is 2.

15.8.2.30 Math.trunc(x)

Returns the integral part of the number x, removing any fractional digits. If x is already an integer, the result is x.

- If x is NaN, the result is NaN.
- If x is −0, the result is −0.
- If x is +0, the result is +0.
- If x is +∞, the result is +∞.
- If x is −∞, the result is −∞.

15.8.2.31 Math.sign(x)

Returns the sign of x, indicating whether x is positive, negative or zero.

- If x is NaN, the result is NaN.
- If x is −0, the result is −0.
- If x is +0, the result is +0.
- If x is negative and not −0, the result is −1.
- If x is positive and not +0, the result is +1.

15.8.2.32 Math.cbrt(x)

Returns an implementation-dependent approximation to the cube root of x.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.
- If x is +∞, the result is +∞.
- If x is −∞, the result is −∞.
15.8.2.33 Math.imul(x, y)

15.7.4.8 Math.imul()

When the Math.imul is called with arguments x and y the following steps are taken:

1. Let a be ToUint32(x).
2. ReturnIfAbrupt(a).
3. Let b be ToUint32(y).
4. ReturnIfAbrupt(b).
5. Let product be \((a \times b) \mod 2^{32}\).
6. If \(product \geq 2^{31}\), return \(product - 2^{32}\), otherwise return product.

15.9 Date Objects

15.9.1 Overview of Date Objects and Definitions of Abstract Operations

The following functions are abstract operations that operate on time values (defined in 15.9.1.1). Note that, in every case, if any argument to one of these functions is NaN, the result will be NaN.

15.9.1.1 Time Values and Time Range

A Date object contains a Number indicating a particular instant in time to within a millisecond. Such a Number is called a time value. A time value may also be NaN, indicating that the Date object does not represent a specific instant of time.

Time is measured in ECMAScript in milliseconds since 01 January, 1970 UTC. In time values leap seconds are ignored. It is assumed that there are exactly 86,400,000 milliseconds per day. ECMAScript Number values can represent all integers from \(-9,007,199,254,740,992\) to \(9,007,199,254,740,992\); this range suffices to measure times to millisecond precision for any instant that is within approximately 285,616 years, either forward or backward, from 01 January, 1970 UTC.

The actual range of times supported by ECMAScript Date objects is slightly smaller: exactly \(-100,000,000\) days to \(100,000,000\) days measured relative to midnight at the beginning of 01 January, 1970 UTC. This gives a range of 8,640,000,000,000,000 milliseconds to either side of 01 January, 1970 UTC.

The exact moment of midnight at the beginning of 01 January, 1970 UTC is represented by the value +0.

15.9.1.2 Day Number and Time within Day

A given time value \(t\) belongs to day number

\[
\text{Day}(t) = \text{floor}(t / \text{msPerDay})
\]

where the number of milliseconds per day is

\[
\text{msPerDay} = 86400000
\]

The remainder is called the time within the day:

\[
\text{TimeWithinDay}(t) = t \mod \text{msPerDay}
\]

15.9.1.3 Year Number

ECMAScript uses an extrapolated Gregorian system to map a day number to a year number and to determine the month and date within that year. In this system, leap years are precisely those which are (divisible by 4) and ((not divisible by 100) or (divisible by 400)). The number of days in year number \(y\) is therefore defined by

\[
\text{DaysInYear}(y) =
\begin{cases} 
365 & \text{if } (y \mod 4) \neq 0 \\
366 & \text{if } (y \mod 4) = 0 \text{ and } (y \mod 100) \neq 0 \\
365 & \text{if } (y \mod 100) = 0 \text{ and } (y \mod 400) \neq 0 \\
366 & \text{if } (y \mod 400) = 0 
\end{cases}
\]
All non-leap years have 365 days with the usual number of days per month and leap years have an extra day in February. The day number of the first day of year 1 is given by:

\[
\text{DayFromYear}(y) = 365 \times (y–1970) + \text{floor}(y–1969)/4 - \text{floor}(y–1901)/100 + \text{floor}(y–1601)/400
\]

The time value of the start of a year is:

\[
\text{TimeFromYear}(y) = \text{msPerDay} \times \text{DayFromYear}(y)
\]

A time value determines a year by:

\[
\text{YearFromTime}(t) = \text{the largest integer } y \text{ (closest to positive infinity) such that } \text{TimeFromYear}(y) \leq t
\]

The leap-year function is 1 for a time within a leap year and otherwise is zero:

\[
\text{InLeapYear}(t) = 0 \text{ if } \text{DaysInYear(YearFromTime(t))} = 365 \\
= 1 \text{ if } \text{DaysInYear(YearFromTime(t))} = 366
\]

15.9.1.4 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:

\[
\text{MonthFromTime}(t) = 0 \text{ if } 0 \leq \text{DayWithinYear}(t) < 31 \\
= 1 \text{ if } 31 \leq \text{DayWithinYear}(t) < 31+\text{InLeapYear}(t) \\
= 2 \text{ if } 31+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 91+\text{InLeapYear}(t) \\
= 3 \text{ if } 91+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 120+\text{InLeapYear}(t) \\
= 4 \text{ if } 120+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 151+\text{InLeapYear}(t) \\
= 5 \text{ if } 151+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 181+\text{InLeapYear}(t) \\
= 6 \text{ if } 181+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 212+\text{InLeapYear}(t) \\
= 7 \text{ if } 212+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 243+\text{InLeapYear}(t) \\
= 8 \text{ if } 243+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 273+\text{InLeapYear}(t) \\
= 9 \text{ if } 273+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 304+\text{InLeapYear}(t) \\
= 10 \text{ if } 304+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 334+\text{InLeapYear}(t) \\
= 11 \text{ if } 334+\text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 365+\text{InLeapYear}(t)
\]

where

\[
\text{DayWithinYear}(t) = \text{Day}(t) - \text{DayFromYear YearFromTime}(t)
\]

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.

15.9.1.5 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 month number is defined by:

\[
\text{DateFromTime}(t) = \text{DayWithinYear}(t)+1 \text{ if } \text{MonthFromTime}(t)=0 \\
= \text{DayWithinYear}(t)–30 \text{ if } \text{MonthFromTime}(t)=1 \\
= \text{DayWithinYear}(t)–58–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=2 \\
= \text{DayWithinYear}(t)–99–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=3 \\
= \text{DayWithinYear}(t)–119–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=4 \\
= \text{DayWithinYear}(t)–150–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=5 \\
= \text{DayWithinYear}(t)–211–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=6 \\
= \text{DayWithinYear}(t)–242–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=7 \\
= \text{DayWithinYear}(t)–272–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=8 \\
= \text{DayWithinYear}(t)–303–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=9 \\
= \text{DayWithinYear}(t)–333–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=10 \\
= \text{DayWithinYear}(t)–364–\text{InLeapYear}(t) \text{ if } \text{MonthFromTime}(t)=11
\]
15.9.1.6 Week Day

The weekday for a particular time value \( t \) is defined as

\[
\text{WeekDay}(t) = \left( \text{Day}(t) + 4 \right) \mod 7
\]

A weekday value of 0 specifies Sunday; 1 specifies Monday; 2 specifies Tuesday; 3 specifies Wednesday; 4 specifies Thursday; 5 specifies Friday; and 6 specifies Saturday. Note that WeekDay(0) = 4, corresponding to Thursday, 01 January, 1970.

15.9.1.7 Local Time Zone Adjustment

An implementation of ECMAScript is expected to determine the local time zone adjustment. The local time zone adjustment is a value LocalTZA measured in milliseconds which when added to UTC represents the local standard time. Daylight saving time is not reflected by LocalTZA.

**NOTE** It is recommended that implementations use the time zone information of the IANA Time Zone Database.

15.9.1.8 Daylight Saving Time Adjustment

An implementation of ECMAScript is expected to make its best effort to determine the local daylight saving time adjustment. An implementation dependent algorithm using best available information on time zones to determine the local daylight saving time adjustment DaylightSavingTA(\( t \)), measured in milliseconds.

15.9.1.9 Local Time

Conversion from UTC to local time is defined by

\[
\text{LocalTime}(t) = t + \text{LocalTZA} + \text{DaylightSavingTA}(t)
\]

Conversion from local time to UTC is defined by

\[
\text{UTC}(t) = t - \text{LocalTZA} - \text{DaylightSavingTA}(t - \text{LocalTZA})
\]

Note that UTC(LocalTime(\( t \))) is not necessarily always equal to \( t \).

15.9.1.10 Hours, Minutes, Second, and Milliseconds

The following functions are useful in decomposing time values:

\[
\begin{align*}
\text{HourFromTime}(t) &= \text{floor}(t / \text{msPerHour}) \mod \text{HoursPerDay} \\
\text{MinFromTime}(t) &= \text{floor}(t / \text{msPerMinute}) \mod \text{MinutesPerHour} \\
\text{SecFromTime}(t) &= \text{floor}(t / \text{msPerSecond}) \mod \text{SecondsPerMinute} \\
\text{msFromTime}(t) &= t \mod \text{msPerSecond}
\end{align*}
\]

where

\[
\begin{align*}
\text{HoursPerDay} &= 24 \\
\text{MinutesPerHour} &= 60 \\
\text{SecondsPerMinute} &= 60 \\
\text{msPerSecond} &= 1000 \\
\text{msPerMinute} &= 60000 = \text{msPerSecond} \times \text{SecondsPerMinute} \\
\text{msPerHour} &= 3600000 = \text{msPerMinute} \times \text{MinutesPerHour}
\end{align*}
\]

15.9.1.11 MakeTime (hour, min, sec, ms)

The operator MakeTime calculates a number of milliseconds from its four arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If hour is not finite or min is not finite or sec is not finite or ms is not finite, return NaN.
2. Let \( h \) be \( \text{ToInteger}(\text{hour}) \).
3. Let \( m \) be \( \text{ToInteger}(\text{min}) \).
4. Let \( s \) be \( \text{ToInteger}(\text{sec}) \).
5. Let \( \text{milli} \) be \( \text{ToInteger}(\text{ms}) \).
6. Let \( t \) be \( h \times \text{msPerHour} + m \times \text{msPerMinute} + s \times \text{msPerSecond} + \text{milli} \), performing the arithmetic according to IEEE 754 rules (that is, as if using the ECMAScript operators \(*\) and \(+\)).
7. Return \( t \).

15.9.1.12 MakeDay (year, month, date)

The operator MakeDay calculates a number of days from its three arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If \( \text{year} \) is not finite or \( \text{month} \) is not finite or \( \text{date} \) is not finite, return \( \text{NaN} \).
2. Let \( y \) be \( \text{ToInteger}(\text{year}) \).
3. Let \( m \) be \( \text{ToInteger}(\text{month}) \).
4. Let \( \text{dt} \) be \( \text{ToInteger}(\text{date}) \).
5. Let \( \text{ym} \) be \( y + \text{floor}(m/12) \).
6. Let \( \text{mn} \) be \( m \mod 12 \).
7. Find a value \( t \) such that \( \text{YearFromTime}(t) \) is \( \text{ym} \) and \( \text{MonthFromTime}(t) \) is \( \text{mn} \) and \( \text{DateFromTime}(t) \) is 1; but if this is not possible (because some argument is out of range), return \( \text{NaN} \).
8. Return \( \text{Day}(t) + \text{dt} - 1 \).

15.9.1.13 MakeDate (day, time)

The operator MakeDate calculates a number of milliseconds from its two arguments, which must be ECMAScript Number values. This operator functions as follows:

1. If \( \text{day} \) is not finite or \( \text{time} \) is not finite, return \( \text{NaN} \).
2. Return \( \text{day} \times \text{msPerDay} + \text{time} \).

15.9.1.14 TimeClip (time)

The operator TimeClip calculates a number of milliseconds from its argument, which must be an ECMAScript Number value. This operator functions as follows:

1. If \( \text{time} \) is not finite, return \( \text{NaN} \).
2. If \( \text{abs}(\text{time}) > 8.64 \times 10^{15} \), return \( \text{NaN} \).
3. Return \( \text{ToInteger}(\text{time}) + (+0) \). (Adding a positive zero converts \(-0\) to \(+0\).)

**NOTE** The point of step 3 is that an implementation is permitted a choice of internal representations of time values, for example as a 64-bit signed integer or as a 64-bit floating-point value. Depending on the implementation, this internal representation may or may not distinguish \(-0\) and \(+0\).

15.9.1.15 DateTime 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.
- \( MM \) is the month of the year from 01 (January) to 12 (December).
- \( DD \) is the day of the month from 01 to 31.
- \( HH \) is the number of complete hours that have passed since midnight as two decimal digits from 00 to 24.
: "::" (colon) appears literally twice in the string.

mm is the number of complete minutes since the start of the hour as two decimal digits from 00 to 59.

ss is the number of complete seconds since the start of the minute as two decimal digits from 00 to 59.

. "." (dot) appears literally in the string.

sss is the number of complete milliseconds since the start of the second as three decimal digits.

Z is the time zone offset specified as "Z" (for UTC) or either "+" or "-" followed by a time expression HH:mm

This format includes date-only forms:

YYYY
YYYY-MM
YYYY-MM-DD

It also includes "date-time" forms that consist of one of the above date-only forms immediately followed by one of the following time forms with an optional time zone offset appended:

THH:mm
THH:mm:ss
THH:mm:ss.sss

All numbers must be base 10. If the MM or DD fields are absent "01" is used as the value. If the HH, mm, or ss fields are absent "00" is used as the value and the value of an absent sss field is "000". If the time zone offset is absent, the date-time is interpreted as a local time.

Illegal values (out-of-bounds as well as syntax errors) in a format string means that the format string is not a valid instance of this format.

NOTE 1 As every day both starts and ends with midnight, the two notations 00:00 and 24:00 are available to distinguish the two midnights that can be associated with one date. This means that the following two notations refer to exactly the same point in time: 1995-02-05T24:00 and 1995-02-06T00:00.

NOTE 2 There exists no international standard that specifies abbreviations for civil time zones like CET, EST, etc. and sometimes the same abbreviation is even used for two very different time zones. For this reason, ISO 8601 and this format specifies numeric representations of date and time.

15.9.1.15.1 Extended years

ECMAScript requires the ability to specify 6 digit years (extended years); approximately 285,426 years, either forward or backward, from 01 January, 1970 UTC. To represent years before 0 or after 9999, ISO 8601 permits the expansion of the year representation, but only by prior agreement between the sender and the receiver. In the simplified ECMAScript format such an expanded year representation shall have 2 extra year digits and is always prefixed with a + or – sign. The year 0 is considered positive and hence prefixed with a + sign.

NOTE Examples of extended years:

-283457-03-21T15:00:59.008Z 283458 B.C.
-000001-01-01T00:00:00Z 2 B.C.
+000000-01-01T00:00:00Z 1 B.C.
+000000-01-01T00:00:00Z 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.
15.9.2 The Date Constructor Called as a Function

When Date is called as a function rather than as a constructor, it returns a String representing the current time (UTC). However, if the this value passed in the call is an Object with an uninitialized [[DateValue]] internal data property, Date initializes the this object using the argument value. This permits Date to be used both as a function for creating data strings and to perform constructor instance initialization.

Date may be subclassed and subclass constructors may perform a super invocation of the Date constructor to initialize the [[DateValue]] state of subclass instances.

15.9.2.1 Date (year, month [, date [, hours [, minutes [, seconds [, ms ]]]]])

This description applies only if the Date constructor is called with at least two arguments.

When the Date function is called the following steps are taken:

1. Let numberOfArgs be the number of arguments passed to this constructor call.
3. Let O be the this value.
4. If Type(O) is Object and O has a [[DateValue]] internal data property and the value of [[DateValue]] is undefined, then
   a. Let y be ToNumber(year).
   b. ReturnIfAbrupt(y).
   c. Let m be ToNumber(month).
   d. ReturnIfAbrupt(m).
   e. If date is supplied then let dt be ToNumber(date); else let dt be 1.
   f. ReturnIfAbrupt(dt).
   g. If hours is supplied then let h be ToNumber(hours); else let h be 0.
   h. ReturnIfAbrupt(h).
   i. If minutes is supplied then let min be ToNumber(minutes); else let min be 0.
   j. ReturnIfAbrupt(min).
   k. If seconds is supplied then let s be ToNumber(seconds); else let s be 0.
   l. ReturnIfAbrupt(s).
   m. If ms is supplied then let milli be ToNumber(ms); else let milli be 0.
   n. ReturnIfAbrupt(milli).
   o. If y is not NaN and 0 ≤ ToInteger(y) ≤ 99, then let yr be 1900+ToInteger(y); otherwise, let yr be y.
   p. Let finalDate be MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli)).
   q. Set the [[DateValue]] internal data property of O to TimeClip(UTC(finalDate)).
   r. Return O.
5. Else, return the result computed as if by the expression (new Date()).toString() where Date is this function and toString is the standard in-built method Date.prototype.toString.

15.9.2.2 Date (value)

This description applies only if the Date constructor is called with exactly one argument.

When the Date function is called the following steps are taken:

1. Let numberOfArgs be the number of arguments passed to this constructor call.
3. Let O be the this value.
4. If Type(O) is Object and O has a [[DateValue]] internal data property and the value of [[DateValue]] is undefined, then
   a. If Type(value) is Object and value has a [[DateValue]] internal data property, then
      i. Let tv be thisTimeValue(value).
   b. Else,
      i. Let v be ToPrimitive(value).
      ii. If Type(v) is String, then

1. Let $r$ be the result of parsing $v$ as a date, in exactly the same manner as for the `parse` method (15.9.4.2). If the parse resulted in an abrupt completion, $r$ is the Completion Record.

   iii. Else,
      1. Let $r$ be ToNumber($v$).
      c. ReturnIfAbrupt($r$).
      d. Set the [[DateValue]] internal data property of $O$ to TimeClip($r$).
      e. Return $O$.

5. Else,
   a. Return the result computed as if by the expression `(new Date()).toString()` where `Date` is this function and `toString` is the standard built-in method `Date.prototype.toString`.

15.9.2.3 Date()

This description applies only if the Date constructor is called with no arguments.

When the Date function is called the following steps are taken:

1. Let numberOfArgs be the number of arguments passed to this constructor call.
2. Assert: numberOfArgs = 0.
3. Let $O$ be the this value.
4. If $O$ is a Date object and $O$ has a [[DateValue]] internal data property and the value of [[DateValue]] is `undefined`, then
   a. Set the [[DateValue]] internal data property of $O$ to the time value (UTC) identifying the current time.
   b. Return $O$.
5. Else,
   a. Return the result computed as if by the expression `(new Date()).toString()` where `Date` is this function and `toString` is the standard built-in method `Date.prototype.toString`.

15.9.3 The Date Constructor

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

15.9.3.1 new Date(...args)

`Date` called as part of a new expression with argument list `args` performs the following steps:

1. Let $F$ be the Date function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct ($F$, argumentsList).

If `Date` is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.9.4 Properties of the Date Constructor

The value of the [[Prototype]] internal data property of the Date constructor is the Function prototype object (15.3.3).

Besides the length property (whose value is 7), the Date constructor has the following properties:

15.9.4.1 Date.prototype

The initial value of Date.prototype is the built-in Date prototype object (15.9.5).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.9.4.2 Date.parse (string)

The parse function applies the ToString operator to its argument. If ToString results in an abrupt completion the Completion Record is immediately returned. Otherwise, parse interprets the resulting String as a date and time; it returns a Number, the UTC time value corresponding to the date and time. The String may be interpreted as a local time, a UTC time, or a time in some other time zone, depending on the contents of the String. The function first attempts to parse the format of the String according to the rules called out in Date Time String Format (15.9.1.15). If the String does not conform to that format the function may fall back to any implementation-specific heuristics or implementation-specific date formats. Unrecognisable Strings or dates containing illegal element values in the format String shall cause Date.parse to return NaN.

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:

```javascript
x.valueOf()
Date.parse(x.toString())
Date.parse(x.toUTCString())
Date.parse(x.toISOString())
```

However, the expression

```javascript
Date.parse(x.toLocaleString())
```

is not required to produce the same Number value as the preceding three expressions and, in general, the value produced by Date.parse is implementation-dependent when given any String value that does not conform to the Date Time String Format (15.9.1.15) and that could not be produced in that implementation by the toString or toUTCString method.

15.9.4.3 Date.UTC (year, month [, date [, hours [, minutes [, seconds [, ms ] ] ] ] ]

When the UTC function is called with fewer than two arguments, the behaviour is implementation-dependent. When the UTC function is called with two to seven arguments, it computes the date from year, month and (optionally) date, hours, minutes, seconds and ms. The following steps are taken:

1. Let y be ToNumber(year).
2. ReturnIfAbrupt(y).
3. Let m be ToNumber(month).
4. ReturnIfAbrupt(m).
5. If date is supplied then let dt be ToNumber(date); else let dt be 1.
6. ReturnIfAbrupt(dt).
7. If hours is supplied then let h be ToNumber(hours); else let h be 0.
8. ReturnIfAbrupt(h).
9. If minutes is supplied then let min be ToNumber(minutes); else let min be 0.
10. ReturnIfAbrupt(min).
11. If seconds is supplied then let s be ToNumber(seconds); else let s be 0.
12. ReturnIfAbrupt(s).
13. If ms is supplied then let milli be ToNumber(ms); else let milli be 0.
14. ReturnIfAbrupt(milli).
15. If y is not NaN and 0 ≤ ToInteger(y) ≤ 99, then let yr be 1900+ToInteger(y); otherwise, let yr be y.
16. Return TimeClip(MakeDate(MakeDay(yr, m, dt), MakeTime(h, min, s, milli))).

The length property of the UTC function is 7.

NOTE The UTC function differs from the Date constructor in two ways: it returns a time value as a Number, rather than creating a Date object, and it interprets the arguments in UTC rather than as local time.
15.9.4.4 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`.

15.9.4.5 Date[@@create] ( )

The `@@create` method of an object `F` performs the following steps:

1. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%DatePrototype%", [[DateValue]])`.
2. ReturnIfAbrupt(`obj`).
3. Return `obj`.

This property has the attributes `[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true`.

NOTE `[[DateValue]]` is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the Date constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.9.5 Properties of the Date Prototype Object

The Date prototype object is itself an ordinary object. It is not a Date instance and does not have a `[[DateValue]]` internal data property.

The value of the `[[Prototype]]` internal data property of the Date prototype object is the standard built-in Object prototype object (15.2.4).

Unless explicitly stated otherwise, the methods of the Date prototype object defined below are not generic and the `this` value passed to them must be an object that has a `[[DateValue]]` internal data property that has been initialized to a time value.

The abstract operation `thisTimeValue(value)` performs the following steps:

1. If `Type(value)` is Object and `value` has a `[[DateValue]]` internal data property, then
   a. Let `n` be the Number that is the value of `value`'s `[[NumberData]]` internal data property.
   b. If `n` is not `undefined`, then return `n`.
2. Throw a `TypeError` exception.

In following descriptions of functions that are properties of the Date prototype object, the phrase "this Date object" refers to the object that is the `this` value for the invocation of the function. The phrase "this time value" within the specification of a method refers to the result returned by calling the abstract operation `thisTimeValue` with the `this` value of the method invocation passed as the argument.

15.9.5.1 Date.prototype.constructor

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

15.9.5.2 Date.prototype.toString ( )

This function returns a String value. If this time value is NaN, the String value is "Invalid Date", otherwise the contents of the String are implementation-dependent, but are intended to represent the Date in the current time zone in a convenient, human-readable form.

NOTE For any Date value `d` whose milliseconds amount is zero, the result of `Date.parse(d.toString())` is equal to `d.valueOf()`. See 15.9.4.2.
15.9.5.3 **Date.prototype.toDateString()**

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the “date” portion of the Date in the current time zone in a convenient, human-readable form.

15.9.5.4 **Date.prototype.toTimeString()**

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the “time” portion of the Date in the current time zone in a convenient, human-readable form.

15.9.5.5 **Date.prototype.toLocaleString()**

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the Date in the current time zone in a convenient, human-readable form that corresponds to the conventions of the host environment’s current locale.

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

15.9.5.6 **Date.prototype.toLocaleDateString()**

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the “date” portion of the Date in the current time zone in a convenient, human-readable form that corresponds to the conventions of the host environment’s current locale.

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

15.9.5.7 **Date.prototype.toLocaleTimeString()**

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the “time” portion of the Date in the current time zone in a convenient, human-readable form that corresponds to the conventions of the host environment’s current locale.

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

15.9.5.8 **Date.prototype.valueOf()**

The `valueOf` function returns a Number, which is this time value.

15.9.5.9 **Date.prototype.getDate()**

1. Return this time value.

15.9.5.10 **Date.prototype.getFullYear()**

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is `NaN`, return `NaN`.
4. Return YearFromTime(LocalTime(\( t \))).

15.9.5.11 **Date.prototype.getUTCFullYear()**

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is `NaN`, return `NaN`.
4. Return YearFromTime(\( t \)).
15.9.5.12 Date.prototype.getMonth ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return MonthFromTime(LocalTime(\( t \))).

15.9.5.13 Date.prototype.getUTCMonth ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return MonthFromTime(\( t \)).

15.9.5.14 Date.prototype.getDate ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return DateFromTime(LocalTime(\( t \))).

15.9.5.15 Date.prototype.getUTCDate ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return DateFromTime(\( t \)).

15.9.5.16 Date.prototype.getDay ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return WeekDay(LocalTime(\( t \))).

15.9.5.17 Date.prototype.getUTCDay ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return WeekDay(\( t \)).

15.9.5.18 Date.prototype.getHours ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return HourFromTime(LocalTime(\( t \))).

15.9.5.19 Date.prototype.getUTCHours ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return HourFromTime(\( t \)).

15.9.5.20 Date.prototype.getMinutes ()
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. If \( t \) is NaN, return NaN.
4. Return MinFromTime(LocalTime(t)).

15.9.5.21 Date.prototype.getUTCMinutes()

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return MinFromTime(t).

15.9.5.22 Date.prototype.getSeconds()

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return SecFromTime(t).

15.9.5.23 Date.prototype.getUTCSecs()s()

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return SecFromTime(t).

15.9.5.24 Date.prototype.getMilliseconds()

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return msFromTime(t).

15.9.5.25 Date.prototype.getUTCMilliseconds()

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return msFromTime(t).

15.9.5.26 Date.prototype.getTimezoneOffset()

Returns the difference between local time and UTC time in minutes.

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return \((t - \text{LocalTime}(t)) / \text{msPerMinute}\).

15.9.5.27 Date.prototype.setTime(time)

1. Let \( v \) be TimeClip(Number(toNumber(time))).
2. ReturnIfAbrupt(v).
3. Set the [[DateValue]] internal data property of this Date object to \( v \).
4. Return \( v \).

15.9.5.28 Date.prototype.setMilliseconds(ms)

1. Let \( t \) be the result of LocalTime(this time value).
2. Let \( time \) be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), toNumber(ms)).
3. Let \( u \) be TimeClipUTC(MakeDate(Day(t), time)).
4. Set the [[DateValue]] internal data property of this Date object to \( u \).
5. Return u.

15.9.5.29 Date.prototype.setUTCMilliseconds (ms)

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let time be MakeTime(HourFromTime(t), MinFromTime(t), SecFromTime(t), ToNumber(ms)).
4. Let v be TimeClip(MakeDate(Day(t), time)).
5. Set the [[DateValue]] internal data property of this Date object to v.
6. Return v.

15.9.5.30 Date.prototype.setSeconds (sec [, ms ])

If ms is not specified, this behaves as if ms were specified with the value getMilliseconds().

1. Let t be the result of LocalTime(this time value).
2. Let s be ToNumber(sec).
3. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
4. Let date be MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s, milli)).
5. Let u be TimeClip(UTC(date)).
6. Set the [[DateValue]] internal data property of this Date object to u.
7. Return u.

The length property of the setSeconds method is 2.

15.9.5.31 Date.prototype.setUTCSecrets (sec [, ms ])

If ms is not specified, this behaves as if ms were specified with the value getUTCMilliseconds().

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let s be ToNumber(sec).
4. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
5. Let date be MakeDate(Day(t), MakeTime(HourFromTime(t), MinFromTime(t), s, milli)).
6. Let v be TimeClip(date).
7. Set the [[DateValue]] internal data property of this Date object to v.
8. Return v.

The length property of the setUTCSecrets method is 2.

15.9.5.32 Date.prototype.setMinutes (min [, sec [, ms ]])

If sec is not specified, this behaves as if sec were specified with the value getSeconds().

If ms is not specified, this behaves as if ms were specified with the value getMilliseconds().

1. Let t be the result of LocalTime(this time value).
2. Let m be ToNumber(min).
3. If sec is not specified, then let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
4. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
5. Let date be MakeDate(Day(t), MakeTime(HourFromTime(t), m, s, milli)).
6. Let u be TimeClip(UTC(date)).
7. Set the [[DateValue]] internal data property of this Date object to u.
8. Return u.

The length property of the setMinutes method is 3.
15.9.5.33 Date.prototype.setUTCMinutes (min [, sec [, ms ]])

If sec is not specified, this behaves as if sec were specified with the value getUTCSeconds().

If ms is not specified, this function behaves as if ms were specified with the value return by getUTCMilliseconds().

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let m be ToNumber(min).
4. If sec is not specified, then let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
5. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
6. Let date be MakeDate(Day(t), MakeTime(HourFromTime(t), m, s, milli)).
7. Let v be TimeClip(date).
8. Set the [[DateValue]] internal data property of this Date object to v.

The length property of the setUTCMinutes method is 3.

15.9.5.34 Date.prototype.setHours (hour [, min [, sec [, ms ]]])

If sec is not specified, this behaves as if sec were specified with the value getSeconds().

If ms is not specified, this behaves as if ms were specified with the value getMilliseconds().

1. Let t be the result of LocalTime(this time value).
2. Let h be ToNumber(hour).
3. If min is not specified, then let m be MinFromTime(t); otherwise, let m be ToNumber(min).
4. If sec is not specified, then let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
5. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
6. Let date be MakeDate(Day(t), MakeTime(h, m, s, milli)).
7. Let v be TimeClip(UTC(date)).
8. Set the [[DateValue]] internal data property of this Date object to v.

The length property of the setHours method is 4.

15.9.5.35 Date.prototype.setUTCHours (hour [, min [, sec [, ms ]]])

If min is not specified, this behaves as if min were specified with the value getUTCMinutes().

If sec is not specified, this behaves as if sec were specified with the value getUTCSeconds().

If ms is not specified, this behaves as if ms were specified with the value getUTCMilliseconds().

1. Let t be this time value.
2. ReturnIfAbrupt(t).
3. Let h be ToNumber(hour).
4. If min is not specified, then let m be MinFromTime(t); otherwise, let m be ToNumber(min).
5. If sec is not specified, then let s be SecFromTime(t); otherwise, let s be ToNumber(sec).
6. If ms is not specified, then let milli be msFromTime(t); otherwise, let milli be ToNumber(ms).
7. Let newDate be MakeDate(Day(t), MakeTime(h, m, s, milli)).
8. Let v be TimeClip(newDate).
9. Set the [[DateValue]] internal data property of this Date object to v.
10. Return v.

The length property of the setUTCHours method is 4.
15.9.5.36 Date.prototype.setDate (date)
1. Let \( t \) be the result of LocalTime(this time value).
2. Let \( dt \) be ToNumber(date).
3. Let \( \text{newDate} \) be MakeDate(MakeDay(YearFromTime(\( t \)), MonthFromTime(\( t \)), \( dt \)), TimeWithinDay(\( t \))).
4. Let \( u \) be TimeClip(UTC(\( \text{newDate} \))).
5. Set the [[DateValue]] internal data property of this Date object to \( u \).
6. Return \( u \).

15.9.5.37 Date.prototype.setUTCDate (date)
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. Let \( dt \) be ToNumber(date).
4. Let \( \text{newDate} \) be MakeDate(MakeDay(YearFromTime(\( t \)), MonthFromTime(\( t \)), \( dt \)), TimeWithinDay(\( t \))).
5. Let \( v \) be TimeClip(\( \text{newDate} \)).
6. Set the [[DateValue]] internal data property of this Date object to \( v \).
7. Return \( v \).

15.9.5.38 Date.prototype.setMonth (month [, date ])
If \( date \) is not specified, this behaves as if \( date \) were specified with the value getDate().
1. Let \( t \) be the result of LocalTime(this time value).
2. ReturnIfAbrupt(\( t \)).
3. Let \( m \) be ToNumber(month).
4. If \( date \) is not specified, then let \( dt \) be DateFromTime(\( t \)); otherwise, let \( dt \) be ToNumber(date).
5. Let \( \text{newDate} \) be MakeDate(MakeDay(YearFromTime(\( t \)), \( m \), \( dt \)), TimeWithinDay(\( t \))).
6. Let \( v \) be TimeClip(UTC(\( \text{newDate} \))).
7. Set the [[DateValue]] internal data property of this Date object to \( v \).
8. Return \( v \).

The length property of the setMonth method is 2.

15.9.5.39 Date.prototype.setUTCMonth (month [, date ])
If \( date \) is not specified, this behaves as if \( date \) were specified with the value getUTCDate().
1. Let \( t \) be this time value.
2. ReturnIfAbrupt(\( t \)).
3. Let \( m \) be ToNumber(month).
4. If \( date \) is not specified, then let \( dt \) be DateFromTime(\( t \)); otherwise, let \( dt \) be ToNumber(date).
5. Let \( \text{newDate} \) be MakeDate(MakeDay(YearFromTime(\( t \)), \( m \), \( dt \)), TimeWithinDay(\( t \))).
6. Let \( v \) be TimeClip(UTC(\( \text{newDate} \))).
7. Set the [[DateValue]] internal data property of this Date object to \( v \).
8. Return \( v \).

The length property of the setUTCMonth method is 2.

15.9.40 Date.prototype.setFullYear (year [, month [, date ]])
If \( month \) is not specified, this behaves as if \( month \) were specified with the value getMonth().
If \( date \) is not specified, this behaves as if \( date \) were specified with the value getDate().
1. Let \( t \) be the result of LocalTime(this time value); but if this time value is NaN, let \( t \) be +0.
2. Let \( y \) be ToNumber(year).
3. If \( month \) is not specified, then let \( m \) be MonthFromTime(\( t \)); otherwise, let \( m \) be ToNumber(month).
4. If \( date \) is not specified, then let \( dt \) be DateFromTime(\( t \)); otherwise, let \( dt \) be ToNumber(date).
5. Let \( \text{newDate} \) be MakeDate(MakeDay(\( y \), \( m \), \( dt \)), TimeWithinDay(\( t \))).
6. Let \( u \) be TimeClip(UTC(newDate)).
7. Set the [[DateValue]] internal data property of this Date object to \( u \).
8. Return \( u \).

The \textit{length} property of the \texttt{setFullYear} method is 3.

15.9.5.41 \texttt{Date.prototype.setUTCFullYear(year [, month [, date ]])}

If \( month \) is not specified, this behaves as if \( month \) were specified with the value \texttt{getUTCMonth}().
If \( date \) is not specified, this behaves as if \( date \) were specified with the value \texttt{getUTCDate}().

1. Let \( t \) be this time value; but if this time value is \texttt{NaN}, let \( t \) be +0.
2. ReturnIfAbrupt(\( t \)).
3. Let \( y \) be ToNumber(\( year \)).
4. If \( month \) is not specified, then let \( m \) be MonthFromTime(\( t \)); otherwise, let \( m \) be ToNumber(\( month \)).
5. If \( date \) is not specified, then let \( dt \) be DateFromTime(\( t \)); otherwise, let \( dt \) be ToNumber(\( date \)).
6. Let \( newDate \) be MakeDate(MakeDay(\( y \), \( m \), \( dt \)), TimeWithinDay(\( t \))).
7. Let \( v \) be TimeClip(\( newDate \)).
8. Set the [[DateValue]] internal data property of this Date object to \( v \).
9. Return \( v \).

The \textit{length} property of the \texttt{setUTCFullYear} method is 3.

15.9.5.42 \texttt{Date.prototype.toUTCString}()

This function returns a String value. The contents of the String are implementation-dependent, but are intended to represent the Date in a convenient, human-readable form in UTC.

\textbf{NOTE} The intent is to produce a String representation of a date that is more readable than the format specified in 15.9.1.15. It is not essential that the chosen format be unambiguous or easily machine parsable. If an implementation does not have a preferred human-readable format it is recommended to use the format defined in 15.9.1.15 but with a space rather than a "T" used to separate the date and time elements.

15.9.5.43 \texttt{Date.prototype.toISOString}()

This function returns a String value represent the instance in time represented by this Date object. The format of the String is the Date Time string format defined in 15.9.1.15. All fields are present in the String. The time zone is always UTC, denoted by the suffix Z. If the time value of this object is not a finite Number a \texttt{RangeError} exception is thrown.

15.9.5.44 \texttt{Date.prototype.toJSON} (key)

This function provides a String representation of a Date object for use by \texttt{JSON.stringify} (15.12.3).

When the \texttt{toJSON} method is called with argument \( \texttt{key} \), the following steps are taken:

1. Let \( O \) be the result of calling \texttt{ToObject}, giving it the \texttt{this} value as its argument.
2. Let \( tv \) be ToPrimitive(\( O \), hint \texttt{Number}).
3. If \( tv \) is a Number and is not finite, return \texttt{null}.
4. Let \( toISO \) be the result of Get(\( O \), \texttt{"toISOString"}).
5. ReturnIfAbrupt(\( toISO \)).
6. If IsCallable(\( toISO \)) is \texttt{false}, throw a \texttt{TypeError} exception.
7. Return the result of calling the [[Call]] internal method of \( toISO \) with \( O \) as \texttt{thisArgument} and an empty \texttt{List} as \texttt{argumentsList}.

\textbf{NOTE 1} The argument is ignored.
NOTE 2  The `toJSON` function is intentionally generic; it does not require that its `this` value be a Date object. Therefore, it can be transferred to other kinds of objects for use as a method. However, it does require that any such object have a `toISOString` method. An object is free to use the argument `key` to filter its stringification.

15.9.5.45 `Date.prototype.[@]ToPrimitive ( hint )`

This function is called by ECMAScript language operators to convert an object to a primitive value. The allowed values for `hint` are "default", "number", and "string". Date objects, are unique among built-in ECMAScript object in that they treat "default" as being equivalent to "string". All other built-in ECMAScript objects treat "default" as being equivalent to "number".

When the `@@ToPrimitive` method is called with argument `hint`, the following steps are taken:

1. Let `O` be this Date object.
2. If `Type(O)` is not Object, then throw a `TypeError` exception.
3. If `hint` is the string value "string" or the string value "default", then
   a. Let `tryFirst` be "string".
4. Else if `hint` is the string value "number", then
   a. Let `tryFirst` be "number".
5. Else, throw a `TypeError` exception.
6. Return the result of `OrdinaryToPrimitive(O, tryFirst)`.

15.9.6 Properties of Date Instances

Date instances are ordinary objects that inherit properties from the Date prototype object. Date instances also have a `[[DateValue]]` internal data property. The `[[DateValue]]` internal data property is the time value represented by this Date object.

15.10 RegExp (Regular Expression) Objects

A RegExp object contains a regular expression and the associated flags.

NOTE  The form and functionality of regular expressions is modelled after the regular expression facility in the Perl 5 programming language.

15.10.1 Patterns

The `RegExp` constructor applies the following grammar to the input pattern String. An error occurs if the grammar cannot interpret the String as an expansion of `Pattern`.

