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Introduction

This specification's source can be found at https://github.com/tc39/ecma402.

The ECMAScript 2023 Internationalization API Specification (ECMA-402 10th Edition), provides key language sensitive functionality as a complement to the ECMAScript 2023 Language Specification (ECMA-262 14th Edition or successor). Its functionality has been selected from that of well-established internationalization APIs such as those of the Internationalization Components for Unicode (ICU) library (https://unicode-org.github.io/icu-docs/), of the .NET framework, or of the Java platform.

The 1st Edition API was developed by an ad-hoc group established by Ecma TC39 in September 2010 based on a proposal by Nebojša Ćirić and Jungshik Shin.

The 2nd Edition API was adopted by the General Assembly of June 2015, as a complement to the ECMAScript 6th Edition.

The 3rd Edition API was the first edition released under Ecma TC39's new yearly release cadence and open development process. A plain-text source document was built from the ECMA-402 source document to serve as the base for further development entirely on GitHub. Over the year of this standard's development, dozens of pull requests and issues were filed representing several of bug fixes, editorial fixes and other improvements. Additionally, numerous software tools were developed to aid in this effort including Ecmarkup, Ecmarkdown, and Grammarkdown.

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

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This Ecma Standard was developed by Technical Committee 39 and was adopted by the General Assembly of June 2023.
Contributing to this Specification

This specification is developed on GitHub with the help of the ECMAScript community. There are a number of ways to contribute to the development of this specification:

- GitHub Repository: https://github.com/tc39/ecma402
- Issues: All Issues, File a New Issue
- Pull Requests: All Pull Requests, Create a New Pull Request
- Test Suite: Test262
- TC39-TG2:
  - Convener: Shane F. Carr (@sffc)
  - Admin group: contact by email
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  - Ujjwal Sharma (@ryzokuken)
- Community:
  - Matrix: #tc39:matrix.org
  - Matrix: #tc39-ecma402:matrix.org

Refer to the colophon for more information on how this document is created.
ECMAScript® 2023 Internationalization API Specification

1 Scope

This Standard defines the application programming interface for ECMAScript objects that support programs that need to adapt to the linguistic and cultural conventions used by different human languages and countries.

2 Conformance

A conforming implementation of the ECMAScript 2023 Internationalization API Specification must conform to the ECMAScript 2023 Language Specification (ECMA-262 14th Edition, or successor), and must provide and support all the objects, properties, functions, and program semantics described in this specification. Nothing in this specification is intended to allow behaviour that is otherwise prohibited by ECMA-262, and any such conflict should be considered an editorial error rather than an override of constraints from ECMA-262.

A conforming implementation of the ECMAScript 2023 Internationalization API Specification is permitted to provide additional objects, properties, and functions beyond those described in this specification. In particular, a conforming implementation of the ECMAScript 2023 Internationalization API Specification 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 is not permitted to add optional arguments to the functions defined in this specification.

A conforming implementation is permitted to accept additional values, and then have implementation-defined behaviour instead of throwing a RangeError, for the following properties of options arguments:

- The options property "localeMatcher" in all constructors and supportedLocalesOf methods.
- The options properties "usage" and "sensitivity" in the Collator constructor.
- The options properties "style", "currencyDisplay", "notation", "compactDisplay", "signDisplay", "currencySign", and "unitDisplay" in the NumberFormat constructor.
- The options properties "minimumIntegerDigits", "minimumFractionDigits", "maximumFractionDigits", "minimumSignificantDigits", and "maximumSignificantDigits" in the NumberFormat constructor, provided that the additional values are interpreted as integer values higher than the specified limits.
- The options properties listed in Table 7 in the DateTimeFormat constructor.
- The options property "formatMatcher" in the DateTimeFormat constructor.
- The options properties "minimumIntegerDigits", "minimumFractionDigits", "maximumFractionDigits", and "minimumSignificantDigits" in the PluralRules constructor, provided that the additional values are interpreted as integer values higher than the specified limits.
- The options property "type" in the PluralRules constructor.
- The options property "style" and "numeric" in the RelativeTimeFormat constructor.
- The options property "style" and "type" in the DisplayNames constructor.

3 Normative References

The following referenced documents are required 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.

https://www.ecma-international.org/publications/standards/Ecma-262.htm
NOTE Throughout this document, the phrase “es2023, x” (where x is a sequence of numbers separated by periods) may be used as shorthand for "ECMAScript 2023 Language Specification (ECMA-262 14th Edition, sub clause x)". Where x is followed by more such sequences of period-separated numbers, separated from each other by commas, each such sequence is also a shorthand for the corresponding sub clause of ECMA-262.

- ISO/IEC 10646:2014: Information Technology – Universal Multiple-Octet Coded Character Set (UCS) plus Amendment 1:2015 and Amendment 2, plus additional amendments and corrigenda, or successor
  - https://www.iso.org/iso/catalogue_detail.htm?csnumber=63182
  - https://www.iso.org/iso/catalogue_detail.htm?csnumber=65047
  - https://www.iso.org/iso/catalogue_detail.htm?csnumber=66791
- ISO 4217:2015 Codes for the representation of currencies and funds, or successor
- IANA Time Zone Database (https://www.iana.org/time-zones/)
- The Unicode Standard (https://unicode.org/versions/latest)
- Unicode Standard Annex #29: Unicode Text Segmentation (https://unicode.org/reports/tr29/)
- Unicode Technical Standard #10: Unicode Collation Algorithm (https://unicode.org/reports/tr10/)
- Unicode Technical Standard #35: Unicode Locale Data Markup Language (LDML)
  (https://unicode.org/reports/tr35/)
  - Part 1 Core, Section 3 Unicode Language and Locale Identifiers
    (https://unicode.org/reports/tr35/#Unicode_Language_and_Locale_Identifiers)
  - Part 2 General, Section 6.2 Unit Identifiers (https://unicode.org/reports/tr35/tr35-
    general.html#Unit_Identifiers)
  - Part 3 Numbers, Section 5.1.1 Operands (https://unicode.org/reports/tr35/tr35-
    numbers.html#Operands)

4 Overview

This section contains a non-normative overview of the ECMAScript 2023 Internationalization API Specification.

4.1 Internationalization, Localization, and Globalization

Internationalization of software means designing it such that it supports or can be easily adapted to support the needs of users speaking different languages and having different cultural expectations, and enables worldwide communication between them. Localization then is the actual adaptation to a specific language and culture. Globalization of software is commonly understood to be the combination of internationalization and localization. Globalization starts at the lowest level by using a text representation that supports all languages in the world, and using standard identifiers to identify languages, countries, time zones, and other relevant parameters. It continues with using a user interface language and data presentation that the user understands, and finally often requires product-specific adaptations to the user's language, culture, and environment.

The ECMAScript 2023 Language Specification lays the foundation by using Unicode for text representation and by providing a few language-sensitive functions, but gives applications little control over the behaviour of these functions. The ECMAScript 2023 Internationalization API Specification builds on this by providing a set of customizable language-sensitive functionality. The API is useful even for applications that themselves are not internationalized, as even applications targeting only one language and one region need to properly support that one language and region. However, the API also enables applications that support multiple languages and regions, even concurrently, as may be needed in server environments.
4.2 API Overview

The ECMAScript 2023 Internationalization API Specification is designed to complement the ECMAScript 2023 Language Specification by providing key language-sensitive functionality. The API can be added to an implementation of the ECMAScript 2023 Language Specification (ECMA-262 14th Edition, or successor) in whole or in part. This specification introduces new language values observable to ECMAScript code (such as the value of a [[FallbackSymbol]] internal slot and the set of values transitively reachable from %Intl% by property access), and also refines the definition of some functions specified in ECMA-262 (as described below). Neither category prohibits behaviour that is otherwise permitted for values and interfaces defined in ECMA-262, in order to support adoption of this specification by any implementation of ECMA-262.

The ECMAScript 2023 Internationalization API Specification provides several key pieces of language-sensitive functionality that are required in most applications: String comparison (collation), number formatting, date and time formatting, relative time formatting, display names, list formatting, locale selection and operation, pluralization rules, case conversion, and text segmentation. While the ECMAScript 2023 Language Specification provides functions for this basic functionality (on `Array.prototype`: `toLocaleString`; on `String.prototype`: `localeCompare`, `toLocaleLowerCase`, `toLocaleUpperCase`; on `Number.prototype`: `toLocaleString`; on `Date.prototype`: `toLocaleString`, `toLocaleDateString`, and `toLocaleTimeString`), their actual behaviour is left largely implementation-defined. The ECMAScript 2023 Internationalization API Specification provides additional functionality, control over the language and over details of the behaviour to be used, and a more complete specification of required functionality.

Applications can use the API in two ways:

1. Directly, by using a service constructor to construct an object, specifying a list of preferred languages and options to configure its behaviour. The object provides a main function (`compare`, `select`, `format`, etc.), which can be called repeatedly. It also provides a `resolvedOptions` function, which the application can use to find out the exact configuration of the object.
2. Indirectly, by using the functions of the ECMAScript 2023 Language Specification mentioned above. The collation and formatting functions are respecified in this specification to accept the same arguments as the Collator, NumberFormat, and DateTimeFormat constructors and produce the same results as their compare or format methods. The case conversion functions are respecified to accept a list of preferred languages.

The Intl object is used to package all functionality defined in the ECMAScript 2023 Internationalization API Specification to avoid name collisions.

NOTE While the API includes a variety of formatters, it does not provide any parsing facilities. This is intentional, has been discussed extensively, and concluded after weighing in all the benefits and drawbacks of including said functionality. See the discussion on the issue tracker.

4.3 API Conventions

Every Intl constructor should behave as if defined by a class, throwing a TypeError exception when called as a function (without NewTarget). For backwards compatibility with past editions, this does not apply to %Collator%, %DateTimeFormat%, or %NumberFormat%, each of which construct and return a new object when called as a function.

NOTE In ECMA 402 v1, Intl constructors supported a mode of operation where calling them with an existing object as a receiver would add relevant internal slots to the receiver, effectively transforming it into an instance of the class. In ECMA 402 v2, this capability was removed, to avoid adding internal slots to existing objects. In ECMA 402 v3, the capability was re-added as "normative optional" in a mode which chains the underlying Intl instance on any object, when the constructor is called. See https://github.com/tc39/ecma402/issues/57 for details.
4.4 Implementation Dependencies

Due to the nature of internationalization, the API specification has to leave several details implementation dependent:

- **The set of locales that an implementation supports with adequate localizations:** Linguists estimate the number of human languages to around 6000, and the more widely spoken ones have variations based on regions or other parameters. Even large locale data collections, such as the Common Locale Data Repository, cover only a subset of this large set. Implementations targeting resource-constrained devices may have to further reduce the subset.
- **The exact form of localizations such as format patterns:** In many cases locale-dependent conventions are not standardized, so different forms may exist side by side, or they vary over time. Different internationalization libraries may have implemented different forms, without any of them being actually wrong. In order to allow this API to be implemented on top of existing libraries, such variations have to be permitted.
- **Subsets of Unicode:** Some operations, such as collation, operate on strings that can include characters from the entire Unicode character set. However, both the Unicode Standard and the ECMA Script standard allow implementations to limit their functionality to subsets of the Unicode character set. In addition, locale conventions typically don't specify the desired behaviour for the entire Unicode character set, but only for those characters that are relevant for the locale. While the Unicode Collation Algorithm combines a default collation order for the entire Unicode character set with the ability to tailor for local conventions, subsets and tailorings still result in differences in behaviour.

4.4.1 Compatibility across implementations

ECMA 402 describes the schema of the data used by its functions. The data contained inside is implementation-dependent, and expected to change over time and vary between implementations. The variation is visible by programmers, and it is possible to construct programs which will depend on a particular output. However, this specification attempts to describe reasonable constraints which will allow well-written programs to function across implementations. Implementations are encouraged to continue their efforts to harmonize linguistic data.

5 Notational Conventions

This standard uses a subset of the notational conventions of the ECMAScript 2023 Language Specification (ECMA-262 14th Edition), as es2023:

- Object Internal Methods and Internal Slots, as described in es2023, 6.1.7.2.
- Algorithm conventions, as described in es2023, 5.2, and the use of abstract operations, as described in es2023, 7.1, 7.2, 7.3, 7.4.
- Internal Slots, as described in es2023, 10.1.
- The List and Record Specification Type, as described in es2023, 6.2.2.

**NOTE**  As described in the ECMAScript Language Specification, algorithms are used to precisely specify the required semantics of ECMAScript constructs, but are not intended to imply the use of any specific implementation technique. Internal slots are used to define the semantics of object values, but are not part of the API. They are defined purely for expository purposes. An implementation of the API must behave as if it produced and operated upon internal slots in the manner described here.

As an extension to the Record Specification Type, the notation "[[<name>]]" denotes a field whose name is given by the variable name, which must have a String value. For example, if a variable s has the value "a", then [[<s>]] denotes the field [[a]].
This specification uses blocks demarcated as **Normative Optional** to denote the sense of Annex B in ECMA 262. That is, normative optional sections are required when the ECMAScript host is a web browser. The content of the section is normative but optional if the ECMAScript host is not a web browser.

### 5.1 Well-Known Intrinsic Objects

The following table extends the Well-Known Intrinsic Objects table defined in es2023, 6.1.7.4.

<table>
<thead>
<tr>
<th>Intrinsic Name</th>
<th>Global Name</th>
<th>ECMAScript Language Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Collator%</td>
<td>Intl.Collator</td>
<td>The Intl.Collator constructor (10.1)</td>
</tr>
<tr>
<td>%DateTimeFormat%</td>
<td>Intl.DateTimeFormat</td>
<td>The Intl.DateTimeFormat constructor (11.1)</td>
</tr>
<tr>
<td>%DisplayNames%</td>
<td>Intl.DisplayNames</td>
<td>The Intl.DisplayNames constructor (12.1)</td>
</tr>
<tr>
<td>%Intl%</td>
<td>Intl</td>
<td>The Intl object (8)</td>
</tr>
<tr>
<td>%ListFormat%</td>
<td>Intl.ListFormat</td>
<td>The Intl.ListFormat constructor (13.1)</td>
</tr>
<tr>
<td>%Locale%</td>
<td>Intl.Locale</td>
<td>The Intl.Locale constructor (14.1)</td>
</tr>
<tr>
<td>%NumberFormat%</td>
<td>Intl.NumberFormat</td>
<td>The Intl.NumberFormat constructor (15.1)</td>
</tr>
<tr>
<td>%PluralRules%</td>
<td>Intl.PluralRules</td>
<td>The Intl.PluralRules constructor (16.1)</td>
</tr>
<tr>
<td>%RelativeTimeFormat%</td>
<td>Intl.RelativeTimeFormat</td>
<td>The Intl.RelativeTimeFormat constructor (17.1).</td>
</tr>
<tr>
<td>%Segmenter%</td>
<td>Intl.Segmenter</td>
<td>The Intl.Segmenter constructor (18.1)</td>
</tr>
</tbody>
</table>

### 6 Identification of Locales, Currencies, Time Zones, Measurement Units, Numbering Systems, Collations, and Calendars

This clause describes the String values used in this specification to identify locales, currencies, time zones, measurement units, numbering systems, collations, and calendars.

#### 6.1 Case Sensitivity and Case Mapping

The String values used to identify locales, currencies, scripts, and time zones are interpreted in an ASCII-case-insensitive manner, treating the code units 0x0041 through 0x005A (corresponding to Unicode characters LATIN CAPITAL LETTER A through LATIN CAPITAL LETTER Z) as equivalent to the corresponding code units 0x0061 through 0x007A (corresponding to Unicode characters LATIN SMALL LETTER A through LATIN SMALL LETTER Z), both inclusive. No other case folding equivalences are applied.

**NOTE**

For example, "ß" (U+00DF) must not match or be mapped to "SS" (U+0053, U+0053). "ı" (U+0131) must not match or be mapped to "I" (U+0049).

The **ASCII-uppercase** of a String value `S` is the String value derived from `S` by replacing each occurrence of an ASCII lowercase letter code unit (0x0061 through 0x007A, inclusive) with the corresponding ASCII uppercase letter code unit (0x0041 through 0x005A, inclusive) while preserving all other code units.
The ASCII-lowercase of a String value \( S \) is the String value derived from \( S \) by replacing each occurrence of an ASCII uppercase letter code unit (0x0041 through 0x005A, inclusive) with the corresponding ASCII lowercase letter code unit (0x0061 through 0x007A, inclusive) while preserving all other code units.

A String value \( A \) is an ASCII-case-insensitive match for String value \( B \) if the ASCII-upercase of \( A \) is exactly the same sequence of code units as the ASCII-upercase of \( B \). A sequence of Unicode code points \( A \) is an ASCII-case-insensitive match for \( B \) if \( B \) is an ASCII-case-insensitive match for \( \text{CodePointsToString}(A) \).

### 6.2 Language Tags

The ECMAScript 2023 Internationalization API Specification identifies locales using Unicode BCP 47 locale identifiers as defined by Unicode Technical Standard #35 LDML § 3 Unicode Language and Locale Identifiers, which may include extensions such as the Unicode BCP 47 U Extension. Their canonical form is specified in Unicode Technical Standard #35 LDML § 3.2.1 Canonical Unicode Locale Identifiers.

Unicode BCP 47 locale identifiers are structurally valid when they match those syntactical formatting criteria of Unicode Technical Standard 35, section 3.2, but it is not required to validate them according to the Unicode validation data. All structurally valid language tags are valid for use with the APIs defined by this standard. However, the set of locales and thus language tags that an implementation supports with adequate localizations is implementation dependent. Intl constructors map the language tags used in requests to locales supported by their respective implementations.

#### 6.2.1 Unicode Locale Extension Sequences

This standard uses the term "Unicode locale extension sequence" - as described in the EBNF grammar for `unicode_locale_extensions` in UTS 35 Unicode Locale Identifier, section 3.2 - for any substring of a language tag that is not part of a private use subtag sequence, starts with a separator "-" and the singleton "u", and includes the maximum sequence of following non-singleton subtags and their preceding "-" separators.

#### 6.2.2 IsStructurallyValidLanguageTag (locale)

The IsStructurallyValidLanguageTag abstract operation determines whether the `locale` argument (which must be a String value) is a language tag recognized by this specification. (It does not consider whether the language tag conveys any meaningful semantics, differentiate between aliased subtags and their preferred replacement subtags, or require canonical casing or subtag ordering.)

IsStructurallyValidLanguageTag returns `true` if all of the following conditions hold, `false` otherwise:

- `locale` can be generated from the EBNF grammar for `unicode_locale_id` in Unicode Technical Standard #35 LDML § 3.2 Unicode Locale Identifier;
- `locale` does not use any of the backwards compatibility syntax described in Unicode Technical Standard #35 LDML § 3.3 BCP 47 Conformance;
- the `unicode_language_id` within `locale` contains no duplicate `unicode_variant_subtag` subtags; and
- if `locale` contains an `extensions*` component, that component
  - does not contain any `other_extensions` components with duplicate `[alphanum-][tTuUxX]` subtags,
  - contains at most one `unicode_locale_extensions` component,
  - contains at most one `transformed_extensions` component, and
  - if a `transformed_extensions` component that contains a `tlang` component is present, then
    - the `tlang` component contains no duplicate `unicode_variant_subtag` subtags.

When evaluating each condition, terminal value characters in the grammar are interpreted as the corresponding Basic Latin code points. Two subtags are duplicates if one is an ASCII-case-insensitive match for the other.
NOTE  Every string for which this function returns true is both a "Unicode BCP 47 locale identifier", consistent with Unicode Technical Standard #35 LDML § 3.2 Unicode Locale Identifier and Unicode Technical Standard #35 LDML § 3.3 BCP 47 Conformance, and a valid BCP 47 language tag.

6.2.3 CanonicalizeUnicodeLocaleId (locale)

The CanonicalizeUnicodeLocaleId abstract operation returns the canonical and case-regularized form of the locale argument (which must be a String value for which IsStructurallyValidLanguageTag(locale) equals true). The following steps are taken:

1. Let localeId be the string locale after performing the algorithm to transform it to canonical syntax per Unicode Technical Standard #35 LDML § 3.2.1 Canonical Unicode Locale Identifiers. (The result is a Unicode BCP 47 locale identifier, in canonical syntax but not necessarily in canonical form.)
2. Let localeId be the string localeId after performing the algorithm to transform it to canonical form. (The result is a Unicode BCP 47 locale identifier, in both canonical syntax and canonical form.)
3. If localeId contains a substring extension that is a Unicode locale extension sequence, then
   a. Let components be !UnicodeExtensionComponents(extension).
   b. Let attributes be components.[[Attributes]].
   c. Let keywords be components.[[Keywords]].
   d. Let newExtension be "u".
   e. For each element attr of attributes, do
      i. Append ":" to newExtension.
      ii. Append attr to newExtension.
   f. For each Record {[[Key]], [[Value]]} keyword in keywords, do
      i. Append ":" to newExtension.
      ii. Append keyword.[[Key]] to newExtension.
      iii. If keyword.[[Value]] is not the empty String, then
          1. Append ":" to newExtension.
          2. Append keyword.[[Value]] to newExtension.
   g. Assert: newExtension is not equal to "u".
   h. Let localeId be localeId with the substring corresponding to extension replaced by the string newExtension.
4. Return localeId.

NOTE  The third step of this algorithm ensures that a Unicode locale extension sequence in the returned language tag contains:
- only the first instance of any attribute duplicated in the input, and
- only the first keyword for a given key in the input.

6.2.4 DefaultLocale ()

The DefaultLocale abstract operation returns a String value representing the structurally valid (6.2.2) and canonicalized (6.2.3) Unicode BCP 47 locale identifier for the host environment's current locale.

6.3 Currency Codes

The ECMAScript 2023 Internationalization API Specification identifies currencies using 3-letter currency codes as defined by ISO 4217. Their canonical form is uppercase.
All well-formed 3-letter ISO 4217 currency codes are allowed. However, the set of combinations of currency code and language tag for which localized currency symbols are available is implementation dependent. Where a localized currency symbol is not available, the ISO 4217 currency code is used for formatting.

6.3.1 IsWellFormedCurrencyCode (currency)

The IsWellFormedCurrencyCode abstract operation verifies that the currency argument (which must be a String value) represents a well-formed 3-letter ISO currency code. The following steps are taken:

1. If the length of currency is not 3, return false.
2. Let normalized be the ASCII-uppercase of currency.
3. If normalized contains any code unit outside of 0x0041 through 0x005A (corresponding to Unicode characters LATIN CAPITAL LETTER A through LATIN CAPITAL LETTER Z), return false.
4. Return true.

6.4 AvailableCanonicalCurrencies ()

The implementation-defined abstract operation AvailableCanonicalCurrencies takes no arguments and returns a List of Strings. The returned List is ordered as if an Array of the same values had been sorted using %Array.prototype.sort% using undefined as comparefn, and contains unique, well-formed, and upper case canonicalized 3-letter ISO 4217 currency codes, identifying the currencies for which the implementation provides the functionality of Intl.DisplayNames and Intl.NumberFormat objects.

6.5 Time Zone Names

The ECMAScript 2023 Internationalization API Specification identifies time zones using the Zone and Link names of the IANA Time Zone Database. Their canonical form is the corresponding Zone name in the casing used in the IANA Time Zone Database except as specifically overridden by CanonicalizeTimeZoneName.

A conforming implementation must recognize "UTC" and all other Zone and Link names (and only such names), and use best available current and historical information about their offsets from UTC and their daylight saving time rules in calculations. However, the set of combinations of time zone name and language tag for which localized time zone names are available is implementation dependent.

6.5.1 IsValidTimeZoneName (timeZone)

The abstract operation IsValidTimeZoneName takes argument timeZone, a String value, and verifies that it represents a valid Zone or Link name of the IANA Time Zone Database.

1. If one of the Zone or Link names of the IANA Time Zone Database is an ASCII-case-insensitive match for timeZone, return true.
2. If timeZone is an ASCII-case-insensitive match for "UTC", return true.
3. Return false.

NOTE Any value returned from DefaultTimeZone must be recognized as valid.

6.5.2 CanonicalizeTimeZoneName (timeZone)

The abstract operation CanonicalizeTimeZoneName takes argument timeZone (a String value that is a valid time zone name as verified by IsValidTimeZoneName). It returns the canonical and case-regularized form of timeZone. It performs the following steps when called:
1. Let *ianaTimeZone* be the String value of the Zone or Link name of the IANA Time Zone Database that is an ASCII-case-insensitive match for *timeZone*.

2. If *ianaTimeZone* is a Link name, let *ianaTimeZone* be the String value of the corresponding Zone name as specified in the file *backward* of the IANA Time Zone Database.

3. If *ianaTimeZone* is one of "Etc/UTC", "Etc/GMT", or "GMT", return "UTC".

4. Return *ianaTimeZone*.

### 6.5.3 **DefaultTimeZone ( )**

The implementation-defined abstract operation DefaultTimeZone takes no arguments and returns a String. It returns a String value representing the host environment's current time zone, which is a valid (6.5.1) and canonicalized (6.5.2) time zone name.

This definition supersedes the definition provided in es2023, 21.4.1.10.

### 6.5.4 **AvailableCanonicalTimeZones ( )**

The implementation-defined abstract operation AvailableCanonicalTimeZones takes no arguments and returns a List of Strings. The returned List is a sorted List of supported Zone and Link names in the IANA Time Zone Database. It performs the following steps when called:

1. Let *names* be a List of all Zone and Link names in the IANA Time Zone Database that are supported by the implementation.

2. Let *result* be a new empty List.

3. For each element *name* of *names*, do
   a. Assert: !IsValidTimeZoneName( *name* ) is true.
   b. Let *canonical* be !CanonicalizeTimeZoneName( *name* ).
   c. If *result* does not contain *canonical*, then
      i. Append *canonical* to the end of *result*.

4. Sort *result* in order as if an Array of the same values had been sorted using %Array.prototype.sort% using undefined as comparefn.

5. Return *result*.

### 6.6 Measurement Unit Identifiers

The ECMAScript 2023 Internationalization API Specification identifies measurement units using a core unit identifier (or equivalently core unit ID) as defined by Unicode Technical Standard #35 Part 2 General, Section 6.2 Unit Identifiers. Their canonical form is a string containing only Unicode Basic Latin lowercase letters (U+0061 LATIN SMALL LETTER A through U+007A LATIN SMALL LETTER Z) with zero or more medial hyphens (U+002D HYPHEN-MINUS).

Only a limited set of core unit identifiers are sanctioned. Attempting to use an unsanctioned core unit identifier results in a RangeError.

#### 6.6.1 **IsWellFormedUnitIdentifier ( unitIdentifier )**

The IsWellFormedUnitIdentifier abstract operation verifies that the *unitIdentifier* argument (which must be a String value) represents a well-formed core unit identifier that is either a sanctioned single unit or a complex unit formed by division of two sanctioned single units. The following steps are taken:

1. If ! IsSanctionedSingleUnitIdentifier( *unitIdentifier* ) is true, then
   a. Return true.
2. Let \( i \) be `StringIndexOf(unitIdentifier, "-per-", 0).
3. If \( i \) is -1 or `StringIndexOf(unitIdentifier, "-per-", \( i + 1 \)) is not -1, then
   a. Return \texttt{false}.
4. \textbf{Assert}: The five-character substring "-per-" occurs exactly once in `unitIdentifier`, at index \( i \).
5. Let \( \text{numerator} \) be the substring of `unitIdentifier` from 0 to \( i \).
6. Let \( \text{denominator} \) be the substring of `unitIdentifier` from \( i + 5 \).
7. If `IsSanctionedSingleUnitIdentifier(numerator)` and `IsSanctionedSingleUnitIdentifier(denominator)` are both \texttt{true}, then
   a. Return \texttt{true}.
8. Return \texttt{false}.

### 6.6.2 `IsSanctionedSingleUnitIdentifier ( unitIdentifier )`

The `IsSanctionedSingleUnitIdentifier` abstract operation verifies that the `unitIdentifier` argument (which must be a String value) is among the single unit identifiers sanctioned in the current version of the ECMAScript Internationalization API Specification, which are a subset of the Common Locale Data Repository release 38 unit validity data; the list may grow over time. As discussed in Unicode Technical Standard #35 Part 2 General, Section 6.2 Unit Identifiers, a single unit identifier is a \textbf{core unit identifier} that is not composed of multiplication or division of other unit identifiers. The following steps are taken:

1. If `unitIdentifier` is listed in Table 2 below, return \texttt{true}.
2. Else, return \texttt{false}.

<table>
<thead>
<tr>
<th>Single Unit Identifier</th>
<th>Table 2: Single units sanctioned for use in ECMAScript</th>
</tr>
</thead>
<tbody>
<tr>
<td>acre</td>
<td></td>
</tr>
<tr>
<td>bit</td>
<td></td>
</tr>
<tr>
<td>byte</td>
<td></td>
</tr>
<tr>
<td>celsius</td>
<td></td>
</tr>
<tr>
<td>centimeter</td>
<td></td>
</tr>
<tr>
<td>day</td>
<td></td>
</tr>
<tr>
<td>degree</td>
<td></td>
</tr>
<tr>
<td>fahrenheit</td>
<td></td>
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<tr>
<td>fluid-ounce</td>
<td></td>
</tr>
<tr>
<td>foot</td>
<td></td>
</tr>
<tr>
<td>gallon</td>
<td></td>
</tr>
<tr>
<td>gigabit</td>
<td></td>
</tr>
<tr>
<td>gigabyte</td>
<td></td>
</tr>
<tr>
<td>gram</td>
<td></td>
</tr>
<tr>
<td>hectare</td>
<td></td>
</tr>
<tr>
<td>hour</td>
<td></td>
</tr>
<tr>
<td>inch</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 (continued)

<table>
<thead>
<tr>
<th>Single Unit Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilobit</td>
</tr>
<tr>
<td>kilobyte</td>
</tr>
<tr>
<td>kilogram</td>
</tr>
<tr>
<td>kilometer</td>
</tr>
<tr>
<td>liter</td>
</tr>
<tr>
<td>megabit</td>
</tr>
<tr>
<td>megabyte</td>
</tr>
<tr>
<td>meter</td>
</tr>
<tr>
<td>microsecond</td>
</tr>
<tr>
<td>mile</td>
</tr>
<tr>
<td>mile-scandinavian</td>
</tr>
<tr>
<td>milliliter</td>
</tr>
<tr>
<td>millimeter</td>
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<td>millisecond</td>
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<tr>
<td>minute</td>
</tr>
<tr>
<td>month</td>
</tr>
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<td>nanosecond</td>
</tr>
<tr>
<td>ounce</td>
</tr>
<tr>
<td>percent</td>
</tr>
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<td>petabyte</td>
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<tr>
<td>pound</td>
</tr>
<tr>
<td>second</td>
</tr>
<tr>
<td>stone</td>
</tr>
<tr>
<td>terabit</td>
</tr>
<tr>
<td>terabyte</td>
</tr>
<tr>
<td>week</td>
</tr>
<tr>
<td>yard</td>
</tr>
<tr>
<td>year</td>
</tr>
</tbody>
</table>

#### 6.6.3 AvailableCanonicalUnits ( )

The abstract operation `AvailableCanonicalUnits` takes no arguments and returns a `List` of Strings. The returned `List` is ordered as if an Array of the same values had been sorted using `%Array.prototype.sort% using `undefined` as `comparefn`, and consists of the unique values of simple unit identifiers listed in every row of Table 2, except the header row.
6.7 Numbering System Identifiers

This specification identifies numbering systems using a numbering system identifier corresponding with the name referenced by Unicode Technical Standard #35 Part 3 Numbers, Section 1 Numbering Systems. Their canonical form is a string containing only Unicode Basic Latin lowercase letters (U+0061 LATIN SMALL LETTER A through U+007A LATIN SMALL LETTER Z).

6.7.1 AvailableCanonicalNumberingSystems ( )

The implementation-defined abstract operation AvailableCanonicalNumberingSystems takes no arguments and returns a List of Strings. The returned List is ordered as if an Array of the same values had been sorted using %Array.prototype.sort% using undefined as comparefn, and contains unique canonical numbering systems identifiers identifying the numbering systems for which the implementation provides the functionality of Intl.DateTimeFormat, Intl.NumberFormat, and Intl.RelativeTimeFormat objects. The list must include the Numbering System value of every row of Table 14, except the header row.

6.8 Collation Types

This specification identifies collations using a collation type as defined by Unicode Technical Standard #35 Part 5 Collation, Section 3.1 Collation Types. Their canonical form is a string containing only Unicode Basic Latin lowercase letters (U+0061 LATIN SMALL LETTER A through U+007A LATIN SMALL LETTER Z) with zero or more medial hyphens (U+002D HYPHEN-MINUS).

6.8.1 AvailableCanonicalCollations ( )

The implementation-defined abstract operation AvailableCanonicalCollations takes no arguments and returns a List of Strings. The returned List is ordered as if an Array of the same values had been sorted using %Array.prototype.sort% using undefined as comparefn, and contains unique canonical collation types identifying the collations for which the implementation provides the functionality of Intl.Collator objects.

6.9 Calendar Types

This specification identifies calendars using a calendar type as defined by Unicode Technical Standard #35 Part 4 Dates, Section 2 Calendar Elements. Their canonical form is a string containing only Unicode Basic Latin lowercase letters (U+0061 LATIN SMALL LETTER A through U+007A LATIN SMALL LETTER Z) with zero or more medial hyphens (U+002D HYPHEN-MINUS).

6.9.1 AvailableCanonicalCalendars ( )

The implementation-defined abstract operation AvailableCanonicalCalendars takes no arguments and returns a List of Strings. The returned List is ordered as if an Array of the same values had been sorted using %Array.prototype.sort% using undefined as comparefn, and contains unique canonical calendar types identifying the calendars for which the implementation provides the functionality of Intl.DateTimeFormat objects. The list must include "iso8601".

7 Requirements for Standard Built-in ECMAScript Objects

Unless specified otherwise in this document, the objects, functions, and constructors described in this standard are subject to the generic requirements and restrictions specified for standard built-in ECMAScript objects in the ECMAScript 2023 Language Specification (ECMA-262 14th Edition, or successor), clause 18.
8 The Intl Object

The Intl object is the `%Intl%` intrinsic object and the initial value of the "Intl" property of the global object. The Intl object is a single ordinary object.

The value of the [[Prototype]] internal slot of the Intl object is the intrinsic object `%Object.prototype%`.

The Intl object is not a function object. It does not have a [[Construct]] internal method; it is not possible to use the Intl object as a constructor with the new operator. The Intl object does not have a [[Call]] internal method; it is not possible to invoke the Intl object as a function.

The Intl object has an internal slot, [[FallbackSymbol]], which is a new `%Symbol%` in the current realm with the [[Description]] "IntlLegacyConstructedSymbol".

8.1 Value Properties of the Intl Object

8.1.1 Intl[ @@toStringTag ]

The initial value of the @@toStringTag property is the String value "Intl".

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

8.2 Constructor Properties of the Intl Object

With the exception of Intl.Locale, each of the following constructors is a service constructor that creates objects providing locale-sensitive services.

8.2.1 Intl.Collator ( . . . )

See 10.

8.2.2 Intl.DateTimeFormat ( . . . )

See 11.

8.2.3 Intl.DisplayNames ( . . . )

See 12.

8.2.4 Intl.ListFormat ( . . . )

See 13.

8.2.5 Intl.Locale ( . . . )

See 14.
8.2.6 Intl.NumberFormat ( . . . )
See 15.

8.2.7 Intl.PluralRules ( . . . )
See 16.

8.2.8 Intl.RelativeTimeFormat ( . . . )
See 17.

8.2.9 Intl.Segmenter ( . . . )
See 18.

8.3 Function Properties of the Intl Object

8.3.1 Intl.getCanonicalLocales ( locales )
When the getCanonicalLocales method is called with argument locales, the following steps are taken:

1. Let \( ll \) be ? CanonicalizeLocaleList(locales).
2. Return CreateArrayFromList(ll).

8.3.2 Intl.supportedValuesOf ( key )
When the supportedValuesOf method is called with argument key, the following steps are taken:

1. Let key be ? ToString(key).
2. If key is "calendar", then
   a. Let list be AvailableCanonicalCalendars().
3. Else if key is "collation", then
   a. Let list be AvailableCanonicalCollations().
4. Else if key is "currency", then
   a. Let list be AvailableCanonicalCurrencies().
5. Else if key is "numberingSystem", then
   a. Let list be AvailableCanonicalNumberingSystems().
6. Else if key is "timeZone", then
   a. Let list be AvailableCanonicalTimeZones().
7. Else if key is "unit", then
   a. Let list be AvailableCanonicalUnits().
8. Else,
   a. Throw a RangeError exception.
9. Return CreateArrayFromList(list).
9 Locale and Parameter Negotiation

Service constructors use a common pattern to negotiate the requests represented by their locales and options arguments against the actual capabilities of their implementations. That common behaviour is explained here in terms of internal slots describing the capabilities and abstract operations using these internal slots.

9.1 Internal slots of Service Constructors

Each service constructor has the following internal slots:

- `[[AvailableLocales]]` is a List that contains structurally valid (6.2.2) and canonicalized (6.2.3) language tags identifying the locales for which the implementation provides the functionality of the constructed objects. Language tags on the list must not have a Unicode locale extension sequence. The list must include the value returned by the DefaultLocale abstract operation (6.2.4), and must not include duplicates. Implementations must include in `[[AvailableLocales]]` locales that can serve as fallbacks in the algorithm used to resolve locales (see 9.2.7). For example, implementations that provide a "de-DE" locale must include a "de" locale that can serve as a fallback for requests such as "de-AT" and "de-CH". For locales that include a script subtag in addition to language and region, the corresponding locale without a script subtag must also be supported; that is, if an implementation recognizes "zh-Hant-TW", it is also expected to recognize "zh-TW". The ordering of the locales within `[[AvailableLocales]]` is irrelevant.

- `[[RelevantExtensionKeys]]` is a List of keys of the language tag extensions defined in Unicode Technical Standard #35 that are relevant for the functionality of the constructed objects.

- `[[SortLocaleData]]` and `[[SearchLocaleData]]` (for Intl.Collator) and `[[LocaleData]]` (for every other service constructor) are records that have fields for each locale contained in `[[AvailableLocales]]`. The value of each of these fields must be a record that has fields for each key contained in `[[RelevantExtensionKeys]]`. The value of each of these fields must be a non-empty list of those values defined in Unicode Technical Standard #35 for the given key that are supported by the implementation for the given locale, with the first element providing the default value.

NOTE For example, an implementation of DateTimeFormat might include the language tag "th" in its `[[AvailableLocales]]` internal slot, and must (according to 11.2.3) include the key "ca" in its `[[RelevantExtensionKeys]]` internal slot. For Thai, the “buddhist” calendar is usually the default, but an implementation might also support the calendars “gregory”, “chinese”, and “islamic” for the locale “th”. The `[[LocaleData]]` internal slot would therefore at least include `{{"th":[{"ca": "buddhist", "gregory", "chinese", "islamic"}]}}`.

9.2 Abstract Operations

Where the following abstract operations take an availableLocales argument, it must be an `[[AvailableLocales]]` List as specified in 9.1.

9.2.1 CanonicalizeLocaleList ( locales )

The abstract operation CanonicalizeLocaleList takes the following steps:

1. If locales is undefined, then
   a. Return a new empty List.
2. Let seen be a new empty List.
3. If Type(locales) is String or Type(locales) is Object and locales has an [[InitializedLocale]] internal slot, then
a. Let \( O \) be \( \text{CreateArrayFromList}(\text{locales}) \).

4. Else,
   a. Let \( O \) be \( \text{?ToObject}(\text{locales}) \).

5. Let \( \text{len} \) be \( \text{?ToLength}(\text{Get}(O, "length")) \).

6. Let \( k \) be 0.

7. Repeat, while \( k < \text{len} \),
   a. Let \( Pk \) be \( \text{!ToString}(k) \).
   b. Let \( k\text{Present} \) be \( \text{?HasProperty}(O, Pk) \).
   c. If \( k\text{Present} \) is true, then
      i. Let \( k\text{Value} \) be \( \text{?Get}(O, Pk) \).
      ii. If \( \text{Type}(k\text{Value}) \) is not String or Object, throw a \( \text{TypeError} \) exception.
      iii. If \( \text{Type}(k\text{Value}) \) is Object and \( k\text{Value} \) has an [[InitializedLocale]] internal slot, then
           1. Let \( \text{tag} \) be \( k\text{Value}.[[\text{Locale}]] \).
      iv. Else,
           1. Let \( \text{tag} \) be \( \text{!ToString}(k\text{Value}) \).
      v. If \( \text{!IsStructurallyValidLanguageTag}(\text{tag}) \) is false, throw a \( \text{RangeError} \) exception.
      vi. Let \( \text{canonicalizedTag} \) be \( \text{!CanonicalizeUnicodeLocaleId}(\text{tag}) \).
      vii. If \( \text{canonicalizedTag} \) is not an element of \( \text{seen} \), append \( \text{canonicalizedTag} \) as the last element of \( \text{seen} \).
   d. Increase \( k \) by 1.

8. Return \( \text{seen} \).

**NOTE 1** Non-normative summary: The abstract operation interprets the \( \text{locales} \) argument as an array and copies its elements into a \( \text{List} \), validating the elements as structurally valid language tags and canonicalizing them, and omitting duplicates.

**NOTE 2** Requiring \( k\text{Value} \) to be a String or Object means that the Number value \( \text{NaN} \) will not be interpreted as the language tag "nan", which stands for Min Nan Chinese.

### 9.2.2 BestAvailableLocale (availableLocales, locale)

The BestAvailableLocale abstract operation compares the provided argument \( \text{locale} \), which must be a String value with a structurally valid and canonicalized Unicode BCP 47 locale identifier, against the locales in \( \text{availableLocales} \) and returns either the longest non-empty prefix of \( \text{locale} \) that is an element of \( \text{availableLocales} \), or \( \text{undefined} \) if there is no such element. It uses the fallback mechanism of RFC 4647, section 3.4. The following steps are taken:

1. Let \( \text{candidate} \) be \( \text{locale} \).
2. Repeat,
   a. If \( \text{availableLocales} \) contains \( \text{candidate} \), return \( \text{candidate} \).
   b. Let \( \text{pos} \) be the character index of the last occurrence of "-" (U+002D) within \( \text{candidate} \). If that character does not occur, return \( \text{undefined} \).
   c. If \( \text{pos} \geq 2 \) and the character "-" occurs at index \( \text{pos} - 2 \) of \( \text{candidate} \), decrease \( \text{pos} \) by 2.
   d. Let \( \text{candidate} \) be the substring of \( \text{candidate} \) from position 0, inclusive, to position \( \text{pos} \), exclusive.

### 9.2.3 LookupMatcher (availableLocales, requestedLocales)

The LookupMatcher abstract operation compares \( \text{requestedLocales} \), which must be a \( \text{List} \) as returned by \( \text{CanonicalizeLocaleList} \), against the locales in \( \text{availableLocales} \) and determines the best available language to meet the request. The following steps are taken:

1. Let \( \text{candidate} \) be \( \text{locale} \).
2. Repeat,
   a. If \( \text{availableLocales} \) contains \( \text{candidate} \), return \( \text{candidate} \).
   b. Let \( \text{pos} \) be the character index of the last occurrence of "-" (U+002D) within \( \text{candidate} \). If that character does not occur, return \( \text{undefined} \).
   c. If \( \text{pos} \geq 2 \) and the character "-" occurs at index \( \text{pos} - 2 \) of \( \text{candidate} \), decrease \( \text{pos} \) by 2.
   d. Let \( \text{candidate} \) be the substring of \( \text{candidate} \) from position 0, inclusive, to position \( \text{pos} \), exclusive.
1. Let result be a new Record.
2. For each element locale of requestedLocales, do
   a. Let noExtensionsLocale be the String value that is locale with any Unicode locale extension sequences removed.
   b. Let availableLocale be BestAvailableLocale(availableLocales, noExtensionsLocale).
   c. If availableLocale is not undefined, then
      i. Set result.[[locale]] to availableLocale.
      ii. If locale and noExtensionsLocale are not the same String value, then
          1. Let extension be the String value consisting of the substring of the Unicode locale extension sequence within locale.
          2. Set result.[[extension]] to extension.
      iii. Return result.
3. Let defLocale be ! DefaultLocale().
4. Set result.[[locale]] to defLocale.
5. Return result.

**NOTE**
The algorithm is based on the Lookup algorithm described in RFC 4647 section 3.4, but options specified through Unicode locale extension sequences are ignored in the lookup. Information about such subsequences is returned separately. The abstract operation returns a record with a [[locale]] field, whose value is the language tag of the selected locale, which must be an element of availableLocales. If the language tag of the request locale that led to the selected locale contained a Unicode locale extension sequence, then the returned record also contains an [[extension]] field whose value is the substring of the Unicode locale extension sequence within the request locale language tag.

### 9.2.4 BestFitMatcher (availableLocales, requestedLocales)

The BestFitMatcher abstract operation compares requestedLocales, which must be a List as returned by CanonicalizeLocaleList, against the locales in availableLocales and determines the best available language to meet the request. The algorithm is implementation dependent, but should produce results that a typical user of the requested locales would perceive as at least as good as those produced by the LookupMatcher abstract operation. Options specified through Unicode locale extension sequences must be ignored by the algorithm. Information about such subsequences is returned separately. The abstract operation returns a record with a [[locale]] field, whose value is the language tag of the selected locale, which must be an element of availableLocales. If the language tag of the request locale that led to the selected locale contained a Unicode locale extension sequence, then the returned record also contains an [[extension]] field whose value is the substring of the Unicode locale extension sequence within the request locale language tag.

### 9.2.5 UnicodeExtensionComponents (extension)

The UnicodeExtensionComponents abstract operation returns the attributes and keywords from extension, which must be a String value whose contents are a Unicode locale extension sequence. If an attribute or a keyword occurs multiple times in extension, only the first occurrence is returned. The following steps are taken:

1. Let attributes be a new empty List.
2. Let keywords be a new empty List.
3. Let keyword be undefined.
4. Let size be the length of extension.
5. Let k be 3.
6. Repeat, while $k < size$,
   a. Let $e$ be StringIndexOf(extension, ",-", $k$).
b. If $e = -1$, let $len$ be $size - k$; else let $len$ be $e - k$.

c. Let $subtag$ be the String value equal to the substring of $extension$ consisting of the code units at indices $k$ (inclusive) through $k + len$ (exclusive).

d. If $keyword$ is $undefined$ and $len \neq 2$, then

i. If $subtag$ is not an element of $attributes$, then

1. Append $subtag$ to $attributes$.

e. Else if $len = 2$, then

i. If $keyword$ is not $undefined$ and $keywords$ does not contain an element whose $[\text{Key}]$ is the same as $keyword.[\text{Key}]$, then

1. Append $keyword$ to $keywords$.

ii. Set $keyword$ to the Record $\{ [\text{Key}]: subtag, [\text{Value}]: "" \}$.

f. Else,

i. If $keyword.[\text{Value}]$ is the empty String, then

1. Set $keyword.[\text{Value}]$ to $subtag$.

ii. Else,

1. Set $keyword.[\text{Value}]$ to the string-concatenation of $keyword.[\text{Value}]$, ",\", and $subtag$.

g. Let $k$ be $k + len + 1$.

7. If $keyword$ is not $undefined$ and $keywords$ does not contain an element whose $[\text{Key}]$ is the same as $keyword.[\text{Key}]$, then

a. Append $keyword$ to $keywords$.

8. Return the Record $\{ [[\text{Attributes}]]: attributes, [[\text{Keywords}]]: keywords \}$.

### 9.2.6 InsertUnicodeExtensionAndCanonicalize ($locale$, $extension$)

The InsertUnicodeExtensionAndCanonicalize abstract operation inserts $extension$, which must be a Unicode locale extension sequence, into $locale$, which must be a String value with a structurally valid and canonicalized Unicode BCP 47 locale identifier. The following steps are taken:

The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar.

1. Assert: $locale$ matches the $\text{unicode.locale.id}$ production.
2. Assert: $locale$ does not contain a Unicode locale extension sequence.
3. Assert: $extension$ is a Unicode locale extension sequence.
4. Let $privateIndex$ be $\text{StringIndexOf}(locale, "-x-", 0)$.
5. If $privateIndex = -1$, then

a. Let $locale$ be the string-concatenation of $locale$ and $extension$.

6. Else,

a. Let $preExtension$ be the substring of $locale$ from position 0, inclusive, to position $privateIndex$, exclusive.

b. Let $postExtension$ be the substring of $locale$ from position $privateIndex$ to the end of the string.

c. Let $locale$ be the string-concatenation of $preExtension$, $extension$, and $postExtension$.

7. Assert: $\text{IsStructurallyValidLanguageTag}(locale)$ is true.
8. Return $\text{CanonicalizeUnicodeLocaleId}(locale)$.

### 9.2.7 ResolveLocale ($availableLocales$, $requestedLocales$, $options$, $relevantExtensionKeys$, $localeData$)

The ResolveLocale abstract operation compares a BCP 47 language priority list $requestedLocales$ against the locales in $availableLocales$ and determines the best available language to meet the request. $availableLocales$, $requestedLocales$, and $relevantExtensionKeys$ must be provided as List values, $options$ and $localeData$ as Records.
The following steps are taken:

1. Let `matcher` be `options.[[localeMatcher]]`.
2. If `matcher` is "lookup", then
   a. Let `r` be `! LookupMatcher(availableLocales, requestedLocales)`.
3. Else,
   a. Let `r` be `! BestFitMatcher(availableLocales, requestedLocales)`.
4. Let `foundLocale` be `r.[[locale]]`.
5. Let `result` be a new `Record`.
6. Set `result.[[dataLocale]]` to `foundLocale`.
7. If `r` has an `[[extension]]` field, then
   a. Let `components` be `! UnicodeExtensionComponents(r.[[extension]])`.
   b. Let `keywords` be `components.[[Keywords]]`.
8. Let `supportedExtension` be "-u".
9. For each element `key` of `relevantExtensionKeys`, do
   a. Let `foundLocaleData` be `localeData.[[<foundLocale>]]`.
   b. Assert: `Type(foundLocaleData)` is `Record`.
   c. Let `keyLocaleData` be `foundLocaleData.[[<key>]]`.
   d. Assert: `Type(keyLocaleData)` is `List`.
   e. Let `value` be `keyLocaleData[0]`.
   f. Assert: `Type(value)` is either String or Null.
   g. Let `supportedExtensionAddition` be "".
   h. If `r` has an `[[extension]]` field, then
      i. If `keywords` contains an element whose `[[Key]]` is the same as `key`, then
         1. Let `entry` be the element of `keywords` whose `[[Key]]` is the same as `key`.
         2. Let `requestedValue` be `entry.[[Value]]`.
         3. If `requestedValue` is not the empty String, then
            a. If `keyLocaleData` contains `requestedValue`, then
               i. Let `value` be `requestedValue`.
               ii. Let `supportedExtensionAddition` be the string-concatenation of "-", `key`, "-", and `value`.
            4. Else if `keyLocaleData` contains "true", then
               a. Let `value` be "true".
               b. Let `supportedExtensionAddition` be the string-concatenation of "-" and `key`.
      i. If `options` has a field `[[<key>]]`, then
         i. Let `optionsValue` be `options.[[<key>]]`.
         ii. Assert: `Type(optionsValue)` is either String, Undefined, or Null.
         iii. If `Type(optionsValue)` is String, then
            1. Let `optionsValue` be the string `optionsValue` after performing the algorithm steps to transform Unicode extension values to canonical syntax per Unicode Technical Standard #35 LDML § 3.2.1 Canonical Unicode Locale Identifiers, treating `key` as `ukey` and `optionsValue` as `uvalue` productions.
            2. Let `optionsValue` be the string `optionsValue` after performing the algorithm steps to replace Unicode extension values with their canonical form per Unicode Technical Standard #35 LDML § 3.2.1 Canonical Unicode Locale Identifiers, treating `key` as `ukey` and `optionsValue` as `uvalue` productions.
            3. If `optionsValue` is the empty String, then
               a. Let `optionsValue` be "true".
               iv. If `SameValue(optionsValue, value)` is `false` and `keyLocaleData` contains `optionsValue`, then
                  1. Let `value` be `optionsValue`.

2. Let $supportedExtensionAddition$ be "".
   j. Set $result.[[<key>]]$ to $value$.
   k. Set $supportedExtension$ to the string-concatenation of $supportedExtension$ and $supportedExtensionAddition$.
10. If $supportedExtension$ is not "-u", then
    a. Set $foundLocale$ to $InsertUnicodeExtensionAndCanonicalize(foundLocale, supportedExtension)$.
11. Set $result.[[locale]]$ to $foundLocale$.
12. Return $result$.

---

NOTE Non-normative summary: Two algorithms are available to match the locales: the Lookup algorithm described in RFC 4647 section 3.4, and an implementation dependent best-fit algorithm. Independent of the locale matching algorithm, options specified through Unicode locale extension sequences are negotiated separately, taking the caller's relevant extension keys and locale data as well as client-provided options into consideration. The abstract operation returns a record with a [[locale]] field whose value is the language tag of the selected locale, and fields for each key in relevantExtensionKeys providing the selected value for that key.

9.2.8 LookupSupportedLocales ( availableLocales, requestedLocales )

The LookupSupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale when using the BCP 47 Lookup algorithm. Locales appear in the same order in the returned list as in requestedLocales. The following steps are taken:

1. Let $subset$ be a new empty List.
2. For each element $locale$ of requestedLocales, do
   a. Let $noExtensionsLocale$ be the String value that is $locale$ with any Unicode locale extension sequences removed.
   b. Let $availableLocale$ be $BestAvailableLocale(availableLocales, noExtensionsLocale)$.
   c. If $availableLocale$ is not undefined, append $locale$ to the end of $subset$.
3. Return $subset$.

9.2.9 BestFitSupportedLocales ( availableLocales, requestedLocales )

The BestFitSupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale when using the Best Fit Matcher algorithm. Locales appear in the same order in the returned list as in requestedLocales. The steps taken are implementation dependent.

9.2.10 SupportedLocales ( availableLocales, requestedLocales, options )

The SupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale. Two algorithms are available to match the locales: the Lookup algorithm described in RFC 4647 section 3.4, and an implementation dependent best-fit algorithm. Locales appear in the same order in the returned list as in requestedLocales. The following steps are taken:
1. Set `options` to `CoerceOptionsToObject(options)`.
3. If `matcher` is "best fit", then
   a. Let `supportedLocales` be `BestFitSupportedLocales(availableLocales, requestedLocales)`.
4. Else,
   a. Let `supportedLocales` be `LookupSupportedLocales(availableLocales, requestedLocales)`.
5. Return `CreateArrayFromList(supportedLocales)`.

### 9.2.11 GetOptionsObject (options)

The abstract operation GetOptionsObject returns an Object suitable for use with `GetOption`, either `options` itself or a default empty Object. It throws a TypeError if `options` is not undefined and not an Object.

1. If `options` is `undefined`, then
   a. Return `OrdinaryObjectCreate(null)`.
2. If `Type(options)` is Object, then
   a. Return `options`.
3. Throw a `TypeError` exception.

### 9.2.12 CoerceOptionsToObject (options)

The abstract operation CoerceOptionsToObject coerces `options` into an Object suitable for use with `GetOption`, defaulting to an empty Object. Because it coerces non-null primitive values into objects, its use is discouraged for new functionality in favour of `GetOptionsObject`.

1. If `options` is `undefined`, then
   a. Return `OrdinaryObjectCreate(null)`.
2. Return `ToObject(options)`.

### 9.2.13 GetOption (options, property, type, values, default)

The abstract operation GetOption takes arguments `options` (an Object), `property` (a property key), `type` (boolean, number, or string), `values` (empty or a List of ECMAScript language values), and `default` (required or an ECMAScript language value). It extracts the value of the specified property of `options`, converts it to the required `type`, checks whether it is allowed by `values` if `values` is not empty, and substitutes `default` if the value is `undefined`. It performs the following steps when called:

1. Let `value` be `Get(options, property)`.
2. If `value` is `undefined`, then
   a. If `default` is required, throw a `RangeError` exception.
   b. Return `default`.
3. If `type` is boolean, then
   a. Set `value` to `ToBoolean(value)`.
4. Else if `type` is number, then
   a. Set `value` to `ToNumber(value)`.
   b. If `value` is `NaN`, throw a `RangeError` exception.
5. Else,
   a. Assert: `type` is string.
   b. Set `value` to `ToString(value)`.
6. If `values` is not empty and `values` does not contain `value`, throw a `RangeError` exception.
7. Return `value`.  

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9.2.14 GetBooleanOrStringNumberFormatOption (options, property, stringValues, fallback)

The abstract operation GetBooleanOrStringNumberFormatOption takes arguments options (an Object), property (a property key), stringValues (a List of Strings), and fallback (an ECMAScript language value) and returns either a normal completion containing either a Boolean, String, or fallback, or a throw completion. It extracts the value of the property named property from the provided options object. It returns fallback if that value is undefined, true if that value is true, false if that value coerces to false, and otherwise coerces it to a String and returns the result if it is allowed by stringValues. It performs the following steps when called:

1. Let value be ? Get(options, property).
2. If value is undefined, return fallback.
3. If value is true, return true.
4. If ToBoolean(value) is false, return false.
5. Let value be ? ToString(value).
6. If stringValues does not contain value, throw a RangeError exception.
7. Return value.

9.2.15 DefaultNumberOption (value, minimum, maximum, fallback)

The abstract operation DefaultNumberOption converts value to a Number value, checks whether it is in the allowed range, and fills in a fallback value if necessary.

1. If value is undefined, return fallback.
2. Set value to ? ToNumber(value).
3. If value is NaN or less than minimum or greater than maximum, throw a RangeError exception.
4. Return floor(value).

9.2.16 GetNumberOption (options, property, minimum, maximum, fallback)

The abstract operation GetNumberOption extracts the value of the property named property from the provided options object, converts it to a Number value, checks whether it is in the allowed range, and fills in a fallback value if necessary.

1. Assert: Type(options) is Object.
2. Let value be ? Get(options, property).
3. Return ? DefaultNumberOption(value, minimum, maximum, fallback).

9.2.17 PartitionPattern (pattern)

The PartitionPattern abstract operation is called with argument pattern. This abstract operation parses an abstract pattern string into a list of Records with two fields, [[Type]] and [[Value]]. The [[Value]] field will be a String value if [[Type]] is "literal", and undefined otherwise. The syntax of the abstract pattern strings is an implementation detail and is not exposed to users of ECMA-402. The following steps are taken:

1. Let result be a new empty List.
2. Let beginIndex be StringIndexOf(pattern, "{" , 0).
3. Let endIndex be 0.
4. Let nextIndex be 0.
5. Let length be the number of code units in pattern.
6. Repeat, while beginIndex is an integer index into pattern,
a. Set `endIndex` to `StringIndexOf(pattern, "\"\")`, `beginIndex`.

b. Assert: `endIndex` is greater than `beginIndex`.

c. If `beginIndex` is greater than `nextIndex`, then
   i. Let `literal` be a substring of `pattern` from position `nextIndex`, inclusive, to position `beginIndex`, exclusive.
   ii. Append a new `Record` `{ [[Type]]: "literal", [[Value]]: literal }` as the last element of the list `result`.

d. Let `p` be the substring of `pattern` from position `beginIndex`, exclusive, to position `endIndex`, exclusive.

e. Append a new `Record` `{ [[Type]]: p, [[Value]]: undefined }` as the last element of the list `result`.

f. Set `nextIndex` to `endIndex` + 1.

g. Set `beginIndex` to `StringIndexOf(pattern, "{", nextIndex)`.

7. If `nextIndex` is less than `length`, then
   a. Let `literal` be the substring of `pattern` from position `nextIndex`, inclusive, to position `length`, exclusive.
   b. Append a new `Record` `{ [[Type]]: "literal", [[Value]]: literal }` as the last element of the list `result`.