Syntax

```plaintext
Pattern ::=
  Disjunction

Disjunction ::= Alternative
  Alternative | Disjunction

Alternative ::= {empty}
  Alternative Term

Term ::= Assertion
  Atom
  Atom Quantifier
```
Assertion ::
  ^
  \b
  \B
  (? = Disjunction )
  (? ! Disjunction )

Quantifier ::
  QuantifierPrefix
  QuantifierPrefix ?

QuantifierPrefix ::
  *
  +
  ?
  { DecimalDigits }
  { DecimalDigits , }
  { DecimalDigits , DecimalDigits }

Atom ::
  PatternCharacter
  \ AtomEscape
  CharacterClass
  ( Disjunction )
  ( ? : Disjunction )

PatternCharacter ::
  SourceCharacter but not one of
  ^ $ \ . * + ? ( ) [ ] { } |

AtomEscape ::
  DecimalEscape
  CharacterEscape
  CharacterClassEscape

CharacterEscape ::
  ControlEscape
c ControlLetter
  HexEscapeSequence
  UnicodeEscapeSequence
  IdentityEscape

ControlEscape :: one of fnrtv

ControlLetter :: one of abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ

IdentityEscape ::
  SourceCharacter but not IdentifierPart
  \<ZW\>
  \<ZWNJ\>

DecimalEscape ::
  DecimalIntegerLiteral [lookahead \ DecimalDigit]
15.10.2 Pattern Semantics

A regular expression pattern is converted into an internal procedure using the process described below. An implementation is encouraged to use more efficient algorithms than the ones listed below, as long as the results are the same. The internal procedure is used as the value of a RegExp object's [[RegExpMatcher]] internal data property.

15.10.2.1 Notation

The descriptions below use the following variables:

- **Input** is the String being matched by the regular expression pattern. The notation `input[n]` means the `n`th character of `input`, where `n` can range between 0 (inclusive) and `InputLength` (exclusive).
- **InputLength** is the number of characters in the Input String.
- **NcapturingParens** is the total number of left capturing parentheses (i.e. the total number of times the `Atom :: ( Disjunction )` production is expanded) in the pattern. A left capturing parenthesis is any pattern character that is matched by the { terminal of the `Atom :: ( Disjunction )` production.
- **IgnoreCase** is the setting of the RegExp object's `ignoreCase` property.
- **Multiline** is the setting of the RegExp object's `multiline` property.

Furthermore, the descriptions below use the following internal data structures:

- A CharSet is a mathematical set of characters.
A State is an ordered pair \((endIndex, captures)\) where \(endIndex\) is an integer and \(captures\) is an internal array of \(n\) \(N\)capturingParens\) 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 \(n\)\(^\text{th}\) element of \(captures\) is either a String that represents the value obtained by the \(n\)\(^\text{th}\) set of capturing parentheses or undefined if the \(n\)\(^\text{th}\) 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 bound in the function that created the closure, the closure uses the values that these variables had at the time the closure was created. The Continuation attempts to match the remaining portion (specified by the closure's already-bound arguments) of the pattern against the input String, starting at the intermediate state given by its State argument. If the match succeeds, the Continuation returns the final State that it reached. If the match fails, the Continuation returns failure.

A Matcher procedure is an internal closure that takes two arguments -- a State and a Continuation -- and returns a MatchResult result. A Matcher attempts to match a middle subpattern (specified by the closure's already-bound arguments) of the pattern against the input String, starting at the intermediate state given by its State argument. The Continuation argument should be a closure that matches the rest of the pattern. After matching the subpattern of a pattern to obtain a new State, the Matcher then calls Continuation on that new State to test if the rest of the pattern can match as well. If it can, the Matcher returns the State returned by Continuation; if not, the Matcher may try different choices at its choice points, repeatedly calling Continuation until it either succeeds or all possibilities have been exhausted.

An AssertionTester procedure is an internal closure that takes a State argument and returns a Boolean result. The assertion tester tests a specific condition (specified by the closure's already-bound arguments) against the current place in the input String and returns true if the condition matched or false if not.

An EscapeValue is either a character or an integer. An EscapeValue is used to denote the interpretation of a DecimalEscape escape sequence: a character \(ch\) means that the escape sequence is interpreted as the character \(ch\), while an integer \(n\) means that the escape sequence is interpreted as a backreference to the \(n\)\(^\text{th}\) set of capturing parentheses.

### 15.10.2.2 Pattern

The production Pattern :: Disjunction evaluates as follows:

1. Evaluate Disjunction to obtain a Matcher \(m\).
2. Return an internal closure that takes two arguments, a String \(str\) and an integer \(index\), and performs the following.
   1. Let \(Input\) be the given String \(str\). This variable will be used throughout the algorithms in 15.10.2.
   2. Let \(InputLength\) be the length of \(Input\). This variable will be used throughout the algorithms in 15.10.2.
   3. Let \(c\) be a Continuation that always returns its State argument as a Successful MatchResult.
   4. Let \(cap\) be an internal array of \(n\) \(N\)capturingParens\) undefined values, indexed 1 through \(n\)\(^\text{th}\) \(N\)capturingParens\).
   5. Let \(x\) be the State \((index, cap)\).
   6. Call \(m(x, c)\) and return its result.

**NOTE** A Pattern evaluates (“compiles”) to an internal procedure value. RegExp.prototype.exec can then apply this procedure to a String and an offset within the String to determine whether the pattern would match starting at exactly that offset within the String, and, if it does match, what the values of the capturing parentheses would be. The algorithms in 15.10.2 are designed so that compiling a pattern may throw a SyntaxError exception; on the other hand, once the pattern is successfully compiled, applying its result internal procedure to find a match in a String cannot throw an exception (except for any host-defined exceptions that can occur anywhere such as out-of-memory).
15.10.2.3 Disjunction

The production `Disjunction :: Alternative` evaluates by evaluating `Alternative` to obtain a Matcher and returning that Matcher.

The production `Disjunction :: Alternative | Disjunction` evaluates as follows:

1. Evaluate `Alternative` to obtain a Matcher `m1`.
2. Evaluate `Disjunction` to obtain a Matcher `m2`.
3. Return an internal Matcher closure that takes two arguments, a State `x` and a Continuation `c`, and performs the following:
   1. Call `m1(x, c)` and let `r` be its result.
   2. If `r` isn't `failure`, return `r`.
   3. Call `m2(x, c)` and return its result.

**NOTE** The `|` regular expression operator separates two alternatives. The pattern first tries to match the left `Alternative` (followed by the sequel of the regular expression); if it fails, it tries to match the right `Disjunction` (followed by the sequel of the regular expression). If the left `Alternative`, the right `Disjunction`, and the sequel all have choice points, all choices in the sequel are tried before moving on to the next choice in the left `Alternative`. If choices in the left `Alternative` are exhausted, the right `Disjunction` is tried instead of the left `Alternative`. Any capturing parentheses inside a portion of the pattern skipped by `|` produce `undefined` values instead of Strings. Thus, for example:

```
/a|ab/.exec("abc")
```

returns the result "a" and not "ab". Moreover,

```
/((a)|(ab))((c)|(bc))/.exec("abc")
```

returns the array

```
["abc", "a", "a", undefined, "bc", undefined, "bc"]
```

and not

```
["abc", "ab", undefined, "ab", "c", "c", undefined]
```

15.10.2.4 Alternative

The production `Alternative :: [empty]` evaluates by returning a Matcher that takes two arguments, a State `x` and a Continuation `c`, and returns the result of calling `c(x)`.

The production `Alternative :: Alternative Term` evaluates as follows:

1. Evaluate `Alternative` to obtain a Matcher `m1`.
2. Evaluate `Term` to obtain a Matcher `m2`.
3. Return an internal Matcher closure that takes two arguments, a State `x` and a Continuation `c`, and performs the following:
   1. Create a Continuation `d` that takes a State argument `y` and returns the result of calling `m2(y, c)`.
   2. Call `m1(x, d)` and return its result.

**NOTE** Consecutive `Terms` try to simultaneously match consecutive portions of the input String. If the left `Alternative`, the right `Term`, and the sequel of the regular expression all have choice points, all choices in the sequel are tried before moving on to the next choice in the right `Term`, and all choices in the right `Term` are tried before moving on to the next choice in the left `Alternative`.

15.10.2.5 Term

The production `Term :: Assertion` evaluates by returning an internal Matcher closure that takes two arguments, a State `x` and a Continuation `c`, and performs the following:

1. Evaluate `Assertion` to obtain an AssertionTester `t`.
2. Call `t(x)` and let `r` be the resulting Boolean value.
3. If `r` is `false`, return `failure`.
4. Call `c(x)` and return its result.

The production `Term :: Atom` evaluates by evaluating `Atom` to obtain a Matcher and returning that Matcher.
The production \[ \text{Term} :: \text{Atom Quantifier} \] evaluates as follows:

1. Evaluate \text{Atom} to obtain a Matcher \( m \).
2. Evaluate \text{Quantifier} to obtain the three results: an integer \( \text{min} \), an integer (or \( \infty \)) \( \text{max} \), and a Boolean \( \text{greedy} \).
3. If \( \text{max} \) is finite and less than \( \text{min} \), then throw a SyntaxError exception.
4. Let \( \text{parenIndex} \) be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion's Term. This is the total number of times the \( \text{Atom} :: (\text{Disjunction}) \) production is expanded prior to this production's Term plus the total number of \( \text{Atom} :: (\text{Disjunction}) \) productions enclosing this Term.
5. Let \( \text{parenCount} \) be the number of left capturing parentheses in the expansion of this production's \( \text{Atom} \). This is the total number of \( \text{Atom} :: (\text{Disjunction}) \) productions enclosed by this production's \( \text{Atom} \).
6. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:
   1. Call \( \text{RepeatMatcher}(m, \text{min}, \text{max}, \text{greedy}, x, c, \text{parenIndex}, \text{parenCount}) \) and return its result.

Runtime Semantics: RepeatMatcher Abstract Operation

The abstract operation \( \text{RepeatMatcher} \) takes eight parameters, a Matcher \( m \), an integer \( \text{min} \), an integer (or \( \infty \)) \( \text{max} \), a Boolean \( \text{greedy} \), a State \( x \), a Continuation \( c \), an integer \( \text{parenIndex} \), and an integer \( \text{parenCount} \), and performs the following:

1. If \( \text{max} \) is zero, then call \( c(1) \) and return its result.
2. Create an internal Continuation closure \( d \) that takes one State argument \( y \) and performs the following:
   1. If \( \text{min} \) is zero and \( y \)'s endIndex is equal to \( x \)'s endIndex, then return failure.
   2. If \( \text{min} \) is zero then let \( \text{min2} \) be zero; otherwise let \( \text{min2} \) be \( \text{min} - 1 \).
   3. If \( \text{max} \) is \( \infty \), then let \( \text{max2} \) be \( \infty \); otherwise let \( \text{max2} \) be \( \text{max} \).
   4. Call \( \text{RepeatMatcher}(m, \text{min2}, \text{max2}, \text{greedy}, x, \text{parenIndex}, \text{parenCount}) \) and return its result.
3. Let \( \text{cap} \) be a fresh copy of \( x \)'s captures internal array.
4. For every integer \( k \) that satisfies \( \text{parenIndex} < k \) and \( k \leq \text{endIndex} + \text{parenCount} \), set \( \text{cap}[k] \) to undefined.
5. Let \( e \) be \( x \)'s endIndex.
6. Let \( x_r \) be the State \( (e, \text{cap}) \).
7. If \( \text{min} \) is not zero, then call \( m(x_r, d) \) and return its result.
8. If \( \text{greedy} \) is false, then
   a. Call \( c(1) \) and let \( z \) be its result.
   b. If \( z \) is not failure, return \( z \).
   c. Call \( m(x_r, d) \) and return its result.
9. Call \( m(x_r, d) \) and let \( z \) be its result.
10. If \( z \) is not failure, return \( z \).
11. Call \( c(1) \) and return its result.

NOTE 1 An \( \text{Atom} \) followed by a \( \text{Quantifier} \) is repeated the number of times specified by the \( \text{Quantifier} \). A \( \text{Quantifier} \) can be non-greedy, in which case the \( \text{Atom} \) pattern is repeated as few times as possible while still matching the sequel, or it can be greedy, in which case the \( \text{Atom} \) pattern is repeated as many times as possible while still matching the sequel. The \( \text{Atom} \) pattern is repeated rather than the input String that it matches, so different repetitions of the \( \text{Atom} \) can match different input substrings.

NOTE 2 If the \( \text{Atom} \) and the sequel of the regular expression all have choice points, the \( \text{Atom} \) 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 next-to-last repetition of \( \text{Atom} \). All choices in the last (n)th repetition of \( \text{Atom} \) are tried before moving on to the next choice in the next-to-last (n-1)th repetition of \( \text{Atom} \) at which point it may turn out that more or fewer repetitions of \( \text{Atom} \) are now possible; these are exhausted (again, starting with either as few or as many as possible) before moving on to the next choice in the (n-1)th repetition of \( \text{Atom} \) and so on.

Compare
```javascript
/a[a-z]{2,4}/.exec("abcdefghijklmnopqrstuvwxyz")
```
which returns "abcdefg" with
```javascript
/a[a-z]{2,4}?/.exec("abcdefghijklmnopqrstuvwxyz")
```
which returns "abo".
Consider also

\[/(aa|aabaac|ba|b|c)/.exec("aabaac")\]

which, by the choice point ordering above, returns the array

\["aaba", "ba"]\]

and not any of:

\["aabaac", "aabaac"]\]

\["aabaac", "c"]\]

The above ordering of choice points can be used to write a regular expression that calculates the greatest common divisor of two numbers (represented in unary notation). The following example calculates the gcd of 10 and 15:

\["aaaaaaaaaaaaaaaaaaaaaaaaa".replace(/^(a+)\|\|1*,$$/, ";$1")\]

which returns the gcd in unary notation "aaaaa".

NOTE 3  Step 4 of the RepeatMatcher clears Atom's captures each time Atom is repeated. We can see its behaviour in the regular expression

\[/(z)((a+)\?\?\(c\))*/.exec("zaacbbbcac")\]

which returns the array

\["zaacbbbcac", "z", "ac", "a", undefined, "c"]\]

and not

\["zaacbbbcac", "z", "ac", "a", "bbb", "c"]\]

because each iteration of the outermost \* clears all captured Strings contained in the quantified Atom, which in this case includes capture Strings numbered 2, 3, 4, and 5.

NOTE 4  Step 1 of the RepeatMatcher's d closure states that, once the minimum number of repetitions has been satisfied, any more expansions of Atom that match the empty String are not considered for further repetitions. This prevents the regular expression engine from falling into an infinite loop on patterns such as:

\[/(a*)*/.exec("b")\]

or the slightly more complicated:

\[/(a*)b\|\|1+/.exec("baaaac")\]

which returns the array

\["b", "]\]

15.10.2.6 Assertion

The production Assertion :: \^ evaluates by returning an internal AssertionTester closure that takes a State argument \x and performs the following:

1. Let \e be \x's endIndex.
2. If \e is zero, return true.
3. If Multiline is false, return false.
4. If the character Input[\e−1] is one of LineTerminator, return true.
5. Return false.

The production Assertion :: $ evaluates by returning an internal AssertionTester closure that takes a State argument \x and performs the following:

1. Let \e be \x's endIndex.
2. If \e is equal to InputLength, return true.
3. If Multiline is false, return false.
4. If the character Input[\e] is one of LineTerminator, return true.
5. Return false.

The production Assertion :: \b evaluates by returning an internal AssertionTester closure that takes a State argument \x and performs the following:

1. Let \e be \x's endIndex.
2. Call IsWordChar(e−1) and let a be the Boolean result.
3. Call IsWordChar(e) and let b be the Boolean result.
4. If \( a \) is true and \( b \) is false, return true.
5. If \( a \) is false and \( b \) is true, return true.
6. Return false.

The production `Assertion :: \ \ b` evaluates by returning an internal AssertionTester closure that takes a State argument \( x \) and performs the following:

1. Let \( e \) be \( x \)'s endIndex.
2. Call `IsWordChar(e–1)` and let \( a \) be the Boolean result.
3. Call `IsWordChar(e)` and let \( b \) be the Boolean result.
4. If \( a \) is true and \( b \) is false, return false.
5. If \( a \) is false and \( b \) is true, return false.
6. Return true.

The production `Assertion :: ( ? = Disjunction )` evaluates as follows:

1. Evaluate `Disjunction` to obtain a Matcher \( m \).
2. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following steps:
   1. Let \( d \) be a Continuation that always returns its State argument as a successful MatchResult.
   2. Call \( m(x, d) \) and let \( r \) be its result.
   3. If \( r \) is failure, return failure.
   4. Let \( y \) be \( r \)'s State.
   5. Let \( cap \) be \( y \)'s captures internal array.
   6. Let \( xe \) be \( x \)'s endIndex.
   7. Let \( z \) be the State \((xe, cap)\).
   8. Call \( c(z) \) and return its result.

The production `Assertion :: ( ? ! Disjunction )` evaluates as follows:

1. Evaluate `Disjunction` to obtain a Matcher \( m \).
2. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following steps:
   1. Let \( d \) be a Continuation that always returns its State argument as a successful MatchResult.
   2. Call \( m(x, d) \) and let \( r \) be its result.
   3. If \( r \) isn't failure, return failure.
   4. Call \( c(x) \) and return its result.

**Runtime Semantics: IsWordChar Abstract Operation**

The abstract operation `IsWordChar` takes an integer parameter \( e \) and performs the following:

1. If \( e \) is -1 or \( e \) is InputLength, return false.
2. Let \( c \) be the character `Input[e]`.
3. If \( c \) is one of the sixty-three characters below, return true.
   ```
   abcdefghijklmnopqrstuvwxyz
   ABCDEFGHIJKLMNOPQRSTUVWXYZ
   0123456789
   ```
4. Return false.

**15.10.2.7 Quantifier**

The production `Quantifier :: QuantifierPrefix` evaluates as follows:

1. Evaluate `QuantifierPrefix` to obtain the two results: an integer \( min \) and an integer \( max \) or \( \infty \).
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 \( \text{false} \).

The production \( \text{QuantifierPrefix} :: \star \) evaluates by returning the two results 0 and \( \infty \).

The production \( \text{QuantifierPrefix} :: + \) evaluates by returning the two results 1 and \( \infty \).

The production \( \text{QuantifierPrefix} :: ? \) evaluates by returning the two results 0 and 1.

The production \( \text{QuantifierPrefix} :: \{ \text{DecimalDigits} \} \) evaluates as follows:
1. Let \( i \) be the MV of \( \text{DecimalDigits} \) (see 7.8.3).
2. Return the two results \( i \) and \( i \).

The production \( \text{QuantifierPrefix} :: \{ \text{DecimalDigits} \, \} \) evaluates as follows:
1. Let \( i \) be the MV of \( \text{DecimalDigits} \).
2. Return the two results \( i \) and \( \infty \).

The production \( \text{QuantifierPrefix} :: \{ \text{DecimalDigits} \, \text{DecimalDigits} \} \) evaluates as follows:
1. Let \( i \) be the MV of the first \( \text{DecimalDigits} \).
2. Let \( j \) be the MV of the second \( \text{DecimalDigits} \).
3. Return the two results \( i \) and \( j \).

15.10.2.8 Atom

The production \( \text{Atom} :: \text{PatternCharacter} \) evaluates as follows:
1. Let \( ch \) be the character represented by \( \text{PatternCharacter} \).
2. Let \( A \) be a one-element CharSet containing the character \( ch \).
3. Call \( \text{CharacterSetMatcher}(A, \text{false}) \) and return its Matcher result.

The production \( \text{Atom} :: \backslash \text{AtomEscape} \) evaluates by evaluating \( \text{AtomEscape} \) to obtain a Matcher and returning that Matcher.

The production \( \text{Atom} :: \text{CharacterClass} \) evaluates as follows:
1. Evaluate \( \text{CharacterClass} \) to obtain a CharSet \( A \) and a Boolean \( \text{invert} \).
2. Call \( \text{CharacterSetMatcher}(A, \text{false}) \) and return its Matcher result.

The production \( \text{Atom} :: \{ \text{Disjunction} \} \) evaluates as follows:
1. Evaluate \( \text{Disjunction} \) to obtain a Matcher \( m \).
2. Let \( \text{parenIndex} \) be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion's initial left parenthesis. This is the total number of times the \( \text{Atom} :: \{ \text{Disjunction} \} \) production is expanded prior to this production's \( \text{Atom} \) plus the total number of \( \text{Atom} :: \{ \text{Disjunction} \} \) productions enclosing this \( \text{Atom} \).
3. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following steps:
   1. Create an internal Continuation closure \( d \) that takes one State argument \( y \) and performs the following steps:
      1. Let \( \text{cap} \) be a fresh copy of \( y \) 's captures internal array.
      2. Let \( xe \) be \( x \) 's endIndex.
3. Let ye be y’s endIndex.
4. Let i be a fresh String whose characters are the characters of Input at positions xe (inclusive) through ye (exclusive).
5. Set cap[parenIndex+1] to i.
6. Let z be the State (ye, cap).
7. Call c(z) and return its result.
2. Call m(x, d) and return its result.

The production Atom ?: ( ? : Disjunction ) evaluates by evaluating Disjunction to obtain a Matcher and returning that Matcher.

Runtime Semantics: CharacterSetMatcher Abstract Operation

The abstract operation CharacterSetMatcher takes two arguments, a CharSet A and a Boolean flag invert, and performs the following:

1. Return an internal Matcher closure that takes two arguments, a State x and a Continuation c, and performs the following steps:
   1. Let e be x’s endIndex.
   2. If e is InputLength, return failure.
   3. Let ch be the character Input[e).
   4. Let cc be the result of Canonicalize(ch).
   5. If invert is false, then
      a. If there does not exist a member a of set A such that Canonicalize(a) is cc, return failure.
      Else invert is true,
      a. If there exists a member a of set A such that Canonicalize(a) is cc, return failure.
   7. Let cap be x’s captures internal array.
   8. Let y be the State (e+1, cap).
   9. Call c(y) and return its result.

Runtime Semantics: Canonicalize Abstract Operation

The abstract operation Canonicalize takes a character parameter ch and performs the following steps:

1. If IgnoreCase is false, return ch.
2. Let u be ch converted to upper case as if by calling the standard built-in method String.prototype.toUpperCase on the one-character String ch.
3. If u does not consist of a single character, return ch.
4. Let cu be u’s character.
5. If ch’s code unit value is greater than or equal to decimal 128 and cu’s code unit value is less than decimal 128, then return ch.
6. Return cu.

NOTE 1 Parentheses of the form ( ? : Disjunction ) serve both to group the components of the Disjunction pattern together and to save the result of the match. The result can be used either in a backreference (\ followed by a nonzero decimal number), referenced in a replace String, or returned as part of an array from the regular expression matching internal procedure. To inhibit the capturing behaviour of parentheses, use the form (? : Disjunction ) instead.

NOTE 2 The form ( ? = Disjunction ) specifies a zero-width positive lookahead. In order for it to succeed, the pattern inside Disjunction must match at the current position, but the current position is not advanced before matching the sequel. If Disjunction can match at the current position in several ways, only the first one is tried. Unlike other regular expression operators, there is no backtracking into a (? = form (this unusual behaviour is inherited from Perl). This only matters when the Disjunction contains capturing parentheses and the sequel of the pattern contains backreferences to those captures.

For example,

```
/ (?=\{a\}) / . exec ("baaabac")
```

matches the empty String immediately after the first b and therefore returns the array:

```
["", "aaa"]
```
To illustrate the lack of backtracking into the lookahead, consider:

```javascript
/(?=(a+))a*b/.exec("baaabac")
```

This expression returns `['aba', 'a']` and not:

`['aaaba', 'a']`

NOTE 3

The form `(?!) Disjunction` specifies a zero-width negative lookahead. In order for it to succeed, the pattern inside `Disjunction` must fail to match at the current position. The current position is not advanced before matching the sequel. `Disjunction` can contain capturing parentheses, but backreferences to them only make sense from within `Disjunction` itself. Backreferences to these capturing parentheses from elsewhere in the pattern always return `undefined` because the negative lookahead must fail for the pattern to succeed. For example,

```javascript
/(.*?)a(?!(a+)b(?!2c))/exec("baaabaac")
```

looks for an `a` not immediately followed by some positive number `n` of `a`, `b`, another `n` `a`s (specified by the first `2`) and `c`. The second `2` is outside the negative lookahead, so it matches against `undefined` and therefore always succeeds.

The whole expression returns the array:

`['baaabaac', 'ba', undefined, 'abaac']`

In case-insensitive matches all characters are implicitly converted to upper case immediately before they are compared.

However, if converting a character to upper case would expand that character into more than one character (such as converting "ß" (u00DF) into "SS"), then the character is left as-is. The character is also left as-is if it is not an ASCII character but converting it to upper case would make it into an ASCII character. This prevents Unicode characters such as `u0131` and `u017F` from matching regular expressions such as `/[a-zA-Z]/i`, which are only intended to match ASCII letters. Furthermore, if these conversions were allowed, then `/[^\W]/i` would match each of `a`, `b`, ..., `h`, but not `i` or `s`.

15.10.2.9 `AtomEscape`

The production `AtomEscape :: DecimalEscape` evaluates as follows:

1. Evaluate `DecimalEscape` to obtain an `EscapeValue E`.
2. If `E` is a character, then
   a. Let `ch` be `E`’s character.
   b. Let `A` be a one-element CharSet containing the character `ch`.
   c. Call `CharacterSetMatcher(A, false)` and return its Matcher result.
3. `E` must be an integer. Let `n` be that integer.
4. If `n=0` or `n>capturingParens` throw a `SyntaxError` exception.
5. Return an internal Matcher closure that takes two arguments, a `State x` and a `Continuation c`, and performs the following:
   1. Let `cap` be `x`’s `captures` internal array.
   2. Let `s` be `cap[i]`.
   3. If `s` is `undefined`, then call `c(s)` and return its result.
   4. Let `e` be `s`’s `endIndex`.
   5. Let `len` be `s`’s length.
   6. Let `f` be `e+len`.
   7. If `f>InputLength`, return failure.
   8. If there exists an integer `i` between 0 (inclusive) and `len` (exclusive) such that `Canonicalize(s[i])` is not the same character as `Canonicalize(Input[e+i])`, then return failure.
   9. Let `y` be the State (`f, cap`).
   10. Call `c(y)` and return its result.

The production `AtomEscape :: CharacterEscape` evaluates as follows:

1. Evaluate `CharacterEscape` to obtain a character `ch`.
2. Let `A` be a one-element CharSet containing the character `ch`.
3. Call `CharacterSetMatcher(A, false)` and return its Matcher result.

The production `AtomEscape :: CharacterClassEscape` evaluates as follows:
1. Evaluate CharacterClassEscape to obtain a CharSet A.
2. Call CharSetMatcher(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 nth set of capturing parentheses (see 15.10.2.11). It is an error if the regular expression has fewer than n capturing parentheses. If the regular expression has n or more capturing parentheses but the nth one is undefined because it has not captured anything, then the backreference always succeeds.

15.10.2.10 CharacterEscape

The production CharacterEscape :: ControlEscape evaluates by returning the character according to Table 35.

Table 35 — ControlEscape Character Values

<table>
<thead>
<tr>
<th>ControlEscape</th>
<th>Code Unit</th>
<th>Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>\u0009</td>
<td>horizontal tab</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>n</td>
<td>\u000A</td>
<td>line feed (new line)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>v</td>
<td>\u000B</td>
<td>vertical tab</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>r</td>
<td>\u000C</td>
<td>form feed</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>x</td>
<td>\u000D</td>
<td>carriage return</td>
<td>&lt;CR&gt;</td>
</tr>
</tbody>
</table>

The production CharacterEscape :: C ControlLetter evaluates as follows:

1. Let ch be the character represented by ControlLetter.
2. Let i be ch’s code unit value.
3. Let j be the remainder of dividing i by 32.
4. Return the character whose code unit value is j.

The production CharacterEscape :: HexEscapeSequence evaluates by evaluating the CV of the HexEscapeSequence (see 7.8.6) and returning its character result.

The production CharacterEscape :: UnicodeEscapeSequence evaluates by evaluating the CV of the UnicodeEscapeSequence (see 7.8.6) and returning its character result.

The production CharacterEscape :: IdentityEscape evaluates by returning the character represented by IdentityEscape.

15.10.2.11 DecimalEscape

The production DecimalEscape :: DecimalIntegerLiteral [lookahead \d] evaluates as follows:

1. Let i be the MV of DecimalIntegerLiteral.
2. If i is zero, return the EscapeValue consisting of a <NUL> character (Unicode value 0000).
3. Return the EscapeValue consisting of the integer i.

The definition of “the MV of DecimalIntegerLiteral” is in 7.8.3.

NOTE If \d is followed by a decimal number n whose first digit is not 0, then the escape sequence is considered to be a backreference. It is an error if n is greater than the total number of left capturing parentheses in the entire regular expression. \0 represents the <NUL> character and cannot be followed by a decimal digit.

15.10.2.12 CharacterClassEscape

The production CharacterClassEscape :: d evaluates by returning the ten-element set of characters containing the characters 0 through 9 inclusive.

The production CharacterClassEscape :: D evaluates by returning the set of all characters not included in the set returned by CharacterClassEscape :: d.
The production `CharacterClassEscape :: s` evaluates by returning the set of characters containing the characters that are on the right-hand side of the `WhiteSpace` (7.2) or `LineTerminator` (7.3) productions.

The production `CharacterClassEscape :: s` evaluates by returning the set of all characters not included in the set returned by `CharacterClassEscape :: s`.

The production `CharacterClassEscape :: w` evaluates by returning the set of characters containing the sixty-three characters:

```
abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789_
```

The production `CharacterClassEscape :: w` evaluates by returning the set of all characters not included in the set returned by `CharacterClassEscape :: w`.

15.10.2.13 `CharacterClass`

The production `CharacterClass :: [ lookahead \{ ^ \} ClassRanges ]` evaluates by evaluating `ClassRanges` to obtain a CharSet and returning that CharSet and the Boolean `false`.

The production `CharacterClass :: [ ^ ClassRanges ]` evaluates by evaluating `ClassRanges` to obtain a CharSet and returning that CharSet and the Boolean `true`.

15.10.2.14 `ClassRanges`

The production `ClassRanges :: [empty]` evaluates by returning the empty CharSet.

The production `ClassRanges :: NonemptyClassRanges` evaluates by evaluating `NonemptyClassRanges` to obtain a CharSet and returning that CharSet.

15.10.2.15 `NonemptyClassRanges`

The production `NonemptyClassRanges :: ClassAtom` evaluates by evaluating `ClassAtom` to obtain a CharSet and returning that CharSet.

The production `NonemptyClassRanges :: ClassAtom NonemptyClassRangesNoDash` evaluates as follows:

1. Evaluate `ClassAtom` to obtain a CharSet A.
2. Evaluate `NonemptyClassRangesNoDash` to obtain a CharSet B.
3. Return the union of CharSets A and B.

The production `NonemptyClassRanges :: ClassAtom ~ ClassAtom ClassRanges` evaluates as follows:

1. Evaluate the first `ClassAtom` to obtain a CharSet A.
2. Evaluate the second `ClassAtom` to obtain a CharSet B.
3. Evaluate `ClassRanges` to obtain a CharSet C.
4. Call `CharacterRange(A, B)` and let D be the resulting CharSet.
5. Return the union of CharSets D and C.

Runtime Semantics: `CharacterRange` Abstract Operation

The abstract operation `CharacterRange` takes two CharSet parameters A and B and performs the following:

1. If A does not contain exactly one character or B does not contain exactly one character then throw a `SyntaxError` exception.
2. Let a be the one character in CharSet A.
3. Let b be the one character in CharSet B.
4. Let $i$ be the code unit value of character $a$.
5. Let $j$ be the code unit value of character $b$.
6. If $i > j$ then throw a SyntaxError exception.
7. Return the set containing all characters numbered $i$ through $j$, inclusive.

15.10.2.16 NonemptyClassRangesNoDash

The production $\text{NonemptyClassRangesNoDash} :: \text{ClassAtom}$ evaluates by evaluating ClassAtom to obtain a CharSet and returning that CharSet.

The production $\text{NonemptyClassRangesNoDash} :: \text{ClassAtomNoDash} \text{NonemptyClassRangesNoDash}$ 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 $\text{NonemptyClassRangesNoDash} :: \text{ClassAtomNoDash} - \text{ClassAtom} \text{ClassRanges}$ evaluates as follows:
1. Evaluate ClassAtomNoDash to obtain a CharSet $A$.
2. Evaluate ClassAtom to obtain a CharSet $B$.
3. Evaluate ClassRanges to obtain a CharSet $C$.
4. Call CharacterRange($A$, $B$) and let $D$ be the resulting CharSet.
5. Return the union of CharSets $D$ and $C$.

NOTE 1 NonemptyClassRangesNoDash can expand into single ClassAtoms and/or ranges of two ClassAtoms separated by dashes. In the latter case the ClassRanges includes all characters between the first ClassAtom and the second ClassAtom, inclusive; an error occurs if either ClassAtom does not represent a single character (for example, if one is \\w) or if the first ClassAtom’s code unit value is greater than the second ClassAtom’s code unit value.

NOTE 2 Even if the pattern ignores case, the case of the two ends of a range is significant in determining which characters belong to the range. Thus, for example, the pattern /[E-F]/i matches only the letters $E$, $F$, $e$, and $f$, while the pattern /[E-F]/i matches all upper and lowercase ASCII letters as well as the symbols $[\sim, \_,$ and $\`$.

NOTE 3 A - character can be treated literally or it can denote a range. It is treated literally if it is the first or last character of ClassRanges, the beginning or end limit of a range specification, or immediately follows a range specification.

15.10.2.17 ClassAtom

The production $\text{ClassAtom} :: -$ evaluates by returning the CharSet containing the one character $-$.

The production $\text{ClassAtom} :: \text{ClassAtomNoDash}$ evaluates by evaluating ClassAtomNoDash to obtain a CharSet and returning that CharSet.

15.10.2.18 ClassAtomNoDash

The production $\text{ClassAtomNoDash} :: SourceCharacter \text{but not one of } \backslash \text{ or } \}$ evaluates by returning a one-element CharSet containing the character represented by SourceCharacter.

The production $\text{ClassAtomNoDash} :: \backslash \text{ClassEscape}$ evaluates by evaluating ClassEscape to obtain a CharSet and returning that CharSet.

15.10.2.19 ClassEscape

The production $\text{ClassEscape} :: \text{DecimalEscape}$ evaluates as follows:
1. Evaluate DecimalEscape to obtain an EscapeValue $E$.
2. If $E$ is not a character then throw a SyntaxError exception.
3. Let \( ch \) be \( E \)'s character.
4. Return the one-element CharSet containing the character \( ch \).

The production \( \text{ClassEscape} :: \ b \) evaluates by returning the CharSet containing the one character `<BS>` (Unicode value 0008).

The production \( \text{ClassEscape} :: \ \text{CharacterEscape} \) evaluates by evaluating \( \text{CharacterEscape} \) to obtain a character and returning a one-element CharSet containing that character.

The production \( \text{ClassEscape} :: \ \text{CharacterClassEscape} \) evaluates by evaluating \( \text{CharacterClassEscape} \) to obtain a CharSet and returning that CharSet.

NOTE A \( \text{ClassAtom} \) can use any of the escape sequences that are allowed in the rest of the regular expression except for `\b`, `\B`, and backreferences. Inside a \( \text{CharacterClass} \), `\b` means the backspace character, while `\B` and backreferences raise errors. Using a backreference inside a \( \text{ClassAtom} \) causes an error.

15.10.3 The \( \text{RegExp} \) Constructor Called as a Function

When \( \text{RegExp} \) is called as a function rather than as a constructor, it creates and initialises a new \( \text{RegExp} \) object. Thus the function call \( \text{RegExp} (...) \) is equivalent to the object creation expression \( \text{new} \ \text{RegExp} (...) \) with the same arguments. However, if the \text{this} value passed in the call is an Object with an [[RegExpMatcher]] internal data property whose value is \text{undefined}, it initializes the \text{this} value using the argument values. This permits \( \text{RegExp} \) to be used both as factory method and to perform constructor instance initialization.

\( \text{RegExp} \) may be subclassed and subclass constructors may perform a super invocation of the \( \text{RegExp} \) constructor to initialize subclass instances.

15.10.3.1 \( \text{RegExp}(\text{pattern}, \text{flags}) \)

The following steps are taken:

1. Let \( \text{func} \) be this \( \text{RegExp} \) function object.
2. Let \( \text{O} \) be the \text{this} value.
3. If Type(\( \text{O} \)) is not Object or Type(\( \text{O} \)) is Object and \( \text{O} \) does not have a [[RegExpMatcher]] internal data property or Type(\( \text{O} \)) is Object and \( \text{O} \) has a [[RegExpMatcher]] internal data property and the value of [[RegExpMatcher]] is not \text{undefined}, then
   a. If Type(\( \text{pattern} \)) is Object and \( \text{O} \) has a [[RegExpMatcher]] internal data property and \( \text{flags} \) is \text{undefined}, then
      i. Return \( \text{pattern} \);
   b. Let \( \text{O} \) be the result of calling the abstract operation \( \text{RegExpAlloc} \) with argument \( \text{func} \).
   c. ReturnIfAbrupt(\( \text{O} \)).
4. If Type(\( \text{pattern} \)) is Object and \( \text{pattern} \) has a [[RegExpMatcher]] internal data property, then
   a. If the value of pattern's [[RegExpMatcher]] internal data property is \text{undefined}, then throw a \text{TypeError} exception.
   b. If \( \text{flags} \) is not \text{undefined}, then throw a \text{TypeError} exception.
   c. Let \( P \) be the value of pattern's [[OriginalSource]] internal data property.
   d. Let \( F \) be the value of pattern's [[OriginalFlags]] internal data property.
5. Else,
   a. let \( P \) be \( \text{pattern} \).
   b. let \( F \) be \( \text{flags} \).
6. Return the result of the abstract operation \( \text{RegExpInitialize} \) with arguments \( \text{O}, P, \) and \( F \).

NOTE If pattern is supplied using a \text{StringLiteral}, the usual escape sequence substitutions are performed before the \text{String} is processed by \( \text{RegExp} \). If pattern must contain an escape sequence to be recognised by \( \text{RegExp} \), any backslash `\` characters must be escaped within the \text{StringLiteral} to prevent them being removed when the contents of the \text{StringLiteral} are formed.

Runtime Semantics: \( \text{RegExpAlloc} \) Abstract Operation
When the abstract operation RegExpAlloc with argument constructor is called, the following steps are taken:

1. Assert: constructor is a constructable function.
2. Let obj be the result of calling OrdinaryCreateFromConstructor(constructor, "%RegExpPrototype%", (((%RegExpMatcher%)) (OriginalSource))% (OriginalFlags)).
3. Let status be the result of DefinePropertyOrThrow(obj, "lastIndex", PropertyDescriptor [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false).
4. ReturnIfAbrupt(status).
5. Return obj.