8. Return `result`.

10 Collator Objects

10.1 The Intl.Collator Constructor

The Intl.Collator constructor is the `%Collator% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

10.1.1 Intl.Collator ( [ locales [, options ] ])

When the Intl.Collator function is called with optional arguments `locales` and `options`, the following steps are taken:

1. If `NewTarget` is `undefined`, let `newTarget` be the active function object, else let `newTarget` be `NewTarget`.

2. Let `internalSlotsList` be « [[InitializedCollator]], [[Locale]], [[Usage]], [[Sensitivity]], [[IgnorePunctuation]], [[Collation]], [[BoundCompare]] ».

3. If `%Collator%.[[RelevantExtensionKeys]] contains "kn", then
   a. Append `[[Numeric]]` as the last element of `internalSlotsList`.

4. If `%Collator%.[[RelevantExtensionKeys]] contains "kf", then
   a. Append `[[CaseFirst]]` as the last element of `internalSlotsList`.

5. Let `collator` be ? OrdinaryCreateFromConstructor(`newTarget`, "%Collator.prototype%", `internalSlotsList`).


10.1.2 InitializeCollator ( `collator`, `locales`, `options` )

The abstract operation InitializeCollator accepts the arguments `collator` (which must be an object), `locales`, and `options`. It initializes `collator` as a Collator object. The following steps are taken:

The following algorithm refers to the type nonterminal from UTS 35’s Unicode Locale Identifier grammar.
1. Let \( \text{requestedLocales} \) be ? \( \text{CanonicalizeLocaleList}(\text{locales}) \).
2. Set \( \text{options} \) to ? \( \text{CoerceOptionsToObject}(\text{options}) \).
3. Let \( \text{usage} \) be ? \( \text{GetOption}(\text{options}, \text{"usage"}, \text{string}, \{ \text{"sort"}, \text{"search"}, \text{"sort"} \}) \).
4. Set \( \text{collator}.[[\text{Usage}]] \) to \( \text{usage} \).
5. If \( \text{usage} \) is \( \text{"sort"} \), then
   a. Let \( \text{localeData} \) be %Collator%.[[SortLocaleData]].
6. Else,
   a. Let \( \text{localeData} \) be %Collator%.[[SearchLocaleData]].
7. Let \( \text{opt} \) be a new \( \text{Record} \).
8. Let \( \text{matcher} \) be ? \( \text{GetOption}(\text{options}, \text{"localeMatcher"}, \text{string}, \{ \text{"lookup"}, \text{"best fit"}, \text{"best fit"} \}) \).
9. Set \( \text{opt}.[[\text{localeMatcher}]] \) to \( \text{matcher} \).
10. Let \( \text{collation} \) be ? \( \text{GetOption}(\text{options}, \text{"collation"}, \text{string}, \text{empty}, \text{undefined}) \).
11. If \( \text{collation} \) is not \( \text{undefined} \), then
   a. If \( \text{collation} \) does not match the Unicode Locale Identifier \text{type} nonterminal, throw a \( \text{RangeError} \) exception.
12. Set \( \text{opt}.[[\text{co}]] \) to \( \text{collation} \).
13. Let \( \text{numeric} \) be ? \( \text{GetOption}(\text{options}, \text{"numeric"}, \text{boolean}, \text{empty}, \text{undefined}) \).
14. If \( \text{numeric} \) is not \( \text{undefined} \), then
   a. Let \( \text{numeric} \) be \( \text{ToString}(\text{numeric}) \).
15. Set \( \text{opt}.[[\text{kn}]] \) to \( \text{numeric} \).
16. Let \( \text{caseFirst} \) be ? \( \text{GetOption}(\text{options}, \text{"caseFirst"}, \text{string}, \{ \text{"upper"}, \text{"lower"}, \text{"false"}, \text{"false"} \}, \text{undefined}) \).
17. Set \( \text{opt}.[[\text{kf}]] \) to \( \text{caseFirst} \).
18. Let \( \text{relevantExtensionKeys} \) be %Collator%.[[RelevantExtensionKeys]].
19. Let \( r \) be \( \text{ResolveLocale}(%\text{Collator%}.[[\text{AvailableLocales}]}, \text{requestedLocales}, \text{opt}, \text{relevantExtensionKeys}, \text{localeData}) \).
20. Set \( \text{collator}.[[\text{Locale}]] \) to \( r.[[\text{locale}]] \).
21. Let \( \text{collation} \) be \( r.[[\text{co}]] \).
22. If \( \text{collation} \) is \( \text{null} \), let \( \text{collation} \) be \"default"\).
23. Set \( \text{collator}.[[\text{Collation}]] \) to \( \text{collation} \).
24. If \( \text{relevantExtensionKeys} \) contains \"kn\", then
   a. Set \( \text{collator}.[[\text{Numeric}]] \) to \( \text{SameValue}(r.[[\text{kn}]], \"true\") \).
25. If \( \text{relevantExtensionKeys} \) contains \"kf\", then
   a. Set \( \text{collator}.[[\text{CaseFirst}]] \) to \( r.[[\text{kf}]] \).
26. Let \( \text{sensitivity} \) be ? \( \text{GetOption}(\text{options}, \text{"sensitivity"}, \text{string}, \{ \text{"base"}, \text{"accent"}, \text{"case"}, \text{"variant"}, \text{"variant"}, \text{"variant"}, \text{"variant"}, \text{"variant"}, \text{undefined}) \).
27. If \( \text{sensitivity} \) is \( \text{undefined} \), then
   a. If \( \text{usage} \) is \"sort\", then
      i. Let \( \text{sensitivity} \) be \"variant\".
   b. Else,
      i. Let \( \text{dataLocale} \) be \( r.[[\text{dataLocale}]] \).
      ii. Let \( \text{dataLocaleData} \) be \( \text{localeData}.[[<\text{dataLocale}>]] \).
      iii. Let \( \text{sensitivity} \) be \( \text{dataLocaleData}.[[\text{sensitivity}]] \).
28. Set \( \text{collator}.[[\text{Sensitivity}]] \) to \( \text{sensitivity} \).
29. Let \( \text{ignorePunctuation} \) be ? \( \text{GetOption}(\text{options}, \text{"ignorePunctuation"}, \text{boolean}, \text{empty}, \text{false}) \).
30. Set \( \text{collator}.[[\text{IgnorePunctuation}]] \) to \( \text{ignorePunctuation} \).
31. Return \( \text{collator} \).

### 10.2 Properties of the Intl.Collator Constructor

The Intl.Collator constructor has the following properties:
10.2.1 Intl.Collator.prototype

The value of Intl.Collator.prototype is %Collator.prototype%.

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

10.2.2 Intl.Collator.supportedLocalesOf ( locales [, options ])

When the supportedLocalesOf method is called with arguments locales and options, the following steps are taken:

1. Let availableLocales be %Collator%.[[AvailableLocales]].
2. Let requestedLocales be ? CanonicalizeLocaleList(locales).

10.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1. The value of the [[RelevantExtensionKeys]] internal slot is a List that must include the element "co", may include any or all of the elements "kf" and "kn", and must not include any other elements.

NOTE Unicode Technical Standard #35 Part 1 Core, Section 3.6.1 Key and Type Definitions describes ten locale extension keys that are relevant to collation: "co" for collator usage and specializations, "ka" for alternate handling, "kb" for backward second level weight, "kc" for case level, "kf" for case first, "kh" for hiragana quaternary, "kk" for normalization, "kn" for numeric, "kr" for reordering, "ks" for collation strength, and "vt" for variable top. Collator, however, requires that the usage is specified through the "usage" property of the options object, alternate handling through the "ignorePunctuation" property of the options object, and case level and the strength through the "sensitivity" property of the options object. The "co" key in the language tag is supported only for collator specializations, and the keys "kb", "kh", "kk", "kr", and "vt" are not allowed in this version of the Internationalization API. Support for the remaining keys is implementation dependent.

The values of the [[SortLocaleData]] and [[SearchLocaleData]] internal slots are implementation-defined within the constraints described in 9.1 and the following additional constraints, for all locale values locale:

- The first element of [[SortLocaleData]].[[<locale>]].[[co]] and [[SearchLocaleData]].[[<locale>]].[[co]] must be null.
- The values "standard" and "search" must not be used as elements in any [[SortLocaleData]].[[<locale>]].[[co]] and [[SearchLocaleData]].[[<locale>]].[[co]] list.
- [[SearchLocaleData]].[[<locale>]] must have a [[sensitivity]] field with a String value equal to "base", "accent", "case", or "variant".

10.3 Properties of the Intl.Collator Prototype Object

The Intl.Collator prototype object is itself an ordinary object. %Collator.prototype% is not an Intl.Collator instance and does not have an [[InitializedCollator]] internal slot or any of the other internal slots of Intl.Collator instance objects.
10.3.1 Intl.Collator.prototype.constructor

The initial value of Intl.Collator.prototype.constructor is %Collator%.

10.3.2 Intl.Collator.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the String value "Intl.Collator".

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

10.3.3 get Intl.Collator.prototype.compare

This named accessor property returns a function that compares two strings according to the sort order of this Collator object.

Intl.Collator.prototype.compare is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let collator be the this value.
2. Perform ? RequireInternalSlot(collator, [[InitializedCollator]]).
3. If collator.[[BoundCompare]] is undefined, then
   a. Let F be a new built-in function object as defined in 10.3.3.1.
   b. Set F.[[Collator]] to collator.
   c. Set collator.[[BoundCompare]] to F.
4. Return collator.[[BoundCompare]].

NOTE The returned function is bound to collator so that it can be passed directly to Array.prototype.sort or other functions.

10.3.3.1 Collator Compare Functions

A Collator compare function is an anonymous built-in function that has a [[Collator]] internal slot.

When a Collator compare function F is called with arguments x and y, the following steps are taken:

1. Let collator be F.[[Collator]].
2. Assert: Type(collator) is Object and collator has an [[InitializedCollator]] internal slot.
3. If x is not provided, let x be undefined.
4. If y is not provided, let y be undefined.
5. Let X be ? ToString(x).
7. Return CompareStrings(collator, X, Y).

The "length" property of a Collator compare function is 2.

10.3.3.2 CompareStrings ( collator, x, y )

When the CompareStrings abstract operation is called with arguments collator (which must be an object initialized as a Collator), x and y (which must be String values), it returns a Number other than NaN representing the result of an implementation-defined locale-sensitive String comparison of x with y. The result is intended to correspond with a sort order of String values according to the effective locale and collation options of collator, and will be negative when x is ordered before y, positive when x is ordered after.
and zero in all other cases (representing no relative ordering between \(x\) and \(y\)). String values must be interpreted as UTF-16 code unit sequences as described in es2023, 6.1.4, and a surrogate pair (a code unit in the range 0xD800 to 0xDBFF followed by a code unit in the range 0xDC00 to 0xDFFF) within a string must be interpreted as the corresponding code point.

Behaviour as described below depends upon locale-sensitive identification of the sequence of collation elements for a string, in particular "base letters", and different base letters always compare as unequal (causing the strings containing them to also compare as unequal). Results of comparing variations of the same base letter with different case, diacritic marks, or potentially other aspects further depends upon `collator`.[[Sensitivity]] as follows:

<table>
<thead>
<tr>
<th>[[Sensitivity]]</th>
<th>Description</th>
<th>&quot;a&quot; vs. &quot;á&quot;</th>
<th>&quot;a&quot; vs. &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;base&quot;</td>
<td>Characters with the same base letter do not compare as unequal, regardless of differences in case and/or diacritic marks.</td>
<td>equal</td>
<td>equal</td>
</tr>
<tr>
<td>&quot;accent&quot;</td>
<td>Characters with the same base letter compare as unequal only if they differ in accents and/or other diacritic marks, regardless of differences in case.</td>
<td>not equal</td>
<td>equal</td>
</tr>
<tr>
<td>&quot;case&quot;</td>
<td>Characters with the same base letter compare as unequal only if they differ in case, regardless of differences in accents and/or other diacritic marks.</td>
<td>equal</td>
<td>not equal</td>
</tr>
<tr>
<td>&quot;variant&quot;</td>
<td>Characters with the same base letter compare as unequal if they differ in case, diacritic marks, and/or potentially other differences.</td>
<td>not equal</td>
<td>not equal</td>
</tr>
</tbody>
</table>

**NOTE 1**  The mapping from input code points to base letters can include arbitrary contractions, expansions, and collisions, including those that apply special treatment to certain characters with diacritic marks. For example, in Swedish, "ö" is a base letter that differs from "o", and "v" and "w" are considered to be the same base letter. In Slovak, "čh" is a single base letter, and in English, "ae" is a sequence of base letters starting with "a" and ending with "e".

If `collator`.[[IgnorePunctuation]] is true, then punctuation is ignored (e.g., strings that differ only in punctuation compare as equal).

For the interpretation of options settable through locale extension keys, see Unicode Technical Standard #35 Part 1 Core, Section 3.6.1 Key and Type Definitions.

The actual return values are implementation-defined to permit encoding additional information in them, but this operation for any given `collator`, when considered as a function of \(x\) and \(y\), is required to be a consistent comparator defining a total ordering on the set of all Strings. This operation is also required to recognize and honour canonical equivalence according to the Unicode Standard, including returning \(+0\) when comparing distinguishable Strings that are canonically equivalent.

**NOTE 2**  It is recommended that the CompareStrings abstract operation be implemented following Unicode Technical Standard #10: Unicode Collation Algorithm, using tailorings for the effective locale and collation options of `collator`. It is recommended that implementations use the tailorings provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).

**NOTE 3**  Applications should not assume that the behaviour of the CompareStrings abstract operation for Collator instances with the same resolved options will remain the same for different versions of the same implementation.
10.3.4 Intl.Collator.prototype.resolvedOptions ( )

This function provides access to the locale and options computed during initialization of the object.

1. Let `collator` be the this value.
3. Let `options` be `OrdinaryObjectCreate(%Object.prototype%)`.
4. For each row of Table 4, except the header row, in table order, do
   a. Let `p` be the Property value of the current row.
   b. Let `v` be the value of `collator`'s internal slot whose name is the Internal Slot value of the current row.
   c. If the current row has an Extension Key value, then
      i. Let `extensionKey` be the Extension Key value of the current row.
      ii. If `%Collator%.[[RelevantExtensionKeys]] does not contain `extensionKey`, then
         1. Let `v` be `undefined`.
   d. If `v` is not `undefined`, then
      i. Perform `! CreateDataPropertyOrThrow(options, p, v)`.
5. Return `options`.

Table 4: Resolved Options of Collator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
<th>Extension Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
<td></td>
</tr>
<tr>
<td>[[Usage]]</td>
<td>&quot;usage&quot;</td>
<td></td>
</tr>
<tr>
<td>[[Sensitivity]]</td>
<td>&quot;sensitivity&quot;</td>
<td></td>
</tr>
<tr>
<td>[[IgnorePunctuation]]</td>
<td>&quot;ignorePunctuation&quot;</td>
<td></td>
</tr>
<tr>
<td>[[Collation]]</td>
<td>&quot;collation&quot;</td>
<td></td>
</tr>
<tr>
<td>[[Numeric]]</td>
<td>&quot;numeric&quot;</td>
<td>&quot;kn&quot;</td>
</tr>
<tr>
<td>[[CaseFirst]]</td>
<td>&quot;caseFirst&quot;</td>
<td>&quot;kf&quot;</td>
</tr>
</tbody>
</table>

10.4 Properties of Intl.Collator Instances

Intl.Collator instances are ordinary objects that inherit properties from `%Collator.prototype%`.

Intl.Collator instances have an [[InitializedCollator]] internal slot.

Intl.Collator instances also have several internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used for collation.
- [[Usage]] is one of the String values "sort" or "search", identifying the collator usage.
- [[Sensitivity]] is one of the String values "base", "accent", "case", or "variant", identifying the collator's sensitivity.
- [[IgnorePunctuation]] is a Boolean value, specifying whether punctuation should be ignored in comparisons.
- [[Collation]] is a String value with the "type" given in Unicode Technical Standard #35 for the collation, except that the values "standard" and "search" are not allowed, while the value "default" is allowed.
Intl.Collator instances also have the following internal slots if the key corresponding to the name of the internal slot in Table 4 is included in the [[RelevantExtensionKeys]] internal slot of Intl.Collator:

- **[[Numeric]]** is a Boolean value, specifying whether numeric sorting is used.
- **[[CaseFirst]]** is one of the String values "upper", "lower", or "false".

Finally, Intl.Collator instances have a [[BoundCompare]] internal slot that caches the function returned by the compare accessor (10.3.3).

## 11 DateTimeFormat Objects

### 11.1 The Intl.DateTimeFormat Constructor

The Intl.DateTimeFormat constructor is the %DateTimeFormat% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

### 11.1.1 Intl.DateTimeFormat ([ locales [, options ] ])

When the Intl.DateTimeFormat function is called with optional arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, let newTarget be the active function object, else let newTarget be NewTarget.
2. Let dateTimeFormat be ? OrdinaryCreateFromConstructor(newTarget, "%DateTimeFormat.prototype", « [[InitializedDateTimeFormat]], [[Locale]], [[Calendar]], [[NumberingSystem]], [[TimeZone]], [[Weekday]], [[Era]], [[Year]], [[Month]], [[Day]], [[DayPeriod]], [[Hour]], [[Minute]], [[Second]], [[FractionalSecondDigits]], [[TimeZoneName]], [[HourCycle]], [[DateTime]], [[TimeStyle]], [[Pattern]], [[RangePatterns]], [[BoundFormat]] »).
3. Perform ? InitializeDateTimeFormat(dateTimeFormat, locales, options).
4. If the implementation supports the normative optional constructor mode of 4.3 Note 1, then
   a. Let this be the this value.
   b. Return ? ChainDateTimeFormat(dateTimeFormat, NewTarget, this).
5. Return dateTimeFormat.

### 11.1.1.1 ChainDateTimeFormat ( dateTimeFormat, newTarget, this )

1. If newTarget is undefined and ? OrdinaryHasInstance(%DateTimeFormat%, this) is true, then
   a. Perform ? DefinePropertyOrThrow(this, %Intl%.[[FallbackSymbol]], PropertyDescriptor{[[Value]]: dateTimeFormat, [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}).
   b. Return this.
2. Return dateTimeFormat.
11.1.2 InitializeDateTimeFormat (\texttt{dateTimeFormat}, \texttt{locales}, \texttt{options})

The abstract operation InitializeDateTimeFormat accepts the arguments \texttt{dateTimeFormat} (which must be an object), \texttt{locales}, and \texttt{options}. It initializes \texttt{dateTimeFormat} as a DateTimeFormat object. This abstract operation functions as follows:

The following algorithm refers to the \texttt{type} nonterminal from UTS 35's Unicode Locale Identifier grammar.

1. Let \texttt{requestedLocales} be ? \texttt{CanonicalizeLocaleList(locales)}.
2. Set \texttt{options} to ? \texttt{ToDateTimeOptions(options, "any", "date").}
3. Let \texttt{opt} be a new \texttt{Record}.
4. Let \texttt{matcher} be ? \texttt{GetOption(options, "localeMatcher", string, « "lookup", "best fit" », "best fit")}.
5. Set \texttt{opt.[[localeMatcher]]} to \texttt{matcher}.
6. Let \texttt{calendar} be ? \texttt{GetOption(options, "calendar", string, empty, undefined)}.
7. If \texttt{calendar} is not \texttt{undefined}, then
   a. If \texttt{calendar} does not match the Unicode Locale Identifier \texttt{type} nonterminal, throw a \texttt{RangeError} exception.
8. Set \texttt{opt.[[ca]]} to \texttt{calendar}.
9. Let \texttt{numberingSystem} be ? \texttt{GetOption(options, "numberingSystem", string, empty, undefined)}.
10. If \texttt{numberingSystem} is not \texttt{undefined}, then
    a. If \texttt{numberingSystem} does not match the Unicode Locale Identifier \texttt{type} nonterminal, throw a \texttt{RangeError} exception.
11. Set \texttt{opt.[[nu]]} to \texttt{numberingSystem}.
12. Let \texttt{hour12} be ? \texttt{GetOption(options, "hour12", boolean, empty, undefined)}.
13. Let \texttt{hourCycle} be ? \texttt{GetOption(options, "hourCycle", string, « "h11", "h12", "h23", "h24" », undefined)}.
14. If \texttt{hour12} is not \texttt{undefined}, then
    a. Set \texttt{hourCycle} to \texttt{null}.
15. Set \texttt{opt.[[hc]]} to \texttt{hourCycle}.
16. Let \texttt{localeData} be \texttt{%DateTimeFormat%.[[LocaleData]]}.
17. Let \texttt{r} be \texttt{ResolveLocale(%DateTimeFormat%.[[AvailableLocales]], requestedLocales, opt, %DateTimeFormat%.[[AvailableLocales]], localeData)}.
18. Set \texttt{dateTimeFormat.[[Locale]]} to \texttt{r.[[locale]]}.
19. Let \texttt{resolvedCalendar} be \texttt{r.[[ca]]}.
20. Set \texttt{dateTimeFormat.[[Calendar]]} to \texttt{resolvedCalendar}.
21. Set \texttt{dateTimeFormat.[[NumberingSystem]]} to \texttt{r.[[nu]]}.
22. Let \texttt{dataLocale} be \texttt{r.[[dataLocale]]}.
23. Let \texttt{dataLocaleData} be \texttt{localeData.[[<dataLocale>]]}.
24. Let \texttt{hcDefault} be \texttt{dataLocaleData.[[hourCycle]]}.
25. If \texttt{hour12} is \texttt{true}, then
    a. If \texttt{hcDefault} is "h11" or "h23", let \texttt{hc} be "h11". Otherwise, let \texttt{hc} be "h12".
26. Else if \texttt{hour12} is \texttt{false}, then
    a. If \texttt{hcDefault} is "h11" or "h23", let \texttt{hc} be "h23". Otherwise, let \texttt{hc} be "h24".
27. Else,
    a. Assert: \texttt{hour12} is \texttt{undefined}.
    b. Let \texttt{hc} be \texttt{r.[[hc]]}.
    c. If \texttt{hc} is \texttt{null}, set \texttt{hc} to \texttt{hcDefault}.
28. Set \texttt{dateTimeFormat.[[HourCycle]]} to \texttt{hc}.
29. Let \texttt{timeZone} be ? \texttt{Get(options, "timeZone")}.
30. If \texttt{timeZone} is \texttt{undefined}, then
    a. Set \texttt{timeZone} to DefaultTimeZone().
31. Else,
a. Set \( \text{timeZone} \) to \( \text{toString}(\text{timeZone}) \).
b. If the result of \( \text{isValidTimeZoneName}(\text{timeZone}) \) is \text{false}, then
   i. Throw a \text{RangeError} exception.
c. Set \( \text{timeZone} \) to \( \text{canonicalizeTimeZoneName}(\text{timeZone}) \).

32. Set \( \text{dateDateTimeFormat}[[\text{TimeZone}]] \) to \( \text{timeZone} \).
33. Let \( \text{formatOptions} \) be a new \text{Record}.
34. Set \( \text{formatOptions}[[\text{hourCycle}]] \) to \( \text{hc} \).
35. Let \( \text{hasExplicitFormatComponents} \) be \text{false}.
36. For each row of Table 7, except the header row, in table order, do
   a. Let \( \text{prop} \) be the name given in the Property column of the row.
   b. If \( \text{prop} \) is \text{"fractionalSecondDigits"}, then
      i. Let \( \text{value} \) be \( \text{getNumberOption}(\text{options}, \text{"fractionalSecondDigits"}, 1, 3, \text{undefined}) \).
   c. Else,
      i. Let \( \text{values} \) be a \text{List} whose elements are the strings given in the Values column of the row.
      ii. Let \( \text{value} \) be \( \text{getOption}(\text{options}, \text{prop}, \text{string}, \text{values}, \text{undefined}) \).
   d. Set \( \text{formatOptions.}[[\text{prop}]] \) to \text{value}.
   e. If \( \text{value} \) is not \text{undefined}, then
      i. Set \( \text{hasExplicitFormatComponents} \) to \text{true}.
37. Let \( \text{matcher} \) be \( \text{getOption}(\text{options}, \text{"formatMatcher"}, \text{string}, \text{"basic"}, \text{"best fit"}, \text{"best fit"}) \).
38. Let \( \text{dateStyle} \) be \( \text{getOption}(\text{options}, \text{"dateStyle"}, \text{string}, \text{"full"}, \text{"long"}, \text{"medium"}, \text{"short"}, \text{undefined}) \).
39. Set \( \text{dateDateTimeFormat}[[\text{DateString}]] \) to \( \text{dateStyle} \).
40. Let \( \text{timeStyle} \) be \( \text{getOption}(\text{options}, \text{"timeStyle"}, \text{string}, \text{"full"}, \text{"long"}, \text{"medium"}, \text{"short"}, \text{undefined}) \).
41. Set \( \text{dateDateTimeFormat}[[\text{TimeString}]] \) to \( \text{timeStyle} \).
42. If \( \text{dateStyle} \) is not \text{undefined} or \( \text{timeStyle} \) is not \text{undefined}, then
   a. If \( \text{hasExplicitFormatComponents} \) is \text{true}, then
      i. Throw a \text{TypeError} exception.
   b. Let \( \text{styles} \) be \( \text{dataLocaleData.}[[\text{styles}]]([[\text{resolvedCalendar}]])) \).
   c. Let \( \text{bestFormat} \) be \( \text{DateTimeStyleFormat}(\text{dateStyle}, \text{timeStyle}, \text{styles}) \).
43. Else,
   a. Let \( \text{formats} \) be \( \text{dataLocaleData.}[[\text{formats}]]([[\text{resolvedCalendar}]])) \).
   b. If \( \text{matcher} \) is \text{"basic"}, then
      i. Let \( \text{bestFormat} \) be \( \text{BasicFormatMatcher}(\text{formatOptions}, \text{formats}) \).
   c. Else,
      i. Let \( \text{bestFormat} \) be \( \text{BestFitFormatMatcher}(\text{formatOptions}, \text{formats}) \).
44. For each row in Table 7, except the header row, in table order, do
   a. Let \( \text{prop} \) be the name given in the Property column of the row.
   b. If \( \text{bestFormat} \) has a field [[\text{prop}]], then
      i. Let \( \text{p} \) be \( \text{bestFormat.}[[\text{prop}]] \).
      ii. Set \( \text{dateDateTimeFormat} \)'s internal slot whose name is the Internal Slot column of the row to \( \text{p} \).
45. If \( \text{dateDateTimeFormat.}[[\text{Hour}]] \) is \text{undefined}, then
   a. Set \( \text{dateDateTimeFormat.}[[\text{HourCycle}]] \) to \text{undefined}.
46. If \( \text{dateDateTimeFormat.}[[\text{HourCycle}]] \) is \text{"h11"} or \text{"h12"}, then
   a. Let \( \text{pattern} \) be \( \text{bestFormat.}[[\text{pattern12}]] \).
   b. Let \( \text{rangePatterns} \) be \( \text{bestFormat.}[[\text{rangePatterns12}]] \).
47. Else,
   a. Let \( \text{pattern} \) be \( \text{bestFormat.}[[\text{pattern}]] \).
   b. Let \( \text{rangePatterns} \) be \( \text{bestFormat.}[[\text{rangePatterns}]] \).
48. Set \( \text{dateDateTimeFormat.}[[\text{Pattern}]] \) to \( \text{pattern} \).
49. Set `dateTimeFormat.[[RangePatterns]]` to `rangePatterns`.
50. Return `dateTimeFormat`.

### 11.2 Properties of the Intl.DateTimeFormat Constructor

The Intl.DateTimeFormat constructor has the following properties:

#### 11.2.1 Intl.DateTimeFormat.prototype

The value of `Intl.DateTimeFormat.prototype` is `%DateTimeFormat.prototype%`. This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.`

#### 11.2.2 Intl.DateTimeFormat.supportedLocalesOf (locales , options )

When the `supportedLocalesOf` method is called with arguments `locales` and `options`, the following steps are taken:

1. Let `availableLocales` be `%DateTimeFormat%.[[AvailableLocales]]`.
2. Let `requestedLocales` be `? CanonicalizeLocaleList(locales)`.

#### 11.2.3 Internal slots

The value of the `[[AvailableLocales]]` internal slot is implementation-defined within the constraints described in 9.1.

The value of the `[[RelevantExtensionKeys]]` internal slot is « "ca", "hc", "nu" ».

**NOTE 1** Unicode Technical Standard #35 describes four locale extension keys that are relevant to date and time formatting: "ca" for calendar, "hc" for hour cycle, "nu" for numbering system (of formatted numbers), and "tz" for time zone. DateTimeFormat, however, requires that the time zone is specified through the "timeZone" property in the options objects.

The value of the `[[LocaleData]]` internal slot is implementation-defined within the constraints described in 9.1 and the following additional constraints, for all locale values `locale`:

- `[[LocaleData]][[<locale>]][[nu]]` must be a List that does not include the values "native", "tradicio", or "finance".
- `[[LocaleData]][[<locale>]][[hc]]` must be « null, "h11", "h12", "h23", "h24" ».
- `[[LocaleData]][[<locale>]][[hourCycle]]` must be a String value equal to "h11", "h12", "h23", or "h24".
- `[[LocaleData]][[<locale>]][[calendar]]` must have a `[[formats]]` field. This `[[formats]]` field must be a Record with `[[<calendar>]]` fields for all calendar values `calendar`. The value of this field must be a list of records, each of which has a subset of the fields shown in Table 7, where each field must have one of the values specified for the field in Table 7. Multiple records in a list may use the same subset of the fields as long as they have different values for the fields. The following subsets must be available for each `locale`:
  - weekday, year, month, day, hour, minute, second, fractionalSecondDigits
  - weekday, year, month, day, hour, minute, second
  - weekday, year, month, day
  - year, month, day
  - year, month
  - month, day
- hour, minute, second, fractionalSecondDigits
- hour, minute, second
- hour, minute
- dayPeriod, hour
- dayPeriod, hour, minute, second
- dayPeriod, hour, minute

Each of the records must also have the following fields:

1. A [[pattern]] field, whose value is a String value that contains for each of the date and time format component fields of the record a substring starting with "{", followed by the name of the field, followed by "}".
2. If the record has an [[hour]] field, it must also have a [[pattern12]] field, whose value is a String value that, in addition to the substrings of the [[pattern]] field, contains at least one of the substrings "{ampm}" or "{dayPeriod}".
3. If the record has a [[year]] field, the [[pattern]] and [[pattern12]] values may contain the substrings "{yearName}" and "{relatedYear}".
4. A [[rangePatterns]] field with a Record value:
   - The [[rangePatterns]] record may have any of the fields in Table 5, where each field represents a range pattern and its value is a Record.
     - The name of the field indicates the largest calendar element that must be different between the start and end dates in order to use this range pattern. For example, if the field name is [[Month]], it contains the range pattern that should be used to format a date range where the era and year values are the same, but the month value is different.
   - The record will contain the following fields:
     - A subset of the fields shown in the Property column of Table 7, where each field must have one of the values specified for that field in the Values column of Table 7. All fields required to format a date for any of the [[PatternParts]] records must be present.
     - A [[PatternParts]] field whose value is a list of Records each representing a part of the range pattern. Each record contains a [[Pattern]] field and a [[Source]] field. The [[Pattern]] field's value is a String of the same format as the regular date pattern String. The [[Source]] field is one of the String values "shared", "startRange", or "endRange". It indicates which of the range's dates should be formatted using the value of the [[Pattern]] field.
   - The [[rangePatterns]] record must have a [[Default]] field which contains the default range pattern used when the specific range pattern is not available. Its value is a list of records with the same structure as the other fields in the [[rangePatterns]] record.
5. If the record has an [[hour]] field, it must also have a [[rangePatterns12]] field. Its value is similar to the Record in [[rangePatterns]], but it uses a String similar to [[pattern12]] for each part of the range pattern.
6. If the record has a [[year]] field, the [[rangePatterns]] and [[rangePatterns12]] fields may contain range patterns where the [[Pattern]] values may contain the substrings "{yearName}" and "{relatedYear}".