NOTE [[RegExpMatcher]] is initially assigned the value undefined as a flag to indicate that the instance has not yet been initialized by the RegExp constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

Runtime Semantics: RegExpInitialize Abstract Operation

When the abstract operation RegExpInitialize with arguments obj, pattern, and flags is called, the following steps are taken:

1. If pattern is undefined, then let P be the empty String.
2. Else, let P be ToString(pattern).
3. ReturnIfAbrupt(P).
4. If flags is undefined, then let F be the empty String.
5. Else, let F be ToString(flags).
6. ReturnIfAbrupt(F).
7. If F contains any character other than "g", "i", "m", "u", or "y" or if it contains the same character more than once, then throw a SyntaxError exception.
8. Parse P interpreted as UTF-16 encoded Unicode characters using the grammars in 15.10.1 for the goal symbol Pattern. Throw a SyntaxError exception if P did not conform to the grammar or if all characters of P were not matched by the parse.
9. Set obj’s [[RegExpMatcher]] internal data property to the internal procedure obtained by evaluating (“complying”) the step 3.8 parse of P and applying the semantics provided in 15.10.2.
10. Set the value of obj’s [[OriginalSource]] internal data property to P.
11. Set the value of obj’s [[OriginalFlags]] internal data property to F.
12. Let putStatus be the result of Put(obj, "lastIndex", 0, true).
13. ReturnIfAbrupt(putStatus).

Runtime Semantics: RegExpCreate Abstract Operation

When the abstract operation RegExpCreate with arguments P and F is called, the following steps are taken:

1. Let obj be the result of calling the abstract operation RegExpAlloc with argument %RegExp%.
2. ReturnIfAbrupt(obj).
3. Return the result of the abstract operation RegExpInitialize with arguments obj, P, and F.

Runtime Semantics: EscapeRegExpPattern Abstract Operation

When the abstract operation EscapeRegExpPattern with arguments P and F is called, the following occurs:

Let S be a String in the form of a Pattern equivalent to P interpreted as UTF-16 encoded Unicode characters, in which certain characters are escaped as described below. S may or may not be identical to P or pattern; however, the internal procedure that would result from evaluating S as a Pattern must behave identically to the internal procedure given by the constructed object’s [[RegExpMatcher]] internal data property. Separate calls to this abstract operation using the same values for P and F must produce identical results.

The characters / occurring in the pattern shall be escaped in S as necessary to ensure that the String value formed by concatenating the Strings P, /, 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 \ 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 “ (?) “.

Return S.

15.10.4 The RegExp Constructor

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

15.10.4.1 new RegExp(... args)

RegExp called as part of a new expression with argument list args it performs the following steps:

1. Let F be the RegExp function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by
   the new operator.
3. Return the result of OrdinaryConstruct (F, argumentsList).

If RegExp is implemented as an ordinary function object, its [[Construct]] internal method will perform the
above steps.

15.10.5 Properties of the RegExp Constructor

The value of the [[Prototype]] internal data property of the RegExp constructor is the standard built-in Function
prototype object (15.3.3).

Besides the length property (whose value is 2), the RegExp constructor has the following properties:

15.10.5.1 RegExp.prototype

The initial value of RegExp.prototype is the RegExp prototype object (15.10.6).

This property shall have the attributes { [[Writable]], false, [[Enumerable]]: false, [[Configurable]]: false }.

15.10.5.2 RegExp[ @@create ] ()

The @@create method of an object F performs the following:

1. Return the result of calling the abstract operation RegExpAlloc with argument F.

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

15.10.6 Properties of the RegExp Prototype Object

The RegExp prototype object is an ordinary object. It is not a RegExp instance and does not have a
[[RegExpMatcher]] internal data property or any of the other internal data properties of RegExp instance
objects.

The value of the [[Prototype]] internal data property of the RegExp prototype object is the standard built-in
Object prototype object (15.2.4).

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

15.10.6.1 RegExp.prototype.constructor

The initial value of RegExp.prototype.constructor is the standard built-in RegExp constructor.
15.10.6.2 RegExp.prototype.exec(string)

Performs a regular expression match of string against the regular expression and returns an Array object containing the results of the match, or null if string did not match.

The String ToString(string) is searched for an occurrence of the regular expression pattern as follows:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[RegExpMatcher]] internal data property, then throw a TypeError exception.
4. If the value of R’s [[RegExpMatcher]] internal data property is undefined, then throw a TypeError exception.
5. Let S be the value of ToString(string)
6. ReturnIfAbrupt(S).
7. Return the result of the RegExpExec abstract operation with arguments R and S.

Runtime Semantics: RegExpExec Abstract Operation

The abstract operation RegExpExec with arguments R (an object) and S (a string) performs the following steps:

1. Assert: R is an initialized RegExp instance.
2. Let matcher be the value of R’s [[RegExpMatcher]] internal data property.
3. Let length be the length of S.
4. Let lastIndex be the result of Get(R,"lastIndex").
5. Let i be the value of ToInteger(lastIndex).
6. ReturnIfAbrupt(i).
7. Let global be the result of ToBoolean(Get(R,"global")).
8. ReturnIfAbrupt(global).
9. If global is false, then let i = 0.
10. Let matchSucceeded be false.
11. Repeat, while matchSucceeded is false
   a. If i < 0 or i > length, then
      i. Let putStatus be the result of Put(R,"lastIndex", 0, true).
      ii. ReturnIfAbrupt(putStatus).
      iii. Return null.
   b. Let e be the result of calling the matcher with arguments S and i.
   c. If e is failure, then
      i. Let i = i + 1.
   d. else
      i. Assert: e is a State.
      ii. Set matchSucceeded to true.
12. Let e be lastIndex value.
13. If global is true,
   a. Let putStatus be the result of Put(R,"lastIndex", e, true).
   b. ReturnIfAbrupt(putStatus).
14. Let n be the length of S’s captures array. (This is the same value as 15.10.2.1’s NcapturingParen.)
15. Let A be the result of the abstract operation ArrayCreate with argument 0.
16. Let matchIndex be i.
17. Assert: The following [[DefineOwnProperty]] calls will not result in an abrupt completion.
18. Call the [[DefineOwnProperty]] internal method of A with arguments “index” and Property Descriptor {{Value}:matchIndex, [Writable]:true, [[Enumerable]]:true, [[Configurable]]:true}.
19. Call the [[DefineOwnProperty]] internal method of A with arguments “input” and Property Descriptor {{Value}:S, [Writable]:true, [[Enumerable]]:true, [[Configurable]]:true}.
20. Call the [[DefineOwnProperty]] internal method of A with arguments “length” and Property Descriptor {{Value}:n + 1}.
21. Let matchedSubstr be the matched substring (i.e. the portion of S between offset i inclusive and offset e exclusive).
22. Call the [[DefineOwnProperty]] internal method of A with arguments "0" and Property Descriptor
[[Value]: matchedSubstr, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true].
23. For each integer i such that i > 0 and i ≤ n
   a. Let captured be i-th element of i's captures array.
   b. Call the [[DefineOwnProperty]] internal method of A with arguments ToString(i) and Property
      Descriptor [[Value]: captured, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true].
24. Return A.

15.10.6.3 get RegExp.prototype.global

RegExp.prototype.global is an accessor property whose set accessor function is undefined. Its get
accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalSource]] internal data property throw a TypeError exception.
4. Let flags be the value of R's [[OriginalFlags]] internal data property.
5. If flags is undefined, then throw a TypeError exception.
6. If flags contains the character "g", then return true.
7. Return false.

15.10.6.4 get RegExp.prototype.ignoreCase

RegExp.prototype.ignoreCase is an accessor property whose set accessor function is undefined. Its get
accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
4. Let flags be the value of R's [[OriginalFlags]] internal data property.
5. If flags is undefined, then throw a TypeError exception.
6. If flags contains the character "i", then return true.
7. Return false.

15.10.6.5 get RegExp.prototype multiline

RegExp.prototype.multiline is an accessor property whose set accessor function is undefined. Its get
accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
4. Let flags be the value of R's [[OriginalFlags]] internal data property.
5. If flags is undefined, then throw a TypeError exception.
6. If flags contains the character "m", then return true.
7. Return false.

15.10.6.6 get RegExp.prototype.source

RegExp.prototype.source is an accessor property whose set accessor function is undefined. Its get
accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalSource]] internal data property throw a TypeError exception.
4. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
5. Let src be the value of R's [[OriginalSource]] internal data property.
6. Let flags be the value of R's [[OriginalFlags]] internal data property.
7. If either src or flags is undefined, then throw a TypeError exception.
8. Return the result of the abstract operation EscapeRegExpPattern with arguments src and flags.

15.10.6.7 get RegExp.prototype.sticky

RegExp.prototype.sticky is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
4. Let flags be the value of R's [[OriginalFlags]] internal data property.
5. If flags is undefined, then throw a TypeError exception.
6. If flags contains the character "y", then return true.
7. Return false.

15.10.6.8 RegExp.prototype.test(string)

The following steps are taken:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[RegExpMatcher]] internal data property, then throw a TypeError exception.
4. If the value of R's [[RegExpMatcher]] internal data property is undefined, then throw a TypeError exception.
5. Let $ be the value of ToString(string).
6. ReturnIfAbrupt($).
7. Let match be the result of the RegExpExec abstract operation with arguments R and $.
8. ReturnIfAbrupt(match).
9. If match is not null, then return true; else return false.

15.10.6.9 get RegExp.prototype.unicode

RegExp.prototype.unicode is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
4. Let flags be the value of R's [[OriginalFlags]] internal data property.
5. If flags is undefined, then throw a TypeError exception.
6. If flags contains the character "u", then return true.
7. Return false.

15.10.6.10 RegExp.prototype.toString()

1. Let R be the this value.
2. If Type(R) is not Object, then throw a TypeError exception.
3. If R does not have a [[OriginalFlags]] internal data property throw a TypeError exception.
4. Let pattern be the result of ToString(Get(R, "source")).
5. Let pattern be the result of ToString(pattern).
6. ReturnIfAbrupt(pattern).
7. Let result be the String value formed by concatenating "/", pattern, and "/".
8. Let global be the result of ToBoolean(Get(R, "global")).
9. ReturnIfAbrupt(global).
10. If global is true, then append "g" as the last character of result.
11. Let ignoreCase be the result of ToBoolean(Get(R, "ignoreCase")).
12. ReturnIfAbrupt(ignoreCase).
13. If ignoreCase is true, then append "i" as the last character of result.
14. Let \texttt{multiline} be the result of ToBoolean(Get(R, \texttt{"multiline"})).  
15. ReturnIfAbrupt(multiline).  
16. If \texttt{multiline} \textbf{is true}, then append \texttt{"m"} as the last character of result.  
17. Let \texttt{unicode} be the result of ToBoolean(Get(R, \texttt{"unicode"})).  
18. ReturnIfAbrupt(unicode).  
19. If \texttt{unicode} \textbf{is true}, then append \texttt{"u"} as the last character of result.  
20. Let \texttt{sticky} be the result of ToBoolean(Get(R, \texttt{"sticky"})).  
21. ReturnIfAbrupt(sticky).  
22. If \texttt{sticky} \textbf{is true}, then append \texttt{"y"} as the last character of result.  
23. Return result.  

\textbf{NOTE} The returned String has the form of a \texttt{RegExpLiteral} that evaluates to another RegExp object with the same behaviour as this object.  

\subsection{15.10.6.11 RegExp.prototype.match (string)}  

When the \texttt{match} method is called with argument \texttt{string}, the following steps are taken:  

1. Let \texttt{rx} be the \texttt{this} value.  
2. If Type(\texttt{rx}) is not Object, then throw a \texttt{TypeError} exception.  
3. If \texttt{rx} does not have a \texttt{[[RegExpMatcher]]} internal data property, then throw a \texttt{TypeError} exception.  
4. If the value of \texttt{rx}’s \texttt{[[RegExpMatcher]]} internal data property is \texttt{undefined}, then throw a \texttt{TypeError} exception.  
5. Let \texttt{S} be the value of ToString(\texttt{string}).  
6. ReturnIfAbrupt(S).  
7. Let global be the result of ToBoolean(Get(\texttt{rx}, \texttt{"global"})).  
8. ReturnIfAbrupt(global).  
9. If global is \textbf{not true}, then  
   a. Return the result of calling the abstract operation `RegExpExec` (see 15.10.6.2) with arguments \texttt{rx} and \texttt{S}.  
10. Else global is \textbf{true},  
   a. Let \texttt{putStatus} be the result of Put(\texttt{rx}, \texttt{"lastIndex"}, 0, \texttt{true}).  
   b. ReturnIfAbrupt(putStatus).  
   c. Let \texttt{A} be the result of the abstract operation \texttt{ArrayCreate} with argument 0.  
   d. Let previousLastIndex be 0.  
   e. Let \texttt{n} be 0.  
   f. Let lastMatch be \textbf{true}.  
   g. Repeat, while lastMatch is \textbf{true}  
      i. Let result be the result of the \texttt{abstract operation RegExpExec} with arguments \texttt{rx} and \texttt{S}.  
      ii. ReturnIfAbrupt(result).  
      iii. If result is \textbf{null}, then set lastMatch to \textbf{false}.  
   iv. Else result is not \textbf{null},  
   i. Let thisIndex be the result of ToInteger(Get(\texttt{rx}, \texttt{"lastIndex"})).  
   ii. ReturnIfAbrupt(thisIndex).  
   iii. If thisIndex = previousLastIndex then  
       a. Let putStatus be the result of Put(\texttt{rx}, \texttt{"lastIndex"}, thisIndex+1, \texttt{true}).  
       b. ReturnIfAbrupt(putStatus).  
       c. Set previousLastIndex to thisIndex+1.  
   iv. Else,  
       a. Set previousLastIndex to thisIndex.  
   v. Let matchStr be the result of Get(result, \texttt{"0"}).  
   vi. Let defineStatus be the result of DefinePropertyOrThrow(\texttt{A}, \texttt{ToString(n)}, Property Descriptor [[[Value]]: matchStr, [[Writable]]: \textbf{true}, [[Enumerable]]: \textbf{true},  
       [[configurable]]: \textbf{true}}).  
   vii. ReturnIfAbrupt(defineStatus).  
   viii. Increment \texttt{n}.  
   ix. Return \texttt{A}.  

15.10.6.12 RegExp.prototype.replace (S, replaceValue)

When the replace method is called with arguments S and replaceValue the following steps are taken:

1. Let rx be the this value.
2. If Type(rx) is not Object, then throw a TypeError exception.
3. If rx does not have a [[RegExpMatcher]] internal data property, then throw a TypeError exception.
4. If the value of rx’s [[RegExpMatcher]] internal data property is undefined, then throw a TypeError exception.
5. Let string be ToString(S).
6. ReturnIfAbrupt(string).
7. If searchValue.global is false, then search string for the first match of the regular expression searchValue. If searchValue.global is true, then search string for all matches of the regular expression searchValue. Do the search in the same manner as in RegExp.prototype.match, including the update of searchValue lastIndex. Let m be the number of left capturing parentheses in searchValue (using NcapturingParens as specified in 15.10.2.1).
8. If replaceValue is a function, then
   a. For each matched substring, call the function with the following m + 3 arguments. Argument 1 is the substring that matched. If searchValue is a regular expression, the next m arguments are all of the captures in the MatchResult (see 15.10.2.1). Argument m + 2 is the offset within string where the match occurred, and argument m + 3 is string. The result is a String value derived from the original input by replacing each matched substring with the corresponding return value of the function call, converted to a String if need be.
9. Else, let newstring denote the result of converting replaceValue to a String. The result is a String value derived from the original input String by replacing each matched substring with a String derived from newstring by replacing elements in newstring by replacement text as specified in a.
   a. Table 34. These $ replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements. For example, "$1,$2".replace(/([^$\d])/g, "$$\$1,$2") returns "$1,$1,$2,$2". A $ in newstring that does not match any of the forms below is left as is.

15.10.6.13 RegExp.prototype.search (S)

When the search method is called with argument S, the following steps are taken:

1. Let rx be the this value.
2. If Type(rx) is not Object, then throw a TypeError exception.
3. If rx does not have a [[RegExpMatcher]] internal data property, then throw a TypeError exception.
4. If the value of rx’s [[RegExpMatcher]] internal data property is undefined, then throw a TypeError exception.
5. Let string be ToString(S).
6. ReturnIfAbrupt(string).
7. Search the value string from its beginning for an occurrence of the regular expression pattern rx. Let result be a Number indicating the offset within string where the pattern matched, or -1 if there was no match. If an abrupt completion occurs during the search, result is that Completion Record. The lastIndex and global properties of regexp are ignored when performing the search. The lastIndex property of regexp is left unchanged.
8. Return result.
15.10.6.14 `RegExp.prototype.split (string, limit)`

Returns an Array object into which substrings of the result of converting `string` to a String have been stored. The substrings are determined by searching from left to right for matches of the `this` value regular expression; these occurrences are not part of any substring in the returned array, but serve to divide up the String value.

The this value may be an empty regular expression or a regular expression that can match an empty String. In this case, regular expression does not match the empty substring at the beginning or end of the input String, nor does it match the empty substring at the end of the previous separator match. (For example, if the regular expression matches the empty String, the String is split up into individual code unit elements; the length of the result array equals the length of the String, and each substring contains one code unit.) Only the first match at a given position of the this String is considered, even if backtracking could yield a non-empty-substring match at that position. (For example, `/a*/.split("ab")` evaluates to the array `"a", "b"`, while `/a*/.split("ab")` evaluates to the array `"\n", "b"`.)

If the `string` is (or converts to) the empty String, the result depends on whether the regular expression can match the empty String. If it can, the result array contains no elements. Otherwise, the result array contains one element, which is the empty String.

If the regular expression that contains capturing parentheses, then each time separator is matched the results (including any `undefined` results) of the capturing parentheses are spliced into the output array. For example, `/<([^<>=]+)>\s*<([^<>=]+)>/.split("A<B>bold</B>and<CODE>coded</CODE>")` evaluates to the array `"A", undefined, "B", "bold", ", "B", "and", undefined, "CODE", "coded", ", "CODE", ","`.

If `limit` is not `undefined`, then the output array is truncated so that it contains no more than `limit` elements.

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

1. Let `rx` be the `this` value.
2. If `Type(rx)` is not `Object`, then throw a `TypeError` exception.
3. If `rx` does not have a `[[RegExpMatcher]]` internal data property, then throw a `TypeError` exception.
4. If the value of `rx`’s `[[RegExpMatcher]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let `matcher` be the value of `rx`’s `[[RegExpMatcher]]` internal data property.
6. Let `S` be `ToString(string)`.
7. ReturnIfAbrupt(S).
8. Let `A` be the result of the abstract operation ArrayCreate with argument 0.
9. ReturnIfAbrupt(A).
10. Let `lengthA` be 0.
11. If `limit` is `undefined`, let `lim = 2^32−1`; else let `lim = ToUint32(limit)`.
12. Let `s` be the number of elements in `S`.
13. Let `p = 0`.
14. If `lim = 0`, return `A`.
15. If `s = 0`, then
   a. Let `z` be the result of calling the `matcher` with arguments `S` and 0.
   b. ReturnIfAbrupt(z).
   c. If `z` is not `failure`, return `A`.
   d. Call the `[[DefineOwnProperty]]` internal method of `A` with arguments "0" and Property Descriptor `[[Value]]: S, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true`.
   e. Assert: the previous step will never result in an abrupt completion.
   f. Return `A`.
16. Let `q = p`.
17. Repeat, while `q < s`
   a. Let `z` be the result of calling the `matcher` with arguments `S` and `q`.
   b. ReturnIfAbrupt(z).
   c. If `z` is `failure`, then let `q = q+1.`
The length property of the split method is 2.

NOTE 1 The split method ignores the value of the global property of this RegExp object.

15.10.6.15 RegExp.prototype @@isRegExp

The initial value of the @@isRegExp property is true.

15.10.7 Properties of RegExp Instances

RegExp instances are ordinary objects that inherit properties from the RegExp prototype object. RegExp instances have internal data properties [[RegExpMatcher]], [[OriginalSource]], and [[OriginalFlags]]. The value of the [[RegExpMatcher]] internal data property is an implementation dependent representation of the Pattern of the RegExp object.

RegExp instances also have the following properties.

15.10.7.1 lastIndex

The value of the lastIndex property specifies the String position at which to start the next match. It is coerced to an integer when used (see 15.10.6.2). This property shall have the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }.

NOTE Unlike the other standard built-in properties of RegExp instances, lastIndex is writable.

15.11 Error Objects

Instances of Error objects are thrown as exceptions when runtime errors occur. The Error objects may also serve as base objects for user-defined exception classes.
15.11.1 The Error Constructor Called as a Function

When Error is called as a function rather than as a constructor, it creates and initialises a new Error object. Thus the function call Error(...) is generally equivalent to the object creation expression new Error(...) with the same arguments. However, if the this value passed in the call is an Object with an uninitialized [[ErrorData]] internal data property, it initializes the this value using the argument value rather than creating a new object. This permits Error to be used both as factory method and to perform constructor instance initialization.

Error may be subclassed and subclass constructors may perform a super invocation of the Error constructor to initialize subclass instances.

15.11.1.1 Error (message)

The following steps are taken:

1. Let func be this Error function object.
2. Let O be the this value.
3. If Type(O) is not Object or Type(O) is Object and O does not have an [[ErrorData]] internal data property or Type(O) is Object and O has an [[ErrorData]] internal data property and the value of [[ErrorData]] is not undefined, then
   a. Let O be the result of calling OrdinaryCreateFromConstructor(func, "%ErrorPrototype\%").
   b. ReturnIfAbrupt(O).
4. Assert: Type(O) is Object.
5. Set the value of O's [[ErrorData]] internal data property to any value other than undefined.
6. If message is not undefined, then
   a. Let msg be ToString(message).
   b. ReturnIfAbrupt(msg).
   c. Let msgDesc be the Property Descriptor {
      [[Value]]: msg, [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true
   }.
   d. Let status be the result of calling the [[DefineOwnProperty]] internal method of O passing "message" and msgDesc as arguments.
   e. ReturnIfAbrupt(status).
   f. If status is false, then throw a TypeError exception.
7. Return O.

15.11.2 The Error Constructor

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

15.11.2.1 new Error(... args)

When Error called as part of a new expression with argument list args it performs the following steps:

1. Let F be the Error function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (F, argumentsList).

If Error is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.11.3 Properties of the Error Constructor

The value of the [[Prototype]] internal data property of the Error constructor is the Function prototype object (15.3.3).
Besides the internal properties and the `length` property (whose value is 1), the Error constructor has the following property:

15.11.3.1 Error.prototype

The initial value of `Error.prototype` is the Error prototype object (15.11.4).

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

15.11.3.2 Error @@create ()

The @@create method of an object `F` performs the following steps:

1. Let `F` be the this value.
2. Let `obj` be the result of calling OrdinaryCreateFromConstructor(`F`, "%ErrorPrototype", ([ErrorData])
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

NOTE [ErrorData] is initially assigned the value `undefined` as a flag to indicate that the instance has not yet been initialized by the Boolean constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.11.4 Properties of the Error Prototype Object

The Error prototype object is an ordinary object. It is not an Error instance and does not have an [[ErrorData]] internal data property.

The value of the [[Prototype]] internal data property of the Error prototype object is the standard built-in Object prototype object (15.2.4).

15.11.4.1 Error.prototype.constructor

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

15.11.4.2 Error.prototype.name

The initial value of `Error.prototype.name` is "Error".

15.11.4.3 Error.prototype.message

The initial value of `Error.prototype.message` is the empty String.

15.11.4.4 Error.prototype.toString ()

The following steps are taken:

1. Let `O` be the this value.
2. If Type(`O`) is not Object, throw a TypeError exception.
3. Let `name` be the result of Get(`O`, "name").
4. ReturnIfAbrupt(name).
5. If `name` is undefined, then let `name` be "Error"; else let `name` be ToString(name).
6. Let `msg` be the result of Get(`O`, "message").
7. ReturnIfAbrupt(msg).
8. If `msg` is undefined, then let `msg` be the empty String; else let `msg` be ToString(msg).
9. If `name` is the empty String, return `name`.
10. If `msg` is the empty String, return name.
11. Return the result of concatenating `name", ":", a single space character, and `msg".
15.11.5 Properties of Error Instances

Error instances are ordinary objects that inherit properties from the Error prototype object and have a [[ErrorData]] internal data property whose initial value is undefined. The only specified uses of [[ErrorData]] is to flag whether or not an Error instance has been initialized by the Error constructor and to identify them as Error objects within object.prototype.toString.

15.11.6 Native Error Types Used in This Standard

One of the BuiltinError objects below is thrown when a runtime error is detected. All of these objects share the same structure, as described in 15.11.7.

15.11.6.1 EvalError

This exception is not currently used within this specification. This object remains for compatibility with previous editions of this specification.

15.11.6.2 RangeError

Indicates a numeric value has exceeded the allowable range. See 15.4.2.2, 15.4.5.1, 15.7.4.2, 15.7.4.5, 15.7.4.6, 15.7.4.7, and 15.9.3.43.

15.11.6.3 ReferenceError

Indicate that an invalid reference value has been detected. See 8.9.1, 8.9.2, 10.2.1, 10.2.1.1.4, 10.2.1.2.4, and 11.13.1.

15.11.6.4 SyntaxError

Indicates that a parsing error has occurred. See 11.1.5, 11.3.1, 11.3.2, 11.4.1, 11.4.4, 11.4.5, 11.13.1, 11.13.2, 12.2.1, 12.10.1, 12.14.1, 13.1, 15.12.1, 15.10.2.9, 15.10.2.19, 15.10.4.1, and 15.12.2.

15.11.6.5 TypeError

Indicates the actual type of an operand is different than the expected type. See 8.6.2, 8.9.2, 8.10.5, 8.12.5, 8.12.7, 8.12.8, 8.12.9, 8.9, 9.10, 10.2.1, 10.2.1.1.3, 10.6, 11.2, 11.2.3, 11.4.1, 11.8.6, 11.8.7, 11.13.1, 13.2, 13.2.3, 15.2.3.5, 15.2.3.3, 15.2.3.4, 15.2.3.5, 15.2.3.6, 15.2.3.7, 15.2.3.8, 15.2.3.9, 15.2.3.10, 15.2.3.11, 15.2.3.12, 15.2.3.13, 15.2.3.14, 15.2.4.3, 15.3.3.2, 15.3.3.3, 15.3.3.4, 15.3.3.5, 15.3.3.5.2, 15.3.3.5.3, 15.3.4, 15.3.4.3, 15.3.4.4, 15.4.3.11, 15.4.3.16, 15.4.3.17, 15.4.3.18, 15.4.3.19, 15.4.3.20, 15.4.3.21, 15.4.3.22, 15.4.5.1, 15.5.4.2, 15.5.4.3, 15.6.4.2, 15.6.4.3, 15.7.4, 15.7.4.2, 15.7.4.4, 15.8.5, 15.9.5.44, 15.10.4.1, 15.10.6, 15.11.4.4 and 15.12.3.

15.11.6.6 URIError

Indicates that one of the global URI handling functions was used in a way that is incompatible with its definition. See 15.1.3.

15.11.7 NativeError Object Structure

When an ECMAScript implementation detects a runtime error, it throws an instance of one of the NativeError objects defined in 15.11.6. Each of these objects has the structure described below, differing only in the name used as the constructor name instead of NativeError, in the name property of the prototype object, and in the implementation-defined message property of the prototype object.

For each error object, references to NativeError in the definition should be replaced with the appropriate error object name from 15.11.6.
15.11.7.1 NativeError Constructors Called as Functions

When a NativeError constructor is called as a function rather than as a constructor, it creates and initialises a new object. A call of the object as a function is equivalent to calling it as a constructor with the same arguments. However, if the this value passed in the call is an Object with an uninitialized [[ErrorData]] internal data property, it initializes the this value using the argument value. This permits Error to be used both as factory method and to perform constructor instance initialization.

A NativeError constructor may be subclassed and subclass constructors may perform a super invocation of the NativeError constructor to initialize subclass instances.

15.11.7.1.1 NativeError (message)

1. Let func be this NativeError function object.
2. Let O be the this value.
3. If Type(O) is not Object or Type(O) is Object and O does not have an [[ErrorData]] internal data property or Type(O) is Object and O has an [[ErrorData]] internal data property and the value of [[ErrorData]] is not undefined, then
   a. Let O be the result of calling OrdinaryCreateFromConstructor(func, "%NativeErrorPrototype%", ( [[ErrorData]] )).  
   ReturnIfAbrupt(O).
4. Assert: Type(O) is Object.
5. Set the value of O’s [[ErrorData]] internal data property to any value other than undefined.
6. If message is not undefined, then
   a. Let msg be ToString(message).
   b. Let msgDesc be the Property Descriptor {
     [[Value]]: msg,  [[Writable]]: true,  [[Enumerable]]: false,  [[Configurable]]: true }.
   c. Let status be the result of calling the [[DefineOwnProperty]] internal method of O passing "message" and msgDesc as arguments.
   d. ReturnIfAbrupt(status).
   e. If status is false, then throw a TypeError exception.
7. Return O.

The actual value of the string passed in step 3.a is either "%EvalErrorPrototype%", "%RangeErrorPrototype%", "%ReferenceErrorPrototype%", "%SyntaxErrorPrototype%", or "%URIErrorPrototype%" corresponding to which NativeError constructor is being defined.

15.11.7.2 The NativeError Constructors

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

15.11.7.2.1 new NativeError (... args)

When a NativeError constructor is called as part of a new expression with argument list args it performs the following steps:

1. Let F be this NativeError function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (F, argumentsList).

If a NativeError constructor is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.
15.11.7.3 Properties of the NativeError Constructors

The value of the [[Prototype]] internal data property of a NativeError constructor is the Error constructor object (15.11.1).

Besides the length property (whose value is 1), each NativeError constructor has the following property:

15.11.7.3.1 NativeError.prototype

The initial value of NativeError.prototype is a NativeError prototype object (15.11.7.4). Each NativeError constructor has a separate prototype object.

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false ).

15.11.7.3.2 NativeError[@create] ()

The @@create method of an object F performs the following steps:

1. Let F be the this value.
2. Let obj be the result of calling OrdinaryCreateFromConstructor(F, NativeErrorPrototype, ( [[ErrorData]] ) ).
3. Return obj.

The actual value passed as NativeErrorPrototype in step 2 is either "%EvalErrorPrototype%", "%RangeErrorPrototype%", "%ReferenceErrorPrototype%", "%SyntaxErrorPrototype%", or "%TypeErrorPrototype%" corresponding to which NativeError constructor is being defined.

This property has the attributes ( [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true ).

NOTE [[ErrorData]] is initially assigned the value undefined as a flag to indicate that the instance has not yet been initialized by the Boolean constructor. This flag value is never directly exposed to ECMAScript code; hence implementation may choose to encode the flag in some other manner.

15.11.7.4 Properties of the NativeError Prototype Objects

Each NativeError prototype object is an ordinary object. It is not an Error instance and does not have an [[ErrorData]] internal data property.

The value of the [[Prototype]] internal data property of each NativeError prototype object is the standard built-in Error prototype object (15.11.4).

15.11.7.4.1 NativeError.prototype.constructor

The initial value of the constructor property of the prototype for a given NativeError constructor is the NativeError constructor function itself (15.11.7).

15.11.7.4.2 NativeError.prototype.name

The initial value of the name property of the prototype for a given NativeError constructor is a string consisting of the name of the constructor (the name used instead of NativeError).

15.11.7.4.3 NativeError.prototype.message

The initial value of the message property of the prototype for a given NativeError constructor is the empty String.
15.11.7.5 Properties of NativeError Instances

NativeError instances are ordinary objects that inherit properties from their NativeError prototype object and have a [[ErrorData]] internal data property whose initial value is undefined. The only specified use of [[ErrorData]] is to flag whether or not an Error or NativeError instance has been initialized by its constructor.

15.12 The JSON Object

The JSON object is a single ordinary object that contains two functions, parse and stringify, that are used to parse and construct JSON texts. The JSON Data Interchange Format is described in RFC 4627 <http://www.ietf.org/rfc/rfc4627.txt>. The JSON interchange format used in this specification is exactly that described by RFC 4627 with two exceptions:

- The top level JSONText production of the ECMAScript JSON grammar may consist of any JSONValue rather than being restricted to being a JSONObject or a JSONArray as specified by RFC 4627.
- Conforming implementations of JSON.parse and JSON.stringify must support the exact interchange format described in this specification without any deletions or extensions to the format. This differs from RFC 4627 which permits a JSON parser to accept non-JSON forms and extensions.

The value of the [[Prototype]] internal data property of the JSON object is the standard built-in Object prototype object (15.2.4). The JSON object has a [[JSONTag]] internal data property whose value is true. The value of the [[Extensible]] internal data property of the JSON object is set to true.

The JSON object does not have a [[Construct]] internal method; it is not possible to use the JSON object as a constructor with the new operator.

The JSON object does not have a [[Call]] internal method; it is not possible to invoke the JSON object as a function.

15.12.1 The JSON Grammar

JSON.stringify produces a String that conforms to the following JSON grammar. JSON.parse accepts a String that conforms to the JSON grammar.

15.12.1.1 The JSON Lexical Grammar

JSON is similar to ECMAScript source text in that it consists of a sequence of Unicode characters conforming to the rules of SourceCharacter. The JSON Lexical Grammar defines the tokens that make up a JSON text similar to the manner that the ECMAScript lexical grammar defines the tokens of an ECMAScript source text. The JSON Lexical Grammar only recognises the white space character specified by the production JSONWhiteSpace. The JSON lexical grammar shares some productions with the ECMAScript lexical grammar. All nonterminal symbols of the grammar that do not begin with the characters “JSON” are defined by productions of the ECMAScript lexical grammar.

Syntax

```
JSONWhiteSpace ::
<TAB>
<CR>
<LF>
<SP>

JSONString ::
" JSONStringCharactersopt "

JSONStringCharacters ::
JSONStringCharacter JSONStringCharactersopt

JSONStringCharacter ::
```

© Ecma International 2012
SourceCharacter but not one of " or \ or U+0000 through U+001F

\JSONEscapeSequence

JSONEscapeSequence ::
  JSONEscapeCharacter
  a HexDigit HexDigit HexDigit HexDigit

JSONEscapeCharacter :: one of
  " / \ b f n r t

JSONNumber ::
  -opt DecimalIntegerLiteral JSONFractionopt ExponentPartopt

JSONFraction ::
  . DecimalDigits

JSONNullLiteral ::
  NullLiteral

JSONBooleanLiteral ::
  BooleanLiteral

15.12.1.2 The JSON Syntactic Grammar

The JSON Syntactic Grammar defines a valid JSON text in terms of tokens defined by the JSON lexical
grammar. The goal symbol of the grammar is JSONText.

Syntax

JSONText ::
  JSONValue

JSONValue ::
  JSONNullLiteral
  JSONBooleanLiteral
  JSONObject
  JSONArray
  JSONString
  JSONNumber

JSONObject ::
  {} ( JSONMemberList )

JSONMember ::
  JSONString : JSONValue

JSONMemberList ::
  JSONMember
  JSONMemberList , JSONMember

JSONArray ::
  [ ] [ JSONElementList ]

JSONElementList ::
  JSONValue
  JSONElementList , JSONValue
15.12.2 JSON.parse( text [ , reviver ] )

The parse function parses a JSON text (a JSON-formatted String) and produces an ECMAScript value. The JSON format is a restricted form of ECMAScript literal. JSON objects are realized as ECMAScript objects. JSON arrays are realized as ECMAScript arrays. JSON strings, numbers, booleans, and null are realized as ECMAScript Strings, Numbers, Booleans, and null. JSON uses a more limited set of white space characters than WhiteSpace and allows Unicode code points U+2028 and U+2029 to directly appear in JSONString without using an escape sequence. The process of parsing is similar to 11.1.4 and 11.1.5 as constrained by the JSON grammar.

The optional reviver parameter is a function that takes two parameters, (key and value). It can filter and transform the results. It is called with each of the key/value pairs produced by the parse, and its return value is used instead of the original value. If it returns what it received, the structure is not modified. If it returns undefined then the property is deleted from the result.

1. Let JText be ToString(text).
2. ReturnIfAbrupt(JText).
3. Parse JText interpreted as UTF-16 encoded Unicode characters using the grammars in 15.12.1. Throw a SyntaxError exception if JText did not conform to the JSON grammar for the goal symbol JSONText.
4. Let scriptText be the result of concatenating " { ", JText, and "} ; ".
5. Let completion be the result of parsing and evaluating scriptText as if it was the source text of an ECMAScript Script but using JSONString in place of StringLiteral. Note that since JText conforms to the JSON grammar this result will be either a primitive value or an object that is defined by either an ArrayLiteral or an ObjectLiteral.
6. Let unfiltered be completion[[value]].
7. If IsCallable(reviver) is true, then
   a. Let root be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
   b. Call CreateOwnProperty(root, the empty String, unfiltered).
   c. Return the result of calling the abstract operation Walk, passing root and the empty String. The abstract operation Walk is described below.
8. Else
   a. Return unfiltered.

Runtime Semantics: Walk Abstract Operation

The abstract operation Walk is a recursive abstract operation that takes two parameters: a holder object and the String name of a property in that object. Walk uses the value of reviver that was originally passed to the above parse function.

1. Let val be the result of Get(holder, name).
2. ReturnIfAbrupt(val).
3. If val is an object, then
   a. If val is an exotic Array object then
      i. Set I to 0.
      ii. Let len be the result of Get(val, "length").
      iii. Assert: len is not an abrupt completion and its value is a positive integer.
      iv. Repeat while I < len,
         1. Let newElement be the result of calling the abstract operation Walk, passing val and ToString(I).
         2. If newElement is undefined, then
            a. Let status be the result of calling the [[Delete]] internal method of val with ToString(I) as the argument.
         3. Else
            a. Let status be the result of calling the [[DefineOwnProperty]] internal method of val with arguments ToString(I) and Property Descriptor 
               { [[value]]: newElement, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true }.
            b. NOTE: The above is intentionally not a strict define and does not throw if status is false.

Commented [AWB15196]: TODO: What about the static semantic rules? Do they all apply to JSON text? Don’t want to recognise __proto..., etc. It may be time to provide independent evaluation semantics for JSONText

Commented [AWB12197]: TODO make this a more extensible condition to check
4. ReturnIfAbrupt(status).
5. Add 1 to i.

b. Else
   i. Let keys be an internal List of String values consisting of the names of all the own
      properties of val whose [[Enumerable]] attribute is true. The ordering of the Strings is
      the same as that used by the Object.keys standard built-in function.
   ii. For each String P in keys do,
        1. Let newElement be the result of calling the abstract operation Walk, passing val and
           P.
        2. If newElement is undefined, then
           a. Let status be the result of calling the [[Delete]] internal method of val with
              P as the argument.
        3. Else
           a. Let status be the result of calling the [[DefineOwnProperty]] internal
              method of val with arguments P and Property Descriptor {
                 [[Value]]: newElement, [[Writable]]: true, [[Enumerable]]: true,
                 [[Configurable]]: true}.
           b. NOTE The above is intentionally not a strict define and does not throw if status is
              false.
        4. ReturnIfAbrupt(status).
4. Return the result of calling the [[Call]] internal method of reviver passing
   holder as this Argument and with a List containing name and val as argumentsList.

It is not permitted for a conforming implementation of JSON.parse to extend the JSON grammars. If an
implementation wishes to support a modified or extended JSON interchange format it must do so by defining a
different parse function.

NOTE In the case where there are duplicate name Strings within an object, lexically preceding values for the same
key shall be overwritten.

15.12.3 JSON.stringify (value [, replacer [, space ]])

The stringify function returns a String in UTF-16 encoded JSON format representing an ECMAScript
value. It can take three parameters. The value parameter is an ECMAScript value, which is usually an object
or array, although it can also be a String, Boolean, Number or null. The optional replacer parameter is either a
function that alters the way objects and arrays are stringified, or an array of Strings and Numbers that acts as
a white list for selecting the object properties that will be stringified. The optional space parameter is a String or
Number that allows the result to have white space injected into it to improve human readability.