- [[LocaleData]][<locale>]] must have a [[styles]] field. The [[styles]] field must be a Record with [[<calendar>]] fields for all calendar values calendar. The calendar records must contain [[DateFormat]], [[TimeFormat]], [[DateTimeFormat]] and [[DateTimeRangeFormat]] fields, the value of these fields are Records, where each of which has [[full]], [[long]], [[medium]] and [[short]] fields. For [[DateFormat]] and [[TimeFormat]], the value of these fields must be a record, which has a subset of the fields shown in Table 7, where each field must have one of the values specified for the field in Table 7. Each of the records must also have the following fields:
  1. A [[pattern]] field, whose value is a String value that contains for each of the date and time format component fields of the record a substring starting with "{", followed by the name of the field, followed by "}".
  2. If the record has an [[hour]] field, it must also have a [[pattern12]] field, whose value is a String value that, in addition to the substrings of the pattern field, contains at least one of the substrings "{ampm}" or "{dayPeriod}".
  3. A [[rangePatterns]] field that contains a record similar to the one described in the [[formats]] field.
  4. If the record has an [[hour]] field, it must also have a [[rangePatterns12]] field. Its value is similar to the record in [[rangePatterns]] but it uses a string similar to [[pattern12]] for each range pattern.

For [[DateTimeFormat]], the field value must be a string pattern which contains the strings "{0}" and "{1}". For [[DateTimeRangeFormat]] the value of these fields must be a nested record which also has [[full]], [[long]], [[medium]] and [[short]] fields. The [[full]], [[long]], [[medium]] and [[short]] fields in the enclosing
NOTE 2  For example, an implementation might include the following record as part of its English locale data:

- 
  ```
  [[rangePatterns]]:
  - 
    `[[hour]]`: "numeric"
  - 
    `[[minute]]`: "numeric"
  - 
    `[[pattern]]`: "(hour):(minute)"
  - 
    `[[pattern12]]`: "(hour):(minute) {ampm}"
  - 
    `[[rangePatterns]]`:
    - 
      `[[Hour]]`:
      - 
        `[[hour]]`: "numeric"
      - 
        `[[minute]]`: "numeric"
      - 
        `[[PatternParts]]`:
        - 
          `[[Source]]`: "startRange", `[[Pattern]]`: "(hour):(minute)"
        - 
          `[[Source]]`: "shared", `[[Pattern]]`: "- "
        - 
          `[[Source]]`: "endRange", `[[Pattern]]`: "(hour):(minute)"
    - 
      `[[Minute]]`:
      - 
        `[[hour]]`: "numeric"
      - 
        `[[minute]]`: "numeric"
      - 
        `[[PatternParts]]`:
        - 
          `[[Source]]`: "startRange", `[[Pattern]]`: "(hour):(minute)"
        - 
          `[[Source]]`: "shared", `[[Pattern]]`: "- "
        - 
          `[[Source]]`: "endRange", `[[Pattern]]`: "(hour):(minute)"
    - 
      `[[Default]]`:
      - 
        `[[year]]`: "2-digit"
      - 
        `[[month]]`: "numeric"
      - 
        `[[day]]`: "numeric"
      - 
        `[[hour]]`: "numeric"
      - 
        `[[minute]]`: "numeric"
      - 
        `[[PatternParts]]`:
        - 
          `[[Source]]`: "startRange", `[[Pattern]]`: "(day)(month)(year), (hour):(minute)"
        - 
          `[[Source]]`: "shared", `[[Pattern]]`: "- "
        - 
          `[[Source]]`: "endRange", `[[Pattern]]`: "(day)(month)(year), (hour):(minute)"
  - 
    `[[rangePatterns12]]`:
    - 
      `[[Hour]]`:
      - 
        `[[hour]]`: "numeric"
      - 
        `[[minute]]`: "numeric"
      - 
        `[[PatternParts]]`:
        - 
          `[[Source]]`: "startRange", `[[Pattern]]`: "(hour):(minute)"
        - 
          `[[Source]]`: "shared", `[[Pattern]]`: "- "
        - 
          `[[Source]]`: "endRange", `[[Pattern]]`: "(hour):(minute)"
      - 
        `[[Minute]]`:
        - 
          `[[hour]]`: "numeric"
        - 
          `[[minute]]`: "numeric"
        - 
          `[[PatternParts]]`:
          - 
            `[[Source]]`: "startRange", `[[Pattern]]`: "(hour):(minute)"
          - 
            `[[Source]]`: "shared", `[[Pattern]]`: "- "
          - 
            `[[Source]]`: "endRange", `[[Pattern]]`: "(hour):(minute)"
      - 
        `[[Default]]`:
        - 
          `[[year]]`: "2-digit"
        - 
          `[[month]]`: "numeric"
        - 
          `[[day]]`: "numeric"
        - 
          `[[hour]]`: "numeric"
        - 
          `[[minute]]`: "numeric"
NOTE 3 It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).

Table 5: Range pattern fields

<table>
<thead>
<tr>
<th>Range Pattern Field</th>
<th>Pattern String Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Era]]</td>
<td>&quot;era&quot;</td>
</tr>
<tr>
<td>[[Year]]</td>
<td>&quot;year&quot;</td>
</tr>
<tr>
<td>[[Month]]</td>
<td>&quot;month&quot;</td>
</tr>
<tr>
<td>[[Day]]</td>
<td>&quot;day&quot;</td>
</tr>
<tr>
<td>[[AmPm]]</td>
<td>&quot;ampm&quot;</td>
</tr>
<tr>
<td>[[DayPeriod]]</td>
<td>&quot;dayPeriod&quot;</td>
</tr>
<tr>
<td>[[Hour]]</td>
<td>&quot;hour&quot;</td>
</tr>
<tr>
<td>[[Minute]]</td>
<td>&quot;minute&quot;</td>
</tr>
<tr>
<td>[[Second]]</td>
<td>&quot;second&quot;</td>
</tr>
<tr>
<td>[[FractionalSecondDigits]]</td>
<td>&quot;fractionalSecondDigits&quot;</td>
</tr>
</tbody>
</table>

11.3 Properties of the Intl.DateTimeFormat Prototype Object

The Intl.DateTimeFormat prototype object is itself an ordinary object. `%DateTimeFormat.prototype%` is not an Intl.DateTimeFormat instance and does not have an [[InitializedDateTimeFormat]] internal slot or any of the other internal slots of Intl.DateTimeFormat instance objects.

11.3.1 Intl.DateTimeFormat.prototype.constructor

The initial value of Intl.DateTimeFormat.prototype.constructor is `%DateTimeFormat%`.

11.3.2 Intl.DateTimeFormat.prototype [ @@toStringTag ]

The initial value of the @@toStringTag property is the String value "Intl.DateTimeFormat".

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

11.3.3 get Intl.DateTimeFormat.prototype.format

Intl.DateTimeFormat.prototype.format is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:
1. Let \( dtf \) be the \textit{this} value.
2. If the implementation supports the normative optional \textit{constructor} mode of 4.3 Note 1, then
   a. Set \( dtf \) to \( ?\ UnwrapDateTimeFormat(dtf) \).
3. Perform \( ?\ RequireInternalSlot(dtf, [[InitializedDateTimeFormat]]) \).
4. If \( dtf. [[BoundFormat]] \) is \textit{undefined}, then
   a. Let \( F \) be a new built-in \textit{function object} as defined in DateTime Format Functions (11.5.5).
   b. Set \( F. [[DateTimeFormat]] \) to \( dtf \).
   c. Set \( dtf. [[BoundFormat]] \) to \( F \).
5. Return \( dtf. [[BoundFormat]] \).

\textbf{NOTE} The returned function is bound to \( dtf \) so that it can be passed directly to \texttt{Array.prototype.map} or other functions. This is considered a historical artefact, as part of a convention which is no longer followed for new features, but is preserved to maintain compatibility with existing programs.

11.3.4 \texttt{Intl.DateTimeFormat.prototype.formatToParts ( date )}

When the \texttt{formatToParts} method is called with an argument \textit{date}, the following steps are taken:

1. Let \( dtf \) be the \textit{this} value.
2. Perform \( ?\ RequireInternalSlot(dtf, [[InitializedDateTimeFormat]]) \).
3. If \textit{date} is \textit{undefined}, then
   a. Let \( x \) be \! \texttt{Call}(%Date.now%, \textit{undefined}, \textit{undefined})).
4. Else,
   a. Let \( x \) be \( ?\ ToNumber(date) \).
5. Return \( ?\ FormatDateTimeToParts(dtf, x) \).

11.3.5 \texttt{Intl.DateTimeFormat.prototype.formatRange ( startDate, endDate )}

When the \texttt{formatRange} method is called with arguments \textit{startDate} and \textit{endDate}, the following steps are taken:

1. Let \( dtf \) be this value.
2. Perform \( ?\ RequireInternalSlot(dtf, [[InitializedDateTimeFormat]]) \).
3. If \textit{startDate} is \textit{undefined} or \textit{endDate} is \textit{undefined}, throw a \textit{TypeError} exception.
4. Let \( x \) be \( ?\ ToNumber(startDate) \).
5. Let \( y \) be \( ?\ ToNumber(endDate) \).
6. Return \( ?\ FormatDateTimeRangeToParts(dtf, x, y) \).

11.3.6 \texttt{Intl.DateTimeFormat.prototype.formatRangeToParts ( startDate, endDate )}

When the \texttt{formatRangeToParts} method is called with arguments \textit{startDate} and \textit{endDate}, the following steps are taken:

1. Let \( dtf \) be this value.
2. Perform \( ?\ RequireInternalSlot(dtf, [[InitializedDateTimeFormat]]) \).
3. If \textit{startDate} is \textit{undefined} or \textit{endDate} is \textit{undefined}, throw a \textit{TypeError} exception.
4. Let \( x \) be \( ?\ ToNumber(startDate) \).
5. Let \( y \) be \( ?\ ToNumber(endDate) \).
6. Return \( ?\ FormatDateTimeRangeToParts(dtf, x, y) \).
11.3.7 Intl.DateTimeFormat.prototype.resolvedOptions ( )

This function provides access to the locale and options computed during initialization of the object.

1. Let dtf be the this value.
2. If the implementation supports the normative optional constructor mode of 4.3 Note 1, then
   a. Set dtf to ? UnwrapDateTimeFormat(dtf).
3. Perform ? RequireInternalSlot(dtf, [[InitializedDateTimeFormat]]).
4. Let options be OrdinaryObjectCreate(%Object.prototype%).
5. For each row of Table 6, except the header row, in table order, do
   a. Let p be the Property value of the current row.
      b. If p is "hour12", then
         i. Let hc be dtf.[[HourCycle]].
         ii. If hc is "h11" or "h12", let v be true.
         iii. Else if, hc is "h23" or "h24", let v be false.
         iv. Else, let v be undefined.
   c. Else,
      i. Let v be the value of dtf's internal slot whose name is the Internal Slot value of the current row.
   d. If the Internal Slot value of the current row is an Internal Slot value in Table 7, then
      i. If dtf.[[DateStyle]] is not undefined or dtf.[[TimeStyle]] is not undefined, then
         1. Let v be undefined.
   e. If v is not undefined, then
      i. Perform ! CreateDataPropertyOrThrow(options, p, v).
6. Return options.

Table 6: Resolved Options of DateTimeFormat Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[Calendar]]</td>
<td>&quot;calendar&quot;</td>
</tr>
<tr>
<td>[[NumberingSystem]]</td>
<td>&quot;numberingSystem&quot;</td>
</tr>
<tr>
<td>[[TimeZone]]</td>
<td>&quot;timeZone&quot;</td>
</tr>
<tr>
<td>[[HourCycle]]</td>
<td>&quot;hourCycle&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;hour12&quot;</td>
</tr>
<tr>
<td>[[Weekday]]</td>
<td>&quot;weekday&quot;</td>
</tr>
<tr>
<td>[[Era]]</td>
<td>&quot;era&quot;</td>
</tr>
<tr>
<td>[[Year]]</td>
<td>&quot;year&quot;</td>
</tr>
<tr>
<td>[[Month]]</td>
<td>&quot;month&quot;</td>
</tr>
<tr>
<td>[[Day]]</td>
<td>&quot;day&quot;</td>
</tr>
<tr>
<td>[[DayPeriod]]</td>
<td>&quot;dayPeriod&quot;</td>
</tr>
<tr>
<td>[[Hour]]</td>
<td>&quot;hour&quot;</td>
</tr>
</tbody>
</table>
Table 6 (continued)

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Minute]]</td>
<td>&quot;minute&quot;</td>
</tr>
<tr>
<td>[[Second]]</td>
<td>&quot;second&quot;</td>
</tr>
<tr>
<td>[[FractionalSecondDigits]]</td>
<td>&quot;fractionalSecondDigits&quot;</td>
</tr>
<tr>
<td>[[TimeZoneName]]</td>
<td>&quot;timeZoneName&quot;</td>
</tr>
<tr>
<td>[[DateStyle]]</td>
<td>&quot;dateStyle&quot;</td>
</tr>
<tr>
<td>[[TimeStyle]]</td>
<td>&quot;timeStyle&quot;</td>
</tr>
</tbody>
</table>

For web compatibility reasons, if the property "hourCycle" is set, the "hour12" property should be set to true when "hourCycle" is "h11" or "h12", or to false when "hourCycle" is "h23" or "h24".

NOTE 1 In this version of the ECMAScript 2023 Internationalization API, the "timeZone" property will be the identifier of the host environment's time zone if no "timeZone" property was provided in the options object provided to the Intl.DateTimeFormat constructor. The first edition left the "timeZone" property undefined in this case.

NOTE 2 For compatibility with versions prior to the fifth edition, the "hour12" property is set in addition to the "hourCycle" property.

11.4 Properties of Intl.DateTimeFormat Instances

Intl.DateTimeFormat instances are ordinary objects that inherit properties from %DateTimeFormat.prototype%.

Intl.DateTimeFormat instances have an [[InitializedDateTimeFormat]] internal slot.

Intl.DateTimeFormat instances also have several internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used for formatting.
- [[Calendar]] is a String value with the "type" given in Unicode Technical Standard #35 for the calendar used for formatting.
- [[NumberingSystem]] is a String value with the "type" given in Unicode Technical Standard #35 for the numbering system used for formatting.
- [[TimeZone]] is a String value that is a time zone identifier from the IANA Time Zone Database used for formatting.
- [[Weekday]], [[Era]], [[Year]], [[Month]], [[Day]], [[DayPeriod]], [[Hour]], [[Minute]], [[Second]], [[TimeZoneName]] are each either undefined, indicating that the component is not used for formatting, or one of the String values given in Table 7, indicating how the component should be presented in the formatted output.
- [[FractionalSecondDigits]] is either undefined or a positive, non-zero integer Number value indicating the fraction digits to be used for fractional seconds. Numbers will be rounded or padded with trailing zeroes if necessary.
- [[HourCycle]] is a String value indicating whether the 12-hour format ("h11", "h12") or the 24-hour format ("h23", "h24") should be used. "h11" and "h23" start with hour 0 and go up to 11 and 23 respectively. "h12" and "h24" start with hour 1 and go up to 12 and 24. [[HourCycle]] is only used when [[Hour]] is not undefined.
- [[DateStyle]], [[TimeStyle]] are each either undefined, or a String value with values "full", "long", "medium", or "short".
- [[Pattern]] is a String value as described in 11.2.3.
• [[RangePatterns]] is a Record as described in 11.2.3.

Finally, Intl.DateTimeFormat instances have a [[BoundFormat]] internal slot that caches the function returned by the format accessor (11.3.3).

11.5 Abstract Operations for DateTimeFormat Objects

Several DateTimeFormat algorithms use values from the following table, which provides internal slots, property names and allowable values for the components of date and time formats:

Table 7: Components of date and time formats

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Weekday]]</td>
<td>&quot;weekday&quot;</td>
<td>&quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>[[Era]]</td>
<td>&quot;era&quot;</td>
<td>&quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>[[Year]]</td>
<td>&quot;year&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>[[Month]]</td>
<td>&quot;month&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;, &quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>[[Day]]</td>
<td>&quot;day&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>[[DayPeriod]]</td>
<td>&quot;dayPeriod&quot;</td>
<td>&quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>[[Hour]]</td>
<td>&quot;hour&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>[[Minute]]</td>
<td>&quot;minute&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>[[Second]]</td>
<td>&quot;second&quot;</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>[[FractionalSecondDigits]]</td>
<td>&quot;fractionalSecondDigits&quot;</td>
<td>1₁, 2₁, 3₁</td>
</tr>
<tr>
<td>[[TimeZoneName]]</td>
<td>&quot;TimeZoneName&quot;</td>
<td>&quot;short&quot;, &quot;long&quot;, &quot;shortOffset&quot;, &quot;longOffset&quot;, &quot;shortGeneric&quot;, &quot;longGeneric&quot;</td>
</tr>
</tbody>
</table>

11.5.1 ToDateTimeOptions ( options, required, defaults )

When the ToDateTimeOptions abstract operation is called with arguments options, required, and defaults, the following steps are taken:

1. If options is undefined, let options be null; otherwise let options be ? ToObject(options).
2. Let options be OrdinaryObjectCreate(options).
3. Let needDefaults be true.
4. If required is "date" or "any", then
   a. For each property name prop of « "weekday", "year", "month", "day" », do
      i. Let value be ? Get(options, prop).
      ii. If value is not undefined, let needDefaults be false.
5. If required is "time" or "any", then
   a. For each property name prop of « "dayPeriod", "hour", "minute", "second", "fractionalSecondDigits" », do
      i. Let value be ? Get(options, prop).
      ii. If value is not undefined, let needDefaults be false.
6. Let dateStyle be ? Get(options, "dateStyle").
7. Let timeStyle be ? Get(options, "timeStyle").
8. If dateStyle is not undefined or timeStyle is not undefined, let needDefaults be false.
9. If `required` is "date" and `timeStyle` is not undefined, then
   a. Throw a TypeError exception.
10. If `required` is "time" and `dateStyle` is not undefined, then
    a. Throw a TypeError exception.
11. If `needDefaults` is true and `defaults` is either "date" or "all", then
    a. For each property name `prop` of « "year", "month", "day" », do
       i. Perform ? CreateDataPropertyOrThrow(`options`, `prop`, "numeric").
12. If `needDefaults` is true and `defaults` is either "time" or "all", then
    a. For each property name `prop` of « "hour", "minute", "second" », do
       i. Perform ? CreateDataPropertyOrThrow(`options`, `prop`, "numeric").
13. Return `options`.

### 11.5.2 DateTimeStyleFormat ( `dateStyle`, `timeStyle`, `styles` )

The DateTimeStyleFormat abstract operation accepts arguments `dateStyle` and `timeStyle`, which are each either undefined, "full", "long", "medium", or "short", at least one of which is not undefined, and `styles`, which is a record from %DateTimeFormat%.%[LocaleData]!%<locale>!%<styles>!%<calendar> for some locale `locale` and calendar `calendar`. It returns the appropriate format record for date time formatting based on the parameters.

1. If `timeStyle` is not undefined, then
   a. Assert: `timeStyle` is one of "full", "long", "medium", or "short".
   b. Let `timeFormat` be `styles`.[DateTimeFormat]!%<timeStyle>!%.
2. If `dateStyle` is not undefined, then
   a. Assert: `dateStyle` is one of "full", "long", "medium", or "short".
   b. Let `dateFormat` be `styles`.[DateTimeFormat]!%<dateStyle>!%.
3. If `dateStyle` is not undefined and `timeStyle` is not undefined, then
   a. Let `format` be a new Record.
   b. Add to `format` all fields from `dateFormat` except [[pattern]] and [[rangePatterns]].
   c. Add to `format` all fields from `timeFormat` except [[pattern]], [[rangePatterns]], [[pattern12]], and [[rangePatterns12]], if present.
   d. Let `connector` be `styles`.[DateTimeFormat]!%<dateStyle>!%.
   e. Let `pattern` be the string `connector` with the substring "(0)" replaced with `timeFormat`.[pattern]
      and the substring "(1)" replaced with `dateFormat`.[pattern].
   f. Set `format`.[pattern] to `pattern`.
   g. If `timeFormat` has a [[pattern12]] field, then
      i. Let `pattern12` be the string `connector` with the substring "(0)" replaced with `timeFormat`.[pattern12]
         and the substring "(1)" replaced with `dateFormat`.[pattern].
      ii. Set `format`.[pattern12] to `pattern12`.
   h. Let `dateTimeRangeFormat` be `styles`.[DateTimeFormat]!%<dateStyle>!%.[<timeStyle>].
      i. Set `format`.[rangePatterns] to `dateTimeRangeFormat`.[rangePatterns].
   j. If `dateTimeRangeFormat` has a [[rangePatterns12]] field, then
      i. Set `format`.[rangePatterns12] to `dateTimeRangeFormat`.[rangePatterns12].
   k. Return `format`.
4. If `timeStyle` is not undefined, then
   a. Return `timeFormat`.
5. Assert: `dateStyle` is not undefined.
6. Return `dateFormat`. 
11.5.3 BasicFormatMatcher (options, formats)

When the BasicFormatMatcher abstract operation is called with two arguments options and formats, the following steps are taken:

1. Let removalPenalty be 120.
2. Let additionPenalty be 20.
3. Let longLessPenalty be 8.
5. Let shortLessPenalty be 6.
7. Let offsetPenalty be 1.
8. Let bestScore be -Infinity.
10. Assert: Type(formats) is List.
11. For each element format of formats, do
   a. Let score be 0.
   b. For each property name property shown in Table 7, do
      i. If options has a field [[property]], let optionsProp be options.[[property]]; else let optionsProp be undefined.
      ii. If format has a field [[property]], let formatProp be format.[[property]]; else let formatProp be undefined.
      iii. If optionsProp is undefined and formatProp is not undefined, decrease score by additionPenalty.
      iv. Else if optionsProp is not undefined and formatProp is undefined, decrease score by removalPenalty.
      v. Else if property is "timeZoneName", then
         1. If optionsProp is "short" or "shortGeneric", then
            a. If formatProp is "shortOffset", decrease score by offsetPenalty.
            b. Else if formatProp is "longOffset", decrease score by (offsetPenalty + shortMorePenalty).
            c. Else if optionsProp is "short" and formatProp is "long", decrease score by shortMorePenalty.
            d. Else if optionsProp is "shortGeneric" and formatProp is "longGeneric", decrease score by shortMorePenalty.
            e. Else if optionsProp ≠ formatProp, decrease score by removalPenalty.
         2. Else if optionsProp is "shortOffset" and formatProp is "longOffset", decrease score by shortMorePenalty.
         3. Else if optionsProp is "long" or "longGeneric", then
            a. If formatProp is "longOffset", decrease score by offsetPenalty.
            b. Else if formatProp is "shortOffset", decrease score by (offsetPenalty + longLessPenalty).
            c. Else if optionsProp is "long" and formatProp is "short", decrease score by longLessPenalty.
            d. Else if optionsProp is "longGeneric" and formatProp is "shortGeneric", decrease score by longLessPenalty.
            e. Else if optionsProp ≠ formatProp, decrease score by removalPenalty.
         4. Else if optionsProp is "longOffset" and formatProp is "shortOffset", decrease score by longLessPenalty.
         5. Else if optionsProp ≠ formatProp, decrease score by removalPenalty.
      vi. Else if optionsProp ≠ formatProp, then
         1. If property is "fractionalSecondDigits", then
a. Let $values$ be « $1_F$, $2_F$, $3_F$ ».
2. Else,
   a. Let $values$ be « "2-digit", "numeric", "narrow", "short", "long" ».
3. Let $optionsPropIndex$ be the index of $optionsProp$ within $values$.
4. Let $formatPropIndex$ be the index of $formatProp$ within $values$.
5. Let $delta$ be $\max(\min(formatPropIndex - optionsPropIndex, 2), -2)$.
6. If $delta = 2$, decrease $score$ by $longMorePenalty$.
7. Else if $delta = 1$, decrease $score$ by $shortMorePenalty$.
8. Else if $delta = -1$, decrease $score$ by $shortLessPenalty$.
9. Else if $delta = -2$, decrease $score$ by $longLessPenalty$.
  
10. c. If $score > bestScore$, then
    i. Let $bestScore$ be $score$.
    ii. Let $bestFormat$ be $format$.

11.5.4 BestFitFormatMatcher ($options$, $formats$)

When the BestFitFormatMatcher abstract operation is called with two arguments $options$ and $formats$, it performs implementation dependent steps, which should return a set of component representations that a typical user of the selected locale would perceive as at least as good as the one returned by BasicFormatMatcher.

11.5.5 DateTime Format Functions

A DateTime format function is an anonymous built-in function that has a [[DateTimeFormat]] internal slot.

When a DateTime format function $F$ is called with optional argument $date$, the following steps are taken:

1. Let $dtf$ be $F$.[[DateTimeFormat]].
2. Assert: Type($dtf$) is Object and $dtf$ has an [[InitializedDateTimeFormat]] internal slot.
3. If $date$ is not provided or is $undefined$, then
   a. Let $x$ be ! Call(%Date.now%, $undefined$).
4. Else,
   a. Let $x$ be ? ToNumber($date$).
5. Return ? FormatDateTime($dtf$, $x$).

The "length" property of a DateTime format function is 1.

11.5.6 FormatDateTimePattern ($dateTimeFormat$, $patternParts$, $x$, $rangeFormatOptions$)

The FormatDateTimePattern abstract operation is called with arguments $dateTimeFormat$ (which must be an object initialized as a DateTimeFormat), $patternParts$ (which is a list of Records as returned by PartitionPattern), $x$ (which must be a Number value), and $rangeFormatOptions$ (which is a range pattern Record as used in [[rangePattern]] or $undefined$), interprets $x$ as a time value as specified in es2023, 21.4.1.1, and creates the corresponding parts according $pattern$ and to the effective locale and the formatting options of $dateTimeFormat$ and $rangeFormatOptions$. The following steps are taken:

1. Let $x$ be TimeClip($x$).
2. If $x$ is NaN, throw a RangeError exception.
3. Let $locale$ be $dateTimeFormat$.[[Locale]].
4. Let $nOptions$ be OrdinaryObjectCreate(null).
5. Perform ! CreateDataPropertyOrThrow($nOptions$, "useGrouping", false).
6. Let \( nf \) be \( ? \) Construct(%NumberFormat%, "locale", nfOptions
).  
7. Let \( nf2Options \) be OrdinaryObjectCreate(null).  
8. Perform 1 CreateDataPropertyOrThrow(nf2Options, "minimumIntegerDigits", 2).  
9. Perform 1 CreateDataPropertyOrThrow(nf2Options, "useGrouping", false).  
10. Let \( nf2 \) be \( ? \) Construct(%NumberFormat%, "locale", nf2Options
).  
11. Let \( fractionalSecondDigits \) be \( \text{dateFormat}.[[\text{FractionalSecondDigits}]] \).  
12. If \( fractionalSecondDigits \) is not undefined, then  
   a. Let \( nf3Options \) be OrdinaryObjectCreate(null).  
   b. Perform 1 CreateDataPropertyOrThrow(nf3Options, "minimumIntegerDigits", fractionalSecondDigits).  
   c. Perform 1 CreateDataPropertyOrThrow(nf3Options, "useGrouping", false).  
   d. Let \( nf3 \) be \( ? \) Construct(%NumberFormat%, "locale", nf3Options
).  
13. Let \( tm \) be ToLocalTime(\( z(R(x) \times 10^6) \), \( \text{.dateFormat}.[[\text{Calendar}]] \), \( \text{dateFormat}.[[\text{TimeZone}]] \)).  
14. Let \( \text{result} \) be a new empty List.  
15. For each \( \text{Record} \) { [[Type]], [[Value]] } \( \text{patternPart} \) in \( \text{patternParts} \), do  
   a. Let \( p \) be \( \text{patternPart}.[[\text{Type}]] \).
   b. If \( p \) is "literal", then  
      i. Append a new \( \text{Record} \) { [[Type]]: "literal", [[Value]]: \( \text{patternPart}.[[\text{Value}]] \) } as the last element of the list \( \text{result} \).
   c. Else if \( p \) is equal to "fractionalSecondDigits", then  
      i. Let \( v \) be \( tm.[[\text{MillisSecond}]] \).
      ii. Let \( v \) be floor(\( v \times 10^{(\text{fractionalSecondDigits} - 3)} \)).
      iii. Let \( fv \) be FormatNumeric(nf3, \( v \)).
      iv. Append a new \( \text{Record} \) { [[Type]]: "fractionalSecond", [[Value]]: \( fv \) } as the last element of \( \text{result} \).
   d. Else if \( p \) is equal to "dayPeriod", then  
      i. Let \( f \) be the value of \( \text{dateFormat}.[[\text{InternalSlot}]] \)'s internal slot whose name is the Internal Slot column of the matching row.
      ii. Let \( fv \) be a String value representing the day period of \( tm \) in the form given by \( f \); the String value depends upon the implementation and the effective locale of \( \text{dateFormat} \).
      iii. Append a new \( \text{Record} \) { [[Type]]: \( p \), [[Value]]: \( fv \) } as the last element of the list \( \text{result} \).
   e. Else if \( p \) is equal to "timeZoneName", then  
      i. Let \( f \) be \( \text{dateFormat}.[[\text{TimeZoneName}]] \).
      ii. Let \( v \) be \( \text{dateFormat}.[[\text{TimeZone}]] \).
      iii. Let \( fv \) be a String value representing \( v \) in the form given by \( f \); the String value depends upon the implementation and the effective locale of \( \text{dateFormat} \). The String value may also depend on the value of the \( [[\text{InDST}]] \) field of \( tm \) if \( f \) is "short", "long", "shortOffset", or "longOffset". If the implementation does not have a localized representation of \( f \), then use the String value of \( v \) itself.
      iv. Append a new \( \text{Record} \) { [[Type]]: \( p \), [[Value]]: \( fv \) } as the last element of the list \( \text{result} \).
   f. Else if \( p \) matches a Property column of the row in Table 7, then  
      i. If \( \text{rangeFormatOptions} \) is not undefined, let \( f \) be the value of \( \text{rangeFormatOptions} \)'s field whose name matches \( p \).
      ii. Else, let \( f \) be the value of \( \text{dateFormat} \)'s internal slot whose name is the Internal Slot column of the matching row.
      iii. Let \( v \) be the value of \( tm.]][[\text{Field}]] \)'s field whose name is the Internal Slot column of the matching row.
      iv. If \( p \) is "year" and \( v < 0 \), let \( v \) be \( 1 - v \).
      v. If \( p \) is "month", increase \( v \) by 1.
      vi. If \( p \) is "hour" and \( \text{dateFormat}.[[\text{HourCycle}]] \) is "h11" or "h12", then
2. If \( v \) is 0 and `dateTimeFormat.[[HourCycle]]` is "h12", let \( v \) be 12.

vii. If \( p \) is "hour" and `dateTimeFormat.[[HourCycle]]` is "h24", then
1. If \( v \) is 0, let \( v \) be 24.

viii. If \( f \) is "numeric", then
1. Let \( fv \) be `FormatNumeric(nf, v)`.

ix. Else if \( f \) is "2-digit", then
1. Let \( fv \) be `FormatNumeric(nf2, v)`.
2. If the "length" property of \( fv \) is greater than 2, let \( fv \) be the substring of \( fv \) containing the last two characters.

x. Else if \( f \) is "narrow", "short", or "long", then let \( fv \) be a String value representing \( v \) in the form given by \( f \); the String value depends upon the implementation and the effective locale and calendar of `dateTimeFormat`. If \( p \) is "month" and `rangeFormatOptions` is undefined, then the String value may also depend on whether `dateTimeFormat.[[Day]]` is undefined. If \( p \) is "month" and `rangeFormatOptions` is not undefined, then the String value may also depend on whether `rangeFormatOptions.[[day]]` is undefined. If \( p \) is "era" and `rangeFormatOptions` is undefined, then the String value may also depend on whether `dateTimeFormat.[[Era]]` is undefined. If \( p \) is "era" and `rangeFormatOptions` is not undefined, then the String value may also depend on whether `rangeFormatOptions.[[era]]` is undefined. If the implementation does not have a localized representation of \( f \), then use the String value of \( v \) itself.

xi. Append a new Record { [[Type]]: p, [[Value]]: \( fv \) } as the last element of the list `result`.

16. Return `result`.
NOTE

It is recommended that implementations use the locale and calendar dependent strings provided by the Common Locale Data Repository (available at https://cldr.unicode.org/), and use CLDR "abbreviated" strings for DateTimeFormat "short" strings, and CLDR "wide" strings for DateTimeFormat "long" strings.

11.5.7 PartitionDateTimePattern (dateTimeFormat, x)

The PartitionDateTimePattern abstract operation is called with arguments dateTimeFormat (which must be an object initialized as a DateTimeFormat) and x (which must be a Number value), interprets x as a time value as specified in es2023, 21.4.1.1, and creates the corresponding parts according to the effective locale and the formatting options of dateTimeFormat. The following steps are taken:

1. Let patternParts be PartitionPattern(dateTimeFormat, [[Pattern]]).
2. Let result be ? FormatDateTimePattern(dateTimeFormat, patternParts, x, undefined).
3. Return result.

11.5.8 FormatDateTime (dateTimeFormat, x)

The FormatDateTime abstract operation is called with arguments dateTimeFormat (which must be an object initialized as a DateTimeFormat) and x (which must be a Number value), and performs the following steps:

1. Let parts be ? PartitionDateTimePattern(dateTimeFormat, x).
2. Let result be the empty String.
3. For each Record { [[Type]], [[Value]] } part in parts, do
   a. Set result to the string-concatenation of result and part.[[Value]].
4. Return result.

11.5.9 FormatDateTimeToParts (dateTimeFormat, x)

The FormatDateTimeToParts abstract operation is called with arguments dateTimeFormat (which must be an object initialized as a DateTimeFormat) and x (which must be a Number value), and performs the following steps:

1. Let parts be ? PartitionDateTimePattern(dateTimeFormat, x).
2. Let result be ! ArrayCreate(0).
3. Let n be 0.
4. For each Record { [[Type]], [[Value]] } part in parts, do
   a. Let O be OrdinaryObjectCreate(%Object.prototype%).
   b. Perform ! CreateDataPropertyOrThrow(O, "type", part.[[Type]]).
   c. Perform ! CreateDataPropertyOrThrow(O, "value", part.[[Value]]).
   d. Perform ! CreateDataProperty(result, ! ToString(n), O).
   e. Increment n by 1.
5. Return result.

11.5.10 PartitionDateTimeRangePattern (dateTimeFormat, x, y)

The PartitionDateTimeRangePattern abstract operation is called with arguments dateTimeFormat (which must be an object initialized as a DateTimeFormat), x (which must be a Number value) and y (which must be a Number value), interprets x and y as time values as specified in es2023, 21.4.1.1, and creates the corresponding parts according to the effective locale and the formatting options of dateTimeFormat. The following steps are taken:
1. Set \( x \) to \( \text{TimeClip}(x) \).
2. If \( x \) is \( \text{NaN} \), throw a \text{RangeError} exception.
3. Set \( y \) to \( \text{TimeClip}(y) \).
4. If \( y \) is \( \text{NaN} \), throw a \text{RangeError} exception.
5. Let \( \text{rangeResult} = (\text{ToLocalTime}(\mathbb{Z}(x) \times 10^6), \text{dateTimeFormat}([ \text{Calendar} ], \text{dateTimeFormat}([ \text{TimeZone} ])) \).
6. Let \( \text{rangeResult} = (\text{ToLocalTime}(\mathbb{Z}(y) \times 10^6), \text{dateTimeFormat}([ \text{Calendar} ], \text{dateTimeFormat}([ \text{TimeZone} ])) \).
7. Let \( \text{rangePatterns} = \text{dateTimeFormat}([ \text{RangePatterns} ]) \).
8. Let \( \text{selectedRangePattern} \) be undefined.
9. Let \( \text{relevantFieldsEqual} \) be true.
10. Let \( \text{checkMoreFields} \) be true.
11. For each row of Table 5, except the header row, in table order, do
    
    a. Let \( \text{fieldName} \) be the name given in the Range Pattern Field column of the row.
    b. If \( \text{rangePatterns} \) has a field \([<\text{fieldName}>]\), let \( \text{rangePattern} \) be \( \text{rangePatterns}[[<\text{fieldName}>]] \); else let \( \text{rangePattern} \) be undefined.
    c. If \( \text{selectedRangePattern} \) is not undefined and \( \text{rangePattern} \) is undefined, then
       i. NOTE: Because there is no range pattern for differences at or below this field, no further checks will be performed.
       ii. Set \( \text{checkMoreFields} \) to false.
    d. If \( \text{relevantFieldsEqual} \) is true and \( \text{checkMoreFields} \) is true, then
       i. Set \( \text{selectedRangePattern} \) to \( \text{rangePattern} \).
       ii. If \( \text{fieldName} \) is equal to \([\text{AmPm}]\), then
           1. If \( \text{tm1}[[\text{Hour}]] \) is less than 12, let \( v1 \) be "am"; else let \( v1 \) be "pm".
           2. If \( \text{tm2}[[\text{Hour}]] \) is less than 12, let \( v2 \) be "am"; else let \( v2 \) be "pm".
       iii. Else if \( \text{fieldName} \) is equal to \([\text{DayPeriod}]\), then
           1. Let \( v1 \) be a String value representing the day period of \( \text{tm1} \); the String value depends upon the implementation and the effective locale of \( \text{dateTimeFormat} \).
           2. Let \( v2 \) be a String value representing the day period of \( \text{tm2} \); the String value depends upon the implementation and the effective locale of \( \text{dateTimeFormat} \).
       iv. Else if \( \text{fieldName} \) is equal to \([\text{FractionalSecondDigits}]\), then
           1. Let \( \text{fractionalSecondDigits} \) be \( \text{dateTimeFormat}([\text{FractionalSecondDigits}]) \).
           2. If \( \text{fractionalSecondDigits} \) is undefined, then
              a. Set \( \text{fractionalSecondDigits} \) to 3.
              b. Let \( \text{exp} \) be \( \text{fractionalSecondDigits} - 3 \).
              c. Let \( v1 \) be \( \text{floor}(\text{tm1}[[\text{Millisecond}]] \times 10^\text{exp}) \).
              d. Let \( v2 \) be \( \text{floor}(\text{tm2}[[\text{Millisecond}]] \times 10^\text{exp}) \).
       v. Else,
           1. Let \( v1 \) be \( \text{tm1}[[\text{fieldName}]] \).
           2. Let \( v2 \) be \( \text{tm2}[[\text{fieldName}]] \).
       vi. If \( v1 \) is not equal to \( v2 \), then
           1. Set \( \text{relevantFieldsEqual} \) to false.
12. If \( \text{relevantFieldsEqual} \) is true, then
    
    a. Let \( \text{collapsedResult} \) be a new empty \text{List}.
    b. Let \( \text{pattern} \) be \( \text{dateTimeFormat}([\text{Pattern}]) \).
    c. Let \( \text{patternParts} \) be \( \text{PartitionPattern}([\text{pattern}]) \).
    d. Let \( \text{resultParts} \) be \? \text{FormatDateTimePattern}([\text{dateTimeFormat}, \text{patternParts}, x, \text{undefined}]).
    e. For each \( \text{Record} \{ [[\text{Type}]], [[\text{Value}]] \} \) \( r \) in \( \text{resultParts} \), do
       i. Append a new \( \text{Record} \{ [[\text{Type}]], [[\text{Value}]] : r.[[\text{Type}]], [[\text{Value}]] : r.[[\text{Value}]], [[\text{Source}]] : "shared" \} \) as the last element of \( \text{collapsedResult} \).
    f. Return \( \text{collapsedResult} \).
13. Let \( \text{rangeResult} \) be a new empty \text{List}.

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14. If `selectedRangePattern` is `undefined`, then
   a. Set `selectedRangePattern` to `rangePatterns.[[Default]]`.
15. For each `Record` { `[[Pattern]]`, `[[Source]]` } `rangePatternPart` in `selectedRangePattern.[[PatternParts]]`, do
   a. Let `pattern` be `rangePatternPart.[[Pattern]]`.
   b. Let `source` be `rangePatternPart.[[Source]]`.
   c. If `source` is "startRange" or "shared", then
      i. Let `z` be `x`.
   d. Else,
      i. Let `z` be `y`.
   e. Let `patternParts` be `PartitionPattern(pattern)`.
   f. Let `resultParts` be `? FormatDateTimePattern(dateTimeFormat, patternParts, z, selectedRangePattern)`.
   g. For each `Record` { `[[Type]]`, `[[Value]]`, `[[Source]]` } `r` in `resultParts`, do
      i. Append a new `Record` { `[[Type]]`: `r.[[Type]]`, `[[Value]]`: `r.[[Value]]`, `[[Source]]`: `source` } as the last element of `rangeResult`.
16. Return `rangeResult`.

11.5.11 `FormatDateTimeRange (dateTimeFormat, x, y)`

The `FormatDateTimeRange` abstract operation is called with arguments `dateTimeFormat` (which must be an object initialized as a `DateTimeFormat`), `x` (which must be a Number value) and `y` (which must be a Number value), and performs the following steps:

1. Let `parts` be `? PartitionDateTimeRangePattern(dateTimeFormat, x, y)`.
2. Let `result` be the empty String.
3. For each `Record` { `[[Type]]`, `[[Value]]`, `[[Source]]` } `part` in `parts`, do
   a. Set `result` to the string-concatenation of `result` and `part.[[Value]]`.
4. Return `result`.

11.5.12 `FormatDateTimeRangeToParts (dateTimeFormat, x, y)`

The `FormatDateTimeRangeToParts` abstract operation is called with arguments `dateTimeFormat` (which must be an object initialized as a `DateTimeFormat`), `x` (which must be a Number value) and `y` (which must be a Number value), and performs the following steps:

1. Let `parts` be `? PartitionDateTimeRangePattern(dateTimeFormat, x, y)`.
2. Let `result` be `! ArrayCreate(0)`.
3. Let `n` be 0.
4. For each `Record` { `[[Type]]`, `[[Value]]`, `[[Source]]` } `part` in `parts`, do
   a. Let `O` be `OrdinaryObjectCreate(%Object.prototype%)`.
   b. Perform `! CreateDataPropertyOrThrow(O, "type", part.[[Type]])`.
   c. Perform `! CreateDataPropertyOrThrow(O, "value", part.[[Value]])`.
   d. Perform `! CreateDataPropertyOrThrow(O, "source", part.[[Source]])`.
   e. Perform `CreateDataProperty(result, ! ToString(n), O)`.
   f. Increment `n` by 1.
5. Return `result`. 
The implementation-defined abstract operation `ToLocalTime` takes arguments `epochNs` (a BigInt), `calendar` (a String), and `timeZoneIdentifier` (a String). It performs the following steps when called:

1. Let `offsetNs` be `GetNamedTimezoneOffsetNanoseconds(timeZoneIdentifier, epochNs)`.
2. Let `tz` be `(epochNs) + offsetNs`.
3. If `calendar` is "gregory", then
   a. Return a record with fields calculated from `tz` according to Table 8.
4. Else,
   a. Return a record with the fields of Column 1 of Table 8 calculated from `tz` for the given `calendar`. The calculations should use best available information about the specified `calendar`.

Table 8: Record returned by `ToLocalTime`

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Value Calculation for Gregorian Calendar</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Weekday]]</code></td>
<td><code>WeekDay(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Era]]</code></td>
<td>Let <code>year</code> be <code>YearFromTime(floor(tz / 10^6))</code>. If <code>year &lt; 1</code>, return &quot;BC&quot;, else return &quot;AD&quot;.</td>
</tr>
<tr>
<td><code>[[Year]]</code></td>
<td><code>YearFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[RelatedYear]]</code></td>
<td><code>undefined</code></td>
</tr>
<tr>
<td><code>[[YearName]]</code></td>
<td><code>undefined</code></td>
</tr>
<tr>
<td><code>[[Month]]</code></td>
<td><code>MonthFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Day]]</code></td>
<td><code>DateFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Hour]]</code></td>
<td><code>HourFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Minute]]</code></td>
<td><code>MinFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Second]]</code></td>
<td><code>SecFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[Millisecond]]</code></td>
<td><code>msFromTime(floor(tz / 10^6))</code></td>
</tr>
<tr>
<td><code>[[InDST]]</code></td>
<td>Calculate <code>true</code> or <code>false</code> using the best available information about the specified <code>calendar</code> and <code>timeZoneIdentifier</code>, including current and historical information from the IANA Time Zone Database about time zone offsets from UTC and daylight saving time rules.</td>
</tr>
</tbody>
</table>

**NOTE** A conforming implementation must recognize "UTC" and all Zone and Link names from the IANA Time Zone Database (and only such names), and use best available current and historical information about their offsets from UTC and their daylight saving time rules in calculations.
11.5.14 UnwrapDateTimeFormat (df)

The UnwrapDateTimeFormat abstract operation returns the DateTimeFormat instance of its input object, which is either the value itself or a value associated with it by %DateTimeFormat% according to the normative optional constructor mode of 4.3 Note 1.

1. If Type(df) is not Object, throw a TypeError exception.
2. If df does not have an [[InitializedDateTimeFormat]] internal slot and ? OrdinaryHasInstance(%DateTimeFormat%, df) is true, then
   a. Return ? Get(df, %Intl%.[[FallbackSymbol]]).
3. Return df.

12 DisplayNames Objects

12.1 The Intl.DisplayNames Constructor

The DisplayNames constructor is the %DisplayNames% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

12.1.1 Intl.DisplayNames (locales, options)

When the Intl.DisplayNames function is called with arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let displayNames be ? OrdinaryCreateFromConstructor(NewTarget, "%DisplayNames.prototype%", « [[InitializedDisplayNames]], [[Locale]], [[Style]], [[Type]], [[Fallback]], [[LanguageDisplay]], [[Fields]] »).
4. If options is undefined, throw a TypeError exception.
5. Set options to ? GetOptionsObject(options).
6. Let opt be a new Record.
7. Let localeData be %DisplayNames%.[[LocaleData]].
9. Set opt.[[localeMatcher]] to matcher.
10. Let r be ResolveLocale(%DisplayNames%.[[AvailableLocales]], requestedLocales, opt, %DisplayNames%.[[ RelevantExtensionKeys]]).
12. Set displayNames.[[Style]] to style.
14. If type is undefined, throw a TypeError exception.
15. Set displayNames.[[Type]] to type.
17. Set displayNames.[[Fallback]] to fallback.
18. Set displayNames.[[Locale]] to r.[[locale]].
19. Let `dataLocale` be `r.[[dataLocale]]`.
20. Let `dataLocaleData` be `localeData.[[<dataLocale>]]`.
21. Let `types` be `dataLocaleData.[[types]]`.
22. Assert: `types` is a `Record` (see 12.2.3).
24. Let `typeFields` be `types.[[<type>]]`.
25. Assert: `typeFields` is a `Record` (see 12.2.3).
26. If `type` is "language", then
   a. Set `displayNames.[[LanguageDisplay]]` to `languageDisplay`.
   b. Let `typeFields` be `typeFields.[[<languageDisplay>]]`.
   c. Assert: `typeFields` is a `Record` (see 12.2.3).
27. Let `styleFields` be `typeFields.[[<style>]]`.
28. Assert: `styleFields` is a `Record` (see 12.2.3).
29. Set `displayNames.[[Fields]]` to `styleFields`.
30. Return `displayNames`.

12.2 Properties of the Intl.DisplayNames Constructor

The Intl.DisplayNames constructor has the following properties:

12.2.1 Intl.DisplayNames.prototype

The value of `Intl.DisplayNames.prototype` is `%DisplayNames.prototype%`.
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

12.2.2 Intl.DisplayNames.supportedLocalesOf ( locales [, options ] )

When the `supportedLocalesOf` method is called with arguments `locales` and `options`, the following steps are taken:

1. Let `availableLocales` be `%DisplayNames%.[[AvailableLocales]]`.
2. Let `requestedLocales` be ? `CanonicalizeLocaleList(locales)`.

12.2.3 Internal slots

The value of the `[[AvailableLocales]]` internal slot is implementation-defined within the constraints described in 9.1.

The value of the `[[ RelevantExtensionKeys]]` internal slot is « ».

The value of the `[[LocaleData]]` internal slot is implementation-defined within the constraints described in 9.1 and the following additional constraints:

- `[[LocaleData]].[[<locale>]]` must have a `[[types]]` field for all locale values `locale`. The value of this field must be a `Record`, which must have fields with the names of all display name types: "language", "region", "script", "currency", "calendar", and "dateTimeField".
- The value of the field "language" must be a `Record` which must have fields with the names of one of the valid language displays: "dialect" and "standard".
The language display fields under display name type "language" should contain Records which must have fields with the names of one of the valid display name styles: "narrow", "short", and "long".

The value of the fields "region", "script", "currency", "calendar", and "dateTimeField" must be Records, which must have fields with the names of all display name styles: "narrow", "short", and "long".

The display name style fields under display name type "language" should contain Records with keys corresponding to language codes matching the unicode_language_id production. The value of these fields must be string values.

The display name style fields under display name type "region" should contain Records with keys corresponding to region codes. The value of these fields must be string values.

The display name style fields under display name type "script" should contain Records with keys corresponding to script codes. The value of these fields must be string values.

The display name style fields under display name type "currency" should contain Records with keys corresponding to currency codes. The value of these fields must be string values.

The display name style fields under display name type "calendar" should contain Records with keys corresponding to a String value with the type given in Unicode Technical Standard 35 for the calendar used for formatting. The value of these fields must be string values.

The display name style fields under display name type "dateTimeField" should contain Records with keys corresponding to codes listed in Table 10. The value of these fields must be string values.

NOTE It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).

12.3 Properties of the Intl.DisplayNames Prototype Object

The Intl.DisplayNames prototype object is itself an ordinary object. %DisplayNames.prototype% is not an Intl.DisplayNames instance and does not have an [[InitializedDisplayNames]] internal slot or any of the other internal slots of Intl.DisplayNames instance objects.

12.3.1 Intl.DisplayNames.prototype.constructor

The initial value of Intl.DisplayNames.prototype.constructor is %DisplayNames%.

12.3.2 Intl.DisplayNames.prototype[ @@toStringTag ]

The initial value of the @@toStringTag property is the String value "Intl.DisplayNames".

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

12.3.3 Intl.DisplayNames.prototype.of ( code )

When the Intl.DisplayNames.prototype.of is called with an argument code, the following steps are taken:

1. Let displayNames be this value.
2. Perform ? RequireInternalSlot(displayNames, [[InitializedDisplayNames]]).
3. Let code be ? ToString(code).
4. Let code be ? CanonicalCodeForDisplayNames(displayNames.[[Type]], code).
5. Let fields be displayNames.[[Fields]].
6. If fields has a field [[<code>]], return fields.[[<code>]].
7. If displayNames.[[Fallback]] is "code", return code.
8. Return undefined.
12.3.4 Intl.DisplayNames.prototype.resolvedOptions ( )

This function provides access to the locale and options computed during initialization of the object.

1. Let displayNames be this value.
2. Perform ? RequireInternalSlot(displayNames, [[InitializedDisplayNames]]).
3. Let options be OrdinaryObjectCreate(%Object.prototype%).
4. For each row of Table 9, except the header row, in table order, do
   a. Let p be the Property value of the current row.
   b. Let v be the value of displayNames's internal slot whose name is the Internal Slot value of the current row.
   c. Assert: v is not undefined.
   d. Perform ! CreateDataPropertyOrThrow(options, p, v).
5. Return options.

Table 9: Resolved Options of DisplayNames Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[Style]]</td>
<td>&quot;style&quot;</td>
</tr>
<tr>
<td>[[Type]]</td>
<td>&quot;type&quot;</td>
</tr>
<tr>
<td>[[Fallback]]</td>
<td>&quot;fallback&quot;</td>
</tr>
<tr>
<td>[[LanguageDisplay]]</td>
<td>&quot;languageDisplay&quot;</td>
</tr>
</tbody>
</table>

12.4 Properties of Intl.DisplayNames Instances

Intl.DisplayNames instances are ordinary objects that inherit properties from %DisplayNames.prototype%.

Intl.DisplayNames instances have an [[InitializedDisplayNames]] internal slot.

Intl.DisplayNames instances also have several internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used for formatting.
- [[Style]] is one of the String values "narrow", "short", or "long", identifying the display name style used.
- [[Type]] is one of the String values "language", "region", "script", "currency", "calendar", or "dateTimeField", identifying the type of the display names requested.
- [[Fallback]] is one of the String values "code" or "none", identifying the fallback return when the system does not have the requested display name.
- [[LanguageDisplay]] is one of the String values "dialect" or "standard", identifying the language display kind. It is only used when [[Type]] has the value "language".
- [[Fields]] is a Record (see 12.2.3) which must have fields with keys corresponding to codes according to [[Style]], [[Type]], and [[LanguageDisplay]].

12.5 Abstract Operations for DisplayNames Objects

12.5.1 CanonicalCodeForDisplayNames ( type, code )

The CanonicalCodeForDisplayNames abstract operation takes arguments type (a String) and code (a String). It verifies that the code argument represents a well-formed code according to the type argument and
returns the case-regularized form of the `code`. The algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar. The following steps are taken:

1. If `type` is "language", then
   a. If `code` does not match the `unicode_language_id` production, throw a `RangeError` exception.
   b. If `IsStructurallyValidLanguageTag(code)` is `false`, throw a `RangeError` exception.
   c. Return ` CanonicalizeUnicodeLocaleId(code).`
2. If `type` is "region", then
   a. If `code` does not match the `unicode_region_subtag` production, throw a `RangeError` exception.
   b. Return the ASCII-uppercase of `code`.
3. If `type` is "script", then
   a. If `code` does not match the `unicode_script_subtag` production, throw a `RangeError` exception.
   b. `Assert`: The length of `code` is 4, and every code unit of `code` represents an ASCII letter (0x0041 through 0x005A and 0x0061 through 0x007A, both inclusive).
   c. Let `first` be the ASCII-uppercase of the substring of `code` from 0 to 1.
   d. Let `rest` be the ASCII-lowercase of the substring of `code` from 1.
   e. Return the string-concatenation of `first` and `rest`.
4. If `type` is "calendar", then
   a. If `code` does not match the Unicode Locale Identifier `type` nonterminal, throw a `RangeError` exception.
   b. If `code` uses any of the backwards compatibility syntax described in Unicode Technical Standard #35 LDML § 3.3 BCP 47 Conformance, throw a `RangeError` exception.
   c. Return the ASCII-lowercase of `code`.
5. If `type` is "dateTimeField", then
   a. If the result of `IsValidDateTimeFieldCode(code)` is `false`, throw a `RangeError` exception.
   b. Return `code`.
6. `Assert`: `type` is "currency".
7. If `IsWellFormedCurrencyCode(code)` is `false`, throw a `RangeError` exception.
8. Return the ASCII-uppercase of `code`.

### 12.5.2 IsValidDateTimeFieldCode ( `field` )

The abstract operation `IsValidDateTimeFieldCode` takes argument `field` (a String). It verifies that the `field` argument represents a valid date time field code. It performs the following steps when called:

1. If `field` is listed in the Code column of Table 10, return `true`.
2. Return `false`.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;era&quot;</td>
<td>The field indicating the era, e.g. AD or BC in the Gregorian or Julian calendar.</td>
</tr>
<tr>
<td>&quot;year&quot;</td>
<td>The field indicating the year (within an era).</td>
</tr>
<tr>
<td>&quot;quarter&quot;</td>
<td>The field indicating the quarter, e.g. Q2, 2nd quarter, etc.</td>
</tr>
<tr>
<td>&quot;month&quot;</td>
<td>The field indicating the month, e.g. Sep, September, etc.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;weekOfYear&quot;</td>
<td>The field indicating the week number within a year.</td>
</tr>
<tr>
<td>&quot;weekday&quot;</td>
<td>The field indicating the day of week, e.g. Tue, Tuesday, etc.</td>
</tr>
<tr>
<td>&quot;day&quot;</td>
<td>The field indicating the day in month.</td>
</tr>
<tr>
<td>&quot;dayPeriod&quot;</td>
<td>The field indicating the day period, either am, pm, etc. or noon, evening, etc.</td>
</tr>
<tr>
<td>&quot;hour&quot;</td>
<td>The field indicating the hour.</td>
</tr>
<tr>
<td>&quot;minute&quot;</td>
<td>The field indicating the minute.</td>
</tr>
<tr>
<td>&quot;second&quot;</td>
<td>The field indicating the second.</td>
</tr>
<tr>
<td>&quot;timeZoneName&quot;</td>
<td>The field indicating the time zone name, e.g. PDT, Pacific Daylight Time, etc.</td>
</tr>
</tbody>
</table>

13 ListFormat Objects

13.1 The Intl.ListFormat Constructor

The ListFormat constructor is the %ListFormat% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

13.1.1 Intl.ListFormat ([ locales [, options ]])

When the Intl.ListFormat function is called with optional arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let listFormat be ? OrdinaryCreateFromConstructor(NewTarget, "%ListFormat.prototype%", {
   [[InitializedListFormat]], [[Locale]], [[Type]], [[Style]], [[Templates]]}).
4. Set options to ? GetOptionsObject(options).
5. Let opt be a new Record.
7. Set opt.[[localeMatcher]] to matcher.
8. Let localeData be %ListFormat%.[[LocaleData]].
9. Let r be ResolveLocale(%ListFormat%.[[AvailableLocales]], requestedLocales, opt, %ListFormat%.[[RelevantExtensionKeys]], localeData).
10. Set listFormat.[[Locale]] to r.[[locale]].
11. Let type be ? GetOption(options, "type", string, « "conjunction", "disjunction", "unit" », "conjunction").
12. Set listFormat.[[Type]] to type.
14. Set listFormat.[[Style]] to style.
15. Let dataLocale be r.[[dataLocale]].
16. Let dataLocaleData be localeData.[[dataLocale]].
17. Let dataLocaleTypes be dataLocaleData.[[type]].
18. Set listFormat.[[Templates]] to dataLocaleTypes.[[style]].
19. Return `listFormat`.

### 13.2 Properties of the Intl.ListFormat Constructor

The Intl.ListFormat constructor has the following properties:

#### 13.2.1 Intl.ListFormat.prototype

The value of `Intl.ListFormat.prototype` is `%ListFormat.prototype%`. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