These are the steps in stringifying an object:

1. Let stack be an empty List.
2. Let indent be the empty String.
3. Let PropertyList and ReplacerFunction be undefined.
4. If Type(replacer) is Object, then
   a. If IsCallable(replacer) is true, then
      i. Let ReplacerFunction be replacer.
   b. Else if replacer is an exotic Array object, then
      i. Let PropertyList be an empty internal List
      ii. For each value v of a property of replacer that has an array index property name. The
          properties are enumerated in the ascending array index order of their names.
          1. Let item be undefined.
          2. If Type(v) is String then let item be v.
          3. Else if Type(v) is Number then let item be ToString(v).
          4. Else if Type(v) is Object then,
             a. If v has a [[StringData]] or [[NumberData]] internal data property, then let
                item be ToString(v).
          5. If item is not undefined and item is not currently an element of PropertyList then,
             a. Append item to the end of PropertyList.
      5. If Type(space) is Object then,
a. If space has a [[NumberData]] internal data property then,
   i. Let value be ToNumber(space).
   b. Else if space has a [[StringData]] internal data property then,
      i. Let value be ToString(space).
6. If Type(space) is Number
   a. Let value be min(10, ToInteger(space)).
   b. Set gap to a String containing space occurrences of code unit 0x0020 (the Unicode space character).
   This will be the empty String if space is less than 1.
7. Else if Type(space) is String
   a. If the number of elements in space is 10 or less, set gap to space otherwise set gap to a String consisting of the first 10 elements of space.
8. Else
   a. Set gap to the empty String.
9. Let wrapper be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
10. Call CreateOwnProperty(wrapper, the empty String, value).
11. Return the result of calling the abstract operation Str with the empty String and wrapper.

Runtime Semantics: Str Abstract Operation

The abstract operation Str(key, holder) has access to ReplacerFunction from the invocation of the stringify method. Its algorithm is as follows:

1. Let value be the result of Get(holder, key).
2. ReturnIfAbrupt(value).
3. If Type(value) is Object, then
   a. Let toJSON be the result of Get(value, "toJSON").
   b. If IsCallable(toJSON) is true
      i. Let value be the result of calling the [[Call]] internal method of toJSON passing value as thisArgument and a List containing key as argumentsList.
      ii. ReturnIfAbrupt(value).
4. If ReplacerFunction is not undefined, then
   a. Let value be the result of calling the [[Call]] internal method of ReplacerFunction passing holder as the this value and with an argument list consisting of key and value.
   b. ReturnIfAbrupt(value).
5. If Type(value) is Object then
   a. If value has an [[NumberData]] internal data property then,
      i. Let value be ToNumber(value).
   b. Else if value has an [[StringData]] internal data property then,
      i. Let value be ToString(value).
   c. Else if value has an [[BooleanData]] internal data property then,
      i. Let value be the value of the [[BooleanData]] internal data property of value.
6. If value is null then return "null".
7. If value is true then return "true".
8. If value is false then return "false".
9. If Type(value) is String, then return the result of calling the abstract operation Quote with argument value.
10. If Type(value) is Number
    a. If value is finite then return ToString(value).
    b. Else, return "null".
11. If Type(value) is Object, and IsCallable(value) is false
    a. If value is an exotic Array object then
       i. Return the result of calling the abstract operation JA with argument value.
    b. Else, return the result of calling the abstract operation JO with argument value.
12. Return undefined.

Runtime Semantics: Quote Abstract Operation

The abstract operation Quote(value) wraps a String value in double quotes and escapes characters within it.

1. Let product be code unit 0x0022 (the Unicode double quote character).
2. For each code unit \( C \) in \( \text{value} \):
   a. If \( C \) is 0x0022 or 0x005C (the Unicode reverse solidus character)
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and code unit 0x005C.
   b. Else if \( C \) is backspace, formfeed, newline, carriage return, or tab
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and code unit 0x005C (the Unicode backslash character).
      ii. Let \( \text{abbrev} \) be the string value corresponding to the value of \( C \) as follows:
          - backspace: "b"
          - formfeed: "f"
          - newline: "n"
          - carriage return: "r"
          - tab: "t"
      iii. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( \text{abbrev} \).
   c. Else if \( C \) has a code unit value less than 0x0020 (the Unicode space character)
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and code unit 0x005C (the Unicode backslash character).
      ii. Let \( \text{hex} \) be the string result of converting the numeric code unit value of \( C \) to a String of four hexadecimal digits. Alphabetic hexadecimal digits are presented as lowercase characters.
      iii. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( \text{hex} \).
   d. Else
      i. Let \( \text{product} \) be the concatenation of \( \text{product} \) and \( C \).
3. Let \( \text{product} \) be the concatenation of \( \text{product} \) and code unit 0x0022 (the Unicode double quote character).
4. Return \( \text{product} \).

**Runtime Semantics: JO Abstract Operation**

The abstract operation \( \text{JO}(\text{value}) \) serializes an object. It has access to the \( \text{stack} \), \( \text{indent} \), \( \text{gap} \), and \( \text{PropertyList} \) of the invocation of the.stringify method.

1. If \( \text{stack} \) contains \( \text{value} \) then throw a \( \text{TypeError} \) exception because the structure is cyclical.
2. Append \( \text{value} \) to \( \text{stack} \).
3. Let \( \text{stepback} \) be \( \text{indent} \).
4. Let \( \text{indent} \) be the concatenation of \( \text{indent} \) and \( \text{gap} \).
5. If \( \text{PropertyList} \) is not undefined, then
   a. Let \( K \) be \( \text{PropertyList} \).
6. Else
   a. Let \( K \) be an internal List of Strings consisting of the keys of all the own properties of \( \text{value} \) whose [[Enumerable]] attribute is true and whose property key is a String value. The ordering of the Strings is the same as that used by the Object.keys standard built-in function.
7. Let \( \text{partial} \) be an empty List.
8. For each element \( P \) of \( K \):
   a. Let \( \text{strP} \) be the result of calling the abstract operation \( \text{Str} \) with arguments \( P \) and \( \text{value} \).
   b. ReturnIfAbrupt(\text{StrP}).
   c. If \( \text{strP} \) is not undefined
      i. Let \( \text{member} \) be the result of calling the abstract operation \( \text{Quote} \) with argument \( P \).
      ii. Let \( \text{member} \) be the concatenation of \( \text{member} \) and the string " : ".
      iii. If \( \text{gap} \) is not the empty String
          1. Let \( \text{member} \) be the concatenation of \( \text{member} \) and code unit 0x0020 (the Unicode space character).
          2. Let \( \text{member} \) be the concatenation of \( \text{member} \) and \( \text{strP} \).
          3. Append \( \text{member} \) to \( \text{partial} \).
     iv. Let \( \text{member} \) be the concatenation of \( \text{member} \) and code unit 0x0022 (the Unicode double quote character).
    v. Append \( \text{member} \) to \( \text{partial} \).
9. If \( \text{partial} \) is empty, then
   a. Let \( \text{final} \) be " ( ) ".
10. Else
    a. If \( \text{gap} \) is the empty String
i. Let properties be a String formed by concatenating all the element Strings of partial with each adjacent pair of Strings separated with code unit 0x002C (the Unicode comma character). A comma is not inserted either before the first String or after the last String.

b. Else gap is not the empty String
i. Let separator be the result of concatenating code unit 0x000A (the comma character), code unit 0x0000 (the line feed character), and indent.

ii. Let properties be a String formed by concatenating all the element Strings of partial with each adjacent pair of Strings separated with separator. The separator String is not inserted either before the first String or after the last String.

iii. Let final be the result of concatenating "\", code unit 0x000A (the line feed character), indent, properties, code unit 0x0000, stepback, and ")."

11. Remove the last element of stack.
12. Let indent be stepback.

Runtime Semantics: JA Abstract Operation

The abstract operation JA(value) serializes an array. It has access to the stack, indent, and gap of the invocation of the stringifying method. The representation of arrays includes only the elements between zero and array.length - 1 inclusive. Properties whose keys are not array indexes are excluded from the stringification. An array is stringified as an open left bracket, elements separated by comma, and a closing right bracket.

1. If stack contains value then throw a TypeError exception because the structure is cyclical.
2. Append value to stack.
3. Let stepback be indent.
4. Let indent be the concatenation of indent and gap.
5. Let partial be an empty List.
6. Assert: value is a standard array object and hence its "length" property is a non-negative integer.
7. Let len be the result of GetValue("length")
8. Let index be 0.
9. Repeat while index ≤ len
a. Let strP be the result of calling the abstract operation Str with arguments ToString(index) and value.
b. ReturnJAbstr(p)
c. If strP is undefined
i. Append "null" to partial.
d. Else
i. Append strP to partial.
e. Increment index by 1.
10. If partial is empty, then
a. Let final be "["]
11. Else
a. If gap is the empty String
i. Let properties be a String formed by concatenating all the element Strings of partial with each adjacent pair of Strings separated with code unit 0x002C (the comma character). A comma is not inserted either before the first String or after the last String.
ii. Let final be the result of concatenating "\", properties, and ")".

b. Else
i. Let separator be the result of concatenating code unit 0x002C (the comma character), code unit 0x0000 (the line feed character), and indent.
ii. Let properties be a String formed by concatenating all the element Strings of partial with each adjacent pair of Strings separated with separator. The separator String is not inserted either before the first String or after the last String.
iii. Let final be the result of concatenating "\", code unit 0x000A (the line feed character), indent, properties, code unit 0x0000, stepback, and ")".

12. Remove the last element of stack.
13. Let indent be stepback.
NOTE 1  JSON structures are allowed to be nested to any depth, but they must be acyclic. If value is or contains a cyclic structure, then the stringify function must throw a TypeError exception. This is an example of a value that cannot be stringified:

```javascript
a = [];  
a[0] = a;  
my_text = JSON.stringify(a);  // This must throw an TypeError.
```

NOTE 2  Symbolic primitive values are rendered as follows:

- The null value is rendered in JSON text as the String null.
- The undefined value is not rendered.
- The true value is rendered in JSON text as the String true.
- The false value is rendered in JSON text as the String false.

NOTE 3  String values are wrapped in double quotes. The characters " and \ are escaped with \ prefixes. Control characters are replaced with escape sequences \uHHHH, or with the shorter forms \b (backspace), \f (formfeed), \n (newline), \r (carriage return), \t (tab).

NOTE 4  Finite numbers are stringified as if by calling ToString(number). NaN and Infinity regardless of sign are represented as the String null.

NOTE 5  Values that do not have a JSON representation (such as undefined and functions) do not produce a String. Instead they produce the undefined value. In arrays these values are represented as the String null. In objects an unrepresentable value causes the property to be excluded from stringification.

NOTE 6  An object is rendered as an opening left brace followed by zero or more properties, separated with commas, closed with a right brace. A property is a quoted String representing the key or property name, a colon, and then the stringified property value. An array is rendered as an opening left bracket followed by zero or more values, separated with commas, closed with a right bracket.

15.13  Binary Data Objects

15.13.1  The BinaryData Module

15.13.2  The BinaryData.Type Object

15.13.2.5  BinaryData.ScalarType Type Instance Objects

15.13.3  The BinaryDataArrayType Object

15.13.4  The BinaryData.StructType Object

15.13.5  ArrayBuffer Objects

15.13.5.1  Abstract Operations For ArrayBuffer Objects

15.13.5.1.1  AllocateArrayBuffer(constructor)

The abstract operation AllocateArrayBuffer with argument constructor is used to create an uninitialized ArrayBuffer object. It performs the following steps:

1. Let oby be the result of calling OrdinaryCreateFromConstructor(constructor, "%ArrayBufferPrototype%", ([[ArrayBufferData]], [[ArrayBufferByteLength]])).
2. ReturnIfAbrupt(oby).
3. Set the [[ArrayBufferByteLength]] internal data property of oby to 0.
4. Return oby.
15.13.5.1.2 SetArrayBufferData(arrayBuffer, bytes)

The abstract operation SetArrayBufferData with arguments arrayBuffer and bytes is used to initialize the storage block encapsulated by an ArrayBuffer object. It performs the following steps:

1. Assert: arrayBuffer has an [[ArrayBufferData]] internal data property.
2. Assert: bytes is a positive integer.
3. Let block be the result of CreateByteBlockWithSize(bytes).
4. ReturnIfAbrupt(block).
5. Set arrayBuffer's [[ArrayBufferData]] to block.
6. Set arrayBuffer's [[ArrayBufferByteLength]] internal data property to bytes.
7. Return arrayBuffer.

15.13.5.1.3 GetValueFromBuffer (arrayBuffer, byteIndex, type, isBigEndian)

The abstract operation GetValueFromBuffer takes four parameters, an ArrayBuffer arrayBuffer, an integer byteIndex, a String valueType, and optionally a Boolean isBigEndian. If isBigEndian is not present, its default value is undefined. This operation performs the following steps:

1. Assert: There are sufficient bytes in arrayBuffer starting at byteIndex to represent a value of valueType.
2. Assert: byteIndex is a positive integer.
3. Let block be arrayBuffer's [[ArrayBufferData]] internal data property.
4. Let elementSize be the Number value of the Element Size value specified in Table 36 for valueType.
5. Let rawValue be the elementSize bytes starting at byteIndex of block.
6. If isBigEndian is undefined, set isBigEndian to either true or false. The choice is implementation dependent and should be the alternative that is most efficient for the implementation. An implementation must use the same value each time this step is executed and the same value must be used for the corresponding step in the SetValueInBuffer abstraction operation.
7. If isBigEndian is true, reverse the order of the bytes of rawValue.
8. If type is "Float32", then
   a. rawValue is interpreted, taking into account the value of isBigEndian, as a bit string encoding of an IEEE 754-2008 binary32 value.
   b. If rawValue is an IEEE 754-2008 binary32 NaN value, return the NaN Number value.
   c. Return the Number value that is encoded by rawValue.
9. If type is "Float64", then
   a. rawValue is interpreted, taking into account the value of isBigEndian, as a bit string encoding of an IEEE 754-2008 binary64 value.
   b. If rawValue is an IEEE 754-2008 binary64 NaN value, return the NaN Number value.
   c. Return the Number value that is encoded by rawValue.
10. If the first character of type is "D", then
    a. Let intValue be the positive integer that is the result of interpreting, taking into account the value of isBigEndian, rawValue as an unsigned binary number.
11. Else
    a. Let intValue be the signed integer that is the result of interpreting, taking into account the value of isBigEndian, rawValue as a binary 2's complement number of bit length elementSize × 4.
12. Return intValue.

NOTE The default number storage format for all implementation is little endian, regardless of the native endianness of the underlying hardware.

15.13.5.1.4 SetValueInBuffer (arrayBuffer, byteIndex, type, value, isBigEndian)

The abstract operation SetValueInBuffer takes five parameters, an ArrayBuffer arrayBuffer, an integer byteIndex, a String valueType, a Number value, and optionally a Boolean isBigEndian. If isBigEndian is not present, its default value is false. This operation performs the following steps:

1. Assert: There are sufficient bytes in arrayBuffer starting at byteIndex to represent a value of valueType.
2. Assert: byteIndex is a positive integer.
3. Let block be arrayBuffer's [[ArrayBufferData]] internal data property.
4. Let `elementSize` be the Number value of the Element Size value specified in Table 36 on the row with Element Type is `type`.
5. Let `rawValue` be the `elementSize` bytes starting at `byteIndex` of `arrayBuffer`.
6. If `isBigEndian` is `undefined`, set `isBigEndian` to either `true` or `false`. The choice is implementation dependent and should be the alternative that is most efficient for the implementation. An implementation must use the same value each time this step is executed and the same value must be used for the corresponding step in the `GetValueFromBuffer` abstraction operation.
7. If `isBigEndian` is `true`, reverse the order of the bytes of `rawValue`.
8. If `type` is “Float32”, then
   a. Set `rawValue` to the 4 bytes that are the result of converting `value` to IEEE-868-2005 binary32 format using “Round to nearest, ties to even” rounding mode. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order. If `value` is NaN, `rawValue` is may be set of any implementation chosen non-signaling NaN encoding.
9. Else, if `type` is “Float64”, then
   a. Set `rawValue` to the 8 bytes that are the IEEE-868-2005 binary64 format encoding of `value`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order. If `value` is NaN, `rawValue` is may be set any implementation chosen non-signaling NaN encoding.
10. Else,
    a. Let `n` be the size Element Type value in Table 36 for the row containing the value of `type` as its Element Type entry.
    b. Let `convOp` be the abstract operation named in the Conversion Operation column in Table 36 for the row containing the value of `type` as its Element Type entry.
    c. Let `intValue` be the result of calling `convOp` with `value` as its argument.
    d. If `intValue >= 0`, then
       i. Let `rawBytes` be the n-byte binary encoding of `intValue`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order.
    e. Else,
       i. Let `rawBytes` be the n-byte binary 2’s complement encoding of `intValue`. If `isBigEndian` is `true`, the bytes are arranged in big endian order. Otherwise, the bytes are arranged in little endian order.
11. Store the individual bytes of `rawBytes` in order starting at position `byteIndex` of `block`.
12. Return `NormalCompletion(undefined)`.  

**15.13.5.2 The ArrayBuffer Object Called as a Function**

When `ArrayBuffer` is called as a function rather than as a constructor, it initializes its `this` value with the internal state that supports the `ArrayBuffer.prototype` internal methods. This permits super invocation of the `ArrayBuffer` constructor by `ArrayBuffer` subclasses. If its `this` value is `undefined`, it creates and initializes a new `ArrayBuffer` object. Thus the function call `ArrayBuffer(…)` is equivalent to the object creation expression `new ArrayBuffer(…)` with the same arguments.

**15.13.5.2.1 ArrayBuffer(length)**

`ArrayBuffer` called as function with argument `length` performs the following steps:

1. Let `O` be the `this` value.
2. If `Type(O)` is neither Object or `undefined`, then throw a `TypeError` exception.
3. If `O` is `undefined` or does not have an `[[ArrayBufferData]]` internal data property, then
   a. Let `F` be this function object.
   b. Let `argumentsList` be the `argumentsList` argument of the `[[Call]]` internal method that invoked `F`.
   c. Return the result of calling `OrdinaryCreateFromConstructor(F, argumentsList)`.
4. If the value of `O`’s `[[ArrayBufferData]]` internal data property is not `undefined`, then throw a `TypeError` exception.
5. Let `numberOfLength` be `ToNumber(length)`.
6. Let `byteLength` be `ToInteger(numberLength)`.
7. Return `Abrupt(throwLength)`.
8. If `numberOfLength ≠ byteLength` or `byteLength < 0`, then throw a `RangeError` exception.
9. Return the result of `SetArrayBufferData(O, byteLength)`.
15.13.5.3 The ArrayBuffer Constructor

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

The ArrayBuffer constructor is designed to be subclassable. It may be used as the value of an extends clause of a class declaration. Subclass constructors that intended to inherit the specified ArrayBuffer behaviour must include a super call to ArrayBuffer.

15.13.5.3.1 new ArrayBuffer(...args)

ArrayBuffer called as part of a new expression with argument length performs the following steps:

1. Let F be the ArrayBuffer function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct(F, argumentsList).

If ArrayBuffer is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.13.5.4 Properties of the ArrayBuffer Constructor

The value of the [[Prototype]] internal data property of the ArrayBuffer constructor is the Function prototype object (15.3.3).

Besides its length property (whose value is 1), the ArrayBuffer constructor has the following properties:

15.13.5.4.1 ArrayBuffer.prototype

The initial value of ArrayBuffer.prototype is the ArrayBuffer prototype object (15.13.5.4).

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

15.13.5.4.2 ArrayBuffer.isView(arg)

The isView function takes one argument arg, and performs the following steps are taken:

1. If Type(arg) is not Object, return false.
2. If arg is an exotic Array object, then return true.
3. If arg has a [[ViewedArrayBuffer]] internal data property, then return true.
4. Return false.

15.13.5.4.3 ArrayBuffer@@create()

The @@create method of a ArrayBuffer function object F performs the following steps:

1. Let F be the this value.
2. Return the result of calling AllocateArrayBuffer(F).

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

15.13.5.5 Properties of the ArrayBuffer Prototype Object

The value of the [[Prototype]] internal data property of the ArrayBuffer prototype object is the standard built-in Object prototype object (15.2.4). The ArrayBuffer prototype object is an ordinary object. It does not have a [[ArrayBufferData]] or [[ArrayBufferByteLength]] internal data property.
15.13.5.5.1 ArrayBuffer.prototype.constructor

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

15.13.5.5.2 get ArrayBuffer.prototype.byteLength

ArrayBuffer.prototype.byteLength is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let O be the result of calling ToObject with the this value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a [[ArrayBufferByteLength]] internal data property throw a TypeError exception.
4. Let length be the value of O’s [[ArrayBufferByteLength]] internal data property.
5. Return length.

15.13.5.5.3 ArrayBuffer.prototype.slice ( start, end)

The following steps are taken:

1. Let O be the result of calling ToObject with the this value as its argument.
2. ReturnIfAbrupt(O).
3. If O does not have a [[ArrayBufferData]] internal data property throw a TypeError exception.
4. Let len be the value of O’s [[ArrayBufferData]] internal data property.
5. Let relativeStart be ToInteger(start).
6. ReturnIfAbrupt(relativeStart).
7. If relativeStart is negative, let first be max((len + relativeStart), 0); else let first be min(relativeStart, len).
8. If end is undefined, let relativeEnd be len; else let relativeEnd be ToInteger(end).
9. ReturnIfAbrupt(relativeEnd).
10. If relativeEnd is negative, let final be max((len + relativeEnd), 0); else let final be min(relativeEnd, len).
11. Let newLen be final-first.
12. Let ctor be the result of GetMethod(O, "constructor").
13. ReturnIfAbrupt(ctor).
14. If IsConstructor(ctor) is false, then throw a TypeError exception.
15. Let new be the result of calling the [[Construct]] internal method of ctor with a new List containing the single element newLen.
16. ReturnIfAbrupt(new).
17. If new does not have a [[ArrayBufferData]] internal data property throw a TypeError exception.
18. Let fromBuf be the value of O’s [[ArrayBufferData]] internal data property.
19. Let toBuf be the value of new’s [[ArrayBufferData]] internal data property.
20. Let status be the result of CopyBlockElements(fromBuf, first, toBuf, 0, newLen).
21. ReturnIfAbrupt(status).
22. Return new.

15.13.5.5.4 ArrayBuffer.prototype[@@toStringTag]

The initial value of the @@toStringTag property is the string value "ArrayBuffer".

15.13.5.6 Properties of the ArrayBuffer Instances

ArrayBuffer instances inherit properties from the ArrayBuffer prototype object. After initialisation by the ArrayBuffer constructor, ArrayBuffer instances also have a [[ArrayBufferData]] internal data property and a [[ArrayBufferByteLength]] internal data property.

15.13.6 TypedArray Object Structures

For each constructor in the Table 36 is a separate TypedArray constructor object, with corresponding prototype and instances. Each of these TypedArray constructor objects has the structure described below, differing only in the name used as the constructor name instead of TypedArray, in Table 36.
In the definitions below, references to `TypedArray` should be replaced with the appropriate constructor name from the above table. The phrase “the element size in bytes” refers to the value in the `Element Size` column of the table in the row corresponding to the constructor. The phrase “element Type” refers to the value in the `Element Type` column for that row.

15.13.6.1 `TypedArray` Constructors Called as a Function

When a `TypedArray` constructor is called as a function rather than as a constructor, it initializes its `this` value with the internal state that supports the `TypedArray.prototype` internal methods. This permits super invocation of the `TypedArray` constructor by `TypedArray` subclasses. If the this value is undefined, it creates and initializes a new `TypedArray` object. Thus the function call `new TypedArray (...)` is equivalent to the object creation expression `new TypedArray ()` with the same arguments.

15.13.6.1.1 `TypedArray (length)`

`TypedArray` called as function with argument `length` performs the following steps:

1. Assert: `Type(length)` is not `Object`.
2. Let `elementType` be the `stringValue` of the `Element Type` value in Table 36 for this `TypedArray` constructor.
3. Let `O` be the `this` value.
4. If `Type(O)` is neither `Object` or `Undefined`, then throw a `TypeError` exception.
5. If `O` is `Undefined` or does not have an `[[ViewedArrayBuffer]]` internal data property, then:
   a. Let `F` be this function object.
   b. Let `argumentsList` be the `argumentsList` argument of the `[[Call]]` internal method that invoked `F`.
   c. Return the result of calling `OrdinaryConstruct` (`F`, `argumentsList`).
6. If the value of `O`'s `[[ViewedArrayBuffer]]` internal data property is not `undefined`, then throw a `TypeError` exception.
7. Let `numberLength` be `ToNumber(length)`.
8. Let `elementLength` be `ToInteger(numberLength)`.
9. ReturnIfAbrupt(`elementLength`).
10. If `numberLength ≠ elementLength` or `elementLength` < `0`, then throw a `RangeError` exception.
11. Let `data` be the result of calling `AllocateArrayBuffer(size)`.
12. ReturnIfAbrupt(`data`).
13. Let `elementSize` be the `Size` Element value in Table 36 for this `TypedArray` constructor.
15. Let `status` be the result of calling `SetArrayBufferData(data, byteLength)`.
16. ReturnIfAbrupt(`status`).
17. Set `O`'s `[[ViewedArrayBuffer]]` to `data`.

---

**Table 36 – The `TypedArray` Constructors**

<table>
<thead>
<tr>
<th>Constructor Name</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</td>
<td>Int8</td>
<td>1</td>
<td>ToInt8</td>
<td>8-bit 2's complement signed char</td>
<td></td>
</tr>
<tr>
<td>Uint8Array</td>
<td>Uint8</td>
<td>1</td>
<td>ToUint8</td>
<td>8-bit unsigned integer unsigned char</td>
<td></td>
</tr>
<tr>
<td>Uint8ClampedArray</td>
<td>Uint8Clamp</td>
<td>1</td>
<td>ToUint8Clamp</td>
<td>8-bit unsigned integer (clamped) unsigned char</td>
<td></td>
</tr>
<tr>
<td>Int16Array</td>
<td>Int16</td>
<td>2</td>
<td>ToInt16</td>
<td>16-bit 2's complement signed integer Short</td>
<td></td>
</tr>
<tr>
<td>Uint16Array</td>
<td>Uint16</td>
<td>2</td>
<td>ToUint16</td>
<td>16-bit unsigned integer unsigned short</td>
<td></td>
</tr>
<tr>
<td>Int32Array</td>
<td>Int32</td>
<td>4</td>
<td>ToInt32</td>
<td>32-bit 2's complement signed integer Int</td>
<td></td>
</tr>
<tr>
<td>Uint32Array</td>
<td>Uint32</td>
<td>4</td>
<td>ToUint32</td>
<td>32-bit unsigned integer unsigned int</td>
<td></td>
</tr>
<tr>
<td>Float32Array</td>
<td>Float32</td>
<td>4</td>
<td>ToFloat32</td>
<td>32-bit IEEE floating point Float</td>
<td></td>
</tr>
<tr>
<td>Float64Array</td>
<td>Float64</td>
<td>8</td>
<td>ToFloat64</td>
<td>64-bit IEEE floating point Double</td>
<td></td>
</tr>
</tbody>
</table>

Commented [AWB13202]: TODO
Commented [AWB13203]: TODO
Commented [AWB13204]: Issue: this is a made up name. What should it be?
Commented [AWB13205]: TODO

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18. Set O’[[TypedArrayElementKind]] internal data property to  elementType.
19. Set O’[[ByteLength]] internal data property to byteLength.
20. Set O’[[ByteOffset]] internal data property to 0.
21. Set O’[[ArrayLength]] internal data property to  elementLength.
22. Return O.

15.3.6.1.2 `TypedArray( typedArray )`

TypedArray called as function with argument typedArray performs the following steps:

1. Assert: `Type(typedArray)` is Object and typedArray has a [[ViewedArrayBuffer]] internal data property.
2. Let srcArray be typedArray.
3. Let `elementType` be the string value of the Element Type value in Table 36 for this `TypedArray` constructor.
4. Let O be the this value.
5. If Type(O) is neither Object or Undefined, then throw a TypeError exception.
6. If O is `undefined` or does not have an [[ViewedArrayBuffer]] internal data property, then
   a. Let F be this function object.
   b. Let argumentsList be the argumentsList argument of the [[Call]] internal method that invoked F.
   c. Return the result of calling OrdinaryConstruct(F, argumentsList).
7. If the value of O’[[ViewedArrayBuffer]] internal data property is not `undefined`, then throw a TypeError exception.
8. Let `elementLength` be the value of srcArray’[[ArrayLength]] internal data property.
9. Let `srcType` be the value of srcArray’[[TypedArrayElementKind]] internal data property.
10. Let `srcData` be the value of srcArray’[[ViewedArrayBuffer]] internal data property.
11. Let data be the result of calling Clone(srcData, srcType, `elementType`, `elementLength`).
12. ReturnIfAbrupt(data).
13. Let `elementSize` be the Size Element value in Table 36 for this `TypedArray` constructor.
15. Let data be the result of SetArrayBufferData(data, `byteLength`).
16. ReturnIfAbrupt(data).
17. Set O’[[ViewedArrayBuffer]] to data.
18. Set O’[[TypedArrayElementKind]] internal data property to `elementType`.
19. Set O’[[ByteLength]] internal data property to `byteLength`.
20. Set O’[[ByteOffset]] internal data property to 0.
21. Set O’[[ArrayLength]] internal data property to `elementLength`.
22. Return O.

15.3.6.1.3 `TypedArray( array )`

TypedArray called as function with argument array performs the following steps:

1. Assert: `Type(array)` is Object and array does not have either a [[ViewedArrayBuffer]] or a [[ArrayBufferData]] internal data property.
2. Let O be the this value.
3. If Type(O) is neither Object or Undefined, then throw a TypeError exception.
4. Let `srcArray` be array.
5. Let `elementType` be the string value of the Element Type value in Table 36 for this `TypedArray` constructor.
6. If O is `undefined` or does not have an [[ViewedArrayBuffer]] internal data property, then
   a. Let F be this function object.
   b. Let argumentsList be the argumentsList argument of the [[Call]] internal method that invoked F.
   c. Return the result of calling OrdinaryConstruct(F, argumentsList).
7. If the value of O’[[ViewedArrayBuffer]] internal data property is not `undefined`, then throw a TypeError exception.
8. Let `arrayLength` be the result of Get(array, "length").
9. Let `numberLength` be ToNumber(arrayLength).
10. Let `elementLength` be ToInteger(numberLength).
11. ReturnIfAbrupt(`elementLength`).
12. If `numberLength` ≠ `elementLength` or `elementLength` < 0, then throw a TypeError exception.
13. Let data be the result of calling AllocateArrayBuffer(%ArrayBuffer%).
14. ReturnIfAbrupt(data).
15. Let `elementSize` be the Size Element value in Table 36 for this `TypedArray` constructor.
16. Let `byteLength` be `elementSize × elementLength`.
17. Let `status` be the result of `SetArrayBufferData(data, byteLength)`.
18. Let `k` be 0.
19. Repeat, while `k < elementLength`
   a. Let `Pk` be `ToString(k)`.
   b. Let `kValue` be the result of `Get(O, Pk)`.
   c. Let `kNumber` be `ToNumber(kValue)`.
   d. Perform `SetValueInBuffer(data, k × elementSize, elementType, kNumber)`.
   e. Increase `k` by 1.
20. Set `O`'s `[[ViewedArrayBuffer]]` to `data`.
21. Set `O`'s `[[TypedArrayElementKind]]` internal data property to `elementType`.
22. Set `O`'s `[[ByteLength]]` internal data property to `byteLength`.
23. Set `O`'s `[[ByteOffset]]` internal data property to 0.
24. Set `O`'s `[[ArrayLength]]` internal data property to `elementLength`.
25. Return `O`.

15.13.6.1.4 `TypedArray ( buffer, byteOffset=0, length=undefined )`

`TypedArray` called as function with arguments `buffer, byteOffset, and length` performs the following steps:

1. Assert: `Type(buffer)` is `Object` and `buffer` has a `[[ArrayBufferData]]` internal data property.
2. Let `O` be the this value.
3. If `Type(O)` is neither `Object` or `Undefined`, then throw a `TypeError` exception.
4. Let `elementType` be the string value of the `Element Type` value in Table 36 for this `TypedArray` constructor.
5. Let `elementSize` be the number value of the `Element Size` value in Table 36 for this `TypedArray` constructor.
6. Let `offset` be `ToInteger(byteOffset)`.
7. ReturnIfAbrupt(`offset`).
8. If `offset < 0`, then throw a `RangeError` exception.
9. If `offset modulo elementSize ≠ 0`, then throw a `RangeError` exception.
10. Let `bufferByteLength` be the value of `buffer`'s `[[ArrayBufferByteLength]]` internal data property.
11. If `offset + elementSize > bufferByteLength`, then throw a `RangeError` exception.
12. If `length` is `undefined`, then
    a. If `bufferByteLength` modulo `elementSize ≠ 0`, then throw a `RangeError` exception.
    b. Let `newByteLength` be `bufferByteLength – offset`.
13. Else,
    a. Let `newLength` be `ToInteger(length)`.
    b. Let `newLength` be `ToInteger(newLength)`.
    c. ReturnIfAbrupt(`newLength`).
    d. If `newLength ≠ newLength` or `newLength < 0`, then throw a `RangeError` exception.
    e. Let `newByteLength` be `newLength × elementSize`.
    f. If `offset + newByteLength > bufferByteLength`, then throw a `RangeError` exception.
14. If the value of `O`'s `[[ViewedArrayBuffer]]` internal data property is `undefined`, then throw a `TypeError` exception.
15. Set `O`'s `[[ViewedArrayBuffer]]` to `buffer`.
16. Set `O`'s `[[TypedArrayElementKind]]` internal data property to `elementType`.
17. Set `O`'s `[[ByteLength]]` internal data property to `newByteLength`.
18. Set `O`'s `[[ByteOffset]]` internal data property to `offset`.
19. Set `O`'s `[[ArrayLength]]` internal data property to `newByteLength / elementSize`.
20. Return `O`.

15.13.6.1.5 `TypedArray ( binary data stuff )`

15.13.6.2 The `TypedArray` Constructors

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

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The `TypedArray` constructor is designed to be subclassable. They may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intend to inherit the specified `TypedArray` behaviour must include a `super` call to the `TypedArray`.

15.13.6.2.1 `new` `TypedArray`(...`args`)

When a `TypedArray` function called as part of a new expression with argument lists `args` performs the following steps:

1. Let `F` be the `TypedArray` function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `TypedArray` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.13.6.3 Properties of the `TypedArray` Constructors

The value of the `[[Prototype]]` internal data property of each `TypedArray` constructor is the Function prototype object (15.3.3).

Besides a `length` property (whose value is 3), each `TypedArray` constructor has the following properties:

15.13.6.3.1 `TypedArray.prototype`

The initial value of `TypedArray.prototype` is the corresponding `TypedArray` prototype object (15.13.5.4).

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

15.13.6.3.2 `TypedArray.prototype[@@create]` ()

The `@@create` method of a `TypedArray` function object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `proto` be the result of `GetPrototypeFromConstructor(F, "%TypedArrayPrototype%")`.
3. ReturnIfAbrupt(`proto`).
4. Let `obj` be the result of calling `IntegerIndexedObjectCreate(proto)`.
5. Add a `[[ViewedArrayBuffer]]` internal data property to `obj` and set its initial value to `undefined`.
6. Add a `[[TypedArrayElementKind]]` internal data property to `obj` and set its initial value to `undefined`.
7. Add a `[[ByteLength]]` internal data property to `obj` and set its initial value to `0`.
8. Add a `[[ByteOffset]]` internal data property to `obj` and set its initial value to `0`.
9. Add a `[[ArrayLength]]` internal data property to `obj` and set its initial value to `0`.
10. Return `obj`.

This property has the attributes `{ [Writable]: false, [[Enumerable]]: false, [[Configurable]]: true }.

15.13.6.4 Properties of the `TypedArray` Prototype Object

The value of the `[[Prototype]]` internal data property of each `TypedArray` prototype object is the standard built-in `Object` prototype object (15.2.4). The `TypedArray` prototype objects are ordinary objects. They do not have a `[[ViewedArrayBuffer]]` or any other of the internal data properties that are specific to `TypedArray` instance objects.

15.13.6.4.1 `TypedArray.prototype.constructor`

The initial value of `TypedArray.prototype.constructor` is the standard built-in `TypedArray` constructor.
15.13.6.4.2 `TypedArray.prototypeBYTES_PER_ELEMENT`  

The value of `TypedArray.prototypeBYTES_PER_ELEMENT` is the number value of the `Element Size` value specified in Table 36 for `TypedArray`.  

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

15.13.6.4.3 `get` `TypedArray.prototype.buffer`  

`TypedArray.prototype.buffer` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(`O`).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Return `buffer`.

15.13.6.4.4 `get` `TypedArray.prototype.byteLength`  

`TypedArray.prototype.byteLength` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(`O`).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `size` be the value of `O`'s `[[ByteLength]]` internal data property.
7. Return `size`.

15.13.6.4.5 `get` `TypedArray.prototype.byteOffset`  

`TypedArray.prototype.byteOffset` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(`O`).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `offset` be the value of `O`'s `[[ByteOffset]]` internal data property.
7. Return `offset`.

15.13.6.4.6 `get` `TypedArray.prototype.length`  

`TypedArray.prototype.length` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(`O`).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
4. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `length` be the value of `O`'s `[[ArrayLength]]` internal data property.
7. Return `length`.
15.13.6.4.7 `TypedArray.prototype.set(array, offset = 0)`

Set multiple values in this `TypedArray`, reading the values from the object `array`. The optional offset value indicates the first element index in this `TypedArray` where values are written. If omitted, it is assumed to be 0.

1. Assert: `typedArray` does not have a `[[ViewedArrayBufferData]]` internal data property. If it does, the definition in 15.13.6.6.8 applies.
2. Let `target` be the result of calling `ToObject` with the `this` value as its argument.
3. ReturnIfAbrupt(`target`).
4. If `target` does not have a `[[ViewedArrayBufferData]]` internal data property throw a `TypeError` exception.
5. Let `targetBuffer` be the value of `target`'s `[[ViewedArrayBufferData]]` internal data property.
6. If `targetBuffer` is `undefined`, then throw a `TypeError` exception.
7. Let `targetLength` be the value of `target`'s `[[ArrayLength]]` internal data property.
8. Let `targetOffset` be `ToInteger` (offset).
9. ReturnIfAbrupt(`targetOffset`).
10. If `targetOffset` < 0, then throw a `RangeError` exception.
11. Let `targetType` be the value of `target`'s `[[TypedArrayElementKind]]` internal data property.
12. Let `targetElementSize` be the Number value of the Element Size value specified in Table 36 for `targetType`.
13. Let `targetByteOffset` be the value of `target`'s `[[ByteOffset]]` internal data property.
14. Let `src` be the result of calling `ToArray` (array).
15. ReturnIfAbrupt(`src`).
16. Let `srcLen` be the result of `Get` (src, "length").
17. Let `numberLength` be `ToNumber` (`srcLen`).
18. Let `srcLength` be `ToInteger` (`numberLength`).
19. ReturnIfAbrupt(`srcLength`).
20. If `numberLength` ≠ `srcLength` or `srcLength` < 0, then throw a `TypeError` exception.
21. If `srcLength` + `targetOffset` > `targetLength`, then throw a `RangeError` exception.
22. Let `targetByteIndex` be `targetOffset` × `targetElementSize` + `targetByteOffset`.
23. Let `k` be 0.
25. Repeat, while `targetByteIndex` < `limit`:
   a. Let `Pk` be `ToString`(k).
   b. Let `kValue` be the result of `Get` (src, `Pk`).
   c. Let `kNumber` be `ToNumber` (`kValue`).
   d. ReturnIfAbrupt(`kNumber`).
   e. Perform `SetValueInBuffer` (targetBuffer, `k` × `targetElementSize`, `targetType`, `kNumber`).
   f. Set `k` to `k` + 1.
   g. Set `targetByteIndex` to `targetByteIndex` + `targetElementSize`.