#### 13.2.2 Intl.ListFormat.supportedLocalesOf ( `locales` [, `options` ] )

When the `supportedLocalesOf` method is called with arguments `locales` and `options`, the following steps are taken:

1. Let `availableLocales` be `%ListFormat%.[[AvailableLocales]].
2. Let `requestedLocales` be ? `CanonicalizeLocaleList(locales)`.

### 13.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1.

The value of the [[RelevantExtensionKeys]] internal slot is « ».

**NOTE 1** Intl.ListFormat does not have any relevant extension keys.

The value of the [[LocaleData]] internal slot is implementation-defined within the constraints described in 9.1 and the following additional constraints, for each locale value `locale` in `%ListFormat%.[[AvailableLocales]]:

- `%LocaleData%.[<locale>]]` is a Record which has three fields [[conjunction]], [[disjunction]], and [[unit]]. Each of these is a Record which must have fields with the names of three formatting styles: [[long]], [[short]], and [[narrow]].
- Each of those fields is considered a ListFormat template set, which must be a List of Records with fields named: [[Pair]], [[Start]], [[Middle]], and [[End]]. Each of those fields must be a template string as specified in LDML List Format Rules. Each template string must contain the substrings "{0}" and "{1}" exactly once. The substring "{0}" should occur before the substring "{1}".

**NOTE 2** It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/). In LDML's listPattern, conjunction corresponds to "standard", disjunction corresponds to "or", and unit corresponds to "unit".

**NOTE 3** Among the list types, conjunction stands for "and"-based lists (e.g., "A, B, and C"), disjunction stands for "or"-based lists (e.g., "A, B, or C"), and unit stands for lists of values with units (e.g., "5 pounds, 12 ounces").
13.3 Properties of the Intl.ListFormat Prototype Object

The Intl.ListFormat prototype object is itself an ordinary object. %ListFormat.prototype% is not an Intl.ListFormat instance and does not have an [[InitializedListFormat]] internal slot or any of the other internal slots of Intl.ListFormat instance objects.

13.3.1 Intl.ListFormat.prototype.constructor

The initial value of Intl.ListFormat.prototype.constructor is %ListFormat%.

13.3.2 Intl.ListFormat.prototype @@toStringTag

The initial value of the @@toStringTag property is the String value "Intl.ListFormat".

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

13.3.3 Intl.ListFormat.prototype.format (list)

When the format method is called with an argument list, the following steps are taken:

1. Let lf be the this value.
2. Perform ? RequireInternalSlot(lf, [[InitializedListFormat]]).
3. Let stringList be ? StringListFromIterable(list).

13.3.4 Intl.ListFormat.prototype.formatToParts (list)

When the formatToParts method is called with an argument list, the following steps are taken:

1. Let lf be the this value.
2. Perform ? RequireInternalSlot(lf, [[InitializedListFormat]]).
3. Let stringList be ? StringListFromIterable(list).
4. Return ! FormatListToParts(lf, stringList).

13.3.5 Intl.ListFormat.prototype.resolvedOptions ()

This function provides access to the locale and options computed during initialization of the object.

1. Let lf be the this value.
2. Perform ? RequireInternalSlot(lf, [[InitializedListFormat]]).
3. Let options be OrdinaryObjectCreate(%Object.prototype%).
4. For each row of Table 11, except the header row, in table order, do
   a. Let p be the Property value of the current row.
   b. Let v be the value of lf's internal slot whose name is the Internal Slot value of the current row.
   c. Assert: v is not undefined.
   d. Perform ! CreateDataPropertyOrThrow(options, p, v).
5. Return options.
Table 11: Resolved Options of ListFormat Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[Type]]</td>
<td>&quot;type&quot;</td>
</tr>
<tr>
<td>[[Style]]</td>
<td>&quot;style&quot;</td>
</tr>
</tbody>
</table>

13.4 Properties of Intl.ListFormat Instances

Intl.ListFormat instances inherit properties from %ListFormat.prototype%.

Intl.ListFormat instances have an [[InitializedListFormat]] internal slot.

Intl.ListFormat instances also have several internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used by the list format styles.
- [[Type]] is one of the String values "conjunction", "disjunction", or "unit", identifying the list of types used.
- [[Style]] is one of the String values "long", "short", or "narrow", identifying the list formatting style used.
- [[Templates]] is a ListFormat template set.

13.5 Abstract Operations for ListFormat Objects

13.5.1 DeconstructPattern (pattern, placeables)

The DeconstructPattern abstract operation is called with arguments pattern (which must be a String) and placeables (which must be a Record), and deconstructs the pattern string into a list of parts.

The placeables record is a record whose keys are placeables tokens used in the pattern string, and values are parts records which will be used in the result List to represent the token part. Example:

NOTE Example:

Input:
DeconstructPattern("AA{xx}BB{yy}CC", {
  [[xx]]: {{[Type]]: "hour", [[Value]]: "15"},
  [[yy]]: {{[Type]]: "minute", [[Value]]: "06"}
})

Output (List of parts records):
```
{{[Type]]: "literal", [[Value]]: "AA"},
{{[Type]]: "hour", [[Value]]: "15"},
{{[Type]]: "literal", [[Value]]: "BB"},
{{[Type]]: "minute", [[Value]]: "06"},
{{[Type]]: "literal", [[Value]]: "CC"}
```

1. Let \textit{patternParts} be \texttt{! PartitionPattern(pattern)}.
2. Let \textit{result} be a new empty List.
3. For each Record \{ [[Type]], [[Value]] \} `patternPart` of `patternParts`, do
   a. Let `part` be `patternPart`\[[[Type]]\].
   b. If `part` is "literal", then
      i. Append Record \{ [[Type]]: "literal", [[Value]]: `patternPart`\[[[Value]] \} to `result`.
   c. Else,
      i. Assert: `placeables` has a field \[<part>\].
      ii. Let `subst` be `placeables`\[<part>\].
      iii. If Type(`subst`) is List, then
           1. For each element `s` of `subst`, do
              a. Append `s` to `result`.
      iv. Else,
           1. Append `subst` to `result`.
4. Return `result`.

13.5.2 CreatePartsFromList ( `listFormat`, `list` )

The `CreatePartsFromList` abstract operation is called with arguments `listFormat` (which must be an object initialized as a ListFormat) and `list` (which must be a List of String values), and creates the corresponding list of parts according to the effective locale and the formatting options of `listFormat`. Each part is a Record with two fields: [[Type]], which must be a string with values "element" or "literal", and [[Value]] which must be a string or a number. The following steps are taken:

1. Let `size` be the number of elements of `list`.
2. If `size` is 0, then
   a. Return a new empty List.
3. If `size` is 2, then
   a. Let `n` be an index into `listFormat`\[[Templates]] based on `listFormat`\[[Locale]], `list`\[0], and `list`\[1].
   b. Let `pattern` be `listFormat`\[[Templates]]\[n\]\[Pair\].
   c. Let `first` be a new Record \{ [[Type]]: "element", [[Value]]: `list`\[0] \}.
   d. Let `second` be a new Record \{ [[Type]]: "element", [[Value]]: `list`\[1] \}.
   e. Let `placeables` be a new Record \{ [[0]]: `first`, [[1]]: `second` \}.
   f. Return DeconstructPattern(`pattern`, `placeables`).
4. Let `last` be a new Record \{ [[Type]]: "element", [[Value]]: `list`\[size - 1] \}.
5. Let `parts` be « `last` ».
7. Repeat, while `i` ≥ 0,
   a. Let `head` be a new Record \{ [[Type]]: "element", [[Value]]: `list`\[i] \}.
   b. Let `n` be an implementation-defined index into `listFormat`\[[Templates]] based on `listFormat`. [[Locale]], `head`, and `parts`.
   c. If `i` is 0, then
      i. Let `pattern` be `listFormat`\[[Templates]]\[n\]\[Start\].
   d. Else if `i` is less than `size` - 2, then
      i. Let `pattern` be `listFormat`\[[Templates]]\[n\]\[Middle\].
   e. Else,
      i. Let `pattern` be `listFormat`\[[Templates]]\[<var>n\]\[End\].
   f. Let `placeables` be a new Record \{ [[0]]: `head`, [[1]]: `parts` \}.
   g. Set `parts` to ! DeconstructPattern(`pattern`, `placeables`).
   h. Decrement `i` by 1.
8. Return `parts`.

NOTE The index `n` to select across multiple templates permits the conjunction to be dependent on the context, as in Spanish, where either "y" or "e" may be selected, depending on the
13.5.3 FormatList (listFormat, list)

The FormatList abstract operation is called with arguments listFormat (which must be an object initialized as a ListFormat) and list (which must be a List of String values), and performs the following steps:

1. Let parts be ! CreatePartsFromList(listFormat, list).
2. Let result be an empty String.
3. For each Record { [Type], [Value] } part in parts, do
   a. Set result to the string-concatenation of result and part.[Value].
4. Return result.

13.5.4 FormatListToParts (listFormat, list)

The FormatListToParts abstract operation is called with arguments listFormat (which must be an object initialized as a ListFormat) and list (which must be a List of String values), and performs the following steps:

1. Let parts be ! CreatePartsFromList(listFormat, list).
2. Let result be ! ArrayCreate(0).
3. Let n be 0.
4. For each Record { [Type], [Value] } part in parts, do
   a. Let O be OrdinaryObjectCreate(%Object.prototype%).
   b. Perform ! CreateDataPropertyOrThrow(O, "type", part.[Type]).
   c. Perform ! CreateDataPropertyOrThrow(O, "value", part.[Value]).
   d. Perform ! CreateDataPropertyOrThrow(result, ! ToString(n), O).
   e. Increment n by 1.
5. Return result.

13.5.5 StringListFromIterable (iterable)

The abstract operation StringListFromIterable performs the following steps:

1. If iterable is undefined, then
   a. Return a new empty List.
2. Let iteratorRecord be ? GetIterator(iterable, sync).
3. Let list be a new empty List.
4. Let next be true.
5. Repeat, while next is not false,
   a. Set next to ? IteratorStep(iteratorRecord).
   b. If next is not false, then
      i. Let nextValue be ? IteratorValue(next).
      ii. If Type(nextValue) is not String, then
         1. Let error be ThrowCompletion(a newly created TypeError object).
      iii. Append nextValue to the end of the List list.
6. Return list.

NOTE This algorithm raises exceptions when it encounters values that are not Strings, because there is no obvious locale-aware coercion for arbitrary values.
14 Locale Objects

14.1 The Intl.Locale Constructor

The Locale constructor is the %Locale% intrinsic object and a standard built-in property of the Intl object.

14.1.1 Intl.Locale ( tag [, options ] )

The following algorithm refers to the type nonterminal from UTS 35’s Unicode Locale Identifier grammar. When the Intl.Locale function is called with an argument tag and an optional argument options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let relevantExtensionKeys be %Locale%.[[RelevantExtensionKeys]].
3. Let internalSlotsList be « [[InitializedLocale]], [[Locale]], [[Calendar]], [[Collation]], [[HourCycle]], [[NumberingSystem]] ».
4. If relevantExtensionKeys contains "kf", then
   a. Append [[CaseFirst]] as the last element of internalSlotsList.
5. If relevantExtensionKeys contains "kn", then
   a. Append [[Numeric]] as the last element of internalSlotsList.
7. If Type(tag) is not String or Object, throw a TypeError exception.
8. If Type(tag) is Object and tag has an [[InitializedLocale]] internal slot, then
   a. Let tag be tag.[[Locale]].
9. Else,
   a. Let tag be ? ToString(tag).
10. Set options to ? CoerceOptionsToObject(options).
11. Set tag to ? ApplyOptionsToTag(tag, options).
12. Let opt be a new Record.
14. If calendar is not undefined, then
   a. If calendar does not match the Unicode Locale Identifier type nonterminal, throw a RangeError exception.
15. Set opt.[[ca]] to calendar.
17. If collation is not undefined, then
   a. If collation does not match the Unicode Locale Identifier type nonterminal, throw a RangeError exception.
18. Set opt.[[co]] to collation.
20. Set opt.[[hc]] to hc.
22. Set opt.[[kf]] to kf.
24. If kn is not undefined, set kn to ! ToString(kn).
25. Set opt.[[kn]] to kn.
26. Let numberingSystem be ? Option(options, "numberingSystem", string, empty, undefined).
27. If `numberingSystem` is not `undefined`, then
   a. If `numberingSystem` does not match the Unicode Locale Identifier `type` nonterminal, throw a `RangeError` exception.
28. Set `opt.([nu])` to `numberingSystem`.
29. Let `r` be `!ApplyUnicodeExtensionToTag(tag, opt, relevantExtensionKeys)`.
30. Set `locale.([Locale])` to `r.([locale])`.
31. Set `locale.([Calendar])` to `r.([ca])`.
32. Set `locale.([Collation])` to `r.([co])`.
33. Set `locale.([HourCycle])` to `r.([hc])`.
34. If `relevantExtensionKeys` contains "kf", then
   a. Set `locale.([CaseFirst])` to `r.([kf])`.
35. If `relevantExtensionKeys` contains "kn", then
   a. If `SameValue(r.([kn]), "true")` is `true` or `r.([kn])` is the empty String, then
      i. Set `locale.([Numeric])` to `true`.
   b. Else,
      i. Set `locale.([Numeric])` to `false`.
36. Set `locale.([NumberingSystem])` to `r.([nu])`.
37. Return `locale`.

14.1.2 `ApplyOptionsToTag ( tag, options )`

The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar.

1. Assert: `Type(tag)` is String.
2. Assert: `Type(options)` is Object.
3. If `!IsStructurallyValidLanguageTag(tag)` is `false`, throw a `RangeError` exception.
4. Let `language` be `?GetOption(options, "language", string, empty, undefined)`.
5. If `language` is not `undefined`, then
   a. If `language` does not match the `unicode_language_subtag` production, throw a `RangeError` exception.
7. If `script` is not `undefined`, then
   a. If `script` does not match the `unicode_script_subtag` production, throw a `RangeError` exception.
8. Let `region` be `?GetOption(options, "region", string, empty, undefined)`.
9. If `region` is not `undefined`, then
   a. If `region` does not match the `unicode_region_subtag` production, throw a `RangeError` exception.
10. Set `tag` to `!CanonicalizeUnicodeLocaleId(tag)`.
11. Assert: `tag` matches the `unicode_locale_id` production.
12. Let `languageId` be the substring of `tag` corresponding to the `unicode_language_id` production.
13. If `language` is not `undefined`, then
    a. Set `languageId` to `languageId` with the substring corresponding to the `unicode_language_subtag` production replaced by the string `language`.
14. If `script` is not `undefined`, then
    a. If `languageId` does not contain a `unicode_script_subtag` production, then
       i. Set `languageId` to the string-concatenation of the `unicode_language_subtag` production of `languageId`, "-", `script`, and the rest of `languageId`.
    b. Else,
       i. Set `languageId` to `languageId` with the substring corresponding to the `unicode_script_subtag` production replaced by the string `script`.
15. If region is not undefined, then
   a. If languageId does not contain a unicode_region_subtag production, then
      i. Set languageId to the string-concatenation of the unicode_language_subtag production of languageId, the substring corresponding to "-" and the `unicode_script_subtag` production if present, "-", region, and the rest of languageId.
   b. Else,
      i. Set languageId to languageId with the substring corresponding to the unicode_region_subtag production replaced by the string region.
16. Set tag to tag with the substring corresponding to the unicode_language_id production replaced by the string languageId.
17. Return ! CanonicalizeUnicodeLocaleId(tag).

14.1.3 ApplyUnicodeExtensionToTag ( tag, options, relevantExtensionKeys )

The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar.

1. Assert: Type(tag) is String.
2. Assert: tag matches the unicode_locale_id production.
3. If tag contains a substring that is a Unicode locale extension sequence, then
   a. Let extension be the String value consisting of the substring of the Unicode locale extension sequence within tag.
   b. Let components be ! UnicodeExtensionComponents(extension).
   c. Let attributes be components.[[Attributes]].
   d. Let keywords be components.[[Keywords]].
4. Else,
   a. Let attributes be a new empty List.
   b. Let keywords be a new empty List.
5. Let result be a new Record.
6. For each element key of relevantExtensionKeys, do
   a. Let value be undefined.
   b. If keywords contains an element whose [[Key]] is the same as key, then
      i. Let entry be the element of keywords whose [[Key]] is the same as key.
      ii. Let value be entry.[[Value]].
   c. Else,
      i. Let entry be empty.
   d. Assert: options has a field [[<key>]].
   e. Let optionsValue be options.[[<key>]].
   f. If optionsValue is not undefined, then
      i. Assert: Type(optionsValue) is String.
      ii. Let value be optionsValue.
      iii. If entry is not empty, then
          1. Set entry.[[Value]] to value.
      iv. Else,
          1. Append the Record { [[Key]]: key, [[Value]]: value } to keywords.
   g. Set result.[[<key>]] to value.
7. Let locale be the String value that is tag with any Unicode locale extension sequences removed.
8. Let newExtension be a Unicode BCP 47 U Extension based on attributes and keywords.
9. If newExtension is not the empty String, then
   a. Let locale be ! InsertUnicodeExtensionAndCanonicalize(locale, newExtension).
10. Set result.[[locale]] to locale.
11. Return `result`.

14.2 Properties of the Intl.Locale Constructor

The Intl.Locale constructor has the following properties:

14.2.1 Intl.Locale.prototype

The value of `Intl.Locale.prototype` is `%Locale.prototype%`. This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

14.2.2 Internal slots

The value of the `[[RelevantExtensionKeys]]` internal slot is « "ca", "co", "hc", "kf", "kn", "nu" ». If `%Collator%.[[RelevantExtensionKeys]]` does not contain "kf", then remove "kf" from `%Locale%.[[RelevantExtensionKeys]]`. If `%Collator%.[[RelevantExtensionKeys]]` does not contain "kn", then remove "kn" from `%Locale%.[[RelevantExtensionKeys]]`.

14.3 Properties of the Intl.Locale Prototype Object

The Intl.Locale prototype object is itself an ordinary object. `%Locale.prototype%` is not an Intl.Locale instance and does not have an `[[InitializedLocale]]` internal slot or any of the other internal slots of Intl.Locale instance objects.

14.3.1 Intl.Locale.prototype.constructor

The initial value of `Intl.Locale.prototype.constructor` is `%Locale%`.

14.3.2 Intl.Locale.prototype[ @@toStringTag ]

The initial value of the `@@toStringTag` property is the String value "Intl.Locale".

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

14.3.3 Intl.Locale.prototype.maximize ( )

1. Let `loc` be the this value.
2. Perform `? RequireInternalSlot(loc, [[InitializedLocale]])`.
3. Let `maximal` be the result of the Add Likely Subtags algorithm applied to `loc.[[Locale]]`. If an error is signaled, set `maximal` to `loc.[[Locale]]`.
4. Return `! Construct(%Locale%, maximal)`.

14.3.4 Intl.Locale.prototype.minimize ( )

1. Let `loc` be the this value.
2. Perform `? RequireInternalSlot(loc, [[InitializedLocale]])`.
3. Let `minimal` be the result of the Remove Likely Subtags algorithm applied to `loc.[[Locale]]`. If an error is signaled, set `minimal` to `loc.[[Locale]]`.
4. Return \( \text{Construct}(%\text{Locale}\%, \text{minimal}) \).

### 14.3.5 Intl.Locale.prototype.toString()

1. Let \( \text{loc} \) be the \this{} value.
2. Perform \( \text{RequireInternalSlot}(\text{loc}, [[\text{InitializedLocale}]]) \).
3. Return \( \text{loc}.[[\text{Locale}]] \).

### 14.3.6 get Intl.Locale.prototype.baseName

\( \text{Intl.Locale.prototype.baseName} \) is an accessor property whose set accessor function is \texttt{undefined}. The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar. Its get accessor function performs the following steps:

1. Let \( \text{loc} \) be the \this{} value.
2. Perform \( \text{RequireInternalSlot}(\text{loc}, [[\text{InitializedLocale}]]) \).
3. Let \( \text{locale} \) be \( \text{loc}.[[\text{Locale}]] \).
4. Return the substring of \( \text{locale} \) corresponding to the \texttt{unicode_language_id} production.

### 14.3.7 get Intl.Locale.prototype.calendar

\( \text{Intl.Locale.prototype.calendar} \) is an accessor property whose set accessor function is \texttt{undefined}. Its get accessor function performs the following steps:

1. Let \( \text{loc} \) be the \this{} value.
2. Perform \( \text{RequireInternalSlot}(\text{loc}, [[\text{InitializedLocale}]]) \).
3. Return \( \text{loc}.[[\text{Calendar}]] \).

### 14.3.8 get Intl.Locale.prototype.caseFirst

This property only exists if \%\text{Locale}\%.[[ Relevant Extension Keys ]] contains "kf".

\( \text{Intl.Locale.prototype.caseFirst} \) is an accessor property whose set accessor function is \texttt{undefined}. Its get accessor function performs the following steps:

1. Let \( \text{loc} \) be the \this{} value.
2. Perform \( \text{RequireInternalSlot}(\text{loc}, [[\text{InitializedLocale}]]) \).
3. Return \( \text{loc}.[[\text{CaseFirst}]] \).

### 14.3.9 get Intl.Locale.prototype.collation

\( \text{Intl.Locale.prototype.collation} \) is an accessor property whose set accessor function is \texttt{undefined}. Its get accessor function performs the following steps:

1. Let \( \text{loc} \) be the \this{} value.
2. Perform \( \text{RequireInternalSlot}(\text{loc}, [[\text{InitializedLocale}]]) \).
3. Return \( \text{loc}.[[\text{Collation}]] \).
14.3.10 get Intl.Locale.prototype.hourCycle

Intl.Locale.prototype.hourCycle is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let loc be the this value.
2. Perform ? RequireInternalSlot(loc, [[InitializedLocale]]).
3. Return loc.[[HourCycle]].

14.3.11 get Intl.Locale.prototype.numeric

This property only exists if %Locale%.[[RelevantExtensionKeys]] contains "kn".

Intl.Locale.prototype.numeric is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let loc be the this value.
2. Perform ? RequireInternalSlot(loc, [[InitializedLocale]]).
3. Return loc.[[Numeric]].

14.3.12 get Intl.Locale.prototype.numberingSystem

Intl.Locale.prototype.numberingSystem is an accessor property whose set accessor function is undefined. Its get accessor function performs the following steps:

1. Let loc be the this value.
2. Perform ? RequireInternalSlot(loc, [[InitializedLocale]]).
3. Return loc.[[NumberingSystem]].

14.3.13 get Intl.Locale.prototype.language

Intl.Locale.prototype.language is an accessor property whose set accessor function is undefined. The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar. Its get accessor function performs the following steps:

1. Let loc be the this value.
2. Perform ? RequireInternalSlot(loc, [[InitializedLocale]]).
3. Let locale be loc.[[Locale]].
4. Assert: locale matches the unicode_locale_id production.
5. Return the substring of locale corresponding to the unicode_language_subtag production of the unicode_language_id.

14.3.14 get Intl.Locale.prototype.script

Intl.Locale.prototype.script is an accessor property whose set accessor function is undefined. The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar. Its get accessor function performs the following steps:

1. Let loc be the this value.
2. Perform ? RequireInternalSlot(loc, [[InitializedLocale]]).
3. Let locale be loc.[[Locale]].
4. Assert: locale matches the unicode_locale_id production.
5. If the `unicode_language_id` production of `locale` does not contain the `"-" unicode_script_subtag` sequence, return `undefined`.
6. Return the substring of `locale` corresponding to the `unicode_script_subtag` production of the `unicode_language_id`.

14.3.15 get Intl.Locale.prototype.region

`Intl.Locale.prototype.region` is an accessor property whose set accessor function is `undefined`. The following algorithm refers to UTS 35's Unicode Language and Locale Identifiers grammar. Its get accessor function performs the following steps:

1. Let `loc` be the this value.
2. Perform ? `RequireInternalSlot(loc, [[InitializedLocale]])`.
3. Let `locale` be `loc`.[[Locale]].
4. Assert: `locale` matches the `unicode_locale_id` production.
5. If the `unicode_language_id` production of `locale` does not contain the `"-" unicode_region_subtag` sequence, return `undefined`.
6. Return the substring of `locale` corresponding to the `unicode_region_subtag` production of the `unicode_language_id`.

15 NumberFormat Objects

15.1 The Intl.NumberFormat Constructor

The NumberFormat constructor is the `%NumberFormat%` intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

15.1.1 Intl.NumberFormat ([ `locales `, `options ` ])

When the `Intl.NumberFormat` function is called with optional arguments `locales` and `options`, the following steps are taken:

1. If NewTarget is `undefined`, let `newTarget` be the active function object, else let `newTarget` be NewTarget.
2. Let `numberFormat` be ? `OrdinaryCreateFromConstructor(newTarget, "%NumberFormat.prototype%", « [[InitializedNumberFormat]], [[Locale]], [[DataLocale]], [[NumberingSystem]], [[Style]], [[Unit]], [[UnitDisplay]], [[Currency]], [[CurrencyDisplay]], [[CurrencySign]], [[MinimumIntegerDigits]], [[MinimumFractionDigits]], [[MaximumFractionDigits]], [[MinimumSignificantDigits]], [[MaximumSignificantDigits]], [[RoundingType]], [[Notation]], [[CompactDisplay]], [[UseGrouping]], [[SignDisplay]], [[RoundingMode]], [[RoundingIncrement]], [[TrailingZeroDisplay]], [[BoundFormat]] »).
3. Perform ? `InitializeNumberFormat(numberFormat, locales, options)`.
4. If the implementation supports the normative optional constructor mode of 4.3 Note 1, then
   a. Let `this` be the this value.
   b. Return ? `ChainNumberFormat(numberFormat, NewTarget, this)`.
5. Return `numberFormat`.
NORMATIVE OPTIONAL

15.1.1.1 ChainNumberFormat ( numberFormat, newTarget, this )

1. If newTarget is undefined and ? OrdinaryHasInstance(%NumberFormat%, this) is true, then
   a. Perform ? DefinePropertyOrThrow(this, %Intl%.[[FallbackSymbol]], PropertyDescriptor{
      [Value]: numberFormat, [Writable]: false, [Enumerable]: false, [Configurable]: false }).
   b. Return this.
2. Return numberFormat.

15.1.2 InitializeNumberFormat ( numberFormat, locales, options )

The abstract operation InitializeNumberFormat accepts the arguments numberFormat (which must be an object), locales, and options. It initializes numberFormat as a NumberFormat object. The following steps are taken:

The following algorithm refers to the type nonterminal from UTS 35's Unicode Locale Identifier grammar.

1. Let requestedLocales be ? CanonicalizeLocaleList(locales).
2. Set options to ? CoerceOptionsToObject(options).
3. Let opt be a new Record.
5. Set opt.[[localeMatcher]] to matcher.
7. If numberingSystem is not undefined, then
   a. If numberingSystem does not match the Unicode Locale Identifier type nonterminal, throw a
      RangeError exception.
8. Set opt.[[nu]] to numberingSystem.
9. Let localeData be %NumberFormat%.[[LocaleData]].
10. Let r be ResolveLocale(%NumberFormat%.[[AvailableLocales]], requestedLocales, opt, %NumberFormat%.[[RelevantExtensionKeys]], localeData).
11. Set numberFormat.[[Locale]] to r.[[locale]].
12. Set numberFormat.[[DataLocale]] to r.[[dataLocale]].
13. Set numberFormat.[[NumberingSystem]] to r.[[nu]].
14. Perform ? SetNumberFormatUnitOptions(numberFormat, options).
15. Let style be numberFormat.[[Style]].
16. If style is "currency", then
   a. Let currency be numberFormat.[[Currency]].
   b. Let cDigits be CurrencyDigits(currency).
   c. Let mnfdDefault be cDigits.
   d. Let mxfdDefault be cDigits.
17. Else, Let mnfdDefault be 0.
19. Set numberFormat.[[Notation]] to notation.
20. Perform ? SetNumberFormatDigitOptions(numberFormat, options, mnfdDefault, mxfdDefault, notation).
22. Let defaultUseGrouping be "auto".
23. If notation is "compact", then
   a. Set numberFormat. [[CompactDisplay]] to compactDisplay.
   b. Set defaultUseGrouping to "min2".
24. NOTE: For historical reasons, the strings "true" and "false" are accepted and replaced with the default value.
26. If useGrouping is "true" or useGrouping is "false", set useGrouping to defaultUseGrouping.
27. If useGrouping is true, set useGrouping to "always".
28. Set numberFormat. [[UseGrouping]] to useGrouping.
30. Set numberFormat. [[SignDisplay]] to signDisplay.
31. Return numberFormat.

15.1.3 SetNumberFormatDigitOptions ( intfObj, options, mnfdDefault, mxfdDefault, notation )