15.13.6.4.8 `TypedArray.prototype.set(typedArray, offset = 0)`

Set multiple values in this `TypedArray`, reading the values from the `typedArray` parameter object. The optional offset value indicates the first element index in this `TypedArray` where values are written. If omitted, it is assumed to be 0.

1. Assert: `typedArray` has a `[[ViewedArrayBufferData]]` internal data property. If it does not, the definition in 15.13.6.6.7 applies.
2. Let `target` be the result of calling `ToObject` with the `this` value as its argument.
3. ReturnIfAbrupt(`target`).
4. If `target` does not have a `[[ViewedArrayBufferData]]` internal data property throw a `TypeError` exception.
5. Let `targetBuffer` be the value of `target`'s `[[ViewedArrayBufferData]]` internal data property.
6. If `targetBuffer` is `undefined`, then throw a `TypeError` exception.
7. Let `targetLength` be the value of `target`'s `[[ArrayLength]]` internal data property.
8. Let `targetOffset` be `ToInteger` (offset).
9. ReturnIfAbrupt(`targetOffset`).
10. If `targetOffset` < 0, then throw a `RangeError` exception.
11. Let `targetType` be the value of `target`'s `[[TypedArrayElementKind]]` internal data property.
12. Let `targetElementSize` be the Number value of the Element Size value specified in Table 36 for `targetType`.
13. Let `targetByteOffset` be the value of `target`'s `[[ByteOffset]]` internal data property.
14. Let `srcBuffer` be the value of `typedArray`’s `[[ViewedArrayBuffer]]` internal data property.
15. If `srcBuffer` is `undefined`, then throw a `TypeError` exception.
16. Let `srcType` be the value of `typedArray`’s `[[TypedArrayElementKind]]` internal data property.
17. Let `srcElementSize` be the Number value of the `Element Size` value specified in Table 36 for `srcType`.
18. Let `srcLength` be the value of `typedArray`’s `[[ArrayLength]]` internal data property.
19. Let `srcByteOffset` be the value of `typedArray`’s `[[ByteOffset]]` internal data property.
20. If `srcLength + targetOffset > targetLength`, then throw a `RangeError` exception.
21. If `SameValue(srcBuffer, targetBuffer)` is true, then
   a. Let `srcBuffer` be the result of calling `ElemsArrayBuffer(srcBuffer, srcBuffer, srcType, srcType, srcLength)`.
22. Let `targetByteIndex` be `targetOffset × srcElementSize + targetByteOffset`.
23. Let `srcBytesIndex` be `srcByteOffset`.
24. Let `limit` be `targetByteIndex + srcElementSize × min(srcLength, targetLength - targetOffset)`.
25. Repeat, while `targetByteIndex ≤ limit`:
   a. Let `value` be the result of `GetValueFromBuffer` (`srcBuffer`, `srcBytesIndex`, `srcType`).
   b. Let `status` be the result of `SetValueInBuffer` (`targetBuffer`, `targetBytesIndex`, `targetType`, `value`).
   c. Set `targetBytesIndex` to `srcBytesIndex + srcElementSize`.

**15.13.6.4.9 `TypedArray.prototype.subarray(begin = 0, end = this.length)`**

Returns a new `TypedArray` object whose element types is the same as this `TypedArray` and whose `ArrayBuffer` is the same as the `ArrayBuffer` of this `TypedArray`, referencing the elements at `begin`, inclusive, up to `end`, exclusive. If either `begin` or `end` is negative, it refers to an index from the end of the array, as opposed to from the beginning.

1. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
2. ReturnIfAbrupt(O).
3. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property, throw a `TypeError` exception.
4. Let `buffer` be the value of `O`’s `[[ViewedArrayBuffer]]` internal data property.
5. If `buffer` is `undefined`, then throw a `TypeError` exception.
6. Let `srcLength` be the value of `O`’s `[[ArrayLength]]` internal data property.
7. Let `beginInt` be `ToInt32(begin)`.
8. ReturnIfAbrupt(beginInt).
9. If `beginInt < 0`, then let `beginInt` be `srcLength + beginInt`.
10. Let `endInt` be `mint(srcLength, max(0, beginInt))`.
11. If `end` is `undefined`, then let `end` be `srcLength`.
12. Let `endInt` be `ToInt32(end)`.
13. ReturnIfAbrupt(endInt).
14. If `endInt` < 0, then let `endInt` be `srcLength + endInt`.
15. Let `endIndex` be `max(0, min(srcLength, endInt))`.
16. If `endIndex < beginIndex`, then let `endIndex` be `beginIndex`.
17. Let `newLength` be `endIndex - beginIndex`.
18. Let `elementType` be the value of `O`’s `[[TypedArrayElementKind]]` internal data property.
19. Let `elementSize` be the Number value of the `Element Size` value specified in Table 36 for `elementType`.
20. Let `srcByteOffset` be the value of `O`’s `[[ByteOffset]]` internal data property.
21. Let `constructor` be the result of `GetO("constructor")`.
22. ReturnIfAbrupt(constructor).
23. If `IsConstructor(constructor)` is false, then throw a `TypeError` exception.
24. Let `argumentsList` be a `List` consisting of `buffer`, `beginByteOffset`, and `newLength`.
25. Return the result of calling the `[[Construct]]` internal method of `constructor` with `argumentsList` as the argument.

**15.13.6.4.10 `TypedArray.prototype[@@elementGet][index]`**

1. Assert: `Type(index)` is number and `index` is an integer.
2. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
3. ReturnIfAbrupt(O).
4. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property, throw a `TypeError` exception.
5. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
6. If `buffer` is `undefined`, then throw a `TypeError` exception.
7. Let `length` be the value of `O`'s `[[ArrayLength]]` internal data property.
8. If `index < 0` or `index ≥ length`, then return `undefined`.
9. Let `offset` be the value of `O`'s `[[ByteOffset]]` internal data property.
10. Let `elementSize` be the Number value of the Element Size value specified in Table 36 for `TypedArray`.
11. Let `indexedPosition = (index × elementSize) + offset`.
12. Let `elementType` be the value of `O`'s `[[TypedArrayElementKind]]` internal data property.
13. Return the result of `GetValueFromBuffer(buffer, indexedPosition, elementType)`.

`15.13.4.11` `TypedArray.prototype@@elementSet(index, value)`

1. Assert: `Type(index)` is number and `index` is an integer.
2. Let `O` be the result of calling `ToObject` with the `this` value as its argument.
3. ReturnIfAbrupt(`O`).
4. If `O` does not have a `[[ViewedArrayBuffer]]` internal data property throw a `TypeError` exception.
5. Let `buffer` be the value of `O`'s `[[ViewedArrayBuffer]]` internal data property.
6. If `buffer` is `undefined`, then throw a `TypeError` exception.
7. Let `length` be the value of `O`'s `[[ArrayLength]]` internal data property.
8. Let `numValue` be `ToNumber(value)`.
9. ReturnIfAbrupt(`numValue`).
10. If `index < 0` or `index ≥ length`, then return `numValue`.
11. Let `offset` be the value of `O`'s `[[ByteOffset]]` internal data property.
12. Let `elementSize` be the Number value of the Element Size value specified in Table 36 for `TypedArray`.
13. Let `indexedPosition = (index × elementSize) + offset`.
14. Let `elementType` be the value of `O`'s `[[TypedArrayElementKind]]` internal data property.
15. Let `status` be the result of `SetValueInBuffer(buffer, indexedPosition, elementType, numValue)`.
16. ReturnIfAbrupt(`status`).
17. Return `numValue`.

`15.13.4.12` `TypedArray.prototype[@@toStringTag]`

The initial value of the `@@toStringTag` property is the string value of the name `TypedArray`.

This property has the attributes (`[[Writable]]: false`, `[[Enumerable]]: false`, `[[Configurable]]: true`).

`15.13.5` Properties of `TypedArray` instances

`TypedArray` instances are exotic Index Delegation objects. Each `TypedArray` instance inherits properties from the corresponding `TypedArray` prototype object. After initialisation by a `TypedArray` constructor, `TypedArray` instances have the following internal data properties: `[[ViewedArrayBuffer]]`, `[[TypedArrayElementKind]]`, `[[ByteLength]]`, `[[ByteOffset]]`, and `[[ArrayLength]]`.

DataView Objects

The following sections define DataViews is derived from the Kronos specification. This material is a very early draft based upon the strawman at http://wiki.ecmascript.org/doku.php?id=strawman:typed_arrays. This material still needs significant work to fully integrate it into the ES6 spec. and also to integrate typed arrays with ES6 binary data.

Don't waste a lot of time reviewing this material until it is closer to a finished state.
15.13.7.1 The DataView Constructor Called as a Function

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

15.13.7.2 The DataView Constructor

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

15.13.7.2.1 new DataView(buffer [, byteOffset [, byteLength]])

The [[Prototype]] internal data property of the newly constructed object is set to the original DataView prototype object, the one that is the initial value of DataView.prototype (15.13.3.1). The [[Class]] internal data property of the newly constructed object is set to “DataView”. The [[Extensible]] internal data property of the newly constructed object is set to true.

The remaining properties are set as follows:

1. Let O be ToObject(buffer)
2. If the [[Class]] internal data property of O is not "ArrayBuffer", throw a TypeError exception.
3. Let byteOffset be the result of calling ToUint32 on byteOffset, if provided, or else 0.
4. Let bufferLength be the result of Get(O, "byteLength").
5. Let byteLength be the result of calling ToUint32 on byteLength, if provided, or else bufferLength – byteOffset.
6. If byteOffset + byteLength is greater than bufferLength, throw a RangeError exception.
7. The byteLength property of the newly constructed object is set to byteLength.
8. The buffer property of the newly constructed object is set to O.
9. The byteOffset property of the newly constructed object is set to byteOffset.

15.13.7.3 Properties of the DataView Constructor

The value of the [[Prototype]] internal data property of the DataView constructor is the Function prototype object (15.3.3).

Besides the internal properties and the length property (whose value is 3), the DataView constructor has the following properties:

15.13.7.3.1 DataView.prototype

The initial value of DataView.prototype is the DataView prototype object (15.13.3.4).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.13.7.4 Properties of the DataView Prototype Object

The value of the [[Prototype]] internal data property of the DataView prototype object is the standard built-in Object prototype object (15.2.4). The [[Class]] internal data property of the newly constructed object is set to “Object”. The [[Extensible]] internal data property of the newly constructed object is set to true.

The abstract operation GetValue(byteOffset, isLittleEndian, type) used by functions on DataView instances is defined as follows:

1. Let byteOffsetInt be ToUint32(byteOffset)
2. If the [[Class]] internal data property of O is not "ArrayBuffer", throw a TypeError exception.
3. Let byteLength be the result of calling ToUint32 on byteLength, if provided, or else 0.
4. If totalOffset ≥ byteLength, throw a RangeError exception.
5. Let value be the result of calling the GetValueFromBuffer abstract operation (2.5.2) with arguments this.buffer.[[NativeBuffer]], totalOffset, 0 and type.
6. **Return value**

The abstract operation `SetValue(byteOffset, isLittleEndian, type, value)` used by functions on DataView instances is defined as follows:

1. Let `byteOffsetInt` be `ToUInt32(byteOffset)`
2. Let `totalOffset` be `byteOffsetInt plus the result of Get(this, "byteOffset").`
3. Let `byteLength` be the result of `Get(this, "byteLength").`
4. If `totalOffset + byteLength` throw a `RangeError` exception.
5. Let value be the result of calling the `SetValueInBuffer` abstract operation (2.5.2) with arguments this.buffer.[[NativeBuffer]], `totalOffset`, 0, value and type.
6. **Return value**

### 15.13.7.4.1 DataView.prototype.constructor

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

### 15.13.7.4.2 DataView.prototype.getInt8(byteOffset)

Gets the Int8 value at offset `byteOffset` in the DataView.

1. Let `O` be `ToObject(this)`
2. If the `[[Class]]` internal data property of `O` is not “DataView”, throw a `TypeError` exception.
3. Return `GetValue(byteOffset, true, Int8)`

### 15.13.7.4.3 DataView.prototype.getUint8(byteOffset)

Gets the UInt8 value at offset `byteOffset` in the DataView.

1. Let `O` be `ToObject(this)`
2. If the `[[Class]]` internal data property of `O` is not “DataView”, throw a `TypeError` exception.
3. Return `GetValue(byteOffset, true, Uint8)`

### 15.13.7.4.4 DataView.prototype.getInt16(byteOffset, littleEndian)

Gets the Int16 value at offset `byteOffset` in the DataView, using the provided endianness.

1. Let `O` be `ToObject(this)`
2. Let `isLittleEndian` be `ToBoolean(littleEndian)` if provided, else `false`
3. If the `[[Class]]` internal data property of `O` is not “DataView”, throw a `TypeError` exception.
4. Return `GetValue(byteOffset, isLittleEndian, Int16)`

### 15.13.7.4.5 DataView.prototype.getUint16(byteOffset, littleEndian)

Gets the Uint16 value at offset `byteOffset` in the DataView, using the provided endianness.

1. Let `O` be `ToObject(this)`
2. Let `isLittleEndian` be `ToBoolean(littleEndian)` if provided, else `false`
3. If the `[[Class]]` internal data property of `O` is not “DataView”, throw a `TypeError` exception.
4. Return `GetValue(byteOffset, isLittleEndian, Uint16)`

### 15.13.7.4.6 DataView.prototype.getInt32(byteOffset, littleEndian)

Gets the Int32 value at offset `byteOffset` in the DataView, using the provided endianness.

1. Let `O` be `ToObject(this)`
2. Let `isLittleEndian` be `ToBoolean(littleEndian)` if provided, else `false`
3. If the `[[Class]]` internal data property of `O` is not “DataView”, throw a `TypeError` exception.
4. Return `GetValue(byteOffset, isLittleEndian, Int32)`

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15.13.7.4.7 DataView.prototype.getUint32(byteOffset, littleEndian)

Gets the Uint32 value at offset byteOffset in the DataView, using the provided endianness.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return GetValue(byteOffset, isLittleEndian, Uint32)

15.13.7.4.8 DataView.prototype.getFloat32(byteOffset, littleEndian)

Gets the Float32 value at offset byteOffset in the DataView, using the provided endianness.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return GetValue(byteOffset, isLittleEndian, Float32)

15.13.7.4.9 DataView.prototype.getFloat64(byteOffset, littleEndian)

Gets the Float64 value at offset byteOffset in the DataView, using the provided endianness.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return GetValue(byteOffset, isLittleEndian, Float64)

15.13.7.4.10 DataView.prototype.setInt8(byteOffset, value)

Sets the Int8 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
3. Return SetValue(byteOffset, true, Int8, ToInt8(value))

15.13.7.4.11 DataView.prototype.setUint8(byteOffset, value)

Sets the Uint8 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
3. Return SetValue(byteOffset, true, Uint8, ToUint8(value))

15.13.7.4.12 DataView.prototype.setInt16(byteOffset, value, littleEndian)

Sets the Int16 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return SetValue(byteOffset, isLittleEndian, Int16, ToInt16(value))

15.13.7.4.13 DataView.prototype.setUint16(byteOffset, value, littleEndian)

Sets the Uint16 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return SetValue(byteOffset, isLittleEndian, Uint16, ToUint16(value))

15.13.7.4.14 DataView.prototype.setInt32(byteOffset, value, littleEndian)
Sets the Int32 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return SetValue(byteOffset, isLittleEndian, Int32, ToInt32(value))

15.13.7.4.15 DataView.prototype.setUint32(byteOffset, value, littleEndian)
Sets the Uint32 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return GetValue(byteOffset, isLittleEndian, Uint32, ToUint32(value))

15.13.7.4.16 DataView.prototype.setFloat32(byteOffset, value, littleEndian)
Sets the Float32 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return SetValue(byteOffset, isLittleEndian, Float32, ToFloat32(value))

15.13.7.4.17 DataView.prototype.setUint16(byteOffset, value, littleEndian)
Sets the Float64 value at offset byteOffset in the DataView.
1. Let O be ToObject(this)
2. Let isLittleEndian be ToBoolean(littleEndian) if provided, else false
3. If the [[Class]] internal data property of O is not “DataView”, throw a TypeError exception.
4. Return SetValue(byteOffset, isLittleEndian, Float64, ToFloat64(value))

15.13.7.5 Properties of DataView Instances
DataView instances inherit properties from the DataView prototype object and their [[Class]] internal data property value is “DataView”. DataView instances also have the following properties.

15.13.7.5.1 byteLength
The value of the byteLength property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }

15.13.7.5.2 buffer
The value of the buffer property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }

15.13.7.5.3 byteOffset
The value of the byteOffset property is the length of the DataView object, which was fixed at creation. This property has attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }
15.14 Map Objects

Map objects are collections of key/value pairs where both the keys and values may be arbitrary ECMAScript language values. A distinct key value may only occur in one key/value pair within the Map's collection. Distinct key values as discriminated using the a comparison algorithm that is selected when the Map is created.

A Map object can iterate its elements in insertion order. Map object must be implemented using either hash tables or other mechanisms that, on average, provide access times that are sublinear on the number of elements in the collection. The data structures used in this Map objects specification is only intended to describe the required observable semantics of Map objects. It is not intended to be a viable implementation model.

15.14.1 The Map Constructor Called as a Function

When Map is called as a function rather than as a constructor, it initializes its this value with the internal state necessary to support the Map.prototype internal methods. The Map constructor is designed to be subclassable. It may be used as the value in an extends clause of a class definition. Subclass constructors that intend to inherit the specified Map behaviour must include a super call to Map.

15.14.1.1 Map (iterable = undefined , comparator = undefined )

When the Map function is called with optional arguments iterable and comparator the following steps are taken:

1. Let map be the this value.
2. If Type(map) is not Object then, throw a TypeError exception.
3. If map does not have a [[MapData]] internal data property, then throw a TypeError exception.
4. If map's [[MapData]] internal data property is not undefined, then throw a TypeError exception.
5. If iterable is not present, let iterable be undefined.
6. If iterable is either undefined or null, then let iter be undefined.
7. Else,
   a. Let hasValues be the result of HasProperty(iterable, "entries").
   b. ReturnIfAbrupt(hasValues).
   c. If hasValues is true, then
      i. Let it be the result of Invoke(iterable, "entries").
   d. Else,
      i. Let iterator be the well-known symbol @@iterator.
      ii. Let iter be the result of Invoke(iterable, iterator).
   e. ReturnIfAbrupt(iter).
   f. ReturnIfAbrupt(iter).
   g. Let adder be the result of Get(map, "set").
   h. ReturnIfAbrupt(adder).
   i. If IsCallable(adder) is false, throw a TypeError Exception.
8. If comparator is not undefined, then
   a. If comparator is not "has", then throw a RangeError Exception.
9. Set map's [[MapData]] internal data property to a new empty List.
10. Set map's [[MapComparator]] internal data property to comparator.
11. If iter is undefined, then return map.
12. Repeat
   a. Let next be the result of Invoke(iter, "next").
   b. ReturnIfAbrupt(next).
   c. If Type(next) is not Object, then throw a TypeError exception.
   d. Let done be IteratorComplete(next).
   e. ReturnIfAbrupt(done).
   f. If done is true, then return NormalCompletion(map).
   g. Let nextItem be IteratorValue(next).
   h. ReturnIfAbrupt(nextItem).
   i. Let k be the result of Get(nextItem, "0").
   j. ReturnIfAbrupt(k).
   k. Let v be the result of Get(nextItem, "1").
1. ReturnIfAbrupt(v).
2. Let status be the result of calling the [[Call]] internal method of `adder` with `map as thisArgument` and a List whose elements are `k` and `v as argumentsList`.
3. ReturnIfAbrupt(status).

**NOTE**
If the parameter `iterable` is present, it is expected to be an object that implements an `@@iterator` method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as an `Map` key and whose second element is the value to associate with that key.

15.14.2 The Map Constructor

When `Map` is called as part of a `new` expression it is a constructor: it initialises a newly created object.

The `Map` constructor is designed to be subclassable. It may be used as the value of an `extends` clause of a class declaration. Subclass constructors that intended to inherit the specified `Map` behaviour must include a `super` call to `Map`.

15.14.2.1 new Map ( ... args )

`Map` called as part of a new expression with argument list `args` performs the following steps:

1. Let `F` be the Map function object on which the `new` operator was applied.
2. Let `argumentsList` be the `argumentsList` argument of the `[[Construct]]` internal method that was invoked by the `new` operator.
3. Return the result of `OrdinaryConstruct(F, argumentsList)`.

If `Map` is implemented as an ordinary function object, its `[[Construct]]` internal method will perform the above steps.

15.14.3 Properties of the Map Constructor

The value of the `[[Prototype]]` internal data property of the Map constructor is the Function prototype object (15.3.3).

Besides the `length` property (whose value is 0), the Map constructor has the following property:

15.14.3.1 Map.prototype

The initial value of `Map.prototype` is the Map prototype object (15.14.4).

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

15.14.3.2 Map[ @@create ] ()

The `@@create` method of a Map function object `F` performs the following steps:

1. Let `F` be the this value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%MapPrototype%", ( [[MapData]], [[MapComparator]] ) )`.
3. Return `obj`.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

15.14.4 Properties of the Map Prototype Object

The value of the `[[Prototype]]` internal data property of the Map prototype object is the standard built-in `Object` prototype object (15.2.4). The Map prototype object is an ordinary object. It does not have a `[[MapData]]` or a `[[MapComparator]]` internal data property.

Commented [AWB12227]: Note that using a method call for inserting pairs during initialization provides allows subclasses to be more expressive.
15.14.1 Map.prototype.constructor

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

15.14.2 Map.prototype.clear()

The following steps are taken:
1. Let `M` be the `this` value.
2. If `Type(M)` is not `Object`, then throw a `TypeError` exception.
3. If `M` does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If `M`'s `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let `entries` be the List that is the value of `M`'s `[[MapData]]` internal data property.
6. Repeat for each Record `{{[key]}, [[value]]} p` that is an element of `entries`,
   a. Set `p.[[key]]` to `empty`.
   b. Set `p.[[value]]` to `empty`.
7. Return `undefined`.

15.14.3 Map.prototype.delete(key)

The following steps are taken:
1. Let `M` be the `this` value.
2. If `Type(M)` is not `Object`, then throw a `TypeError` exception.
3. If `M` does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If `M`'s `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. If `M`'s `[[MapComparator]]` internal data property is `undefined`, then let `same` be the abstract operation `SameValueZero`.
6. Else, let `same` be the abstract operation `SameValue`.
7. Let `entries` be the List that is the value of `M`'s `[[MapData]]` internal data property.
8. Repeat for each Record `{{[key]}, [[value]]} p` that is an element of `entries`,
   a. If `same(p.[[key]], key)`, then
      i. Set `p.[[key]]` to `empty`
      ii. Set `p.[[value]]` to `empty`
      iii. Return `true`.
9. Return `false`.

15.14.4 Map.prototype.forEach(callbackfn, thisArg = undefined)

`callbackfn` should be a function that accepts three arguments. `forEach` calls `callbackfn` once for each key-value pair present in the map object, in key insertion order. `callbackfn` is called only for keys of the map which actually exist; it is not called for keys that have been deleted from the map.

If a `thisArg` parameter is provided, it will be used as the `this` value for each invocation of `callbackfn`. If it is not provided, `undefined` is used instead.

NOTE: If `callbackfn` is an Arrow Function, this was lexically bound when the function was created so `thisArg` will have no effect.

`callbackfn` is called with three arguments: the value of the item, the key of the item, and the Map object being traversed.

`forEach` does not directly mutate the object on which it is called but the object may be mutated by the calls to `callbackfn`.

NOTE: Each key is visited only once with the value that is current at the time of the visit. If the value associated with a key is modified after it has been visited, it is not re-visited. Keys that are deleted after the call to `forEach` begins and before being visited are not visited. New keys added, after the call to `forEach` begins are visited.
When the `forEach` method is called with one or two arguments, the following steps are taken:

1. Let `M` be the this value.
2. If `Type(M)` is not Object, then throw a `TypeError` exception.
3. If `M` does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If `M`'s `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. If `IsCallable(callbackFn)` is false, throw a `TypeError` exception.
6. If `thisArg` was supplied, let `T` be `thisArg`; else let `T` be `undefined`.
7. Let `entries` be the List that is the value of `M`'s `[[MapData]]` internal data property.
8. Repeat for each Record `{[[key]], [[value]]} e` that is an element of `entries`, in original key insertion order
   a. If `e.[[key]]` is not empty, then
      i. Let `funcResult` be the result of calling the `[[Call]]` internal method of `callbackFn` with `T` as `thisArgument` and a List containing `e.[[value]], e.[[key]],` and `M` as `argumentsList`.
      ii. ReturnIfAbrupt(`funcResult`).
9. Return `undefined`.

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

15.14.4.5 `Map.prototype.get (key)`

The following steps are taken:

1. Let `M` be the this value.
2. If `Type(M)` is not Object, then throw a `TypeError` exception.
3. If `M` does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If `M`'s `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. Let `entries` be the List that is the value of `M`'s `[[MapData]]` internal data property.
6. If `M`'s `[[MapComparator]]` internal data property is `undefined`, then let `same` be the abstract operation `SameValueZero`.
7. Else, let `same` be the abstract operation `SameValue`.
8. Repeat for each Record `{[[key]], [[value]]} p` that is an element of `entries`,
   a. If `same(p.[[key]], key)`, then return `p.[[value]]`
9. Return `undefined`.

15.14.4.6 `Map.prototype.has (key)`

The following steps are taken:

1. Let `M` be the this value.
2. If `Type(M)` is not Object, then throw a `TypeError` exception.
3. If `M` does not have a `[[MapData]]` internal data property throw a `TypeError` exception.
4. If `M`'s `[[MapData]]` internal data property is `undefined`, then throw a `TypeError` exception.
5. If `M`'s `[[MapComparator]]` internal data property is `undefined`, then let `same` be the abstract operation `SameValueZero`.
6. Else, let `same` be the abstract operation `SameValue`.
8. Repeat for each Record `{[[key]], [[value]]} p` that is an element of `entries`,
   a. If `same(p.[[key]], key)`, then return true
9. Return false.

15.14.4.7 `Map.prototype.entries ()`

The following steps are taken:

1. Let `M` be the this value.
2. If `Type(M)` is not Object, then throw a `TypeError` exception.
3. Return the result of calling the `CreateMapIterator` abstract operation with arguments `M` and "key+value".
15.14.4.8 Map.prototype.keys ()

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. Return the result of calling the CreateMapIterator abstract operation with arguments M and "key".

15.14.4.9 Map.prototype.set (key, value)

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[MapData]] internal data property throw a TypeError exception.
4. If M's [[MapData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of M's [[MapData]] internal data property.
6. If M's [[MapComparator]] internal data property is undefined, then let same be the abstract operation SameValueZero.
7. Else, let same be the abstract operation SameValue.
8. Repeat for each Record {
5.\[key\], \[value\]} p that is an element of entries
   a. If same(p.\[key\], key), then
      i. Set p.\[value\] to value.
      ii. Return M.
9. Let p be the Record {
   5.\[key\]: key, \[value\]: value
10. Append p as the last element of entries.
11. Return M.

15.14.4.10 get Map.prototype.size

Map.prototype.size is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[MapData]] internal data property throw a TypeError exception.
4. If M's [[MapData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of M's [[MapData]] internal data property.
6. Let count be 0.
7. For each Record {
      5.\[key\], \[value\]} p that is an element of entries
       a. If p.\[key\] is not empty then
          i. Set count to count+1.
8. Return count.

15.14.4.11 Map.prototype.values ()

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. Return the result of calling the CreateMapIterator abstract operation with arguments M and "value".

15.14.4.12 Map.prototype[@@iterator]

The initial value of the @@iterator property is the same function object as the initial value of the entries property.

Commented [AWB10229]: This is how we identify a property whose key is a built-in Symbol.

Commented [AWB10230]: Do we really want to do this sort of method sharing. It has a bad smell.
15.14.4.13 Map.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value “Map”.

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

15.14.5 Properties of Map Instances

Map instances inherit properties from the Map prototype. After initialisation by the Map constructor, Map instances also have a [[MapData]] internal data property and a [[MapComparator]] internal data property.

15.14.6 Map Iterator Object Structure

A Map Iterator is an object, with the structure defined below, that represent a specific iteration over some specific Map instance object. There is not a named constructor for Map Iterator objects. Instead, map iterator objects are created by calling certain methods of Map instance objects.

15.14.6.1 CreateMapIterator Abstract Operation

Several methods of Map objects return iterator objects. The abstract operation CreateMapIterator with arguments map and kind is used to create and such iterator objects. It performs the following steps:

1. Let M be the result of calling ToObject(map).
2. ReturnIfAbrupt(M).
3. If M does not have a [[MapData]] internal data property throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[MapData]] internal data property.
5. Let itr be the result of ObjectCreate(%MapIteratorPrototype%.
   ([[Map]], [[MapNextIndex]],
   [[MapIterationKind]])).
6. Set itr’s [[Map]] internal data property to M.
7. Set itr’s [[MapNextIndex]] internal data property to 0.
8. Set itr’s [[MapIterationKind]] internal data property to kind.
9. Return itr.

15.14.6.2 The Map Iterator Prototype

All Map Iterator Objects inherit properties from a common Map Iterator Prototype object. The [[Prototype]] internal data property of the Map Iterator Prototype is the %ObjectPrototype% intrinsic object. In addition, the Map Iterator Prototype as the following properties:

15.14.6.2.1 MapIterator.prototype.constructor

15.14.6.2.2 MapIterator.prototype.next( )

1. Let O be the this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If O does not have all of the internal properties of a Map Iterator Instance (15.14.7.1.2), throw a TypeError exception.
4. Let m be the value of the [[Map]] internal data property of O.
5. Let index be the value of the [[MapNextIndex]] internal data property of O.
6. Let itemKind be the value of the [[MapIterationKind]] internal data property of O.
7. Assert: m has a [[MapData]] internal data property and m has been initialized so the value of [[MapData]] is not undefined.
8. Let entries be the List that is the value of the [[MapData]] internal data property of m.
9. Repeat while index is less than the total number of element of entries. The number of elements must be redetermined each time this method is evaluated.
   a. Let e be the Record { [[key]], [[value]] } at 0-originated insertion position index of entries.
   b. Set index to index+1;
   c. Set the [[MapNextIndex]] internal data property of O to index.
   d. If e.[[key]] is not empty, then...
i. If `itemKind` is "key" then, let `result` be `e.[[key]].
ii. Else if `itemKind` is "value" then, let `result` be `e.[[value]].
iii. Else,
   1. Assert: `itemKind` is "key+value".
   2. Let `result` be the result of the abstract operation `ArrayCreate` with argument 2.
   3. Assert: `result` is a new, well-formed Array object so the following operations will never fail.
   4. Call `CreateOwnProperty`(`result", "0", e.[[key]])
   5. Call `CreateOwnProperty`(`result", "1", e.[[value]])
iv. Return `CreateItrResultObject`(`result", false)
10. Return `CreateItrResultObject`(`undefined", true)

15.14.6.2.3 `MapIterator.prototype @@iterator ( )`
The following steps are taken:
1. Return the this value.

15.14.6.2.4 `MapIterator.prototype @@toStringTag`
The initial value of the `@@toStringTag` property is the string value "Map Iterator".

15.14.6.3 Properties of Map Iterator Instances
Map iterator instances inherit properties from the Map iterator prototype (the intrinsic, `%MapIteratorPrototype%`) Map iterator instances are initially created with the internal properties described in Table 37.

Table 37 — Internal Data Properties of Map Iterator Instances

<table>
<thead>
<tr>
<th>Internal Data Property Name</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 iteration.</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>

15.15 WeakMap Objects
WeakMap objects are collections of key/value pairs where the keys are ECMA-Script objects and values may be arbitrary ECMA-Script language values. A WeakMap may be queried to see if it contains a key/value pair with a specific key, but no mechanisms is provided for enumerating the objects it holds as keys. If an object that is being used as the key of a WeakMap key/value pair is only reachable by following a chain of references that start within that WeakMap, then that key/value pair is inaccessible and is automatically removed from the WeakMap. WeakMap implementations must detect and remove such key/value pairs and any associated resources.

An implementation may impose an arbitrarily determined latency between the time a key/value pair of a WeakMap becomes inaccessible and the time when the key/value pair is removed from the WeakMap. If this latency was observable to ECMA-Script program, it would be a source of indeterminacy that could impact program execution. For that reason, an ECMA-Script 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 structures used in this WeakMap objects specification are only intended to describe the required observable semantics of WeakMap objects. It is not intended to be a viable implementation model.

NOTE

WeakMap are intended to provide a mechanism for dynamically associating state with an object in a manner that does not “leak” memory resources if, in the absence of the WeakMap, the object otherwise became inaccessible and subject to resource reclamation by the implementation’s garbage collection mechanisms. Achieving this characteristic requires coordination between the WeakMap implementation and the garbage collector. The following references describe mechanism that may be useful to implementations of WeakMap:


15.15.1 The WeakMap Constructor Called as a Function

When WeakMap is called as a function rather than as a constructor, it initializes its this value with the internal state necessary to support the WeakMap.prototype methods. The WeakMap constructor is designed to be subclassable. It may be used as the value in an extends clause of a class definition. Subclass constructors that intend to inherit the specified WeakMap behaviour must include a super call to WeakMap.

15.15.1.1 WeakMap (iterable = undefined )

When the WeakMap function is called with optional argument iterable the following steps are taken:

1. Let map be the this value.
2. If Type(map) is not Object then, throw a TypeError exception.
3. If map does not have a [[WeakMapData]] internal data property, then throw a TypeError exception.
4. If map’s [[WeakMapData]] internal data property is not undefined, then throw a TypeError exception.
5. If iterable is not present, let iterable be undefined.
6. If iterable is either undefined or null, then let itr be undefined.
7. Else,
   a. Let iterator be the well-known symbol @@iterator.
   b. Let k be the result of Get(iterable, iterator).
   c. ReturnIfAbrupt(k).
   d. Let adder be the result of Get(map, “set”).
   e. ReturnIfAbrupt(adder).
   f. If IsCallable(adder) is false, throw a TypeError Exception.
   g. Set map’s [[WeakMapData]] internal data property to a new empty List.
   h. If itr is undefined, then return map.
   i. Repeat
      a. Let next be the result of Invoke(itr, “next”).
      b. ReturnIfAbrupt(next).
      c. If Type(next) is not Object, then throw a TypeError exception.
      d. Let done be IteratorComplete(next).
      e. ReturnIfAbrupt(done).
      f. If done is true, then return NormalCompletion(map).
      g. Let nextValue be IteratorValue(next).
      h. ReturnIfAbrupt(nextValue).
      i. Let k be the result of Get(nextValue, “0”).
      j. ReturnIfAbrupt(k).
      k. Let v be the result of Get(nextValue, “1”).
      l. ReturnIfAbrupt(v).
      m. Let status be the result of calling the [[Call]] internal method of adder with map as thisArgument and a List whose elements are k and v as argumentsList.
      n. ReturnIfAbrupt(status).

Commented [AWB12232]: Note that using a method call for inserting pairs during initialization provides allows subclasses to be more expressive.
NOTE If the parameter *iterable* is present, it is expected to be an object that implements an \@\@iterator method that returns an iterator object that produces two element array-like objects whose first element is a value that will be used as a WeakMap key and whose second element is the value to associate with that key.

15.15.2 The WeakMap Constructor

When *WeakMap* is called as part of a *new* expression it is a constructor: it initialises a newly created object.

15.15.2.1 *new* WeakMap ( ... *args*)

*WeakMap* called as part of a new expression with argument list *args* performs the following steps:

1. Let *F* be the *WeakMap* function object on which the *new* operator was applied.
2. Let *argumentsList* be the *argumentsList* argument of the [[Construct]] internal method that was invoked by the *new* operator.
3. Return the result of OrdinaryConstruct(*F*, *argumentsList*).

If *WeakMap* is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.15.3 Properties of the WeakMap Constructor

The value of the [[Prototype]] internal data property of the *WeakMap* constructor is the Function prototype object (15.3.3).

Besides the *length* property (whose value is 0), the *WeakMap* constructor has the following property:

15.15.3.1 *WeakMap.prototype*

The initial value of *WeakMap.prototype* is the *WeakMap* prototype object (15.15.4).

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

15.15.3.2 *WeakMap.[@@create] ()*

The \@create method of a *WeakMap* object *F* performs the following steps:

1. Let *F* be the this value.
2. Let *obj* be the result of calling OrdinaryCreateFromConstructor(*F*, "%WeakMapPrototype%", \{
   [[WeakMapData]]
\}).
3. Return *obj*.

This property has the attributes { [[Writable]]: *false*, [[Enumerable]]: *false*, [[Configurable]]: *true* }.

15.15.4 Properties of the WeakMap Prototype Object

The value of the [[Prototype]] internal data property of the *WeakMap* prototype object is the standard built-in Object prototype object (15.2.4). The *WeakMap* prototype object is an ordinary object. It does not have a [[WeakMapData]] internal data property.

15.15.4.1 *WeakMap.prototype.constructor*

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

15.15.4.2 *WeakMap.prototype.clear ()*

The following steps are taken:

1. Let *M* be the this value.

Commented [AWB14233]: Because the \@create method is essential to the integrity of this “class” definition, just like the prototype property, it seems appropriate to freeze it in the same manner.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal data property throw a TypeError exception.
4. If M’s [[WeakMapData]] internal data property is undefined, then throw a TypeError exception.
5. Set the value of M’s [[WeakMapData]] internal data property to a new empty List.
6. Return undefined.

15.15.4.3 WeakMap.prototype.delete ( key )

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal data property throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[WeakMapData]] internal data property.
5. If entries is undefined, then throw a TypeError exception.
6. If Type(key) is not Object, then throw a TypeError exception.
7. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] and key are the same object, then
      i. Set p.[[key]] to empty.
      ii. Set p.[[value]] to empty.
      iii. Return true.
8. Return false.

15.15.4.4 WeakMap.prototype.get ( key )

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal data property throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[WeakMapData]] internal data property.
5. If entries is undefined, then throw a TypeError exception.
6. If Type(key) is not Object, then throw a TypeError exception.
7. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] and key are the same object, then return p.[[value]]
8. Return undefined.

15.15.4.5 WeakMap.prototype.has ( key )

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal data property throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[WeakMapData]] internal data property.
5. If entries is undefined, then throw a TypeError exception.
6. If Type(key) is not Object, then throw a TypeError exception.
7. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] and key are the same object, then return true.
8. Return false.

15.15.4.6 WeakMap.prototype.set ( key , value )

The following steps are taken:
1. Let M be the this value.
2. If Type(M) is not Object, then throw a TypeError exception.
3. If M does not have a [[WeakMapData]] internal data property throw a TypeError exception.
4. Let entries be the List that is the value of M’s [[WeakMapData]] internal data property.
5. If entries is undefined, then throw a TypeError exception.
6. If Type(key) is not Object, then throw a TypeError exception.
7. Repeat for each Record {[[key]], [[value]]} p that is an element of entries,
   a. If p.[[key]] and key are the same object, then
      i. Set p.[[value]] to value.
      ii. Return M.
8. Let p be the Record {[[key]], [[value]]: value}
9. Append p as the last element of entries.
10. Return M.

15.15.4.7 WeakMap.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value "WeakMap".

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

15.15 Properties of WeakMap Instances

WeakMap instances are ordinary objects that inherit properties from the WeakMap prototype. WeakMap instances also have a [[WeakMapData]] internal data property.

15.16 Set Objects

Set objects are collections of ECMAScript language values. A distinct value may only occur once as an element of a Set's collection. Distinct values are discriminated using a comparison algorithm that is selected when the Set is created.

A Set object can iterate its elements in insertion order. Set objects must be implemented using either hash tables or other mechanisms that, on average, provide access times that are sublinear on the number of elements in the collection. The data structures used in this Set objects specification is only intended to describe the required observable semantics of Set objects. It is not intended to be a viable implementation model.

15.16.1 The Set Constructor Called as a Function

When Set is called as a function rather than as a constructor, it initializes its this value with the internal state necessary to support the Set.prototype internal methods. The Set constructor is designed to be subclassable. The [[Construct]] internal method of the constructor may be used as the value in an extends clause of a class definition. Subclass constructors that intend to inherit the specified Set behaviour must include a super call to Set.

15.16.1.1 Set (iterable = undefined, comparator = undefined )

When the Set function is called with optional arguments iterable and comparator the following steps are taken:

1. Let set be the this value.
2. If Type(set) is not Object then, throw a TypeError exception.
3. If set does not have a [[SetData]] internal data property, then throw a TypeError exception.
4. If set's [[SetData]] internal data property is not undefined, then throw a TypeError exception.
5. If iterable is not present, let iterable be undefined.
6. If iterable is null, then let itr be undefined.
7. Else,
   a. Let iterator be the well-known symbol @@iterator.
   b. Let itr be the result of Invoke(iterable, iterator).
   c. ReturnIfAbrupt(itr).
   d. Let adder be the result of Get(set, "add").
   e. ReturnIfAbrupt(adder).
   f. If IsCallable(adder) is false, throw a TypeError Exception.
8. If comparator is not present, let comparator be undefined.
9. If comparator is not undefined, then
   a. If comparator is not "is", then throw a RangeError Exception.
10. Set set’s [[SetData]] internal data property to a new empty List.
11. Set set’s [[SetComparator]] internal data property to comparator.
12. If itr is undefined, then return set.
13. Repeat
   a. Let next be the result of Invoke(itr, "next").
   b. ReturnIfAbrupt(next).
   c. If Type(next) is not Object, then throw a TypeError exception.
   d. Let done be IteratorComplete(next).
   e. ReturnIfAbrupt(done).
   f. If done is true, then return NormalCompletion(set).
   g. Let nextValue be IteratorValue(next).
   h. ReturnIfAbrupt(nextValue).
   i. Let status be the result of calling the [[Call]] internal method of adder with set as thisArgument and a List whose sole element is nextValue as argumentsList.
   j. ReturnIfAbrupt(status).
15.16.2 The Set Constructor
When Set is called as part of a new expression it is a constructor: it initialises a newly created object.

15.16.2.1 new Set ( ... args)
Set called as part of a new expression with argument list args performs the following steps:
1. Let F be the Set function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct(F, argumentsList).
If Set is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.16.3 Properties of the Set Constructor
The value of the [[Prototype]] internal data property of the Set constructor is the Function prototype object (15.3.3).
Besides the length property (whose value is 0), the Set constructor has the following property:

15.16.3.1 Set.prototype
The initial value of Set.prototype is the intrinsic %SetPrototype% object (15.16.4). This property has the attributes [ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false ].

15.16.3.2 Set @@create()
The @@create method of a Set function object F performs the following steps:
1. Let F be the this value.
2. Let obj be the result of calling OrdinaryCreateFromConstructor(F, "%SetPrototype", ( [[SetData]], [[SetComparator]] )).
3. Return obj.
This property has the attributes [ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true ].

Commented [AWB12235]: Note that using a method call for inserting pairs during initialization allows subclasses to be more expressive.

Commented [AWB14236]: Because the @@create method is essential to the integrity of this "class" definition, just like the prototype property, it seems appropriate to freeze it in the same manner.
15.16.4 Properties of the Set Prototype Object

The value of the [[Prototype]] internal data property of the Set prototype object is the standard built-in Object prototype object (15.2.4). The set prototype object is an ordinary object. It does not have a [[SetData]] or a [[SetComparator]] internal data property.

15.16.4.1 Set.prototype.constructor

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

15.16.4.2 Set.prototype.add (value)

The following steps are taken:

1. Let S be the this value.
2. If Type(S) is not Object, then throw a TypeError exception.
3. If S does not have a [[SetData]] internal data property throw a TypeError exception.
4. If S’s [[SetData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of S’s [[SetData]] internal data property.
6. If S’s [[SetComparator]] internal data property is undefined, then let same be the abstract operation SameValueZero.
7. Else, let same be the abstract operation SameValue.
8. Repeat for each e that is an element of entries, in original insertion order
   a. If e is not empty and same(e, value) is true, then
      i. Return S.
9. Append value as the last element of entries.
10. Return S.

15.16.4.3 Set.prototype.clear ()

The following steps are taken:

1. Let S be the this value.
2. If Type(S) is not Object, then throw a TypeError exception.
3. If S does not have a [[SetData]] internal data property throw a TypeError exception.
4. If S’s [[SetData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of S’s [[SetData]] internal data property.
6. Repeat for each e that is an element of entries,
   1. Replace the element of entries whose value is e with an element whose value is empty.
7. Return undefined.

15.16.4.4 Set.prototype.delete (value)

The following steps are taken:

1. Let S be the this value.
2. If Type(S) is not Object, then throw a TypeError exception.
3. If S does not have a [[SetData]] internal data property throw a TypeError exception.
4. If S’s [[SetData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of S’s [[SetData]] internal data property.
6. If S’s [[SetComparator]] internal data property is undefined, then let same be the abstract operation SameValueZero.
7. Else, let same be the abstract operation SameValue.
8. Repeat for each e that is an element of entries, in original insertion order
   a. If e is not empty and same(e, value) is true, then
      i. Replace the element of entries whose value is e with an element whose value is empty.
      ii. Return true.
9. Return false.
15.16.4.5 Set.prototype.entries ( )

The following steps are taken:

1. Let S be the this value.
2. If Type(S) is not Object, then throw a TypeError exception.
3. Return the result of calling the CreateSetIterator abstract operation with arguments S and "key+value".

NOTE For iteration purposes, a Set appears similar to a Map where each entry has the same value for its key and value.

15.16.4.6 Set.prototype.forEach ( callbackfn , thisArg = undefined )

callbackfn should be a function that accepts three arguments. forEach calls callbackfn once for each value present in the set object, in value insertion order. callbackfn is called only for values of the Set which actually exist; it is not called for keys that have been deleted from the set.

If a thisArg parameter is provided, it will be used as the this value for each invocation of callbackfn. If it is not provided, undefined is used instead.

NOTE 1 If callbackfn is an Arrow Function, this was lexically bound when the function was created so thisArg will have no effect.

callbackfn is called with three arguments: the first two arguments are a value contained in the Set. The same value of passed for both arguments. The Set object being traversed is passed as the third argument.

NOTE 2 The callbackfn is called with three arguments to be consistent with the callback functions used by forEach methods for Map and Array. For Sets, each item value is considered to be both the key and the value.

forEach does not directly mutate the object on which it is called but the object may be mutated by the calls to callbackfn.

NOTE 3 Each value is normally visited only once. However, a value will be revisited if it is deleted after it has been visited and then re-added before the to forEach call completes. Values that are deleted after the call to forEach begins and before being visited are not visited unless the value is added again before the to forEach call completes. New values added, after the call to forEach begins are visited.

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, then throw a TypeError exception.
3. If S does not have a [[SetData]] internal data property throw a TypeError exception.
4. If S’s [[SetData]] internal data property is undefined, then throw a TypeError exception.
5. If IsCallable(callbackfn) is false, throw a TypeError exception.
6. If thisArg was supplied, let T be thisArg; else let T be undefined.
7. Let entries be the List that is the value of S’s [[SetData]] internal data property.
8. Repeat for each e that is an element of entries, in original insertion order
   a. If e is not empty, then
      i. Let funcResult be the result of calling the [[Call]] internal method of callbackfn with T as thisArgument and a List containing e, e, and S as argumentsList.
      ii. ReturnIfAbrupt(funcResult).
9. Return undefined.

The length property of the forEach method is 1.

15.16.4.7 Set.prototype.has ( value )

The following steps are taken:

1. Let S be the this value.
2. If $\text{Type}(S)$ is not Object, then throw a $\text{TypeError}$ exception.
3. If $S$ does not have a [[setData]] internal data property, then throw a $\text{TypeError}$ exception.
4. If $S$'s [[setData]] internal data property is $\text{undefined}$, then throw a $\text{TypeError}$ exception.
5. Let $\text{entries}$ be the List that is the value of $S$'s [[setData]] internal data property.
6. If $S$'s [[setComparator]] internal data property is $\text{undefined}$, then let $\text{same}$ be the abstract operation $\text{SameValueZero}$.
7. Else, let $\text{same}$ be the abstract operation $\text{SameValue}$.
8. Repeat for each $e$ that is an element of $\text{entries}$:
   a. If $e$ is empty and $\text{same}(e, value)$, then return $\text{true}$.
9. Return $\text{false}$.

15.16.4.8 Set.prototype.keys ()

The initial value of the keys property is the same function object as the initial value of the values property.

**NOTE**
For iteration purposes, a Set appears similar to a Map where each entry has the same value for its key and value.

15.16.4.9 get Set.prototype.size

Set.prototype.size is an accessor property whose set accessor function is $\text{undefined}$. Its get accessor function performs the following steps:

1. Let $S$ be the this value.
2. If $\text{Type}(S)$ is not Object, then throw a $\text{TypeError}$ exception.
3. If $S$ does not have a [[setData]] internal data property, then throw a $\text{TypeError}$ exception.
4. If $S$'s [[setData]] internal data property is $\text{undefined}$, then throw a $\text{TypeError}$ exception.
5. Let $\text{entries}$ be the List that is the value of $S$'s [[setData]] internal data property.
6. Let $\text{count}$ be 0.
7. For each $e$ that is an element of $\text{entries}$:
   a. If $e$ is not empty then
      i. Set $\text{count}$ to $\text{count} + 1$.
8. Return $\text{count}$.

15.16.4.10 Set.prototype.values ()

The following steps are taken:

1. Let $S$ be the this value.
2. If $\text{Type}(S)$ is not Object, then throw a $\text{TypeError}$ exception.
3. Return the result of calling the CreateDataProperty abstract operation with argument $S$ and "value".

15.16.4.11 Set.prototype[@@iterator] ()

The initial value of the @@iterator property is the same function object as the initial value of the values property.

15.16.4.12 Set.prototype[@@toStringTag]

The initial value of the @@toStringTag property is the string value "Set".

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

15.16.5 Properties of Set Instances

Set instances inherit properties from the Set prototype. After initialisation by the Set constructor, Set instances also have a [[setData]] internal data property and a [[setComparator]] internal data property.
15.16.6 Set Iterator Object Structure

A Set Iterator is an ordinary object, with the structure defined below, that represents a specific iteration over some specific Set instance object. There is not a named constructor for Set Iterator objects. Instead, set iterator objects are created by calling certain methods of Set instance objects.

15.16.6.1 CreateSetIterator Abstract Operation

Several methods of Set objects return iterator objects. The abstract operation CreateSetIterator with arguments set and kind is used to create and such iterator objects. It performs the following steps:

1. Let $S$ be the result of calling ToObject(set).
2. ReturnIfAbrupt(S).
3. If $S$ does not have a [[SetData]] internal data property throw a TypeError exception.
4. If $S$’s [[SetData]] internal data property is undefined, then throw a TypeError exception.
5. Let entries be the List that is the value of $S$’s [[SetData]] internal data property.
6. Let itr be the result of ObjectCreate(%SetIteratorPrototype%, [[IteratedSet]], [[SetNextIndex]], [[SetIterationKind]]).
7. Set itr’s [[IteratedSet]] internal data property to $S$.
8. Set itr’s [[SetNextIndex]] internal data property to 0.
9. Set itr’s [[SetIterationKind]] internal data property to kind.
10. Return itr.

15.16.6.2 The Set Iterator Prototype

All Set Iterator Objects inherit properties from a common Set Iterator Prototype object. The [[Prototype]] internal data property of the Set Iterator Prototype is the %ObjectPrototype% intrinsic object. In addition, the Set Iterator Prototype as the following properties:

15.16.6.2.1 SetIterator.prototype.constructor

15.16.6.2.2 SetIterator.prototype.next()

1. Let O be the this value.
2. If Type(O) is not Object, throw a TypeError exception.
3. If $O$ does not have all of the internal properties of a Set Iterator Instance (15.16.7.1.2), throw a TypeError exception.
4. Let $s$ be the value of the [[IteratedSet]] internal data property of $O$.
5. Let index be the value of the [[SetNextIndex]] internal data property of $O$.
6. Let itemKind be the value of the [[SetIterationKind]] internal data property of $O$.
7. Assert: $s$ has a [[SetData]] internal data property and $s$ has been initialized so the value of [[SetData]] is not undefined.
8. Let entries be the List that is the value of the [[SetData]] internal data property of $s$.
9. Repeat while index is less than the total number of element of entries. The number of elements must be determined each time this method is evaluated.
   a. Let $e$ be the element at 0-originated insertion position index of entries.
   b. Set index to index + 1;
   c. Set the [[SetNextIndex]] internal data property of $O$ to index.
   d. If $e$ is not empty, then
      i. If itemKind is "key" then,
         1. Let result be the result of the abstract operation ArrayCreate with argument $e$.
         2. Assert: result is a new, well-formed Array object so the following operations will never fail.
         3. Call CreateOwnProperty(result, "0", $e$).
         4. Call CreateOwnProperty(result, "1", $e$).
         5. Return CreateItrResultObject(result, false).
      ii. If itemKind is "value" then,
   10. Return CreateItrResultObject(undefined, true).

Commented [AWB10240]: TODO: need to decide what to use for a constructor for these sort of objects.
15.16.6.2.3 `SetIterator.prototype[@@iterator]()`

The following steps are taken:

1. Return the this value.

15.16.6.2.4 `SetIterator.prototype[@@toStringTag`

The initial value of the `@@toStringTag` property is the string value "Set Iterator".

15.16.6.3 Properties of Set Iterator Instances

Set Iterator instances inherit properties from the Set Iterator prototype (the intrinsic, `%SetIteratorPrototype%`). Set Iterator instances are initially created with the internal properties specified in Table 38.

<table>
<thead>
<tr>
<th>Internal Data Property Name</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 iteration.</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>

15.17 The Reflect Module

This is a placeholder for the material in http://wiki.ecmascript.org/doku.php?id=harmony:reflect_api

15.17.1 Exported Function Properties Reflecting the Essential Internal Methods

15.17.1.1 Reflect.getPrototypeOf(target)

When the `getPrototypeOf` function is called with argument `target` the following steps are taken:

1. Let `obj` be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the `[[GetInheritance]]` internal method of `obj`.

15.17.1.2 Reflect.setPrototypeOf(target, proto)

When the `setPrototypeOf` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. Let `obj` be ToObject(target).
2. ReturnIfAbrupt(obj).
3. If Type(proto) is not Object and proto is not null, then throw a TypeError exception
4. Return the result of calling the `[[SetInheritance]]` internal method of `obj` with argument proto.

15.17.1.3 Reflect.isExtensible(target)

When the `isExtensible` function is called with argument `target` the following steps are taken:

1. Let `obj` be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling `isExtensible(obj)`.

Commented [AWB10241]: TODO
15.1.7.4 Reflect.preventExtensions (target)

When the `preventExtensions` function is called with argument `target`, the following steps are taken:

5. Let `obj` be `ToObject(target)`.
6. ReturnIfAbrupt(`obj`).
7. Return the result of calling the `[[SetIntegrity]]` internal method of `obj` with argument "nonextensible".

15.1.7.5 Reflect.has (target, propertyKey)

When the `has` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. Let `key` be `ToPropertyKey(propertyKey)`.
4. ReturnIfAbrupt(`key`).
5. Return the result of calling the `[[HasProperty]]` internal method of `obj` with argument `key`.

15.1.7.6 Reflect.hasOwn (target, propertyKey)

When the `hasOwn` function is called with arguments `target` and `propertyKey`, the following steps are taken:

6. Let `obj` be `ToObject(target)`.
7. ReturnIfAbrupt(`obj`).
8. Let `key` be `ToPropertyKey(propertyKey)`.
9. ReturnIfAbrupt(`key`).
10. Return the result of calling the `[[HasOwnProperty]]` internal method of `obj` with argument `key`.

15.1.7.7 Reflect.getOwnPropertyDescriptor(target, propertyKey)

When the `getOwnPropertyDescriptor` function is called with arguments `target` and `propertyKey`, the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. Let `key` be `ToPropertyKey(propertyKey)`.
4. ReturnIfAbrupt(`key`).
5. Let `desc` be the result of calling the `[[GetOwnProperty]]` internal method of `obj` with argument `key`.
6. ReturnIfAbrupt(`desc`).
7. Return the result of calling `FromPropertyDescriptor(desc)`.

15.1.7.8 Reflect.get (target, propertyKey, receiver=target)

When the `get` function is called with arguments `target`, `propertyKey`, and `receiver` the following steps are taken:

1. Let `obj` be `ToObject(target)`.
2. ReturnIfAbrupt(`obj`).
3. Let `key` be `ToPropertyKey(propertyKey)`.
4. ReturnIfAbrupt(`key`).
5. If `receiver` is not present, then
   a. Let `receiver` be `target`.
6. Return the result of calling the `[[Get]]` internal method of `obj` with arguments `key` and `receiver`.

15.1.7.9 Reflect.set (target, propertyKey, V, receiver=target)

When the `set` function is called with arguments `target`, `V`, `propertyKey`, and `receiver` the following steps are taken:

1. Let `obj` be `ToObject(target)`. 

2. ReturnIfAbrupt(obj).
3. Let key be ToPropertyDescriptor(propertyKey).
4. ReturnIfAbrupt(key).
5. If receiver is not present, then
   a. Let receiver be target.
6. Return the result of calling the [[Set]] internal method of obj with arguments key, V, and receiver.

15.1.10 Reflect.deleteProperty (target, propertyKey)

When the deleteProperty function is called with arguments target and propertyKey, the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Let key be ToPropertyDescriptor(propertyKey).
4. ReturnIfAbrupt(key).
5. Return the result of calling the [[Delete]] internal method of obj with argument key.

15.1.11 Reflect.defineProperty(target, propertyKey, attributes)

When the defineProperty function is called with arguments target, propertyKey, and attributes the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Let key be ToPropertyDescriptor(propertyKey).
4. ReturnIfAbrupt(key).
5. Let desc be the result of calling ToPropertyDescriptor with attributes as the argument.
6. ReturnIfAbrupt(desc).
7. Return the result of calling the [[DefineOwnProperty]] internal method of obj with arguments key, and desc.

15.1.12 Reflect.enumerate (target)

When the enumerate function is called with argument target the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Let itr be the result of calling the [[Enumerate]] internal method of obj.
4. Return itr.

15.1.13 Reflect.ownKeys (target)

When the ownKeys function is called with argument target the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Let keys be the result of calling the [[OwnPropertyKeys]] internal method of obj.

15.1.14 Reflect.freeze (target)

When the freeze function is called with argument target the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the [[Freeze]] internal method of obj.

15.1.15 Reflect.seal (target)

When the seal function is called with argument target the following steps are taken:
1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the [[Seal]] internal method of obj.

15.17.1.16 Reflect.isFrozen (target)

When the isFrozen function is called with argument target the following steps are taken:

1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the [[IsFrozen]] internal method of obj.

15.17.1.17 Reflect.isSealed (target)

When the isSealed function is called with argument target the following steps are taken:

1. Let obj be ToObject(target).
2. ReturnIfAbrupt(obj).
3. Return the result of calling the [[IsSealed]] internal method of obj.

15.18 Proxy Objects

15.19 The "std:iteration" Module

The "std:iteration" module defines built-in objects that support the for-of statement and similar iteration use cases. It also defines the built-in objects that support Generator Functions.

15.19.1 Common Iteration Interfaces

An interface is a set of object property keys whose associated values match a specific specification. Any object that provides all the properties of an interface in conformance to the interface's specification conforms to that interface. An interface isn’t represented by a single object and there may be many distinctly implemented objects that conform to any interface. An individual object may conform to multiple interfaces.

15.19.1.1 The Iterable Interface

The Iterable interface includes the following property:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>@@iterator</td>
<td>A zero arguments function that returns an object.</td>
<td>The function returns an object that conforms to the iterator interface.</td>
</tr>
</tbody>
</table>

15.19.1.2 The Iterator Interface

The Iterator interface includes the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>next</td>
<td>A function that returns an object.</td>
<td>The function returns an object that conforms to the Iterator interface.</td>
</tr>
</tbody>
</table>

NOTE Arguments may be passed to the next function but their interpretation and validity is dependent upon the target Iterator. Generic use of Iterators should not pass any arguments.
15.19.1.3 The *ItrResult* Interface

The *ItrResult* interface includes the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>done</td>
<td>Either true or false.</td>
<td>This is the result status of the an <a href="https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Iteration_control_statements#The_next_method">iterator next method call</a>. If the end of the iterator was reached then <code>done</code> is true. If the end was not reached then <code>done</code> is false and a value is available.</td>
</tr>
<tr>
<td>value</td>
<td>Any ECMAScript language value.</td>
<td>If <code>done</code> is false, this is the current iteration element value. If <code>done</code> is true, 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 <code>undefined</code>. In that case, the <code>value</code> property may be absent form the conforming object if it does not inherit an explicit <code>value</code> property.</td>
</tr>
</tbody>
</table>

15.19.2 “std:iteration” Exports

The “std:iteration” module exports the names:

- iterator
- GeneratorFunction
- Generator

15.19.3 GeneratorFunction Objects

Generator Function objects are constructor functions that are usually created by evaluating *GeneratorDeclaration*, *GeneratorExpression*, and *GeneratorMethod* syntactic productions. They may also be created by calling the `GeneratorFunction` constructor.
15.19.3.1 The GeneratorFunction Constructor

The GeneratorFunction constructor is the %GeneratorFunction% intrinsic object and the value of the name GeneratorFunction exported from the built-in module "std:iteration". When GeneratorFunction is called as a function rather than as a constructor, it creates and initialises a new GeneratorFunction object. Thus the function call GeneratorFunction(...) is equivalent to the object creation expression new GeneratorFunction(...) with the same arguments. However, if the this value passed in the call is an Object with an [[Code]] internal data property whose value is undefined, it initializes the this value using the argument values. This permits GeneratorFunction to be used both as a factory method and to perform constructor instance initialization.

GeneratorFunction may be subclassed and subclass constructors may perform a super invocation of the GeneratorFunction constructor to initialize subclass instances. However, all syntactic forms for defining generator function objects create direct instances of GeneratorFunction. There is no syntactic means to create instances of GeneratorFunction subclasses.
15.19.3.1.1 GeneratorFunction (p1, p2, ..., pn, body)

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

When the `GeneratorFunction` function is called with some arguments `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 `argCount` be the total number of arguments passed to this function invocation.
2. Let `P` be the empty String.
3. If `argCount = 0`, let `bodyText` be the empty String.
4. Else if `argCount = 1`, let `bodyText` be that argument.
5. Else `argCount > 1`,
   a. Let `firstArg` be the first argument.
   b. Let `P` be `ToString(firstArg)`.
   c. Return `Abrupt(P)`.
   d. Let `k` be 2.
   e. Repeat, while `k < argCount`
      i. Let `nextArg` be the `k`th argument.
      ii. Let `nextArgString` be `ToString(nextArg)`.
      iii. Return `Abrupt(nextArgString)`.
      iv. Let `P` be the result of concatenating the previous value of `P`, the String "," (a comma), and `nextArgString`.
      v. Increase `k` by 1.
   f. Let `bodyText` be the `k`th argument.
6. Let `bodyText` be `ToString(bodyText)`.
7. Return `Abrupt(bodyText)`.
8. Let `parameters` be the result of parsing `P`, interpreted as UTF-16 encoded Unicode text as described in 8.4, using `FormalParameters` as the goal symbol. Throw a `SyntaxError` exception if the parse fails.
9. Let `funcBody` be the result of parsing `bodyText`, interpreted as UTF-16 encoded Unicode text as described in 8.4, using `FunctionBody` as the goal symbol. Throw a `SyntaxError` exception if the parse fails or if any static semantics errors are detected.
10. If `funcBody` contains `YieldExpression` is `false`, then throw a `SyntaxError` exception.
11. If `IsSimpleParameterList of parameters` is `false` and any element of the `BoundNames` of `parameters` also occurs in the `VarDeclaredNames of funcBody`, then throw a `SyntaxError` exception.
12. If any element of the `BoundNames of parameters` also occurs in the `LexicallyDeclaredNames of funcBody`, then throw a `SyntaxError` exception.
13. Let `scope` be the `GlobalEnvironment`.
14. Let `F` be the `this` value.
15. If `Type(F)` is `Object` or `if F does not have a [[Code]] internal data property or if the value of `[[Code]]` is `undefined`, then
   a. Let `P` be the result of calling `FunctionAllocate` with arguments `"Generator"` and "generator".
16. If the value of `F`'s `[[FunctionBody]]` internal data property is not "generator", then throw a `TypeError` exception.
17. Using `funcBody` as the `FunctionBody` production, let `body` be the supplemental syntactic grammar production: `GeneratorBody; FunctionBody`.
18. Perform the `FunctionInitialize` abstract operation with arguments `F`, `Normal`, `parameters`, `body`, `scope`, and `strict`.
19. Let `prototype` be the result of the abstract operation `ObjectCreate` with the intrinsic object `%GeneratorPrototype%` as its argument.
20. Perform the abstract operation `MakeConstructor` with arguments `F`, `true`, and `prototype`.

A `prototype` property is automatically created for every function created using the `GeneratorFunction` constructor, to provide for the possibility that the function will be used as a constructor.
15.19.3.1.2 new GeneratorFunction (... argumentsList)

When GeneratorFunction is called as part of a new expression, it creates and initialises a newly created object.

1. Let \( F \) be the GeneratorFunction function object on which the new operator was applied.
2. Let argumentsList be the argumentsList argument of the [[Construct]] internal method that was invoked by the new operator.
3. Return the result of OrdinaryConstruct (\( F \), argumentsList).

If GeneratorFunction is implemented as an ordinary function object, its [[Construct]] internal method will perform the above steps.

15.19.3.2 Properties of the GeneratorFunction Constructor

The GeneratorFunction constructor is a built-in Function object that inherits from the Function constructor. The value of the [[Prototype]] internal data property of the GeneratorFunction constructor is the intrinsic object %Function%.

The value of the [[Extensible]] internal data property of the GeneratorFunction constructor is true.

The GeneratorFunction constructor has the following properties:

15.19.3.2.1 GeneratorFunction.prototype

The initial value of generatorFunction.prototype is %Generator%, the standard built-in GeneratorFunction prototype.

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

15.19.3.2.2 GeneratorFunction.length

This is a data property with a value of 1. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.19.3.2.3 GeneratorFunction @@create ()

The @@create method of an object \( F \) performs the following steps:

1. Let \( F \) be the this value.
2. Let proto be the result of GetPrototypeFromConstructor(\( F \), "%Generator%").
3. ReturnIfAbrupt(proto).
4. Let obj be the result of calling FunctionAllocate with argument proto and "generator".
5. Return obj.

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

NOTE The GeneratorFunction @@create function is intentionally generic; it does not require that its this value be the GeneratorFunction constructor object. It can be transferred to other constructor functions for use as a @@create method. When used with other constructors, this function will create a function object whose [[Prototype]] value is obtained from the associated constructor.

15.19.3.3 Properties of the GeneratorFunction Prototype Object

The GeneratorFunction prototype object is an ordinary object. It is not a function object and does not have a [[Code]] internal data property or any other of the internal data properties listed in Table 13. In addition to being the value of the prototype property of the %GeneratorFunction% intrinsic and is itself the %Generator% intrinsic.
The value of the `[[Prototype]]` internal data property of the `GeneratorFunction` prototype object is the `%FunctionPrototype%` intrinsic object. The initial value of the `[[Extensible]]` internal data property of the `GeneratorFunction` prototype object is `true`.

15.19.3.3.1 `GeneratorFunction.prototype.constructor`

The initial value of `GeneratorFunction.prototype.constructor` is the intrinsic object `%GeneratorFunction%`.

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.19.3.3.2 `GeneratorFunction.prototype.prototype`

The value of `Function.prototype.prototype` is the `%GeneratorPrototype%`.

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.19.3.3.3 `GeneratorFunction.prototype @@toStringTag`

The initial value of the `@@toStringTag` property is the string value "GeneratorFunction".

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.19.3.3.4 `GeneratorFunction.prototype @@create ()`

The `@@create` method of an object `F` performs the following steps:

1. Let `F` be the `this` value.
2. Let `obj` be the result of calling `OrdinaryCreateFromConstructor(F, "%GeneratorPrototype!", ( [[GeneratorState]], [[GeneratorContext]] )).`
3. Return `obj`.

This property has the attributes { `[[Writable]]`: true, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.19.3.4 `GeneratorFunction` Instances

Every `GeneratorFunction` instance is an ordinary function object and has the internal data properties listed in Table 13. The value of the `[[FunctionKind]]` internal data property for all such instances is "generator".

The `GeneratorFunction` instances have the following own properties:

15.3.4.1 `length`

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

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.3.4.2 `prototype`

Whenever a `GeneratorFunction` instance is created another ordinary object is also created and is the initial value of the `generatorFunction`'s `prototype` property. The value of the prototype property is used to initialise the `[[Prototype]]` internal data property of a newly created `Generator` object before the `generatorFunction` object is invoked as a constructor for that newly created object.

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.
NOTE Unlike function instances, the object that is the value of the a GeneratorFunction’s `prototype` property does not have a `constructor` property whose value is the GeneratorFunction instance.

15.19.4 Generator Objects

A Generator object is an instance of a generator function and conforms to both the `Iterator` and `Iterable` interfaces.

Generator instances directly inherit properties from the object that is the value of the `prototype` property of the Generator function that created the instance. Generator instances indirectly inherit properties from the Generator Prototype intrinsic `%GeneratorPrototype%`.

15.19.4.2 Properties of Generator Prototype

The Generator prototype object is the `%GeneratorPrototype%` intrinsic. It is also the initial value of the `prototype` property of the `%Generator%` intrinsic (the GeneratorFunction.prototype).

The Generator prototype is an ordinary object. It is not a Generator instance and does not have a `[[GeneratorState]]` internal data property.

The value of the `[[Prototype]]` internal data property of the Generator prototype object is the intrinsic object `%ObjectPrototype%` (15.2.4). The initial value of the `[[Extensible]]` internal data property of the Function prototype object is `true`.

All Generator instances indirectly inherit properties of the Generator prototype object.

15.19.4.2.1 `Generator.prototype.constructor`

The initial value of `Generator.prototype.constructor` is the intrinsic object `%Generator%`.

This property has the attributes { `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: true }.

15.19.4.2.3 `Generator.prototype.next (value)`

The `next` method performs the following steps:

1. Let `g` be the this value.
2. Return the result of `GeneratorResume(g, value)`.

15.19.4.2.4 `Generator.prototype.throw (exception)`

The `throw` method performs the following steps:

1. Let `g` be the this value.
2. If `Type(g)` is not `Object`, then throw a `TypeError` exception.
3. If `generator` does not have a `[[GeneratorState]]` internal data property, then throw a `TypeError` exception.
4. Let `state` be the value of `generator`’s `[[GeneratorState]]` internal data property.
5. Assert: `generator` also has a `[[GeneratorContext]]` internal data property.
6. If `state` is neither `"suspendedStart"` or `"suspendedYield"`, then throw a `TypeError` exception.
7. Let `E` be `Completion` { `[[type]]`: `throw`, `[[value]]`: `exception`, `[[target]]`: empty }.
8. If `state` is `"suspendedStart"` then,
   a. Set `generator`’s `[[GeneratorState]]` internal data property to `"completed"`.
   b. Once a generator enters the `"completed"` state it never leaves it and its associated execution context is never resumed. Any execution state associated with `generator` can be discarded at this point.
   c. Return `E`.
9. Let `gContext` be value of `generator`’s `[[GeneratorContext]]` internal data property.
10. Let `methodContext` be the running execution context.
12. Set generator’s [[GeneratorState]] internal data property to “executing”.
13. Push gContext onto the execution context stack; gContext is now the running execution context.
14. Resume the suspended evaluation of gContext using E as the result of the operation that suspended it. Let result be the value returned by the resumed computation.
15. Assert: When we return here, gContext has already been removed from the execution context stack and methodContext is the currently running execution context.
16. Return result.

15.19.4.2.5 Generator.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the string value “Generator”.

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

15.19.4.2 Properties of Generator Instances

Generator instances are initially created with the internal data properties described in Table 37.

Table 39 — Internal Data Properties of Generator Instances

<table>
<thead>
<tr>
<th>Internal Data Property Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[GeneratorState]]</td>
<td>The current execution state of the generator. The possible values are: undefined, “suspendedStart”, “suspendedYield”, “executing”, and “completed”.</td>
</tr>
<tr>
<td>[[GeneratorContext]]</td>
<td>The execution context that is used when executing the code of this generator.</td>
</tr>
</tbody>
</table>

15.19.4.2.1 @@iterator

The value of the @@iterator own property of a Generator instance is that Generator instance.

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

15.19.4.3 Iteration Related Abstract Operations

15.19.4.3.1 GeneratorStart (generator, generatorBody)

1. Let genContext be the running execution context.
2. Set the Generator component of genContext to generator.
3. Set the code evaluation state of genContext such that when evaluation is resumed for that execution context the following steps will be performed:
   a. Let result be the result of evaluating generatorBody.
   b. Assert: If we return here, the generator either threw an exception or performed either an implicit or explicit return.
   c. Remove genContext from the execution context stack and restore the execution context that is at the top of the execution context stack as the running execution context.
   d. Set g’s [[GeneratorState]] internal data property to “completed”.
   e. Once a generator enters the “completed” state it never leaves it and its associated execution context is never resumed. Any execution state associated with generator can be discard at this point.
   f. ReturnIfAbrupt(result).
   g. Return CreateIterResultObject(result, true).
4. Set generator’s [[GeneratorContext]] internal data property to genContext.
5. Set generator’s [[GeneratorState]] internal data property to “suspendedStart”.
6. Return NormalCompletion(generator).
15.19.4.3.2 GeneratorResume ( generator, value )

The abstract operation GeneratorResume with arguments generator and value performs the following steps:

1. If Type(generator) is not Object, then throw a TypeError exception.
2. If generator does not have a [[GeneratorState]] internal data property, then throw a TypeError exception.
3. Let state be the value of generator’s [[GeneratorState]] internal data property.
4. Assert: generator also has a [[GeneratorContext]] internal data property.
5. If state is neither “suspendedStart” or “suspendedYield”, then throw a TypeError exception.
6. If state is “suspendedStart” and value is not undefined, then throw a TypeError exception.
7. Let gContext be value of generator’s [[GeneratorContext]] internal data property.
8. Let methodContext be the running execution context.
10. Set generator’s [[GeneratorState]] internal data property to “executing”.
11. Push gContext onto the execution context stack; gContext is now the running execution context.
12. Resume the suspended evaluation of gContext using NormalCompletion(value) as the result of the operation that suspended it. Let result be the value returned by the resumed computation.
13. Assert: When we return here, gContext has already been removed from the execution context stack and methodContext is the currently running execution context.
14. Return result.

15.19.4.3.3 GeneratorYield ( itrNextObj )

The abstract operation GeneratorYield with argument itrNextObj performs the following steps:

1. Assert: itrNextObj is an Object that implemented the ItrResult interface.
2. Let genContext be the running execution context.
3. Assert: genContext is the execution context of a generator.
4. Let generator be the value of the Generator component of genContext.
5. Set the value of generator’s [[GeneratorState]] internal data property to “suspendedYield”.
6. Remove genContext from the execution context stack and restore the execution context that is at the top of the execution context stack as the running execution context.
7. Set the code evaluation state of genContext such that when evaluation is resumed with a Completion resumptionValue the following steps will be performed:
   a. Return resumptionValue.
   b. NOTE: This returns to the evaluation of the YieldExpression production that originally called this abstract operation.
8. Resume the suspended evaluation of gContext using NormalCompletion(value) as the result of the operation that suspended it. Let result be the value returned by the resumed computation.
9. Assert: When we return here, gContext has already been removed from the execution context stack and methodContext is the currently running execution context.
10. Return NormalCompletion(itrNextObj).
11. NOTE: This returns to the evaluation of the operation that had most previously resumed evaluation of gContext.

15.19.4.3.4 CreateItrResultObject ( value, done )

The abstract operation CreateItrResultObject with arguments value and done creates an object that supports the ItrResult interface by performing the following steps:

1. Assert: Type(done) is Boolean.
2. Let obj be the result of performing ObjectCreate().
3. Perform CreateOwnProperty(obj, “value”, value).
4. Perform CreateOwnProperty(obj, “done”, done).
5. Return obj.

15.19.4.3.5 IteratorComplete ( itrResult )

The abstract operation IteratorComplete with argument itrResult performing the following steps:

1. Assert: Type(itrResult) is Object.
2. Let done be the result of Get(itrResult, "done").
3. Return ToBoolean(done).

15.19.4.3 IteratorValue (itrResult)

The abstract operation IteratorValue with argument itrResult performing the following steps:

1. Assert: Type(itrResult) is Object.
2. Return the result of Get(itrResult, "value").

16 Errors

An implementation must report most errors at the time the relevant ECMAScript language construct is evaluated. An early error is an error that can be detected and reported prior to the evaluation of any construct in the Script containing the error. An implementation must report early errors in a Script prior to the first evaluation of that Script. Early errors in eval code are reported at the time eval is called but prior to evaluation of any construct within the eval code. All errors that are not early errors are runtime errors.

An implementation must treat as an early error any instance of an early error that is specified in a static

An implementation shall not treat other kinds of errors as early errors even if the compiler can prove that a construct cannot execute without error under any circumstances. An implementation may issue an early warning in such a case, but it should not report the error until the relevant construct is actually executed.