The abstract operation SetNumberFormatDigitOptions takes arguments intfObj (an Object), options (an Object), mnfdDefault (a Number), mxfdDefault (a Number), and notation (a String). It populates the internal slots of intfObj that affect locale-independent number rounding (see 15.5.3). It performs the following steps when called:

1. Let mnid be ? GetNumberOption(options, "minimumIntegerDigits", 1, 21, 1).
2. Let mnfd be ? Get(options, "minimumFractionDigits").
3. Let mxfd be ? Get(options, "maximumFractionDigits").
4. Let mnsd be ? Get(options, "minimumSignificantDigits").
5. Let mxsd be ? Get(options, "maximumSignificantDigits").
7. Let roundingPriority be ? GetOption(options, "roundingPriority", string, "auto", "morePrecision", "lessPrecision" », "auto").
8. Let roundingIncrement be ? GetNumberOption(options, "roundingIncrement", 1, 5000, 1).
9. If roundingIncrement is not in 1, 2, 5, 10, 20, 25, 50, 100, 200, 250, 500, 1000, 2000, 2500, 5000 », throw a RangeError exception.
10. Let roundingMode be ? GetOption(options, "roundingMode", string, "ceil", "floor", "trunc", "halfCeil", "halfFloor", "halfExpand", "halfTrunc", "halfEven" », "halfExpand").
12. NOTE: All fields required by SetNumberFormatDigitOptions have now been read from options. The remainder of this AO interprets the options and may throw exceptions.
13. If roundingIncrement is not 1, set mxfdDefault to mnfdDefault.
14. Set intfObj. [[RoundingIncrement]] to roundingIncrement.
15. Set intfObj. [[RoundingMode]] to roundingMode.
17. If mnsd is not undefined or mxsd is not undefined, then
   a. Let hasSd be true.
18. Else,
a. Let has\(Sd\) be false.

19. If \(mnfd\) is not undefined or \(mxfd\) is not undefined, then
   a. Let has\(Fd\) be true.

20. Else,
   a. Let has\(Fd\) be false.

21. Let need\(Sd\) be true.

22. Let need\(Fd\) be true.

23. If \(roundingPriority\) is "auto", then
   a. Set need\(Sd\) to has\(Sd\).
   b. If need\(Sd\) is true, or has\(Fd\) is false and \(notation\) is "compact", then
      i. Set need\(Fd\) to false.

24. If need\(Sd\) is true, then
   a. If has\(Sd\) is true, then
      i. Set \(intlObj.\{MinimumSignificantDigits\}\) to DefaultNumberOption\((mnsd, 1, 21, 1)\).
      ii. Set \(intlObj.\{MaximumSignificantDigits\}\) to DefaultNumberOption\((mxsd, intlObj.\{MinimumSignificantDigits\}, 21, 21)\).
   b. Else,
      i. Set \(intlObj.\{MinimumSignificantDigits\}\) to 1.
      ii. Set \(intlObj.\{MaximumSignificantDigits\}\) to 21.

25. If need\(Fd\) is true, then
   a. If has\(Fd\) is true, then
      i. Set \(mnfd\) to DefaultNumberOption\((mnfd, 0, 20, undefined)\).
      ii. Set \(mxfd\) to DefaultNumberOption\((mxfd, 0, 20, undefined)\).
      iii. If \(mnfd\) is undefined, set \(mnfd\) to min\((mnfdDefault, mxfd)\).
      iv. Else if \(mxfd\) is undefined, set \(mxfd\) to max\((mxfdDefault, mnfd)\).
      v. Else if \(mnfd\) is greater than \(mxfd\), throw a RangeError exception.
      vi. Set \(intlObj.\{MinimumFractionDigits\}\) to \(mnfd\).
      vii. Set \(intlObj.\{MaximumFractionDigits\}\) to \(mxfd\).
   b. Else,
      i. Set \(intlObj.\{MinimumFractionDigits\}\) to \(mnfdDefault\).
      ii. Set \(intlObj.\{MaximumFractionDigits\}\) to \(mxfdDefault\).

26. If need\(Sd\) is false and need\(Fd\) is false, then
   a. Set \(intlObj.\{MinimumFractionDigits\}\) to 0.
   b. Set \(intlObj.\{MaximumFractionDigits\}\) to 0.
   c. Set \(intlObj.\{MinimumSignificantDigits\}\) to 1.
   d. Set \(intlObj.\{MaximumSignificantDigits\}\) to 2.
   e. Set \(intlObj.\{RoundingType\}\) to morePrecision.

27. Else if \(roundingPriority\) is "morePrecision", then
   a. Set \(intlObj.\{RoundingType\}\) to morePrecision.

28. Else if \(roundingPriority\) is "lessPrecision", then
   a. Set \(intlObj.\{RoundingType\}\) to lessPrecision.

29. Else if has\(Sd\) is true, then
   a. Set \(intlObj.\{RoundingType\}\) to significantDigits.

30. Else,
   a. Set \(intlObj.\{RoundingType\}\) to fractionDigits.

31. If \(roundingIncrement\) is not 1, then
   a. If \(intlObj.\{RoundingType\}\) is not fractionDigits, throw a TypeError exception.
   b. If \(intlObj.\{MaximumFractionDigits\}\) is not equal to \(intlObj.\{MinimumFractionDigits\}\), throw a RangeError exception.
15.1.4 SetNumberFormatUnitOptions ( intlObj, options )

The abstract operation SetNumberFormatUnitOptions resolves the user-specified options relating to units onto the `intl` object.

1. Assert: Type(intlObj) is Object.
2. Assert: Type(options) is Object.
3. Let style be ? GetOption(options, "style", string, « "decimal", "percent", "currency", "unit" », "decimal").
4. Set intlObj.[[Style]] to style.
6. If currency is undefined, then
   a. If style is "currency", throw a TypeError exception.
7. Else,
   a. If IsWellFormedCurrencyCode(currency) is false, throw a RangeError exception.
11. If unit is undefined, then
    a. If style is "unit", throw a TypeError exception.
12. Else,
    a. If ! IsWellFormedUnitIdentifier(unit) is false, throw a RangeError exception.
14. If style is "currency", then
    a. Set intlObj.[[Currency]] to the ASCII-uppercase of currency.
    b. Set intlObj.[[CurrencyDisplay]] to currencyDisplay.
    c. Set intlObj.[[CurrencySign]] to currencySign.
15. If style is "unit", then
    a. Set intlObj.[[Unit]] to unit.
    b. Set intlObj.[[UnitDisplay]] to unitDisplay.

15.2 Properties of the Intl.NumberFormat Constructor

The Intl.NumberFormat constructor has the following properties:

15.2.1 Intl.NumberFormat.prototype

The value of Intl.NumberFormat.prototype is %NumberFormat.prototype%.

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

15.2.2 Intl.NumberFormat.supportedLocalesOf ( locales [ , options ] )

When the supportedLocalesOf method is called with arguments locales and options, the following steps are taken:

1. Let availableLocales be %NumberFormat%.[[AvailableLocales]].
2. Let requestedLocales be ? CanonicalizeLocaleList(locales).

15.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1.

The value of the [[RelevantExtensionKeys]] internal slot is « "nu" ».

NOTE 1 Unicode Technical Standard #35 describes three locale extension keys that are relevant to number formatting: "cu" for currency, "cf" for currency format style, and "nu" for numbering system. Intl.NumberFormat, however, requires that the currency of a currency format is specified through the currency property in the options objects, and the currency format style of a currency format is specified through the currencySign property in the options objects.

The value of the [[LocaleData]] internal slot is implementation-defined within the constraints described in 9.1 and the following additional constraints:

- The list that is the value of the "nu" field of any locale field of [[LocaleData]] must not include the values "native", "traditio", or "finance".
- [[LocaleData]].[[locales]] must have a [[patterns]] field for all locale values locale. The value of this field must be a Record, which must have fields with the names of the four number format styles: "decimal", "percent", "currency", and "unit".
- The two fields "currency" and "unit" noted above must be Records with at least one field, "fallback". The "currency" may have additional fields with keys corresponding to currency codes according to 6.3. Each field of "currency" must be a Record with fields corresponding to the possible currencyDisplay values: "code", "symbol", "narrowSymbol", and "name". Each of those fields must contain a Record with fields corresponding to the possible currencySign values: "standard" or "accounting". The "unit" field (of [[LocaleData]].[[locales]]) may have additional fields beyond the required field "fallback" with keys corresponding to core measurement unit identifiers corresponding to 6.6. Each field of "unit" must be a Record with fields corresponding to the possible unitDisplay values: "narrow", "short", and "long".
- All of the leaf fields so far described for the patterns tree ("decimal", "percent", great-grandchildren of "currency", and grandchildren of "unit") must be Records with the keys "positivePattern", "negativePattern", and "scientificExponent".
- The value of the aforementioned fields (the sign-dependent pattern fields) must be string values that must contain the substring "{number}". "positivePattern" must contain the substring "{plusSign}" but not "{minusSign}"; "negativePattern" must contain the substring "{minusSign}" but not "{plusSign}"; and "scientificPattern" must not contain either "{plusSign}" or "{minusSign}". Additionally, the values within the "percent" field must also contain the substring "{percentSign}"; the values within the "currency" field must also contain one or more of the following substrings: "{currencyCode}", "{currencyPrefix}", or "{currencyPrefix}"; and the values within the "unit" field must also contain one or more of the following substrings: "{unitPrefix}" or "{unitSuffix}". The pattern strings, when interpreted as a sequence of UTF-16 encoded code points as described in es2023, 6.1.4, must not contain any code points in the General Category "Number, decimal digit" as specified by the Unicode Standard.
- [[LocaleData]].[[locales]] must also have a [[notationSubPatterns]] field for all locale values locale. The value of this field must be a Record, which must have two fields: [[scientific]] and [[compact]]. The [[scientific]] field must be a string value containing the substrings "{number}", "{scientificSeparator}", and "{scientificExponent}". The [[compact]] field must be a Record with two fields: "short" and "long". Each of these fields must be a Record with integer keys corresponding to all discrete magnitudes the implementation supports for compact notation. Each of these fields must be a string value which may contain the substring "{number}". Strings descended from "short" must contain the substring "{compactSymbol}", and strings descended from "long" must contain the substring "{compactName}".

NOTE 2 It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).
15.3 Properties of the Intl.NumberFormat Prototype Object

The Intl.NumberFormat prototype object is itself an ordinary object. `%NumberFormat.prototype%` is not an Intl.NumberFormat instance and does not have an `[[InitializedNumberFormat]]` internal slot or any of the other internal slots of Intl.NumberFormat instance objects.

15.3.1 Intl.NumberFormat.prototype.constructor

The initial value of `Intl.NumberFormat.prototype.constructor` is `%NumberFormat%`.

15.3.2 Intl.NumberFormat.prototype [ @@toStringTag ]

The initial value of the `@@toStringTag` property is the String value "Intl.NumberFormat".

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

15.3.3 `get Intl.NumberFormat.prototype.format`

`Intl.NumberFormat.prototype.format` is an accessor property whose set accessor function is `undefined`. Its get accessor function performs the following steps:

1. Let `nf` be the this value.
2. If the implementation supports the normative optional `constructor` mode of 4.3 Note 1, then
   a. Set `nf` to ? `UnwrapNumberFormat(nf)`.
3. Perform ? `RequireInternalSlot(nf, [[InitializedNumberFormat]])`.
4. If `nf.([BoundFormat])` is `undefined`, then
   a. Let `F` be a new built-in function object as defined in Number Format Functions (15.5.2).
   b. Set `F.([NumberFormat])` to `nf`.
   c. Set `nf.([BoundFormat])` to `F`.
5. Return `nf.([BoundFormat])`.

NOTE The returned function is bound to `nf` so that it can be passed directly to `Array.prototype.map` or other functions. This is considered a historical artefact, as part of a convention which is no longer followed for new features, but is preserved to maintain compatibility with existing programs.

15.3.4 Intl.NumberFormat.prototype.formatToParts ( `value` )

When the `formatToParts` method is called with an optional argument `value`, the following steps are taken:

1. Let `nf` be the this value.
2. Perform ? `RequireInternalSlot(nf, [[InitializedNumberFormat]])`.
3. Let `x` be ? `ToIntlMathematicalValue(value)`.
4. Return ? `FormatNumericToParts(nf, x)`.

15.3.5 Intl.NumberFormat.prototype.formatRange ( `start, end` )

When the `formatRange` method is called with arguments `start` and `end`, the following steps are taken:
1. Let \( nf \) be the this value.
2. Perform ? `RequireInternalSlot(nf, [[InitializedNumberFormat]])`.
3. If \( start \) is undefined or \( end \) is undefined, throw a `TypeError` exception.
4. Let \( x \) be `ToIntlMathematicalValue(start)`.
5. Let \( y \) be `ToIntlMathematicalValue(end)`.
6. Return ? `FormatNumericRange(nf, x, y)`.

### 15.3.6 `Intl.NumberFormat.prototype.formatRangeToParts (start, end)`

When the `formatRangeToParts` method is called with arguments `start` and `end`, the following steps are taken:

1. Let \( nf \) be the this value.
2. Perform ? `RequireInternalSlot(nf, [[InitializedNumberFormat]])`.
3. If \( start \) is undefined or \( end \) is undefined, throw a `TypeError` exception.
4. Let \( x \) be `.ToIntlMathematicalValue(start)`.
5. Let \( y \) be `.ToIntlMathematicalValue(end)`.
6. Return ? `FormatNumericRangeToParts(nf, x, y)`.

### 15.3.7 `Intl.NumberFormat.prototype.resolvedOptions()`

This function provides access to the locale and options computed during initialization of the object.

1. Let \( nf \) be the this value.
2. If the implementation supports the normative optional constructor mode of 4.3 Note 1, then
   a. Set \( nf \) to ? `UnwrapNumberFormat(nf)`.
3. Perform ? `RequireInternalSlot(nf, [[InitializedNumberFormat]])`.
4. Let \( options \) be `OrdinaryObjectCreate(%Object.prototype%)`.
5. For each row of Table 12, except the header row, in table order, do
   a. Let \( p \) be the Property value of the current row.
   b. Let \( v \) be the value of \( nf \)'s internal slot whose name is the Internal Slot value of the current row.
   c. If \( v \) is not undefined, then
      i. Perform ! `CreateDataPropertyOrThrow(options, p, v)`.
6. If \( nf.[[RoundingType]] \) is morePrecision, then
   a. Perform ! `CreateDataPropertyOrThrow(options, "roundingPriority", "morePrecision")`.
7. Else if \( nf.[[RoundingType]] \) is lessPrecision, then
   a. Perform ! `CreateDataPropertyOrThrow(options, "roundingPriority", "lessPrecision")`.
8. Else,
   a. Perform ! `CreateDataPropertyOrThrow(options, "roundingPriority", "auto")`.
9. Return \( options \).

Table 12: Resolved Options of NumberFormat Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[NumberingSystem]]</td>
<td>&quot;numberingSystem&quot;</td>
</tr>
<tr>
<td>[[Style]]</td>
<td>&quot;style&quot;</td>
</tr>
</tbody>
</table>
### 15.4 Properties of Intl.NumberFormat Instances

Intl.NumberFormat instances are ordinary objects that inherit properties from `%NumberFormat.prototype%`. Intl.NumberFormat instances have an `[[InitializedNumberFormat]]` internal slot.

Intl.NumberFormat instances also have several internal slots that are computed by the `constructor`:

- `[[Locale]]` is a `String` value with the language tag of the locale whose localization is used for formatting.
- `[[DataLocale]]` is a `String` value with the language tag of the nearest locale for which the implementation has data to perform the formatting operation. It will be a parent locale of `[[Locale]]`.
- `[[NumberingSystem]]` is a `String` value with the "type" given in Unicode Technical Standard #35 for the numbering system used for formatting.
- `[[Style]]` is one of the `String` values "decimal", "currency", "percent", or "unit", identifying the type of quantity being measured.
- `[[Currency]]` is a `String` value with the currency code identifying the currency to be used if formatting with the "currency" unit type. It is only used when `[[Style]]` has the value "currency".
- `[[CurrencyDisplay]]` is one of the `String` values "code", "symbol", "narrowSymbol", or "name", specifying whether to display the currency as an ISO 4217 alphabetic currency code, a localized currency symbol, or a localized currency name if formatting with the "currency" style. It is only used when `[[Style]]` has the value "currency".
- `[[CurrencySign]]` is one of the `String` values "standard" or "accounting", specifying whether to render negative numbers in accounting format, often signified by parenthesis. It is only used when `[[Style]]` has the value "currency" and when `[[SignDisplay]]` is not "never".

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Currency]]</code></td>
<td>&quot;currency&quot;</td>
</tr>
<tr>
<td><code>[[CurrencyDisplay]]</code></td>
<td>&quot;currencyDisplay&quot;</td>
</tr>
<tr>
<td><code>[[CurrencySign]]</code></td>
<td>&quot;currencySign&quot;</td>
</tr>
<tr>
<td><code>[[Unit]]</code></td>
<td>&quot;unit&quot;</td>
</tr>
<tr>
<td><code>[[UnitDisplay]]</code></td>
<td>&quot;unitDisplay&quot;</td>
</tr>
<tr>
<td><code>[[MinimumIntegerDigits]]</code></td>
<td>&quot;minimumIntegerDigits&quot;</td>
</tr>
<tr>
<td><code>[[MinimumFractionDigits]]</code></td>
<td>&quot;minimumFractionDigits&quot;</td>
</tr>
<tr>
<td><code>[[MaximumFractionDigits]]</code></td>
<td>&quot;maximumFractionDigits&quot;</td>
</tr>
<tr>
<td><code>[[MinimumSignificantDigits]]</code></td>
<td>&quot;minimumSignificantDigits&quot;</td>
</tr>
<tr>
<td><code>[[MaximumSignificantDigits]]</code></td>
<td>&quot;maximumSignificantDigits&quot;</td>
</tr>
<tr>
<td><code>[[UseGrouping]]</code></td>
<td>&quot;useGrouping&quot;</td>
</tr>
<tr>
<td><code>[[Notation]]</code></td>
<td>&quot;notation&quot;</td>
</tr>
<tr>
<td><code>[[CompactDisplay]]</code></td>
<td>&quot;compactDisplay&quot;</td>
</tr>
<tr>
<td><code>[[SignDisplay]]</code></td>
<td>&quot;signDisplay&quot;</td>
</tr>
<tr>
<td><code>[[RoundingMode]]</code></td>
<td>&quot;roundingMode&quot;</td>
</tr>
<tr>
<td><code>[[RoundingIncrement]]</code></td>
<td>&quot;roundingIncrement&quot;</td>
</tr>
<tr>
<td><code>[[TrailingZeroDisplay]]</code></td>
<td>&quot;trailingZeroDisplay&quot;</td>
</tr>
</tbody>
</table>
• [[Unit]] is a core unit identifier. It is only used when [[Style]] has the value "unit".
• [[UnitDisplay]] is one of the String values "short", "narrow", or "long", specifying whether to display the unit as a symbol, narrow symbol, or localized long name if formatting with the "unit" style. It is only used when [[Style]] has the value "unit".
• [[MinimumIntegerDigits]] is a non-negative integer Number value indicating the minimum integer digits to be used. Numbers will be padded with leading zeroes if necessary.
• [[MinimumFractionDigits]] and [[MaximumFractionDigits]] are non-negative integer Number values indicating the minimum and maximum fraction digits to be used. Numbers will be rounded or padded with trailing zeroes if necessary. These properties are only used when [[RoundingType]] is fractionDigits, morePrecision, or lessPrecision.
• [[MinimumSignificantDigits]] and [[MaximumSignificantDigits]] are positive integer Number values indicating the minimum and maximum fraction digits to be shown. If present, the formatter uses however many fraction digits are required to display the specified number of significant digits. These properties are only used when [[RoundingType]] is significantDigits, morePrecision, or lessPrecision.
• [[UseGrouping]] is a Boolean or String value indicating the conditions under which a grouping separator should be used. The positions of grouping separators, and whether to display grouping separators for a given number, is implementation-defined. A value "always" hints the implementation to display grouping separators if possible; "min2", if there are at least 2 digits in a group; "auto", if the locale prefers to use grouping separators for the number. A value false disables grouping separators.
• [[RoundingType]] is one of the values fractionDigits, significantDigits, morePrecision, or lessPrecision, indicating which rounding strategy to use. If fractionDigits, the number is rounded according to [[MinimumFractionDigits]] and [[MaximumFractionDigits]], as described above. If significantDigits, the number is rounded according to [[MinimumSignificantDigits]] and [[MaximumSignificantDigits]] as described above. If morePrecision or lessPrecision, all four of those settings are used, with specific rules for disambiguating when to use one set versus the other. [[RoundingType]] is derived from the "roundingPriority" option and is converted back to "roundingPriority" in 15.3.7.
• [[Notation]] is one of the String values "standard", "scientific", "engineering", or "compact", specifying whether the number should be displayed without scaling, scaled to the units place with the power of ten in scientific notation, scaled to the nearest thousand with the power of ten in scientific notation, or scaled to the nearest locale-dependent compact decimal notation power of ten with the corresponding compact decimal notation affix.
• [[CompactDisplay]] is one of the String values "short" or "long", specifying whether to display compact notation affixes in short form ("$K") or long form ("5 thousand") if formatting with the "compact" notation. It is only used when [[Notation]] has the value "compact".
• [[SignDisplay]] is one of the String values "auto", "always", "never", "exceptZero", or "negative", specifying when to include a sign (with non-"auto" options respectively corresponding with inclusion always, never, only for non-zero numbers, or only for non-zero negative numbers). In scientific notation, this slot affects the sign display of the mantissa but not the exponent.
• [[RoundingMode]] is one of the String values in the Identifier column of Table 13, specifying which rounding mode to use.
• [[RoundingIncrement]] is an integer-valued Number that evenly divides 10, 100, 1000, or 10000 into tenths, fifths, quarters, or halves. It indicates the increment at which rounding should take place relative to the calculated rounding magnitude. For example, if [[MaximumFractionDigits]] is 2 and [[RoundingIncrement]] is 5, then the number is rounded to the nearest 0.05 ("nickel rounding").
• [[TrailingZeroDisplay]] is one of the String values "auto" or "stripfInteger", indicating whether to strip trailing zeros if the formatted number is an integer (i.e., has no non-zero fraction digit).

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Description</th>
<th>Examples: Round to 0 fraction digits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-1.5</td>
</tr>
<tr>
<td>&quot;cell&quot;</td>
<td>Toward positive infinity</td>
<td>[ ] [-1]</td>
</tr>
<tr>
<td>&quot;floor&quot;</td>
<td>Toward negative infinity</td>
<td>[ ] [-2]</td>
</tr>
<tr>
<td>&quot;expand&quot;</td>
<td>Away from zero</td>
<td>[ ] [-2]</td>
</tr>
</tbody>
</table>
Table 13 (continued)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Description</th>
<th>Examples: Round to 0 fraction digits</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;trunc&quot;</td>
<td>Toward zero</td>
<td>[-1] ⬆ [0] ⬆ [0] ⬆ [0] ⬆ [1]</td>
</tr>
<tr>
<td>&quot;halfCeil&quot;</td>
<td>Ties toward positive infinity</td>
<td>[-1] ⬆ [0] ⬆ [1] ⬆ [1] ⬆ [2]</td>
</tr>
<tr>
<td>&quot;halfFloor&quot;</td>
<td>Ties toward negative infinity</td>
<td>[-2] ⬆ [0] ⬆ [0] ⬆ [1] ⬆ [1]</td>
</tr>
<tr>
<td>&quot;halfExpand&quot;</td>
<td>Ties away from zero</td>
<td>[-2] ⬆ [0] ⬆ [1] ⬆ [1] ⬆ [2]</td>
</tr>
<tr>
<td>&quot;halfTrunc&quot;</td>
<td>Ties toward zero</td>
<td>[-1] ⬆ [0] ⬆ [0] ⬆ [1] ⬆ [1]</td>
</tr>
<tr>
<td>&quot;halfEven&quot;</td>
<td>Ties toward an even rounding increment multiple</td>
<td>[-2] ⬆ [0] ⬆ [0] ⬆ [1] ⬆ [2]</td>
</tr>
</tbody>
</table>

NOTE The examples are illustrative of the unique behaviour of each option. ⬆ means "resolves toward positive infinity"; ⬇ means "resolves toward negative infinity".

Finally, Intl.NumberFormat instances have a [[BoundFormat]] internal slot that caches the function returned by the format accessor (15.3.3).

15.5 Abstract Operations for NumberFormat Objects

15.5.1 CurrencyDigits (currency)

When the CurrencyDigits abstract operation is called with an argument currency (which must be an uppercase String value), the following steps are taken:

1. If the ISO 4217 currency and funds code list contains currency as an alphabetic code, return the minor unit value corresponding to the currency from the list; otherwise, return 2.

15.5.2 Number Format Functions

A Number format function is an anonymous built-in function that has a [[NumberFormat]] internal slot.

When a Number format function $F$ is called with optional argument value, the following steps are taken:

1. Let $nf$ be $F$.[[NumberFormat]].
2. Assert: Type($nf$) is Object and $nf$ has an [[InitializedNumberFormat]] internal slot.
3. If value is not provided, let value be undefined.
4. Let $x$ be ? ToIntlMathematicalValue(value).
5. Return ? FormatNumeric($nf$, $x$).

The "length" property of a Number format function is 1.

15.5.3 FormatNumericToString (intlObject, $x$)

The FormatNumericToString abstract operation is called with arguments intlObject (which must be an object with [[RoundingMode]], [[RoundingType]], [[MinimumSignificantDigits]], [[MaximumSignificantDigits]], [[MinimumIntegerDigits]], [[MinimumFractionDigits]], [[MaximumFractionDigits]], [[RoundingIncrement]], and
[[TrailingZeroDisplay]] internal slots), and \(x\) (which must be a mathematical value or negative-zero). It rounds \(x\) to an Intl mathematical value according to the internal slots of \(intlObject\) and returns a Record with a [[RoundedNumber]] field containing that result and a [[FormattedString]] field containing a String value representation of that result formatted according to the internal slots of \(intlObject\).

1. If \(x\) is negative-zero, then
   a. Let \(isNegative\) be true.
   b. Set \(x\) to 0.
2. Else,
   a. Assert: \(x\) is a mathematical value.
   b. If \(x < 0\), let \(isNegative\) be true; else let \(isNegative\) be false.
   c. If \(isNegative\) is true, then
      i. Set \(x\) to \(-x\).
3. Let \(unsignedRoundingMode\) be GetUnsignedRoundingMode(\(intlObject\.[[RoundingMode]]\), \(isNegative\)).
4. If \(intlObject\.[[RoundingType]]\) is significantDigits, then
   a. Let \(result\) be ToRawPrecision(\(x\), \(intlObject\.[[Minimum SignificantDigits]]\), \(intlObject\.[[Maximum SignificantDigits]]\), \(unsignedRoundingMode\)).
5. Else if \(intlObject\.[[RoundingType]]\) is fractionDigits, then
   a. Let \(result\) be ToRawFixed(\(x\), \(intlObject\.[[Minimum FractionDigits]]\), \(intlObject\.[[Maximum FractionDigits]]\), \(intlObject\.[[RoundingIncrement]]\), \(unsignedRoundingMode\)).
6. Else,
   a. Let \(sResult\) be ToRawPrecision(\(x\), \(intlObject\.[[Minimum SignificantDigits]]\), \(intlObject\.[[Maximum SignificantDigits]]\), \(unsignedRoundingMode\)).
   b. Let \(fResult\) be ToRawFixed(\(x\), \(intlObject\.[[Minimum FractionDigits]]\), \(intlObject\.[[Maximum FractionDigits]]\), \(intlObject\.[[RoundingIncrement]]\), \(unsignedRoundingMode\)).
   c. If \(intlObject\.[[RoundingType]]\) is morePrecision, then
      i. If \(sResult\.[[RoundingMagnitude]]\) ≤ \(fResult\.[[RoundingMagnitude]]\), then
         1. Let \(result\) be \(sResult\).
         ii. Else,
             1. Let \(result\) be \(fResult\).
   d. Else,
      i. Assert: \(intlObject\.[[RoundingType]]\) is lessPrecision.
      ii. If \(sResult\.[[RoundingMagnitude]]\) ≤ \(fResult\.[[RoundingMagnitude]]\), then
          1. Let \(result\) be \(fResult\).
      iii. Else,
          1. Let \(result\) be \(sResult\).
7. Set \(x\) to \(result\.[[RoundedNumber]]\).
8. Let \(string\) be \(result\.[[FormattedString]]\).
9. If \(intlObject\.[[TrailingZeroDisplay]]\) is "stripIfInteger" and \(x\) modulo \(1 = 0\), then
   a. Let \(i\) be StringIndexOf(\(string\), ".", 0).
   b. If \(i \neq -1\), set \(string\) to the substring of \(string\) from 0 to \(i\).
10. Let \(int\) be \(result\.[[IntegerDigitsCount]]\).
11. Let \(minInteger\) be \(intlObject\.[[Minimum IntegerDigits]]\).
12. If \(int < minInteger\), then
    a. Let \(forwardZeros\) be the String consisting of \(minInteger - int\) occurrences of the code unit 0x0030 (DIGIT ZERO).
    b. Set \(string\) to the string-concatenation of \(forwardZeros\) and \(string\).
13. If \(isNegative\) is true, then
    a. If \(x\) is 0, set \(x\) to negative-zero. Otherwise, set \(x\) to \(-x\).
14. Return the Record \{ [[RoundedNumber]]: \(x\), [[FormattedString]]: \(string\) \}. 