An implementation shall report all errors as specified, except for the following:

- An implementation may extend script syntax and regular expression pattern or flag syntax. To permit this, all operations (such as calling eval, using a regular expression literal, or using the Function or RegExp constructor) that are allowed to throw SyntaxError are permitted to exhibit implementation-defined behaviour instead of throwing SyntaxError when they encounter an implementation-defined extension to the script syntax or regular expression pattern or flag syntax.
- An implementation may provide additional types, values, objects, properties, and functions beyond those described in this specification. This may cause constructs (such as looking up a variable in the global scope) to have implementation-defined behaviour instead of throwing an error (such as ReferenceError).
- An implementation may define behaviour other than throwing RangeError for toFixed, toExponential, and toPrecision when the fractionDigits or precision argument is outside the specified range.
Annex A
(informative)

Grammar Summary

A.1 Lexical Grammar

SourceCharacter :: See clause 6
any Unicode code unit

InputElementDiv :: See clause 7
WhiteSpace
LineTerminator
Comment
Token
DivPunctuator

InputElementRegExp :: See clause 7
WhiteSpace
LineTerminator
Comment
Token
RegularExpressionLiteral

WhiteSpace :: See 7.2
<TAB>
<VT>
<FF>
<SP>
<NBSP>
<BOM>
<USP>

LineTerminator :: See 7.3
<LF>
<CR>
<LS>
<PS>

LineTerminatorSequence :: See 7.3
<LF>
<CR> [lookahead ≠ <LF> ]
<LS>
<PS>
<CR> <LF>

Comment :: See 7.4
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

SingleLineCommentChars ::
  SingleLineCommentChar SingleLineCommentChars-opt

SingleLineCommentChar ::
  SourceCharacter but not LineTerminator

Token ::
  IdentifierName
  Punctuator
  NumericLiteral
  StringLiteral

Identifier ::
  IdentifierName but not ReservedWord

IdentifierName ::
  IdentifierStart
  IdentifierName IdentifierPart

IdentifierStart ::
  UnicodeLetter
  $
  \ UnicodeEscapeSequence

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.4

See 7.5

See 7.6

See 7.6

See 7.6
IdentifierPart ::=
  IdentifierStart
  UnicodeCombiningMark
  UnicodeDigit
  <ZWNJ>
  <ZWJ>

IdentifierStart ::=
  UnicodeLetter

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

UnicodeCombiningMark ::=
  any character in the Unicode categories "Non-spacing mark (Mn)" or "Combining
  spacing mark (Mc)"

UnicodeDigit ::=
  any character in the Unicode category "Decimal number (Nd)"

UnicodeConnectorPunctuation ::=
  any character in the Unicode category "Connector
  punctuation (Pc)"

ReservedWord ::=
  Keyword
  FutureReservedWord
  NullLiteral
  BooleanLiteral

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

FutureReservedWord ::=
  one of
  class  enum  extends  super
  const  export  import

The following tokens are also considered to be FutureReservedWords when parsing strict mode
  code (see 10.1.1).
  implements  let  private  public
  interface  package  protected  static
  yield
Punctuator :: one of

DivPunctuator :: one of
/ =

Literal ::
NullLiteral
BooleanLiteral
NumericLiteral
StringLiteral
RegularExpressionLiteral

NullLiteral ::
null

BooleanLiteral ::
true
false

NumericLiteral ::
DecimalLiteral
HexIntegerLiteral

DecimalLiteral ::
DecimalIntegerLiteral . DecimalDigitsopt ExponentPartopt
. DecimalDigits ExponentPart
DecimalIntegerLiteral ExponentPart

DecimalIntegerLiteral ::
0
NonZeroDigit DecimalDigitsopt

DecimalDigits ::
DecimalDigit
DecimalDigits DecimalDigit

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

ExponentPart ::
  ExponentIndicator SignedInteger

ExponentIndicator :: one of
  e E

SignedInteger ::
  DecimalDigits
  + DecimalDigits
  - DecimalDigits

HexIntegerLiteral ::
  0x HexDigit
  0X HexDigit
  HexIntegerLiteral HexDigit

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

SingleStringCharacters ::
  SingleStringCharacter SingleStringCharacters

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 a 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 ::
  x HexDigit HexDigit

UnicodeEscapeSequence ::
  u HexDigit HexDigit HexDigit HexDigit

RegularExpressionLiteral ::
  / RegularExpressionBody / RegularExpressionFlags

RegularExpressionBody ::
  RegularExpressionFirstChar RegularExpressionChars

RegularExpressionChars ::
  [empty]
  RegularExpressionChars RegularExpressionChar

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

RegularExpressionChar ::
  RegularExpressionNon Terminator but not \ or / or [
   RegularExpressionBackslashSequence
   RegularExpressionClass

RegularExpressionBackslashSequence ::
  \ RegularExpressionNon Terminator

RegularExpressionNon Terminator ::
  SourceCharacter but not LineTerminator

RegularExpressionClass ::
  [ RegularExpressionClassChars ]

RegularExpressionClassChars ::
  [empty]
  RegularExpressionClassChars  RegularExpressionClassChar

RegularExpressionClassChar ::
  RegularExpressionNon Terminator but not ) or \ 
  RegularExpressionBackslashSequence
A.2 Number Conversions

StringNumericLiteral ::=
  StrWhiteSpaceopt
  StrWhiteSpatStrNumericLiteralStrWhiteSpaceopt

StrWhiteSpace ::=
  StrWhiteSpaceCharStrWhiteSpaceopt

StrWhiteSpaceChar ::= WhiteSpace
  LineTerminator

StrNumericLiteral ::= StrDecimalLiteral
  HexIntegerLiteral

StrDecimalLiteral ::= StrUnsignedDecimalLiteral
  + StrUnsignedDecimalLiteral
  - StrUnsignedDecimalLiteral

StrUnsignedDecimalLiteral ::=
  Infinity
  DecimalDigits . DecimalDigitsExponentPartopt
  . DecimalDigits ExponentPartopt
  DecimalDigits ExponentPartopt

DecimalDigit ::= DecimalDigit
  DecimalDigits

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

ExponentPart ::= ExponentIndicatorSignedInteger

ExponentIndicator::= one of
  e E

SignedInteger ::= DecimalDigits
  + DecimalDigits
  - DecimalDigits
HexIntegerLiteral ::= 0x HexDigit 0X HexDigit HexIntegerLiteral HexDigit

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

A.3 Expressions

PrimaryExpression :
  this Identifier Literal ArrayLiteral ObjectLiteral ( Expression )

ArrayLiteral :
  [ Elementopt ]
  [ ElementList ]
  [ ElementList , Elementopt ]

ElementList :
  Elisionopt AssignmentExpression ElementList , AssignmentExpression

Elision :
  ,
  Elision ,

ObjectLiteral :
  { }
  { PropertyDefinitionList }
  { PropertyDefinitionList , }

PropertyDefinitionList :
  PropertyDefinition PropertyDefinitionList , PropertyDefinition

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

PropertyName :
  IdentifierName StringLiteral NumericLiteral

PropertySetParameterList :
  Identifier

See 9.1.3.1
See 11.1
See 11.1.4
See 11.1.4
See 11.1.5
See 11.1.5
See 11.1.5
See 11.1.5
See 11.1.5
MemberExpression : See 11.2
  PrimaryExpression
  FunctionExpression
  MemberExpression [ Expression ]
  MemberExpression . IdentifierName
  new MemberExpression Arguments

NewExpression : See 11.2
  MemberExpression
  new NewExpression

CallExpression : See 11.2
  MemberExpression Arguments
  CallExpression Arguments
  CallExpression [ Expression ]
  CallExpression . IdentifierName

Arguments : See 11.2
  ( }
  ( ArgumentList )

ArgumentList : See 11.2
  AssignmentExpression
  ArgumentList , AssignmentExpression

LeftHandSideExpression : See 11.2
  NewExpression
  CallExpression

PostfixExpression : See 11.3
  LeftHandSideExpression
  LeftHandSideExpression [ no LineTerminator here] ++
  LeftHandSideExpression [ no LineTerminator here] --

UnaryExpression : See 11.4
  PointerExpression
delete UnaryExpression
  void UnaryExpression
typeof UnaryExpression
  ++ UnaryExpression
  -- UnaryExpression
  + UnaryExpression
  - UnaryExpression
  ~ UnaryExpression
  † UnaryExpression

MultiplicativeExpression : See 11.5
  UnaryExpression
  MultiplicativeExpression • UnaryExpression
  MultiplicativeExpression / UnaryExpression
  MultiplicativeExpression % UnaryExpression
AdditiveExpression :  
  MultiplicativeExpression  
  AdditiveExpression + MultiplicativeExpression  
  AdditiveExpression - MultiplicativeExpression  

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

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

RelationalExpressionNoIn :  
  ShiftExpressionNoIn  
  RelationalExpressionNoIn < ShiftExpressionNoIn  
  RelationalExpressionNoIn > ShiftExpressionNoIn  
  RelationalExpressionNoIn <= ShiftExpressionNoIn  
  RelationalExpressionNoIn >= ShiftExpressionNoIn  
  RelationalExpressionNoIn instanceof ShiftExpressionNoIn  

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

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

BitwiseANDExpression :  
  EqualityExpression  
  BitwiseANDExpression & EqualityExpression  

BitwiseANDExpressionNoIn :  
  EqualityExpressionNoIn  
  BitwiseANDExpressionNoIn & EqualityExpressionNoIn
BitwiseXORExpression :
  BitwiseXORExpression
  BitwiseXORExpression ^ BitwiseANDExpression

BitwiseXORExpressionNoIn :
  BitwiseANDExpressionNoIn
  BitwiseXORExpressionNoIn ^ BitwiseANDExpressionNoIn

BitwiseORExpression :
  BitwiseXORExpression
  BitwiseORExpression | BitwiseXORExpression

BitwiseORExpressionNoIn :
  BitwiseANDExpressionNoIn
  BitwiseORExpressionNoIn | BitwiseORExpressionNoIn

LogicalANDExpression :
  BitwiseORExpression
  LogicalANDExpression && BitwiseORExpression

LogicalANDExpressionNoIn :
  BitwiseORExpressionNoIn
  LogicalANDExpressionNoIn && BitwiseORExpressionNoIn

LogicalORExpression :
  LogicalANDExpression
  LogicalORExpression || LogicalANDExpression

LogicalORExpressionNoIn :
  LogicalANDExpressionNoIn
  LogicalORExpressionNoIn || LogicalANDExpressionNoIn

ConditionalExpression :
  LogicalORExpression
  LogicalORExpression ? AssignmentExpression : AssignmentExpression

ConditionalExpressionNoIn :
  LogicalORExpressionNoIn
  LogicalORExpressionNoIn ? AssignmentExpression : AssignmentExpressionNoIn

AssignmentExpression :
  ConditionalExpression
  LeftHandSideExpression = AssignmentExpression

AssignmentExpressionNoIn :
  ConditionalExpressionNoIn
  LeftHandSideExpression = AssignmentExpressionNoIn
AssignmentOperator : one of
  /=  //=  +=  -=  <<=  >>=  >>>=  &=  ^=  |=
  See 11.13

Expression : 
  AssignmentExpression
  See 11.14
  Expression , AssignmentExpression

ExpressionNoIn : 
  AssignmentExpressionNoIn
  See 11.14
  ExpressionNoIn , AssignmentExpressionNoIn

A.4 Statements

Statement : 
  Block
  See clause 12
  VariableStatement
  EmptyStatement
  ExpressionStatement
  IfStatement
  IterationStatement
  ContinueStatement
  BreakStatement
  ReturnStatement
  WithStatement
  LabelledStatement
  SwitchStatement
  ThrowStatement
  TryStatement
  DebuggerStatement

Block : 
  { StatementListopt }
  See 12.1

StatementList : 
  Statement
  StatementList Statement
  See 12.1

VariableStatement : 
  var VariableDeclarationList ;
  See 12.2

VariableDeclarationList : 
  VariableDeclaration
  VariableDeclarationList , VariableDeclaration
  See 12.2

VariableDeclarationListNoIn : 
  VariableDeclarationNoIn
  VariableDeclarationListNoIn , VariableDeclarationNoIn
  See 12.2

VariableDeclaration : 
  Identifier Initialiseropt
  See 12.2

VariableDeclarationNoIn : 
  Identifier InitialiserNoIn
  See 12.2
Initialiser : 
  = AssignmentExpression

InitialiserNoIn : 
  = AssignmentExpressionNoIn

EmptyStatement : 
  ;

ExpressionStatement : 
  [lookahead ≠ { ( function )}] Expression ;

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

IterationStatement : 
  do Statement while ( Expression ) ;
  while ( Expression ) Statement
  for ( ExpressionNoInopt ; Expressionopt ; Expressionopt ) Statement
  for ( var VariableDeclarationListNoIn ; Expressionopt ) Statement
  for ( LeftHandSideExpression in Expression ) Statement
  for ( var VariableDeclarationNoIn in Expression ) Statement

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

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

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

WithStatement : 
  with ( Expression ) Statement

SwitchStatement : 
  switch ( Expression ) CaseBlock

CaseBlock : 
  { CaseClausesopt } 
  { CaseClausesopt DefaultClause CaseClausesopt }

CaseClauses : 
  CaseClause
  CaseClauses CaseClause
CaseClause : 
  case Expression : StatementListopt

DefaultClause : 
  default : StatementListopt

LabelledStatement : 
  Identifier : Statement

ThrowStatement : 
  throw [no LineTerminator here] Expression ;

TryStatement : 
  try Block Catch
  try Block Finally
  try Block Catch Finally

Catch : 
  catch ( Identifier ) Block

Finally : 
  finally Block

DebuggerStatement : 
  debugger ;

A.5 Functions and Scripts

FunctionDeclaration : 
  function Identifier ( FormalParameterListopt ) { FunctionBody }

FunctionExpression : 
  function Identifier ( FormalParameterListopt ) { FunctionBody }

FormalParameterList : 
  Identifier FormalParameterList , Identifier

FunctionBody : 
  SourceElementsopt

Program : 
  SourceElementsopt

SourceElements : 
  SourceElement
  SourceElements SourceElement
A.6 Universal Resource Identifier Character Classes

\texttt{uri ::= uriCharacters_{opt}}

\texttt{uriCharacters ::= uriCharacter uriCharacters_{opt}}

\texttt{uriCharacter ::= uriReserved uriUnescaped uriEscaped}

\texttt{uriReserved ::= \texttt{\textbackslash ; / ? : @ & = + \textbackslash ,}}

\texttt{uriUnescaped ::= uriAlpha DecimalDigit uriMark}

\texttt{uriEscaped ::= \% HexDigit HexDigit}

\texttt{uriAlpha ::= \texttt{\textbackslash 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}}

\texttt{uriMark ::= \texttt{\textbackslash one of - _ . ! ~ * ' ( )}}

A.7 Regular Expressions

\texttt{Pattern ::= Disjunction}

\texttt{Disjunction ::= Alternative Disjunction}

\texttt{Alternative ::= [empty] Alternative Term}

\texttt{Term ::= Assertion Atom Atom Quantifier}
Assertion :: 
   ^ $ \ b \ B 
   (? = Disjunction ) 
   (? ! Disjunction )

Quantifier :: 
   QuantifierPrefix 
   QuantifierPrefix ?

QuantifierPrefix :: 
   * + ?
   { DecimalDigits }
   { DecimalDigits , }
   { DecimalDigits , DecimalDigits }

Atom :: 
   PatternCharacter 
   - 
   \ AtomEscape 
   CharacterClass 
   ( Disjunction ) 
   ( ? : Disjunction )

PatternCharacter :: 
   SourceCharacter but not one of 
   ^ $ \ . * + ? ( ) [ ] { } | 

AtomEscape :: 
   DecimalEscape 
   CharacterEscape 
   CharacterClassEscape 

CharacterEscape :: 
   ControlEscape 
   c ControlLetter 
   HexEscapeSequence 
   UnicodeEscapeSequence 
   IdentityEscape 

ControlEscape :: one of 
   f n r t v 

ControlLetter :: one of 
   a b c d e f g h i j k l m n o p q r s t u v w x y z 
   A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
IdentityEscape ::= SourceCharacter but not IdentifierPart
<ZWJ>
<ZWNN>

DecimalEscape ::= DecimalIntegerLiteral \[ lookahead \[ DecimalDigit \] \]

CharacterClassEscape ::= one of
  d  D  s  S  w  W

CharacterClass ::= [ \[ lookahead \[ \^ \] \] \] ClassRanges ]
  [ ^ ClassRanges ]

ClassRanges ::= [empty]
NonemptyClassRanges

NonemptyClassRanges ::= ClassAtom NonemptyClassRangesNoDash
ClassAtom – ClassAtom ClassRanges

NonemptyClassRangesNoDash ::= ClassAtom
ClassAtomNoDash NonemptyClassRangesNoDash
ClassAtomNoDash – ClassAtom ClassRanges

ClassAtom ::= –
  ClassAtomNoDash

ClassAtomNoDash ::= SourceCharacter but not one of \ or \} or –
  \ ClassEscape

ClassEscape ::= DecimalEscape
  b
  CharacterEscape
  CharacterClassEscape

A.8 JSON

A.8.1 JSON Lexical Grammar

JSONWhiteSpace ::= \[ \[ \<TAB\>
\[ \<CR\> \]

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.10.1

See 15.12.1.1
A.8.2 JSON Syntactic Grammar

JSONText : JSONValue

JSONValue : JSONNullLiteral JSONBooleanLiteral JSONObject JSONArray JSONString JSONNumber

JSONObject : { } JSONMemberList

JSONMember : JSONString : JSONValue

JSONArray : [ ] JSONElementList

JSONElementList : JSONMemberList , JSONMember
See 15.12.1.2
Annex B
(normative)

Additional ECMAScript Features for Web Browsers

The ECMAScript language syntax and semantics defined in this annex are required when the ECMAScript host is a web browser. The content of this annex is normative but optional if the ECMAScript host is not a web browser.

B.1 Additional Syntax

B.1.1 Numeric Literals

The syntax and semantics of 7.8.3 is extended as follows except that this extension is not allowed for strict mode code:

Syntax

NumericLiteral ::
  DecimalLiteral
  BinaryIntegerLiteral
  OctalIntegerLiteral
  HexIntegerLiteral
  LegacyOctalIntegerLiteral

LegacyOctalIntegerLiteral ::
  0 OctalDigit
  LegacyOctalIntegerLiteral OctalDigit

Static Semantics

- The MV of LegacyOctalIntegerLiteral :: 0 OctalDigit is the MV of OctalDigit.
- The MV of LegacyOctalIntegerLiteral :: LegacyOctalIntegerLiteral OctalDigit is (the MV of LegacyOctalIntegerLiteral times 8) plus the MV of OctalDigit.

B.1.2 String Literals

The syntax and semantics of 7.8.4 is extended as follows except that this extension is not allowed for strict mode code:

Syntax

EscapeSequence ::
  CharacterEscapeSequence
  OctalEscapeSequence
  HexEscapeSequence
  UnicodeEscapeSequence

OctalEscapeSequence ::
  OctalDigit [lookahead ≠ DecimalDigit]
  ZeroToThree OctalDigit [lookahead ≠ DecimalDigit]
  FourToSeven OctalDigit
  ZeroToThree OctalDigit OctalDigit

ZeroToThree :: one of
  0 1 2 3
FourToSeven :: one of
4 5 6 7

Static Semantics

- The CV of EscapeSequence :: OctalEscapeSequence is the CV of the OctalEscapeSequence.
- The CV of OctalEscapeSequence :: OctalDigit [lookahead = DecimalDigit] is the character whose code unit value is the MV of the OctalDigit.
- The CV of OctalEscapeSequence :: ZeroToThree OctalDigit [lookahead = DecimalDigit] is the character whose code unit value is (8 times the MV of the ZeroToThree) plus the MV of the OctalDigit.
- The CV of OctalEscapeSequence :: FourToSeven OctalDigit [lookahead = DecimalDigit] is the character whose code unit value is (8 times the MV of the FourToSeven) plus the MV of the OctalDigit.
- The CV of OctalEscapeSequence :: ZeroToThree OctalDigit OctalDigit is the character whose code unit value is (64 (that is, 8²) times the MV of the ZeroToThree) plus (8 times the MV of the first OctalDigit) plus the MV of the second OctalDigit.
- The MV of ZeroToThree :: 0 is 0.
- The MV of ZeroToThree :: 1 is 1.
- The MV of ZeroToThree :: 2 is 2.
- The MV of ZeroToThree :: 3 is 3.
- The MV of FourToSeven :: 4 is 4.
- The MV of FourToSeven :: 5 is 5.
- The MV of FourToSeven :: 6 is 6.
- The MV of FourToSeven :: 7 is 7.

B.1.3 HTML-like Comments

TODO See http://javascript.spec.whatwg.org/#comment-syntax

B.2 Additional Properties

When the ECMAScript host is a web browser the following additional properties of the standard built-in objects are defined.

B.2.1 Additional Properties of the Global Object

B.2.1.1 escape (string)

The escape function is a property of the global object. It computes a new version of a String value in which certain characters have been replaced by a hexadecimal escape sequence.

For those characters being replaced whose code unit value is 0xFF or less, a two-digit escape sequence of the form %xx is used. For those characters being replaced whose code unit value is greater than 0xFF, a four-digit escape sequence of the form %uxxxx is used.

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

1. Call ToString(string).
2. Compute the number of characters in Result(1).
3. Let R be the empty string.
4. Let k be 0.
5. If k equals Result(2), return R.
6. Get the character (represented as a 16-bit unsigned integer) at position k within Result(1).
7. If Result(6) is one of the 69 nonblank characters
   "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789@*_+-./"
   then go to step 13.
8. If Result(6) is less than 256, go to step 11.
9. Let \( S \) be a String containing six characters "%uwxzy" where \( wxyz \) are four hexadecimal digits encoding the value of Result(6).
11. Let \( S \) be a String containing three characters "%xy" where \( xy \) are two hexadecimal digits encoding the value of Result(6).
13. Let \( S \) be a String containing the single character Result(6).
14. Let \( R \) be a new String value computed by concatenating the previous value of \( R \) and \( S \).
15. Increase \( k \) by 1.
16. Go to step 5.

NOTE: The encoding is partly based on the encoding described in RFC 1738, but the entire encoding specified in this standard is described above without regard to the contents of RFC 1738. This encoding does not reflect changes to RFC 1738 made by RFC 3986.

B.2.1.2 unescape (string)

The \texttt{unescape} function is a property of the global object. It computes a new version of a String value in which each escape sequence of the sort that might be introduced by the \texttt{escape} function is replaced with the character that it represents.

When the \texttt{unescape} function is called with one argument \texttt{string}, the following steps are taken:

1. Call \texttt{ToString\(\text{string}\).}
2. Compute the number of characters in Result(1).
3. Let \( R \) be the empty String.
4. Let \( k \) be 0.
5. If \( k \) equals Result(2), return \( R \).
6. Let \( c \) be the character at position \( k \) within Result(1).
7. If \( c \) is not \%, go to step 18.
8. If \( k \) is greater than Result(2)\(\text{–}6\), go to step 14.
9. If the character at position \( k+1 \) within Result(1) is not u, go to step 14.
10. If the four characters at positions \( k+2, k+3, k+4, \) and \( k+5 \) within Result(1) are not all hexadecimal digits, go to step 14.
11. Let \( c \) be the character whose code unit value is the integer represented by the four hexadecimal digits at positions \( k+2, k+3, k+4, \) and \( k+5 \) within Result(1).
12. Increase \( k \) by 5.
14. If \( k \) is greater than Result(2)\(\text{–}3\), go to step 18.
15. If the two characters at positions \( k+1 \) and \( k+2 \) within Result(1) are not both hexadecimal digits, go to step 18.
16. Let \( c \) be the character whose code unit value is the integer represented by two zeroes plus the two hexadecimal digits at positions \( k+1 \) and \( k+2 \) within Result(1).
17. Increase \( k \) by 2.
18. Let \( R \) be a new String value computed by concatenating the previous value of \( R \) and \( c \).
19. Increase \( k \) by 1.
20. Go to step 5.

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

\textbf{get Object.prototype.__proto__}

The value of the [[Get]] attribute is a built-in function that requires no arguments. It performs the following steps:
1. Let $O$ be the this value.
2. If `Type(O)` is not Object, then throw a `TypeError` exception.
3. Return the result of calling the `[[GetInheritance]]` internal method of $O$.

```javascript
set Object.prototype.__proto__
```

The value of the `[[Set]]` attribute is a built-in function that takes an argument `proto`. It performs the following steps:

1. Let $O$ be the this value.
2. If `Type(O)` is not Object, then throw a `TypeError` exception.
3. If `Type(proto)` is neither Object or Null, then throw a `TypeError` exception.
4. Let `status` be the result of calling the `[[SetInheritance]]` internal method of $O$ with argument `proto`.
5. ReturnIfAbrupt(`status`).
6. If `status` is false, then throw a `TypeError` exception.
7. Return `proto`.

### B.2.3 Additional Properties of the `String.prototype` Object

#### B.2.3.1 `String.prototype.substr` (start, length)

The `substr` method takes two arguments, `start` and `length`, and returns a substring of the result of converting the this object to a String, starting from character position `start` and running for `length` characters (or through the end of the String if `length` is `undefined`). If `start` is negative, it is treated as `(sourceLength+start)` where `sourceLength` is the length of the String. The result is a String value, not a String object. The following steps are taken:

1. Let $O$ be `CheckObjectCoercible(this value)`.
2. Let $S$ be `ToString(O)`.
3. Let `intStart` be `ToInteger(start)`.
4. ReturnIfAbrupt(`intStart`).
5. If `length` is `undefined`, let `end` be `$\infty$`; otherwise let `end` be `ToInteger(length)`.
6. ReturnIfAbrupt(`end`).
7. Let `size` be the number of characters in $S$.
8. If `intStart` is negative, then let `intStart` be `max(size + intStart,0)`.
9. Let `resultLength` be `min(max(end,0), size - intStart)`.
10. If `resultLength` ≤ 0, return the empty String `""`.
11. Return a String containing `resultLength` consecutive characters from $S$ beginning with the character at position `start`.  

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

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

#### B.2.3.2 `String.prototype.anchor` (name)

When the `anchor` method is called with argument `name`, the following steps are taken:

1. Let $S$ be the this value.
2. Return the result of performing the abstract operation `CreateHTML` with arguments $S$, "<" and `name`.

The abstract operation `CreateHTML` is called with arguments `string`, `tag`, `attribute`, and `value`. The arguments `tag` and `attribute` must be string values. The following steps are taken:

1. Let `str` be `CheckObjectCoercible(string)`.
2. Let $S$ be `ToString(str)`.
3. ReturnIfAbrupt($S$).
4. Let `p` be the string value that is the concatenation of "<" and `tag`.  

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5. If `attribute` is not the empty String, then
   a. Let `V` be the result of performing `ToString(value)`.
   b. ReturnIfAbrupt(`V`).
   c. Let `escapedV` be the string value that is the same as `V` except that each occurrence of the character " (code unit value 0x0022) in `V` has been replaced with the six character sequence "\'\"\"."
   d. Let `p1` be the string value that is the concatenation of
      • `p1`
      • a single space code unit 0x0020
      • `attribute`
      • `\"\``
      • `\"\`
      • `escapedV`
      • `\"\`
   6. Let `p2` be the string value that is the concatenation of `p1` and "\".
   7. Let `p3` be the string value that is the concatenation of `p2` and `S`.
   8. Let `p4` be the string value that is the concatenation of `p3`, "\<\/>`, `tag`, and "\>".
   9. Return `p4`

B.2.3.3 String.prototype.big()

When the `big` method is called with no arguments, the following steps are taken:
1. Let `S` be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments `S`, "\b\"", "\" and "\"."

B.2.3.4 String.prototype.blink()

When the `blink` method is called with no arguments, the following steps are taken:
1. Let `S` be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments `S`, "\b\n\", "\" and "\"."

B.2.3.5 String.prototype.bold()

When the `bold` method is called with no arguments, the following steps are taken:
1. Let `S` be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments `S`, "\b\", "\" and "\"."

B.2.3.6 String.prototype.fixed()

When the `fixed` method is called with no arguments, the following steps are taken:
1. Let `S` be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments `S`, "\tt\", "\" and "\"."

B.2.3.7 String.prototype.fontcolor ( color )

When the `fontcolor` method is called with argument `color`, the following steps are taken:
1. Let `S` be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments `S`, "\font\", "\color" and `color`.

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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\font"", "\size" and "\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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\i"", "\"" and "\"".

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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\a"", "\href" and 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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\small"", "\"" and "\"".

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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\strike"", "\"" and "\"".

B.2.3.13 String.prototype.sub ()

When the sub method is called with no arguments, the following steps are taken:

1. Let \( S \) be the this value.
2. Return the result of performing the abstract operation CreateHTML with arguments \( S \), "\sub"", "\"" and "\"".

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 the result of performing the abstract operation CreateHTML with arguments \( S \), "\sup"", "\"" and "\"".

B.2.4 Additional Properties of the Date.prototype Object

B.2.4.1 Date.prototype.getYear ()

NOTE The getFullYear method is preferred for nearly all purposes, because it avoids the "year 2000 problem."

When the getYear method is called with no arguments, the following steps are taken:

1. Let \( t \) be this time value.
2. ReturnIfAbrupt(t).
3. If \( t \) is NaN, return NaN.
4. Return YearFromTime(LocalTime(\( t \)) − 1900).

### B.2.4.2 Date.prototype.setYear (year)

**NOTE** The setFullYear method is preferred for nearly all purposes, because it avoids the “year 2000 problem.”

When the setYear method is called with one argument \( y \), the following steps are taken:

1. Let \( t \) be the result of LocalTime(this time value); but if this \( t \) time value is NaN, let \( t \) be +0.
2. Let \( y \) be ToNumber(\( y \)).
3. If \( y \) is NaN, set the \([\text{DateValue}]\) internal data property of this Date object to NaN and return NaN.
4. If \( y \) is not NaN and 0 ≤ ToInteger(\( y \)) ≤ 99 then let yyyy be ToInteger(\( y \)) + 1900; Otherwise, let yyyy be \( y \).
5. Let \( d \) be MakeDay(yyyy, MonthFromTime(\( t \)), DateFromTime(\( t \))).
6. Let date be UTC(MakeDate(d, TimeWithinDay(\( t \)))).
7. Set the \([\text{DateValue}]\) internal data property of this Date object to TimeClip(date).
8. Return the value of the \([\text{DateValue}]\) internal data property 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 no arguments, the following steps are taken:

1. Let \( O \) be the this value.
2. If Type(\( O \)) is not Object or Type(\( O \)) is Object and \( O \) does not have a \([\text{RegExpMatcher}]\) internal data property, then
   a. Throw a TypeError exception.
3. Let extensible be the result of calling the \([\text{IsExtensible}]\) internal method of \( O \).
4. If extensible is false, then throw a TypeError exception.
5. If Type(pattern) is Object and pattern has a \([\text{RegExpMatcher}]\) internal data property, then
   a. If the value of pattern’s \([\text{RegExpMatcher}]\) internal data property is undefined, then throw a TypeError exception.
   b. If flags is not undefined, then throw a TypeError exception.
   c. Let \( P \) be the value of pattern’s \([\text{OriginalSource}]\) internal data property.
   d. Let \( F \) be the value of pattern’s \([\text{OriginalFlags}]\) internal data property.
5. Else,
   a. let \( P \) be pattern.
   b. let \( F \) be flags.
6. Return the result of the abstract operation RegExpInitialize with arguments obj, \( P \), and \( F \).

**NOTE** The compile method completely reinitialized the this object RegExp with a new pattern and flags. An implementaton may interpret use of this method as an assertion that the resulting RegExp object will be used multiple times and hence is a candidate for extra optimization.

### B.3 Other Additional Features

#### B.3.1 __proto__ Property Names in Object Initialisers

In 11.1.5 the Property Definition Evaluation algorithm for the production PropertyDefinition : PropertyName : AssignmentExpression is replaced with the following:
PropertyDefinition : PropertyName : AssignmentExpression

1. Let propName be PropName of PropertyName.
2. Let exprValue be the result of evaluating AssignmentExpression.
3. Let propValue be GetValue(exprValue).
4. ReturnIfAbrupt(propValue).
5. If propName is the string value "__proto__", then
   a. If Type(v) is neither Object or Null, then throw a TypeError exception.
   b. Return the result of calling the [[SetInheritance]] internal method of object with argument propValue.
6. Let desc be the Property Descriptor{[Value]: propValue, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true}
7. Return the result of DefinePropertyOrThrow(object, propName desc).

B.3.2 Web Legacy Compatibility for Block-Level Function Declarations

Prior to the Sixth Edition, the ECMA-Script specification did not define the occurrence of a FunctionDeclaration as an element of a Block statement's StatementList. However, support for that form of FunctionDeclaration was an allowable extension and most browser-hosted ECMAScript implementations permitted them. However, the semantics of such declarations differ among those implementations. Because of these semantic differences, existing web ECMAScript code that uses Block level function declarations is only portable among browser implementations if the usage only depends upon the semantic intersection of all of the browser implementations for such declarations. The following are the use cases that fall within that intersection semantics:

1. A function is declared and only referenced within a single block
   - A function declaration with the name $f$ is declared exactly once within the function code of an enclosing function $g$ and that declaration is nested within a Block.
   - No other declaration of $f$ that is not a var declaration occurs within the function code of $g$
   - All references to $f$ occur within the StatementList of the Block containing the declaration of $f$.

2. A function is declared and possibly used within a single Block but also referenced by an inner function definition that is not contained within that same Block.
   - A function declaration with the name $f$ is declared exactly once within the function code of an enclosing function $g$ and that declaration is nested within a Block.
   - No other declaration of $f$ that is not a var declaration occurs within the function code of $g$
   - References to $f$ may occur within the StatementList of the Block containing the declaration of $f$.
   - References to $f$ occur within the function code of $g$ that lexically follows the Block containing the declaration of $f$.

3. A function is declared and possibly used within a single block but also referenced within subsequent blocks.
   - A function declaration with the name $f$ is declared exactly once within the function code of an enclosing function $g$ and that declaration is nested within a Block.
   - No other declaration of $f$ that is not a var declaration occurs within the function code of $g$
   - References to $f$ may occur within the StatementList of the Block containing the declaration of $f$.
   - References to $f$ occur within another function $h$ that is nested within $g$ and no other declaration of $f$ shadows the references to $f$ from within $h$.
   - All invocations of $h$ occur after the declaration of $f$ has been evaluated.

The first use case is interoperable with the inclusion of Block level function declarations in the sixth edition. Any pre-existing ECMAScript code that employees that use case will operate using the Block level function declarations semantics defined by clauses 10 and 13 of this specification.

Sixth edition interoperability for the second and third use cases requires the following extensions to the clauses 10 and 13 semantics. These extensions are applied to a non-strict mode functions $g$ if the above pre-conditions of use cases 2 and 3 above exist at the time of static semantic analysis of $g$. However, the last pre-condition of use case 3 is not included in this determination and the determination is not applied to any
function declaration that is nested within syntactic constructs that are specified in the Fifth edition of this specification.

1. Let $B$ be environment record for the construct within $g$ that introduces a new environment contour and which most closely encloses the declaration of $f$, all function code references to $f$, and the definitions of all nested functions that contain unshadowed references to $f$. This syntactic construct may be the definition of $g$ itself, in which case $B$ is the function environment record for $g$.

2. As part of the instantiation of $B$, its CreateMutableBinding concrete method is called with arguments "f" (the string name of the function) and false. This creates an uninitialised binding for the name $f$. Any reference that resolves to that binding prior to step 3 below will throw a ReferenceError exception.

3. When the InitialiseBinding concrete method is used to initialise the binding for the function declaration $f$ also invoke InitializeBind on $B$ using the same arguments.

If an ECMAScript implication has a mechanism that produces diagnostic warning messages, a warning should be produced for each function $g$ for which the above steps are performed.
Annex C
(informative)

The Strict Mode of ECMAScript

The strict mode restriction and exceptions

- The identifiers "implements", "interface", "let", "package", "private", "protected", "public", "static", and "yield" are classified as FutureReservedWord tokens within strict mode code. (7.6.1.2).
- A conforming implementation, when processing strict mode code, may not extend the syntax of NumericLiteral (7.8.3) to include OctalIntegerLiteral as described in B.1.1.
- A conforming implementation, when processing strict mode code (see 10.1.1), may not extend the syntax of EscapeSequence to include OctalEscapeSequence as described in B.1.2.
- Assignment to an undeclared identifier or otherwise unresolvable reference does not create a property in the global object. When a simple assignment occurs within strict mode code, its LeftHandSide must not evaluate to an unresolvable Reference. If it does a ReferenceError exception is thrown (8.9.2). The LeftHandSide also may not be a reference to a data property with the attribute value {[[Writable]]:false}, to an accessor property with the attribute value {[[Set]]:undefined}, nor to a non-existent property of an object whose [[Extensible]] internal data property has the value false. In these cases a TypeError exception is thrown (11.13.1).
- The identifier eval or arguments may not appear as the LeftHandSideExpression of an Assignment operator (11.13) or of a PostfixExpression (11.3) or as the UnaryExpression operated upon by a Prefix Increment (11.4.4) or a Prefix Decrement (11.4.5) operator.
- Arguments objects for strict mode functions define non-configurable accessor properties named "caller" and "callee" which throw a TypeError exception on access (10.6).
- Arguments objects for strict mode functions do not dynamically share their array indexed property values with the corresponding formal parameter bindings of their functions. (10.6).
- For strict mode functions, if an arguments object is created the binding of the local identifier arguments to the arguments object is immutable and hence may not be the target of an assignment expression. (10.5).
- It is a SyntaxError if strict mode code contains an ObjectLiteral with more than one definition of any data property (11.1.5).
- It is a SyntaxError if the Identifier "eval" or the Identifier "arguments" occurs as the Identifier in a PropertySetParameterList of a PropertyDefinition that is contained in strict code or if its FunctionBody is strict code (11.1.5).
- Strict mode eval code cannot instantiate variables or functions in the variable environment of the caller to eval. Instead, a new variable environment is created and that environment is used for declaration binding instantiation for the eval code (10.4.2).
- If this is evaluated within strict mode code, then the this value is not coerced to an object. A this value of null or undefined is not converted to the global object and primitive values are not converted to wrapper objects. The this value passed via a function call (including calls made using Function.prototype.apply and Function.prototype.call) do not coerce the passed this value to an object (10.4.3, 11.1.1, 15.3.3.3, 15.3.3.4).
- When a delete operator occurs within strict mode code, a SyntaxError is thrown if its UnaryExpression is a direct reference to a variable, function argument, or function name(11.4.1).
- When a `delete` operator occurs within strict mode code, a `TypeError` is thrown if the property to be deleted has the attribute `[[Configurable]]: false` (11.4.1).
- It is a `SyntaxError` if a `VariableDeclaration` or `VariableDeclarationNoIn` occurs within strict code and its `Identifier` is `eval` or `arguments` (12.2.1).
- Strict mode code may not include a `WithStatement`. The occurrence of a `WithStatement` in such a context is an `SyntaxError` (12.10).
- It is a `SyntaxError` if a `TryStatement` with a `Catch` occurs within strict code and the `Identifier` of the `Catch` production is `eval` or `arguments` (12.14.1).
- It is a `SyntaxError` if the identifier `eval` or `arguments` appears within the `FormalParameters` of a strict mode `FunctionDeclaration` or `FunctionExpression` (13.1).
- A strict mode function may not have two or more formal parameters that have the same name. An attempt to create such a function using a `FunctionDeclaration`, `FunctionExpression`, or `Function` constructor is a `SyntaxError` (13.1, 15.3.1).
- An implementation may not extend, beyond that defined in this specification, the meanings within strict mode functions of properties named `caller` or `arguments` of function instances. ECMAScript code may not create or modify properties with these names on function objects that correspond to strict mode functions (8.3, 16.6, 10.6, 15.3.3.5.3).
- It is a `SyntaxError` to use within strict mode code the identifiers `eval` or `arguments` as the `Identifier` of a `FunctionDeclaration` or `FunctionExpression` or as a formal parameter name (13.1). Attempting to dynamically define such a strict mode function using the `Function` constructor (15.3.1) will throw a `SyntaxError` exception.
Annex D
(informative)
Corrections and Clarifications with Possible Compatibility Impact

In Edition 6

15.9.1.14: Previous editions permitted the TimeClip abstract operation to return either +0 or −0 as the representation of a 0 time value. The 6th Edition specifies that +0 always returned. This means that for the 6th Edition the time value of a Date object is never observably −0 and methods that return time values never return −0.

15.9.1.15: If a time zone offset is not present, the local time zone is used. Edition 5.1 incorrectly stated that a missing time zone should be interpreted as "z".

15.9.5.2: Previous editions did not specify the value returned by Date.prototype.toString when this time value is NaN. The 6th Edition specifies the result to be the String value is "Invalid Date"

In Edition 5.1

7.8.4: CV definitions added for DoubleStringCharacter :: LineContinuation and SingleStringCharacter :: LineContinuation.

10.2.1.1.3: The argument S is not ignored. It controls whether an exception is thrown when attempting to set an immutable binding.

10.2.1.2.2: In algorithm step 5, true is passed as the last argument to [[DefineOwnProperty]].

10.5: Former algorithm step 5.e is now 5.f and a new step 5.e was added to restore compatibility with 3rd Edition when redefining global functions.

11.5.3: In the final bullet item, use of IEEE 754 round-to-nearest mode is specified.

12.6.3: Missing ToBoolean restored in step 3.a.ii of both algorithms.

12.6.4: Additional final sentences in each of the last two paragraphs clarify certain property enumeration requirements.

12.7, 12.8, 12.9: BNF modified to clarify that a continue or break statement without an Identifier or a return statement without an Expression may have a LineTerminator before the semi-colon.

12.14: Step 3 of algorithm 1 and step 2.a of algorithm 3 are corrected such that the value field of B is passed as a parameter rather than B itself.

15.1.2.2: In step 2 of algorithm, clarify that S may be the empty string.

15.1.2.3: In step 2 of algorithm clarify that trimmedString may be the empty string.

15.1.3: Added notes clarifying that ECMAScript’s URI syntax is based upon RFC 2396 and not the newer RFC 3986. In the algorithm for Decode, a step was removed that immediately preceded the current step 4.d.vii.10.a because it tested for a condition that cannot occur.

15.2.3.7: Corrected use of variable P in steps 5 and 6 of algorithm.
15.2.4.2: Edition 5 handling of `undefined` and `null` as this value caused existing code to fail. Specification modified to maintain compatibility with such code. New steps 1 and 2 added to the algorithm.

15.3.3.3: Steps 5 and 7 of Edition 5 algorithm have been deleted because they imposed requirements upon the `argArray` argument that are inconsistent with other uses of generic array-like objects.

15.4.3.12: In step 9.a, incorrect reference to `relativeStart` was replaced with a reference to `actualStart`.

15.4.3.15: Clarified that the default value for `fromIndex` is the length minus 1 of the array.

15.4.3.18: In step 9 of the algorithm, `undefined` is now the specified return value.

15.4.3.22: In step 9.c.i.ii the first argument to the `[[Call]]` internal method has been changed to `undefined` for consistency with the definition of `Array.prototype.reduce`.

15.4.5.1: In Algorithm steps 3.i.ii and 3.i.iii the variable name was inverted resulting in an incorrectly inverted test.

15.5.4.9: Normative requirement concerning canonically equivalent strings deleted from paragraph following algorithm because it is listed as a recommendation in NOTE 2.

15.5.4.14: In `split` algorithm step 11.a and 13.a, the positional order of the arguments to `SplitMatch` was corrected to match the actual parameter signature of `SplitMatch`. In step 13.a.iii, `lengthA` replaces `A.length`.

15.5.5.2: In first paragraph, removed the implication that the individual character property access had "array index" semantics. Modified algorithm steps 3 and 5 such that they do not enforce "array index" requirement.

15.9.1.15: Specified legal value ranges for fields that lacked them. Eliminated "time-only" formats. Specified default values for all optional fields.

15.10.2.2: The step numbers of the algorithm for the internal closure produced by step 2 were incorrectly numbered in a manner that implied that they were steps of the outer algorithm.

15.10.2.6: In the abstract operation `IsWordChar` the first character in the list in step 3 is "a" rather than "A".

15.10.2.8: In the algorithm for the closure returned by the abstract operation `CharacterSetMatcher`, the variable defined by step 3 and passed as an argument in step 4 was renamed to `ch` in order to avoid a name conflict with a formal parameter of the closure.

15.10.6.2: Step 9.e was deleted because it performed an extra increment of `i`.

15.11.1.1: Removed requirement that the `message` own property is set to the empty String when the `message` argument is `undefined`.

15.11.1.2: Removed requirement that the `message` own property is set to the empty String when the `message` argument is `undefined`.

15.11.4.4: Steps 6-10 modified/added to correctly deal with missing or empty `message` property value.

15.12.3: In step 10.b.iii of the `$A` abstract operation, the last element of the concatenation is "\".

B.2.1: Added to NOTE that the encoding is based upon RFC 1738 rather than the newer RFC 3986.

Annex C: An item was added corresponding to 7.6.12 regarding `FutureReservedWords` in strict mode.
In Edition 5

Throughout: In the Edition 3 specification the meaning of phrases such as “as if by the expression `new Array()`” are subject to misinterpretation. In the Edition 5 specification text for all internal references and invocations of standard built-in objects and methods has been clarified by making it explicit that the intent is that the actual built-in object is to be used rather than the current dynamically resolved value of the correspondingly identifier binding.

11.8.1: ECMAScript generally uses a left to right evaluation order, however the Edition 3 specification language for the `>` and `<<` operators resulted in a partial right to left order. The specification has been corrected for these operators such that it now specifies a full left to right evaluation order. However, this change of order is potentially observable if side-effects occur during the evaluation process.

11.1.4: Edition 5 clarifies the fact that a trailing comma at the end of an `ArrayInitialiser` does not add to the length of the array. This is not a semantic change from Edition 3 but some implementations may have previously misinterpreted this.

11.2.3: Edition 5 reverses the order of steps 2 and 3 of the algorithm. The original order as specified in Editions 1 through 3 was incorrectly specified such that side-effects of evaluating `Arguments` could affect the result of evaluating `MemberExpression`.

12.4: In Edition 3, an object is created, as if by `new Object()` to serve as the scope for resolving the name of the exception parameter passed to a `catch` clause of a `try` statement. If the actual exception object is a function and it is called from within the `catch` clause, the scope object will be passed as the `this` value of the call. The body of the function can then define new properties on its `this` value and those property names become visible identifiers bindings within the scope of the `catch` clause after the function returns. In Edition 5, when an exception parameter is called as a function, `undefined` is passed as the `this` value.

13: In Edition 3, the algorithm for the production `FunctionExpression` with an `Identifier` adds an object created as if by `new Object()` to the scope chain to serve as a scope for looking up the name of the function. The identifier resolution rules (10.1.4 in Edition 3) when applied to such an object will, if necessary, follow the object’s prototype chain when attempting to resolve an identifier. This means all the properties of `Object.prototype` are visible as identifiers within that scope. In practice most implementations of Edition 3 have not implemented this semantics. Edition 5 changes the specified semantics by using a Declarative Environment Record to bind the name of the function.

14: In Edition 3, the algorithm for the production `SourceElements : SourceElements SourceElement` did not correctly propagate statement result values in the same manner as `Block`. This could result in the `eval` function producing an incorrect result when evaluating a `Program` text. In practice most implementations of Edition 3 have implemented the correct propagation rather than what was specified in Edition 5.

15.10.6: RegExp.prototype is now a RegExp object rather than an instance of Object. The value of its `[[Class]]` internal data property which is observable using `Object.prototype.toString` is now “RegExp” rather than “Object”.
Annex E
(informative)

Additions and Changes that Introduce Incompatibilities with Prior Editions

In the 6th Edition

12.6: In Edition 6, a terminating semi-colon is no longer required at the end of a do-while statement.

12.14: In Edition 6, it is an early error for a Catch clause to contained a var declaration for the same Identifier that appears as the Catch clause parameter. In previous editions, such a variable declaration would be instantiated in the enclosing variable environment but the declaration’s Initializer value would be assigned to the Catch parameter.

13.3 In Edition 6, the function objects that are created as the values of the [[Get]] or [[Set]] attribute of accessor properties in an ObjectLiteral are not constructor functions. In Edition 5, they were constructors.

15.2.3.5 and 15.2.3.7: In Edition 6, all property additions and changes are processed, even if one of them throws an exception. If an exception occurs during such processing, the first such exception is thrown after all propertie are processed. In Edition 5, proceeding of property additions and changes immediately terminated when the first exception occurred.

15.5.4 In Edition 6, the Array prototype object is not a Array instance. In previous editions it was an Array instance with a length property whose value was +0.

15.5.4 In Edition 6, the String prototype object is not a String instance. In previous editions it was a String instance whose String value was the empty string.

15.6.4 In Edition 6, the Boolean prototype object is not a Boolean instance. In previous editions it was a Boolean instance whose Boolean value was false.

15.7.4 In Edition 6, the Number prototype object is not a Number instance. In previous editions it was a Number instance whose number value was +0.

15.9.5 In Edition 6, the Date prototype object is not a Date instance. In previous editions it was a Date instance whose TimeValue was NaN.

15.10.6 In Edition 6, the RegExp prototype object is not a RegExp instance. In previous editions it was a RegExp instance whose pattern is the empty string.

15.10.7 In Edition 6, source, global, ignoreCase, and multiline are accessor properties defined on the RegExp prototype object. In previous editions they were data properties defined on RegExp instances.

In the 5th Edition

7.1: Unicode format control characters are no longer stripped from ECMAScript source text before processing. In Edition 5, if such a character appears in a StringLiteral or RegularExpressionLiteral the character will be incorporated into the literal where in Edition 3 the character would not be incorporated into the literal.

7.2: Unicode character <BOM> is now treated as whitespace and its presence in the middle of what appears to be an identifier could result in a syntax error which would not have occurred in Edition 3

7.3: Line terminator characters that are preceded by an escape sequence are now allowed within a string literal token. In Edition 3 a syntax error would have been produced.
7.8.5: Regular expression literals now return a unique object each time the literal is evaluated. This change is detectable by any programs that test the object identity of such literal values or that are sensitive to the shared side effects.

7.8.5: Edition 5 requires early reporting of any possible RegExp constructor errors that would be produced when converting a `RegularExpressionLiteral` to a RegExp object. Prior to Edition 5 implementations were permitted to defer the reporting of such errors until the actual execution time creation of the object.

7.8.5: In Edition 5 unescaped `/` characters may appear as a `CharacterClass` in a regular expression literal. In Edition 3 such a character would have been interpreted as the final character of the literal.

10.4.2: In Edition 5, indirect calls to the `eval` function use the global environment as both the variable environment and lexical environment for the eval code. In Edition 3, the variable and lexical environments of the caller of an indirect `eval` were used as the environments for the eval code.

15.4.3: In Edition 5 all methods of `Array.prototype` are intentionally generic. In Edition 3 `toString` and `toLocaleString` were not generic and would throw a `TypeError` exception if applied to objects that were not instances of Array.

10.6: In Edition 5 the array indexed properties of argument objects that correspond to actual formal parameters are enumerable. In Edition 3, such properties were not enumerable.

10.6: In Edition 5 the value of the `[[Class]]` internal data property of an arguments object is "Arguments". In Edition 3, it was "Object". This is observable if `toString` is called as a method of an arguments object.

12.6.4: for-in statements no longer throw a `TypeError` if the in expression evaluates to null or `undefined`. Instead, the statement behaves as if the value of the expression was an object with no enumerable properties.

15: In Edition 5, the following new properties are defined on built-in objects that exist in Edition 3: `Object.getOwnPropertyDescriptor`, `Object.getOwnPropertyNames`, `Object.create`, `Object.defineProperty`, `Object.getPrototypeOf`, `Object.preventExtensions`, `Object.isExtensible`, `Object.isSealed`, `Object.isFrozen`, `Array.prototype.lastIndexOf`, `Array.prototype.every`, `Array.prototype.some`, `Array.prototype.map`, `Array.prototype.filter`, `Array.prototype.reduce`, `Array.prototype.reduceRight`, `String.prototype.trim`, `Date.prototype.toISOString`, `Date.prototype.toJSON`.

15: Implementations are now required to ignore extra arguments to standard built-in methods unless otherwise explicitly specified. In Edition 3 the handling of extra arguments was unspecified and implementations were explicitly allowed to throw a `TypeError` exception.

15.1.1: The value properties `NaN`, `Infinity`, and `undefined` of the Global Object have been changed to be read-only properties.

15.1.2.1: Implementations are no longer permitted to restrict the use of eval in ways that are not a direct call. In addition, any invocation of eval that is not a direct call uses the global environment as its variable environment rather than the caller’s variable environment.

15.1.2.2: The specification of the function `parseFloat` no longer allows implementations to treat Strings beginning with a 0 character as octal values.

15.3.3.3: In Edition 3, a `TypeError` is thrown if the second argument passed to `Function.prototype.apply` is neither an array object nor an arguments object. In Edition 5, the second argument may be any kind of generic array-like object that has a valid length property.

15.3.3.3, 15.3.3.4: In Edition 3 passing `undefined` or `null` as the first argument to either `Function.prototype.apply` or `Function.prototype.call` causes the global object to be passed to
the indirectly invoked target function as the this value. If the first argument is a primitive value the result of calling ToObject on the primitive value is passed as the this value. In Edition 5, these transformations are not performed and the actual first argument value is passed as the this value. This difference will normally be unobservable to existing ECMAScript Edition 3 code because a corresponding transformation takes place upon activation of the target function. However, depending upon the implementation, this difference may be observable by host object functions called using apply or call. In addition, invoking a standard built-in function in this manner with null or undefined passed as the this value will in many cases cause behaviour in Edition 5 implementations that differ from Edition 3 behaviour. In particular, in Edition 5 built-in functions that are specified to actually use the passed this value as an object typically throw a TypeError exception if passed null or undefined as the this value.

15.3.4.2: In Edition 5, the prototype property of Function instances is not enumerable. In Edition 3, this property was enumerable.

15.5.5.2: In Edition 5, the individual characters of a String object's [[StringData]] may be accessed as array indexed properties of the String object. These properties are non-writable and non-configurable and shadow any inherited properties with the same names. In Edition 3, these properties did not exist and ECMAScript code could dynamically add and remove writable properties with such names and could access inherited properties with such names.

15.9.4.2: Date.parse is now required to first attempt to parse its argument as an ISO format string. Programs that use this format but depended upon implementation specific behaviour (including failure) may behave differently.

15.10.2.12: In Edition 5, \s now additionally matches <BOM>.

15.10.4.1: In Edition 3, the exact form of the String value of the source property of an object created by the RegExp constructor is implementation defined. In Edition 5, the String must conform to certain specified requirements and hence may be different from that produced by an Edition 3 implementation.

15.10.6.4: In Edition 3, the result of RegExp.prototype.toString need not be derived from the value of the RegExp object's source property. In Edition 5 the result must be derived from the source property in a specified manner and hence may be different from the result produced by an Edition 3 implementation.

15.11.2.1, 15.11.4.3: In Edition 5, if an initial value for the message property of an Error object is not specified via the Error constructor the initial value of the property is the empty String. In Edition 3, such an initial value is implementation defined.

15.11.4.4: In Edition 3, the result of Error.prototype.toString is implementation defined. In Edition 5, the result is fully specified and hence may differ from some Edition 3 implementations.

15.12: In Edition 5, the name JSON is defined in the global environment. In Edition 3, testing for the presence of that name will show it to be undefined unless it is defined by the program or implementation.
# Annex F

(informative)

## Static Semantic Rule Cross Reference

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Purpose</th>
<th>Definitions</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>BoundNames</td>
<td>Produces a list of the Identifiers bound by a production. Does not include Identifiers that are bound within inner environments associated with the production.</td>
<td>12.2.1, 12.2.2, 12.2.4, 12.5.4, 13.1, 13.3, 13.5</td>
<td></td>
</tr>
<tr>
<td>ConstructorMethod</td>
<td>From a ClassBody return the first ClassElement whose PropName is &quot;constructor&quot;. Returns empty if the ClassBody does not contain one.</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>Contains</td>
<td>Determine if a grammar production either directly or indirectly includes a grammar symbol.</td>
<td>5.3, 13.1, 13.2, 13.5</td>
<td></td>
</tr>
<tr>
<td>CoveredFormalsList</td>
<td>Reparse a covered Expression using FormalsList as the goal symbol.</td>
<td>13.2</td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td>Determines the &quot;character value&quot; of a component of a StringLiteral.</td>
<td>7.8.4</td>
<td></td>
</tr>
<tr>
<td>Elision Width</td>
<td>Determine the number of commas in an Elision.</td>
<td>11.1.4.1</td>
<td></td>
</tr>
<tr>
<td>ExpectedArgumentCount</td>
<td>Determine the &quot;length&quot; of an argument list for the purpose of initializing the &quot;length&quot; property of a function object.</td>
<td>13.1, 13.2, 13.3</td>
<td></td>
</tr>
<tr>
<td>HasInitialiser</td>
<td>Determines whether the production contains an Initialiser production.</td>
<td>12.2.4, 13.1</td>
<td></td>
</tr>
<tr>
<td>IsConstantDeclaration</td>
<td>Determines whether the production introduces a immutable environment record binding</td>
<td>12.2, 13.1, 13.5</td>
<td></td>
</tr>
<tr>
<td>IsInvalidAssignmentPattern</td>
<td>Determines if a LeftHandSideExpression is a valid assignment target. Primarily for dealing with destructuring assignment targets.</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>LexicalDeclarations</td>
<td>Return a List containing the components of a production that are processed as lexical declarations</td>
<td>12.1, 12.11, 12.5</td>
<td></td>
</tr>
<tr>
<td>LexicallyDeclaredNames</td>
<td>Returns a list of the lexically scoped identifiers declared by a production.</td>
<td>12.1, 13.1, 13.2, 13.5</td>
<td></td>
</tr>
<tr>
<td>PrototypeMethodDefinitions</td>
<td>Return a list of the non-static MethodDefinition productions that are part of a ClassElementList.</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>MV</td>
<td>Determines the &quot;mathematical value&quot; of a numeric</td>
<td>7.8.3</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
<td>References</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Literal or component of a numeric literal.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PropName</td>
<td>Determines the string value of the property name referenced by a production.</td>
<td>11.5.1, 13.3, 13.5</td>
<td></td>
</tr>
<tr>
<td>PropNameList</td>
<td>Returns a List of the string values of the property names referenced by a production. The list reflects the order of the references in the source text. The list may contain duplicate elements.</td>
<td>11.5.1, 13.5</td>
<td></td>
</tr>
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<td>13.5</td>
<td></td>
</tr>
<tr>
<td>ReferencesSuper</td>
<td>Determine if a MethodDefinition contains any references to the ReservedWord <code>super</code>.</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>SpecialMethod</td>
<td>Determine if a MethodDefinition defines a generator method or an accessor property.</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>StaticMethodDefinitions</td>
<td>Return a list of the static MethodDefinition productions that are part of a ClassElementList.</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td>Determines the “string value” of a StringLiteral or component of a StringLiteral.</td>
<td>7.8.4</td>
<td></td>
</tr>
<tr>
<td>VarDeclaredNames</td>
<td>Returns a list of the local top-level scoped identifiers declared by a production. These are identifiers that are scoped as if by a var statement.</td>
<td>12.1, 12.5, 12.6.1, 12.6.2, 12.6.3, 12.6.4, 12.12, 13.1, 13.5</td>
<td></td>
</tr>
</tbody>
</table>
Scrap Heap

A place to temporarily hand on to stuff that’s been deleted

MemberExpression :
  MemberExpression <|
TriangleLiteral

TriangleLiteral :
  SealedArrayLiteral
  SealedObjectLiteral
  FunctionExpression
  ArrowFunction
  ValueLiteral

CallExpression :
  CallExpression <|
TriangleLiteral

15.2.3.15 Object.isObject ( O )

When the isObject function is called with argument O, the following steps are taken:

1. If Type(O) is Object return true.
2. Return false.

15.5.4.25 String.prototype.toArray()

The following steps are taken:

1. Let O be CheckObjectCoercible(this value).
2. Let S be ToString(O).
3. ReturnIfAbrupt(S).
4. Let len be the number of characters in S.
5. Let array be the result of the abstract operation ArrayCreate with argument len.
6. Let n be 0
7. Repeat, while n < len:
   a. Let c be the character at position n in S.
   b. Call the [[DefineOwnProperty]] internal method of array with arguments ToString(n), the
      PropertyDescriptor {[[Value]]: c, [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true},
      and false.
   c. Increment n by 1.
8. Return array.

The length property of the toArray method is 0.

NOTE 1 Returns an Array object with elements corresponding to the characters of this object (converted to a String).

NOTE 2 The toArray function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.
Static Semantics:  TopLevelLexicallyDeclaredNames

OuterStatementList : OuterStatementList OuterItem

1. Let names be TopLevelLexicallyDeclaredNames of OuterStatementList.
2. Append to names the elements of the TopLevelLexicallyDeclaredNames of OuterItem.
3. Return names.

OuterItem : StatementList

1. Return a new empty List.

StatementListItem : Declaration

1. If Declaration is Declaration : FunctionDeclaration, then return a new empty List.
2. Return the BoundNames of Declaration.

8.4.4 Symbol Exotic Objects

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

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

Exotic Symbol objects provide alternative definitions for all of the essential internal methods.

8.4.4.1 [[GetInheritance]] ( )

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

1. Return null.

8.4.4.2 [[SetInheritance]] (V)

When the [[SetInheritance]] internal method of an exotic Symbol object O is called with argument V the following steps are taken:

1. Assert: Either Type(V) is Object or Type(V) is Null.
2. Return false.

8.4.4.3 [[HasIntegrity]] (Level)

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

1. Assert: Level is one of "nonextensible", "sealed", or "frozen".
2. Return true.

8.4.4.4 [[SetIntegrity]] (Level)

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

1. Assert: Level is one of "nonextensible", "sealed", or "frozen".
2. Return true.
8.4.4.5  [[HasOwnProperty]] (P)

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

1. Return false.

8.4.4.6  [[GetOwnProperty]] (P)

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

1. Return undefined.

8.4.4.7  [[DefineOwnProperty]] (P, Desc)

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

1. Return false.

8.4.4.8  [[HasProperty]] (P)

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

1. Return false.

8.4.4.9  [[Get]] (P, Receiver)

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

1. Assert: IsPropertyKey(P) is true.
2. If P is "toString", then
   a. Let ctx be the running execution context.
   b. Let ctxRealm be ctx's Realm component.
   c. Return ctxRealm.[[intrinsic]].%ObjProto_toString %.
3. Return undefined.

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

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

1. Return false.

8.4.4.11  [[Delete]] (P)

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

1. Assert: IsPropertyKey(P) is true.
2. Return true.

8.4.4.12  [[Enumerate]] ()

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

1. Return an Iterator object (reference xxxx) whose next method immediately throws %StopIteration% and forms no other action.

Commented [AWB6245]: TODO
When the `OwnPropertyKeys` internal method of an exotic Symbol object `O` is called the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method immediately throws `%StopIteration%` and forms no other action.

When the `Enumerate` internal method of `O` is called with Boolean arguments `includePrototype` and `onlyEnumerable`, the following steps are taken:

1. Return an Iterator object (reference xxxx) whose next method iterates over all the keys of enumerable property keys of `O`. If `includePrototype` is `false`, then only own properties of `O` are included. If `onlyEnumerable` is `false`, then all properties that do not have private name keys are included. The mechanics and order of enumerating the properties is not specified but must conform to the rules specified below.

Enumerated properties do not include properties whose property key is a private name. Properties of the object being enumerated may be deleted during enumeration. If a property that has not yet been visited during enumeration is deleted, then it will not be visited. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be visited in the active enumeration. A property name must not be visited more than once in any enumeration.

Enumerating the properties of an object includes enumerating properties of its prototype, and the prototype of the prototype, and so on, recursively; but a property of a prototype is not enumerated if it is “shadowed” because some previous object in the prototype chain has a property with the same name. The values of `[[Enumerable]]` attributes are not considered when determining if a property of a prototype object is shadowed by a previous object on the prototype chain.

The following is an informative algorithm that conforms to these rules:

1. Let `obj` be `O`.
2. Let `proto` be the value of the `[[Prototype]]` internal data property of `O`.
3. If `includePrototype` is `false` or `proto` is the value `null`, then
   a. Let `propList` be a new empty List.
   4. Else
      a. Let `propList` be the result of calling the `[[Enumerate]]` internal method of `proto` with arguments `true` and `onlyEnumerable`.
5. For each string `name` that is the property key of an own property of `O`
   a. Let `desc` be the result of calling the `[[OwnProperty]]` internal method of `O` with argument `name`.
   b. If `name` is an element of `propList`, then remove `name` as an element of `propList`.
   c. If `onlyEnumerable` is `false` or `desc.[[Enumerable]]` is `true`, then add `name` as an element of `propList`.
6. Order the elements of `propList` in an implementation defined order.
7. Return `propList`.

This follow version places function body declarations in scope of parameter initializers.

### 9.1.11 ToPositiveInteger

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

1. Let `number` be the result of calling `ToNumber` on the input argument.
2. ReturnIfAbrupt(`number`).
3. If `number` is `NaN`, return `+0`.
4. If `number` is `+∞`, or `-∞`, return `number`.
5. If `number` ≤ 0, return `-0`.
6. Return the result of computing `Math.floor(number)`.

### 10.5.3 Function Declaration Instantiation

**NOTE** When an execution context is established for evaluating function code a new Declarative Environment Record is created and bindings for each formal parameter, and each function level variable, constant, or function declared in the function are instantiated in the environment record. Formal parameters and functions are initialized as part of this process. All other bindings are initialized during execution of the function code.

Function Declaration Instantiation is performed as follows using arguments `func`, `argumentsList`, and `env`, `func` is the function object that for which the execution context is being established. `env` is the declarative environment record in which bindings are to be created.

1. Let `code` be the value of the `[[Code]]` internal property of `func`.
2. Let `strict` be the value of the `[[Strict]]` internal property of `func`.
3. Let `formals` be the value of the `[[FormalParameterList]]` internal property of `func`.
4. Let `parameterNames` be the `BoundNames` of `formals`.
5. Let `varDeclarations` be the `VarScopedDeclarations` of `code`.
6. Let `functionsToInitialize` be an empty list.
7. Let `argumentsObjectNotNeeded` be `false`.
8. For each `d` in `varDeclarations`, in reverse list order do
   a. If `d` is a `FunctionDeclaration` then
      i. **NOTE** If there are multiple `FunctionDeclarations` for the same name, the last declaration is used.
      ii. Let `fn` be the sole element of the `BoundNames` of `d`.
      iii. If `fn` is `arguments`, then let `argumentsObjectNotNeeded` be `true`.
      iv. Let `alreadyDeclared` be the result of calling `env`’s `HasBinding` concrete method passing `fn` as the argument.
      v. If `alreadyDeclared` is `false`, then
         1. Let `status` be the result of calling `env`’s `CreateMutableBinding` concrete method passing `fn` as the argument.
         2. Assert: `status` is never an Abrupt Completion.
         3. Append `d` to `functionsToInitialize`.
   b. Let `alreadyDeclared` be the result of calling `env`’s `HasBinding` concrete method passing `paramName` as the argument.
      a. NOTE Duplicate parameter names can only occur in non-strict functions. Parameter names that are the same as function declaration names do not get initialized to `undefined`.
      b. If `alreadyDeclared` is `false`, then
         i. If `paramName` is `arguments`, then let `argumentsObjectNotNeeded` be `true`.
         ii. Let `status` be the result of calling `env`’s `CreateMutableBinding` concrete method passing `paramName` as the argument.
         iii. Assert: `status` is never an Abrupt Completion.
         iv. Call `env`’s `InitialiseBinding` concrete method passing `paramName`, and `undefined` as the arguments.
9. For each `String paramName` in `parameterNames`, do
   a. Let `alreadyDeclared` be the result of calling `env`’s `HasBinding` concrete method passing `paramName` as the argument.
   b. If `alreadyDeclared` is `false`, then
      i. Call `env`’s `CreateImmutableBinding` concrete method passing the `String”arguments”` as the argument.
   c. If `strict` is `true`, then
      i. If `paramName` is `arguments`, then let `argumentsObjectNotNeeded` be `true`.
      ii. Call `env`’s `CreateImmutableBinding` concrete method passing the `String”arguments”` as the argument.
10. **NOTE** If there is a function declaration or formal parameter with the name “arguments” then an argument object is not created.
11. If `argumentsObjectNotNeeded` is `false`, then
    a. If `strict` is `true`, then
       i. Call `env`’s `CreateImmutableBinding` concrete method passing the `String”arguments”` as the argument.
    b. Else,
       i. Call `env`’s `CreateMutableBinding` concrete method passing the `String”arguments”` as the argument.
12. Let `varNames` be the `VarDeclaredNames` of `code`.
13. For each `String varName` in `varNames`, in list order do
    a. Let `alreadyDeclared` be the result of calling `env`’s `HasBinding` concrete method passing `varName` as the argument.
b. **NOTE** A VarDeclaredNames is only instantiated and initialized here if it is not also the name of a formal parameter or a FunctionDeclarations.

c. If alreadyDeclared is false, then 
   i. Call env’s CreateMutableBinding concrete method passing varName as the argument.

14. Let lexDeclarations be the LexicalDeclarations of code.

15. For each element d in lexDeclarations do
   a. **NOTE** A lexically declared name cannot be the same as a function declaration, formal parameter, or a var name. Lexically declared names are only instantiated here but not initialized.
   b. For each element dn of the BoundNames of d do
      i. If IsConstantDeclaration of d is true, then
         1. Call env’s CreateImmutableBinding concrete method passing dn as the argument.
      ii. Else,
         1. Call env’s CreateMutableBinding concrete method passing dn and false as the arguments.

16. For each FunctionDeclaration f in functionsToInitialize, do
   a. Let fn be the sole element of the BoundNames of f.
   b. Let fo be the result of performing InstantiateFunctionObject for f with argument env.
   c. Call env’s SetMutableMinding concrete method passing fn, fo, and false as the arguments.

17. **NOTE** Function declaration are initialised prior to parameter initialisation so that default value expressions may reference them. It is not extended code. “arguments” is not initialized until after parameter initialization.

18. Let ao be the result of InstantiateArgumentsObject with argument argumentList.

19. **NOTE** If argumentsObjectNotNeeded is true then the value of ao is not directly observable to ECMAScript code and need not actually exist. In that case, its use in the above steps is strictly as a device for specifying formal parameter initialization semantics.

20. If argumentsObjectNotNeeded is false, then
    a. If strict is true, then
       i. Perform the abstract operation CompleteStrictArgumentsObject with argument a0.
    b. Else,
       i. Perform the abstract operation CompleteMappedArgumentsObject with arguments a0, func, formals, and env.
    c. Call env’s InitialiseBinding concrete method passing ”arguments” and ao as arguments.

21. Let formalStatus be the result of performing Binding Initialisation for formals with ao and undefined as arguments.

22. ReturnIfAbrupt(formalStatus).

23. Return NormalCompletion(empty).

**F.1.1 The __proto__ pseudo property.**

**F.1.1.1 Object.prototype.__proto__**

The initial value of the __proto__ property of the Object prototype object is a data property whose initial value is null. This property initially has the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true }.

Manipulations of this property as tracked by the Boolean valued primordial internal variable UnderscoreProtoEnabled. The default initial value of UnderscoreProtoEnabled is true only if this property is initially present on the primordial Object prototype object.

**NOTE** Any modification of this property or its attributes causes UnderscoreProtoEnabled to be set to false.

**F.1.1.2 Changes To Internal Methods**

The definition of the [[Get]] internal method given in 8.12.3 is replaced with the following:

1. If P is the string value "__proto__" and UnderscoreProtoEnabled is true, then
   a. Let desc be the result of calling the [[GetProperty]] internal method of O with property name P
   b. If desc is not undefined and was created by step 1.a to describe the property defined in B.3.1.1 then,
      i. Return the value of the [[Prototype]] internal data property of O.
2. Continue by executing the steps of 8.12.3 starting with step 1.
The definition of the [[Put]] internal method given in 8.12.5 is replaced with the following:

1. If `P` is the string value "\_\_\_proto\_\_" and UnderscoreProtoEnabled is true and `O` is not the standard built-in Object prototype object, then
   a. Let `desc` be the result of calling the [[GetProperty]] internal method of `O` with property name `P`.
   b. If `desc` is not undefined and was created by step 1.a to describe the property defined in B.3.1.1 then,
      i. If the type of `V` is neither Object or Null, return
      ii. Set the value of the [[Prototype]] internal data property of `O` to `V`.
      iii. Return.
2. Continue by executing the steps of 8.12.5 starting with step 1.

The definition of the [[Delete]] internal method given in 8.12.7 is replaced with the following:

1. If UnderscoreProtoEnabled is true and `P` is the string value "\_\_\_proto\_\_" and `O` is the standard built-in Object prototype object, then
   a. Set UnderscoreProtoEnabled to false.
2. Continue by executing the steps of 8.12.7 starting with step 1.

The definition of the [[DefineOwnProperty]] internal method given in 8.12.9 is replaced with the following:

1. If UnderscoreProtoEnabled is true and `P` is the string value "\_\_\_proto\_\_" and `O` is the standard built-in Object prototype object, then
   a. If any attribute contained in `Desc` is not present or has a different value from the corresponding attribute in `{ [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true }` then,
      i. Set UnderscoreProtoEnabled to false.
   b. Continue by executing the steps of 8.12.9 starting with step 1.

F.1.1.3 __proto__ Object Initialisers

Definitions of two algorithms in 11.1.5 are replaced with the following:

The production `PropertyDefinitionList : PropertyDefinition` is evaluated as follows:

1. Let `obj` be the result of the abstract operation ObjectCreate with the intrinsic object %ObjectPrototype% as its argument.
2. Let `propId` be the result of evaluating `PropertyDefinition`.
3. If `propId`.name is the string value "\_\_\_proto\_\_" and UnderscoreProtoEnabled is true and IsDataDescriptor(`propId`.descriptor) is true, then
   a. Let `v` be `propId`.descriptor.value.
   b. If `desc` be `propId`.descriptor
   c. If the type of `v` is either Object or Null,
      i. Set the value of the [[Prototype]] internal data property of `obj` to `v`.
   d. Return `obj`.
4. Call the [[DefineOwnProperty]] internal method of `obj` with arguments `propId`.name, `propId`.descriptor, and false.
5. Return `obj`.

The production `PropertyDefinitionList : PropertyDefinitionList , PropertyDefinition` is evaluated as follows:

1. Let `obj` be the result of evaluating `PropertyDefinitionList`.

Commented [AWB12256]: Need to be updated to use [[SetP]]

Commented [AWB12257]: This whole thing needs to be rewritten, and in the process we will eliminate using [[GetProperty]]

Commented [AWB258]: Note that Object.defineProperty(obj, '__proto__', desc) nor any other call of [[DefineOwnProperty]] does not modify [[Prototype]].

Commented [AWB12258]: Need to be updated to use [[SetP]]
2. Let `propId` be the result of evaluating `PropertyDefinition`.
3. Let `previous` be the result of calling the `[[GetOwnProperty]]` internal method of `obj` with argument `propId.name`.
4. If `previous` is not `undefined` then throw a `SyntaxError` exception if any of the following conditions are true
   a. This production is contained in strict code and `IsDataDescriptor(previous)` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`.
   b. `IsDataDescriptor(previous)` is `true` and `IsAccessorDescriptor(propId.descriptor)` is `true`.
   c. `IsAccessorDescriptor(previous)` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`.
   d. `IsAccessorDescriptor(previous)` is `true` and `IsDataDescriptor(propId.descriptor)` is `true` and either both `previous` and `propId.descriptor` have `[[Get]]` fields or both `previous` and `propId.descriptor` have `[[Set]]` fields.
5. If `propId.name` is the string value `"__proto__"` and `UnderscoreProtoEnabled` is `true` and `IsDataDescriptor(propId.descriptor)` is `true`, then
   a. Let `v` be `propId.descriptor.value`.
   b. If `desc` be `propId.descriptor`
   c. If the type of `v` is either `Object` or `Null`, then
      i. Set the value of the `[[Prototype]]` internal data property of `obj` to `v`.
   d. Return `obj`.
6. Call the `[[DefineOwnProperty]]` internal method of `obj` with arguments `propId.name`, `propId.descriptor`, and `false`.
7. Return `obj`.
<table>
<thead>
<tr>
<th>Internal Property</th>
<th>Value Type</th>
<th>Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[BuiltinBrand]]</td>
<td>primitive</td>
<td></td>
<td>The BuiltinBrand enumeration. A tag value used by this specification to categorize various kinds of ECMA Script objects defined in this specification.</td>
</tr>
<tr>
<td>[[PrimitiveValue]]</td>
<td>primitive</td>
<td></td>
<td>Internal state information associated with this object. Of the standard built-in ECMA Script objects, only Boolean, Date, Number, and String objects implement [[PrimitiveValue]].</td>
</tr>
<tr>
<td>[[Scope]]</td>
<td>Lexical</td>
<td>Environment</td>
<td>A lexical environment that is the environment in which a Function object is executed. Of the standard built-in ECMA Script objects, only Function objects implement [[Scope]].</td>
</tr>
<tr>
<td>[[FormalParameters]]</td>
<td>Parse Tree</td>
<td></td>
<td>A parse tree for ECMA Script code parsed with FormalParameters as the goal symbol. Of the standard built-in ECMA Script objects, only Function objects implement [[FormalParameters]].</td>
</tr>
<tr>
<td>[[Code]]</td>
<td>Parse Tree</td>
<td></td>
<td>A parse tree for ECMA Script code parsed with FunctionBody as the goal symbol. Of the standard built-in ECMA Script objects, only Function objects implement [[Code]].</td>
</tr>
<tr>
<td>[[Strict]]</td>
<td>Boolean</td>
<td>true</td>
<td>true if a Function object is a strict mode function. Of the standard built-in ECMA Script objects, only Function objects implement [[Strict]].</td>
</tr>
<tr>
<td>[[BoundTargetFunction]]</td>
<td>Object</td>
<td></td>
<td>The target function of a function object created using the standard built-in Function.prototype.bind method. Only ECMA Script objects created using Function.prototype.bind have a [[BoundTargetFunction]] internal property.</td>
</tr>
<tr>
<td>[[BoundThis]]</td>
<td>any</td>
<td></td>
<td>The pre-bound this value of a function Object created using the standard built-in Function.prototype.bind method. Only ECMA Script objects created using Function.prototype.bind have a [[BoundThis]] internal property.</td>
</tr>
<tr>
<td>[[BoundArguments]]</td>
<td>List of any</td>
<td></td>
<td>The pre-bound argument values of a function Object created by the standard built-in Function.prototype.bind method. Only objects created by Function.prototype.bind have a [[BoundArguments]] internal property.</td>
</tr>
<tr>
<td>[[RegExpMatcher]]</td>
<td>SpecOpt(String, index) → MatchResult</td>
<td></td>
<td>Tests for a regular expression match and returns a MatchResult value (see 15.10.2.1). Of the standard built-in ECMA Script objects, only RegExp objects implement [[RegExpMatcher]].</td>
</tr>
<tr>
<td>[[ParameterMap]]</td>
<td>Object</td>
<td></td>
<td>Provides a mapping between the properties of an arguments object (see 10.6) and the formal parameters of the associated function. Only objects that are arguments objects have a [[ParameterMap]] internal property.</td>
</tr>
</tbody>
</table>
Bibliography