15.5.4 PartitionNumberPattern (numberFormat, x)

The abstract operation PartitionNumberPattern takes arguments numberFormat (an object initialized as a NumberFormat) and x (an Intl mathematical value). It creates the parts representing the mathematical value of x according to the effective locale and the formatting options of numberFormat. It performs the following steps when called:

1. Let exponent be 0.
2. If x is not-a-number, then
   a. Let n be an implementation- and locale-dependent (ILD) String value indicating the NaN value.
3. Else if x is positive-infinity, then
   a. Let n be an ILD String value indicating positive infinity.
4. Else if x is negative-infinity, then
   a. Let n be an ILD String value indicating negative infinity.
5. Else,
   a. If x is not negative-zero, then
      i. Assert: x is a mathematical value.
      ii. If numberFormat.[[Style]] is "percent", set x be 100 × x.
      iii. Let exponent be ComputeExponent(numberFormat, x).
      iv. Set x to x × 10⁻exponent.
   b. Let formatNumberResult be FormatNumericToString(numberFormat, x).
   c. Let n be formatNumberResult.[[FormattedString]].
   d. Set x to formatNumberResult.[[RoundedNumber]].
6. Let pattern be GetNumberFormatPattern(numberFormat, x).
7. Let result be a new empty List.
8. Let patternParts be PartitionPattern(pattern).
9. For each Record {[[Type]], [[Value]]} patternPart of patternParts, do
   a. Let p be patternPart.[[Type]].
   b. If p is "literal", then
      i. Append a new Record {[[Type]]: "literal", [[Value]]: patternPart.[[Value]]} as the last element of result.
   c. Else if p is equal to "number", then
      i. Let notationSubParts be PartitionNotationSubPattern(numberFormat, x, n, exponent).
      ii. Append all elements of notationSubParts to result.
   d. Else if p is equal to "plusSign", then
      i. Let plusSignSymbol be the ILND String representing the plus sign.
      ii. Append a new Record {[[Type]]: "plusSign", [[Value]]: plusSignSymbol} as the last element of result.
   e. Else if p is equal to "minusSign", then
      i. Let minusSignSymbol be the ILND String representing the minus sign.
      ii. Append a new Record {[[Type]]: "minusSign", [[Value]]: minusSignSymbol} as the last element of result.
   f. Else if p is equal to "percentSign" and numberFormat.[[Style]] is "percent", then
      i. Let percentSignSymbol be the ILND String representing the percent sign.
      ii. Append a new Record {[[Type]]: "percentSign", [[Value]]: percentSignSymbol} as the last element of result.
   g. Else if p is equal to "unitPrefix" and numberFormat.[[Style]] is "unit", then
      i. Let unit be numberFormat.[[Unit]].
      ii. Let unitDisplay be numberFormat.[[UnitDisplay]].
      iii. Let mu be an ILD String value representing unit before x in unitDisplay form, which may depend on x in languages having different plural forms.
The following steps are taken:

h. Else if \( p \) is equal to "unitSuffix" and \( \text{numberFormat} .[[\text{Style}]] \) is "unit", then
   i. Let \( \text{unit} \) be \( \text{numberFormat} .[[\text{Unit}]] \).
   ii. Let \( \text{unitDisplay} \) be \( \text{numberFormat} .[[\text{UnitDisplay}]] \).
   iii. Let \( \mu \) be an ILD String value representing \( \text{unit} \) after \( x \) in \( \text{unitDisplay} \) form, which may depend on \( x \) in languages having different plural forms.
   iv. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{unit}" , [[\text{Value}]]: \mu \} \) as the last element of \( \text{result} \).

i. Else if \( p \) is equal to "currencyCode" and \( \text{numberFormat} .[[\text{Style}]] \) is "currency", then
   i. Let \( \text{currency} \) be \( \text{numberFormat} .[[\text{Currency}]] \).
   ii. Let \( \text{cd} \) be "currency".
   iii. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{currency}" , [[\text{Value}]]: \text{cd} \} \) as the last element of \( \text{result} \).

j. Else if \( p \) is equal to "currencyPrefix" and \( \text{numberFormat} .[[\text{Style}]] \) is "currency", then
   i. Let \( \text{currencyDisplay} \) be \( \text{numberFormat} .[[\text{CurrencyDisplay}]] \).
   ii. Let \( \text{cd} \) be an ILD String value representing \( \text{currency} \) before \( x \) in \( \text{currencyDisplay} \) form, which may depend on \( x \) in languages having different plural forms.
   iv. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{currency}" , [[\text{Value}]]: \text{cd} \} \) as the last element of \( \text{result} \).

k. Else if \( p \) is equal to "currencySuffix" and \( \text{numberFormat} .[[\text{Style}]] \) is "currency", then
   i. Let \( \text{currency} \) be \( \text{numberFormat} .[[\text{Currency}]] \).
   ii. Let \( \text{currencyDisplay} \) be \( \text{numberFormat} .[[\text{CurrencyDisplay}]] \).
   iii. Let \( \text{cd} \) be an ILD String value representing \( \text{currency} \) after \( x \) in \( \text{currencyDisplay} \) form, which may depend on \( x \) in languages having different plural forms. If the implementation does not have such a representation of \( \text{currency} \), use \( \text{currency} \) itself.
   iv. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{currency}" , [[\text{Value}]]: \text{cd} \} \) as the last element of \( \text{result} \).

l. Else,
   i. Let \( \text{unknown} \) be an ILND String based on \( x \) and \( p \).
   ii. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{unknown}" , [[\text{Value}]]: \text{unknown} \} \) as the last element of \( \text{result} \).

10. Return \( \text{result} \).

15.5.5 PartitionNotationSubPattern ( \text{numberFormat} , x , n , exponent )

The PartitionNotationSubPattern abstract operation is called with arguments \( \text{numberFormat} \) (which must be an object initialized as a NumberFormat), \( x \) (which is an Intl mathematical value after rounding is applied), \( n \) (which is an intermediate formatted string), and \( \text{exponent} \) (an integer), and creates the corresponding parts for the number and notation according to the effective locale and the formatting options of \( \text{numberFormat} \). The following steps are taken:

1. Let \( \text{result} \) be a new empty \text{List}.
2. If \( x \) is not-a-number, then
   a. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{nan}" , [[\text{Value}]]: \text{n} \} \) as the last element of \( \text{result} \).
3. Else if \( x \) is positive-infinity or negative-infinity, then
   a. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{infinity}" , [[\text{Value}]]: \text{n} \} \) as the last element of \( \text{result} \).
4. Else,
   a. Let \( \text{notationSubPattern} \) be \( \text{GetNotationSubPattern}(\text{numberFormat} , \text{exponent}) \).
   b. Let \( \text{patternParts} \) be \( \text{PartitionPattern}(\text{notationSubPattern}) \).
   c. For each \( \text{Record} \{ [[\text{Type}]] , [[\text{Value}]] \} \) \( \text{patternPart} \) of \( \text{patternParts} \), do
      i. Let \( p \) be \( \text{patternPart} .[[\text{Type}]] \).
      ii. If \( p \) is "literal", then
          1. Append a new \( \text{Record} \{ [[\text{Type}]]: "\text{literal}" , [[\text{Value}]]: \text{patternPart} .[[\text{Value}]] \} \) as the last element of \( \text{result} \).
      iii. Else if \( p \) is equal to "number", then
1. If the `numberFormat`.[[NumberingSystem]] matches one of the values in the Numbering System column of Table 14 below, then
   a. Let `digits` be a List whose elements are the code points specified in the Digits column of the matching row in Table 14.
   b. **Assert**: The length of `digits` is 10.
   c. Let `transliterated` be the empty String.
   d. Let `len` be the length of `n`.
   e. Let `position` be 0.
   f. Repeat, while `position` < `len`,
      i. Let `c` be the code unit at index `position` within `n`.
      ii. If 0x0030 ≤ `c` ≤ 0x0039, then
         i. **NOTE**: `c` is an ASCII digit.
         ii. Let `i` be `c` - 0x0030.
         iii. Set `c` to `CodePointsToString`(`digits`[`i`]).
      iii. Set `transliterated` to the string-concatenation of `transliterated` and `c`.
      iv. Set `position` to `position` + 1.
   g. Set `n` to `transliterated`.
2. Else use an implementation dependent algorithm to map `n` to the appropriate representation of `n` in the given numbering system.
3. Let `decimalSepIndex` be `StringIndexOf`(`n`, `"."`, 0).
4. If `decimalSepIndex` > 0, then
   a. Let `integer` be the substring of `n` from position 0, inclusive, to position `decimalSepIndex`, exclusive.
   b. Let `fraction` be the substring of `n` from position `decimalSepIndex`, exclusive, to the end of `n`.
5. Else,
   a. Let `integer` be `n`.
   b. Let `fraction` be `undefined`.
6. If the `numberFormat`.[[UseGrouping]] is `false`, then
   a. Append a new `Record` { [[Type]]: "integer", [[Value]]: `integer` } as the last element of `result`.
7. Else,
   a. Let `groupSepSymbol` be the implementation-, locale-, and numbering system-dependent (ILND) String representing the grouping separator.
   b. Let `groups` be a List whose elements are, in left to right order, the substrings defined by ILND set of locations within the `integer`, which may depend on the value of `numberFormat`.[[UseGrouping]].
   c. **Assert**: The number of elements in `groups` List is greater than 0.
   d. Repeat, while `groups` List is not empty,
      i. Remove the first element from `groups` and let `integerGroup` be the value of that element.
      ii. Append a new `Record` { [[Type]]: "integer", [[Value]]: `integerGroup` } as the last element of `result`.
      iii. If `groups` List is not empty, then
         i. Append a new `Record` { [[Type]]: "group", [[Value]]: `groupSepSymbol` } as the last element of `result`.
8. If `fraction` is not `undefined`, then
   a. Let `decimalSepSymbol` be the ILND String representing the decimal separator.
   b. Append a new `Record` { [[Type]]: "decimal", [[Value]]: `decimalSepSymbol` } as the last element of `result`.
c. Append a new Record { [[Type]]: "fraction", [[Value]]: fraction } as the last element of result.

iv. Else if p is equal to "compactSymbol", then
1. Let compactSymbol be an ILD string representing exponent in short form, which may depend on x in languages having different plural forms. The implementation must be able to provide this string, or else the pattern would not have a "{compactSymbol}" placeholder.
2. Append a new Record { [[Type]]: "compact", [[Value]]: compactSymbol } as the last element of result.

v. Else if p is equal to "compactName", then
1. Let compactName be an ILD string representing exponent in long form, which may depend on x in languages having different plural forms. The implementation must be able to provide this string, or else the pattern would not have a "{compactName}" placeholder.
2. Append a new Record { [[Type]]: "compact", [[Value]]: compactName } as the last element of result.

vi. Else if p is equal to "scientificSeparator", then
1. Let scientificSeparator be the ILND String representing the exponent separator.
2. Append a new Record { [[Type]]: "exponentSeparator", [[Value]]: scientificSeparator } as the last element of result.

vii. Else if p is equal to "scientificExponent", then
1. If exponent < 0, then
   a. Let minusSignSymbol be the ILND String representing the minus sign.
   b. Append a new Record { [[Type]]: "exponentMinusSign", [[Value]]: minusSignSymbol } as the last element of result.
   c. Let exponent be -exponent.
2. Let exponentResult be ToRawFixed(exponent, 0, 0, 1, undefined).
3. Append a new Record { [[Type]]: "exponentInteger", [[Value]]: exponentResult. [[FormattedString]] } as the last element of result.

viii. Else,
1. Let unknown be an ILND String based on x and p.
2. Append a new Record { [[Type]]: "unknown", [[Value]]: unknown } as the last element of result.

5. Return result.

Table 14: Numbering systems with simple digit mappings

<table>
<thead>
<tr>
<th>Numbering System</th>
<th>Digits</th>
</tr>
</thead>
<tbody>
<tr>
<td>adm1</td>
<td>U+1E950 to U+1E959</td>
</tr>
<tr>
<td>ahom</td>
<td>U+11730 to U+11739</td>
</tr>
<tr>
<td>arab</td>
<td>U+0660 to U+0669</td>
</tr>
<tr>
<td>arabext</td>
<td>U+06F0 to U+06F9</td>
</tr>
<tr>
<td>bali</td>
<td>U+1B50 to U+1B59</td>
</tr>
<tr>
<td>beng</td>
<td>U+09E6 to U+09EF</td>
</tr>
<tr>
<td>bhks</td>
<td>U+11C50 to U+11C59</td>
</tr>
<tr>
<td>brah</td>
<td>U+11066 to U+1106F</td>
</tr>
</tbody>
</table>
Table 14 (continued)

<table>
<thead>
<tr>
<th>Numbering System</th>
<th>Digits</th>
</tr>
</thead>
<tbody>
<tr>
<td>cakm</td>
<td>U+11136 to U+1113F</td>
</tr>
<tr>
<td>cham</td>
<td>U+AA50 to U+AA59</td>
</tr>
<tr>
<td>deva</td>
<td>U+0966 to U+096F</td>
</tr>
<tr>
<td>diak</td>
<td>U+11950 to U+11959</td>
</tr>
<tr>
<td>fullwide</td>
<td>U+FF10 to U+FF19</td>
</tr>
<tr>
<td>gong</td>
<td>U+11DA0 to U+11DA9</td>
</tr>
<tr>
<td>gonm</td>
<td>U+11D50 to U+11D59</td>
</tr>
<tr>
<td>gujr</td>
<td>U+0AE6 to U+0AEF</td>
</tr>
<tr>
<td>guru</td>
<td>U+0A66 to U+0A6F</td>
</tr>
<tr>
<td>hanidec</td>
<td>U+3007, U+4E00, U+4E8C, U+4E09, U+56DB, U+4E94, U+516D, U+4E03, U+516B, U+4E5D</td>
</tr>
<tr>
<td>hmng</td>
<td>U+16B50 to U+16B59</td>
</tr>
<tr>
<td>hmnp</td>
<td>U+1E140 to U+1E149</td>
</tr>
<tr>
<td>java</td>
<td>U+A9D0 to U+A9D9</td>
</tr>
<tr>
<td>kali</td>
<td>U+A900 to U+A909</td>
</tr>
<tr>
<td>kawi</td>
<td>U+11F50 to U+11F59</td>
</tr>
<tr>
<td>khmr</td>
<td>U+17E0 to U+17E9</td>
</tr>
<tr>
<td>knda</td>
<td>U+0CE6 to U+0CEF</td>
</tr>
<tr>
<td>lana</td>
<td>U+1A80 to U+1A89</td>
</tr>
<tr>
<td>lanatham</td>
<td>U+1A90 to U+1A99</td>
</tr>
<tr>
<td>laoo</td>
<td>U+0ED0 to U+0ED9</td>
</tr>
<tr>
<td>latn</td>
<td>U+0030 to U+0039</td>
</tr>
<tr>
<td>lepc</td>
<td>U+C40 to U+C49</td>
</tr>
<tr>
<td>limb</td>
<td>U+1946 to U+194F</td>
</tr>
<tr>
<td>mathbold</td>
<td>U+1D7CE to U+1D7D7</td>
</tr>
<tr>
<td>mathdbl</td>
<td>U+1D7D8 to U+1D7E1</td>
</tr>
<tr>
<td>mathmono</td>
<td>U+1D7F6 to U+1D7FF</td>
</tr>
<tr>
<td>mathsanb</td>
<td>U+1D7EC to U+1D7F5</td>
</tr>
<tr>
<td>mathsans</td>
<td>U+1D7E2 to U+1D7EB</td>
</tr>
<tr>
<td>mlym</td>
<td>U+0D66 to U+0D6F</td>
</tr>
<tr>
<td>modi</td>
<td>U+11650 to U+11659</td>
</tr>
<tr>
<td>Numbering System</td>
<td>Digits</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>mong</td>
<td>U+1810 to U+1819</td>
</tr>
<tr>
<td>mroo</td>
<td>U+16A60 to U+16A69</td>
</tr>
<tr>
<td>mtei</td>
<td>U+ABF0 to U+ABF9</td>
</tr>
<tr>
<td>mymr</td>
<td>U+1040 to U+1049</td>
</tr>
<tr>
<td>mymrshan</td>
<td>U+1090 to U+1099</td>
</tr>
<tr>
<td>mymrtlng</td>
<td>U+A9F0 to U+A9F9</td>
</tr>
<tr>
<td>nagm</td>
<td>U+1E4F0 to U+1E4F9</td>
</tr>
<tr>
<td>newa</td>
<td>U+11450 to U+11459</td>
</tr>
<tr>
<td>nkoo</td>
<td>U+07C0 to U+07C9</td>
</tr>
<tr>
<td>olck</td>
<td>U+1C50 to U+1C59</td>
</tr>
<tr>
<td>orya</td>
<td>U+0B66 to U+0B6F</td>
</tr>
<tr>
<td>osma</td>
<td>U+104A0 to U+104A9</td>
</tr>
<tr>
<td>rohg</td>
<td>U+10D30 to U+10D39</td>
</tr>
<tr>
<td>saur</td>
<td>U+A8D0 to U+A8D9</td>
</tr>
<tr>
<td>segment</td>
<td>U+1FBF0 to U+1FBF9</td>
</tr>
<tr>
<td>shrd</td>
<td>U+111D0 to U+111D9</td>
</tr>
<tr>
<td>sind</td>
<td>U+112F0 to U+112F9</td>
</tr>
<tr>
<td>sinh</td>
<td>U+0DE6 to U+0DEF</td>
</tr>
<tr>
<td>sora</td>
<td>U+110F0 to U+110F9</td>
</tr>
<tr>
<td>sund</td>
<td>U+1BB0 to U+1BB9</td>
</tr>
<tr>
<td>takr</td>
<td>U+116C0 to U+116C9</td>
</tr>
<tr>
<td>talu</td>
<td>U+19D0 to U+19D9</td>
</tr>
<tr>
<td>tamldec</td>
<td>U+0BE6 to U+0BEF</td>
</tr>
<tr>
<td>telu</td>
<td>U+0C66 to U+0C6F</td>
</tr>
<tr>
<td>thai</td>
<td>U+0E50 to U+0E59</td>
</tr>
<tr>
<td>tibt</td>
<td>U+0F20 to U+0F29</td>
</tr>
<tr>
<td>tirh</td>
<td>U+114D0 to U+114D9</td>
</tr>
<tr>
<td>tnsa</td>
<td>U+16AC0 to U+16AC9</td>
</tr>
<tr>
<td>vaii</td>
<td>U+A620 to U+A629</td>
</tr>
<tr>
<td>wara</td>
<td>U+118E0 to U+118E9</td>
</tr>
<tr>
<td>wcho</td>
<td>U+1E2F0 to U+1E2F9</td>
</tr>
</tbody>
</table>
NOTE 1  The computations rely on String values and locations within numeric strings that are
dependent upon the implementation and the effective locale of `numberFormat` ("ILD") or upon
the implementation, the effective locale, and the numbering system of `numberFormat`
("ILND"). The ILD and ILND Strings mentioned, other than those for currency names, must
not contain any code points in the General Category "Number, decimal digit" as specified by
the Unicode Standard.

NOTE 2  It is recommended that implementations use the locale provided by the Common Locale Data
Repository (available at `https://cldr.unicode.org/`).

15.5.6  `FormatNumeric (numberFormat, x)`

The `FormatNumeric` abstract operation is called with arguments `numberFormat` (which must be an object
initialized as a NumberFormat) and `x` (which must be an Intl mathematical value), and performs the following
steps:

1. Let `parts` be `PartitionNumberPattern(numberFormat, x)`.
2. Let `result` be the empty String.
3. For each `Record { [[Type]], [[Value]] } part in parts`, do
   a. Set `result` to the string-concatenation of `result` and `part. [[Value]]`.
4. Return `result`.

15.5.7  `FormatNumericToParts (numberFormat, x)`

The `FormatNumericToParts` abstract operation is called with arguments `numberFormat` (which must be an object
initialized as a NumberFormat) and `x` (which must be an Intl mathematical value), and performs the following
steps:

1. Let `parts` be `PartitionNumberPattern(numberFormat, x)`.
2. Let `result` be `ArrayCreate(0)`.
3. Let `n` be `0`.
4. For each `Record { [[Type]], [[Value]] } part in parts`, do
   a. Let `O` be `OrdinaryObjectCreate(%Object.prototype%)`.
   b. Perform `CreateDataPropertyOrThrow(O, "type", part. [[Type]])`.
   c. Perform `CreateDataPropertyOrThrow(O, "value", part. [[Value]])`.
   d. Perform `CreateDataPropertyOrThrow(result, ! ToString(n), O)`.
   e. Increment `n` by `1`.
5. Return `result`.

15.5.8  `ToRawPrecision (x, minPrecision, maxPrecision, unsignedRoundingMode)`

`ToRawPrecision` is an abstract operation that involves solving the following equation, which returns a valid
mathematical value given integer inputs:

\[
\text{ToRawPrecisionFn}(n, e, p) = n \times 10^{e - p + 1}
\]

where \(10^{-1} \leq n < 10^0\)

When the `ToRawPrecision` abstract operation is called with arguments `x` (which must be a finite non-negative
mathematical value), `minPrecision`, `maxPrecision` (both must be integers between `1` and `21`), and
`unsignedRoundingMode` (a specification type from the Unsigned Rounding Mode column of Table 15 or
undefined), the following steps are taken:
1. Let \( p \) be \( \text{maxPrecision} \).
2. If \( x = 0 \), then
   a. Let \( m \) be the String consisting of \( p \) occurrences of the code unit 0x0030 (DIGIT ZERO).
   b. Let \( e \) be 0.
   c. Let \( x\text{Final} \) be 0.
3. Else,
   a. Let \( n1 \) and \( e1 \) each be an integer and \( r1 \) a mathematical value, with \( r1 = \text{ToRawPrecisionFn}(n1, e1, p) \), such that \( r1 \leq x \) and \( r1 \) is maximized.
   b. Let \( n2 \) and \( e2 \) each be an integer and \( r2 \) a mathematical value, with \( r2 = \text{ToRawPrecisionFn}(n2, e2, p) \), such that \( r2 \geq x \) and \( r2 \) is minimized.
   c. Let \( r \) be \( \text{ApplyUnsignedRoundingMode}(x, r1, r2, \text{unsignedRoundingMode}) \).
   d. If \( r \) is \( r1 \), then
      i. Let \( n \) be \( n1 \).
      ii. Let \( e \) be \( e1 \).
      iii. Let \( x\text{Final} \) be \( r1 \).
   e. Else,
      i. Let \( n \) be \( n2 \).
      ii. Let \( e \) be \( e2 \).
      iii. Let \( x\text{Final} \) be \( r2 \).
   f. Let \( m \) be the String consisting of the digits of the decimal representation of \( n \) (in order, with no leading zeroes).
4. If \( e \geq (p - 1) \), then
   a. Set \( m \) to the string-concatenation of \( m \) and \( e - p + 1 \) occurrences of the code unit 0x0030 (DIGIT ZERO).
   b. Let \( \text{int} \) be \( e + 1 \).
5. Else if \( e \geq 0 \), then
   a. Set \( m \) to the string-concatenation of the first \( e + 1 \) code units of \( m \), the code unit 0x002E (FULL STOP), and the remaining \( p - (e + 1) \) code units of \( m \).
   b. Let \( \text{int} \) be \( e + 1 \).
6. Else,
   a. Assert: \( e < 0 \).
   b. Set \( m \) to the string-concatenation of "0." ,-(\( e + 1 \)) occurrences of the code unit 0x0030 (DIGIT ZERO), and \( m \).
   c. Let \( \text{int} \) be 1.
7. If \( m \) contains the code unit 0x002E (FULL STOP) and \( \text{maxPrecision} > \text{minPrecision} \), then
   a. Let \( \text{cut} \) be \( \text{maxPrecision} - \text{minPrecision} \).
   b. Repeat, while \( \text{cut} > 0 \) and the last code unit of \( m \) is 0x0030 (DIGIT ZERO),
      i. Remove the last code unit from \( m \).
      ii. Decrease \( \text{cut} \) by 1.
   c. If the last code unit of \( m \) is 0x002E (FULL STOP), then
      i. Remove the last code unit from \( m \).
8. Return the Record \{ [[\text{FormattedString}]]: \( m \), [[\text{RoundedNumber}]]: \( x\text{Final} \), [[\text{IntegerDigitsCount}]]: \( \text{int} \),
     [[\text{RoundingMagnitude}]]: \( e-p+1 \} \).

15.5.9 \text{ToRawFixed} ( x, \text{minFraction}, \text{maxFraction}, \text{roundingIncrement}, \text{unsignedRoundingMode} )

\text{ToRawFixed} is an abstract operation that involves solving the following equation, which returns a valid mathematical value given integer inputs:
\[
\text{ToRawFixedFn}(n, f) = n \times 10^{-f}
\]
When the ToRawFixed abstract operation is called with arguments \( x \) (which must be a finite non-negative mathematical value), \( \text{minFraction} \), \( \text{maxFraction} \) (which must be integers between 0 and 20), \( \text{roundingIncrement} \) (an integer), and \( \text{unsignedRoundingMode} \) (a specification type from the Unsigned Rounding Mode column of Table 15 or undefined), the following steps are taken:

1. Let \( f \) be \( \text{maxFraction} \).
2. Let \( n1 \) be an integer and \( r1 \) a mathematical value, with \( r1 = \text{ToRawFixedFn}(n1, f) \), such that \( n1 \mod \text{roundingIncrement} = 0 \), \( r1 \leq x \), and \( r1 \) is maximized.
3. Let \( n2 \) be an integer and \( r2 \) a mathematical value, with \( r2 = \text{ToRawFixedFn}(n2, f) \), such that \( n2 \mod \text{roundingIncrement} = 0 \), \( r2 \geq x \), and \( r2 \) is minimized.
4. Let \( r \) be \( \text{ApplyUnsignedRoundingMode}(x, r1, r2, \text{unsignedRoundingMode}) \).
5. If \( r = r1 \), then
   a. Let \( n \) be \( n1 \).
   b. Let \( x\text{Final} \) be \( r1 \).
6. Else,
   a. Let \( n \) be \( n2 \).
   b. Let \( x\text{Final} \) be \( r2 \).
7. If \( n = 0 \), let \( m \) be "0". Otherwise, let \( m \) be the String consisting of the digits of the decimal representation of \( n \) (in order, with no leading zeroes).
8. If \( f \neq 0 \), then
   a. Let \( k \) be the length of \( m \).
   b. If \( k \leq f \), then
      i. Let \( z \) be the String value consisting of \( f + 1 - k \) occurrences of the code unit 0x0030 (DIGIT ZERO).
      ii. Set \( m \) to the string-concatenation of \( z \) and \( m \).
      iii. Set \( k \) to \( f + 1 \).
   c. Let \( a \) be the first \( k - f \) code units of \( m \), and let \( b \) be the remaining \( f \) code units of \( m \).
   d. Set \( m \) to the string-concatenation of \( a \), ".", and \( b \).
   e. Let \( \text{int} \) be the length of \( a \).
9. Else, let \( \text{int} \) be the length of \( m \).
10. Let \( \text{cut} \) be \( \text{maxFraction} - \text{minFraction} \).
11. Repeat, while \( \text{cut} > 0 \) and the last code unit of \( m \) is 0x0030 (DIGIT ZERO),
    a. Remove the last code unit from \( m \).
    b. Decrease \( \text{cut} \) by 1.
12. If the last code unit of \( m \) is 0x002E (FULL STOP), then
    a. Remove the last code unit from \( m \).
13. Return the Record ([[FormattedString]]: \( m \), [[RoundedNumber]]: \( x\text{Final} \), [[IntegerDigitsCount]]: \( \text{int} \), [[RoundingMagnitude]]: \( -f \)).

**NORMATIVE OPTIONAL**

### 15.5.10 UnwrapNumberFormat ( \( nf \) )

The UnwrapNumberFormat abstract operation returns the NumberFormat instance of its input object, which is either the value itself or a value associated with it by %NumberFormat% according to the normative optional constructor mode of 4.3 Note 1.

1. If Type(\( nf \)) is not Object, throw a TypeError exception.
2. If \( nf \) does not have an [[InitializedNumberFormat]] internal slot and
   a. OrdinaryHasInstance(%NumberFormat%, \( nf \)) is true, then
      a. Return \( \text{Get}(nf, %\text{Intl}%.[[FallbackSymbol]]) \).
3. Return \( nf \).
15.5.11 GetNumberFormatPattern (numberFormat, x)

The abstract operation GetNumberFormatPattern considers the resolved unit-related options in the number format object along with the final scaled and rounded number being formatted (an Intl mathematical value) and returns a pattern, a String value as described in 15.2.3.

1. Let localeData be %NumberFormat%.[[LocaleData]].
2. Let dataLocale be numberFormat.[[DataLocale]].
3. Let dataLocaleData be localeData.[[<dataLocale>]].
4. Let patterns be dataLocaleData.[[patterns]].
5. Assert: patterns is a Record (see 15.2.3).
6. Let style be numberFormat.[[Style]].
7. If style is "percent", then
   a. Let patterns be patterns.[[percent]].
8. Else if style is "unit", then
   a. Let unit be numberFormat.[[Unit]].
   b. Let unitDisplay be numberFormat.[[UnitDisplay]].
   c. Let patterns be patterns.[[unit]].
   d. If patterns doesn't have a field [[<unit>]], then
      i. Let unit be "fallback".
   e. Let patterns be patterns.[[<unit>]].
   f. Let patterns be patterns.[[<unitDisplay>]].
9. Else if style is "currency", then
   a. Let currency be numberFormat.[[Currency]].
   b. Let currencyDisplay be numberFormat.[[CurrencyDisplay]].
   c. Let currencySign be numberFormat.[[CurrencySign]].
   d. Let patterns be patterns.[[currency]].
   e. If patterns doesn't have a field [[<currency>]], then
      i. Let currency be "fallback".
   f. Let patterns be patterns.[[<currency>]].
   g. Let patterns be patterns.[[<currencyDisplay>]].
   h. Let patterns be patterns.[[<currencySign>]].
10. Else,
    a. Assert: style is "decimal".
    b. Let patterns be patterns.[[decimal]].
11. If x is negative-infinity, then
    a. Let category be negative-non-zero.
12. Else if x is negative-zero, then
    a. Let category be negative-zero.
13. Else if x is not-a-number, then
    a. Let category be positive-zero.
14. Else if x is positive-infinity, then
    a. Let category be positive-non-zero.
15. Else,
    a. Assert: x is a mathematical value.
    b. If x < 0, then
       i. Let category be negative-non-zero.
    c. Else if x > 0, then
       i. Let category be positive-non-zero.
    d. Else,
       i. Let category be positive-zero.
16. Let `signDisplay` be `numberFormat`.[[SignDisplay]].
17. If `signDisplay` is "never", then
   a. Let `pattern` be `patterns`.[[zeroPattern]].
18. Else if `signDisplay` is "auto", then
   a. If `category` is positive-non-zero or positive-zero, then
      i. Let `pattern` be `patterns`.[[zeroPattern]].
   b. Else,
      i. Let `pattern` be `patterns`.[[negativePattern]].
19. Else if `signDisplay` is "always", then
   a. If `category` is positive-non-zero or positive-zero, then
      i. Let `pattern` be `patterns`.[[positivePattern]].
   b. Else,
      i. Let `pattern` be `patterns`.[[negativePattern]].
20. Else if `signDisplay` is "exceptZero", then
   a. If `category` is positive-zero or negative-zero, then
      i. Let `pattern` be `patterns`.[[zeroPattern]].
   b. Else if `category` is positive-non-zero, then
      i. Let `pattern` be `patterns`.[[positivePattern]].
   c. Else,
      i. Let `pattern` be `patterns`.[[negativePattern]].
21. Else,
   a. Assert: `signDisplay` is "negative".
   b. If `category` is negative-non-zero, then
      i. Let `pattern` be `patterns`.[[negativePattern]].
   c. Else,
      i. Let `pattern` be `patterns`.[[zeroPattern]].
22. Return `pattern`.

### 15.5.12 GetNotationSubPattern ( `numberFormat`, `exponent` )

The abstract operation GetNotationSubPattern considers the resolved notation and `exponent`, and returns a String value for the notation sub pattern as described in 15.2.3.

1. Let `localeData` be `%NumberFormat%`.[[LocaleData]].
2. Let `dataLocale` be `numberFormat`.[[DataLocale]].
3. Let `dataLocaleData` be `localeData`.[[<dataLocale>]].
4. Let `notationSubPatterns` be `dataLocaleData`.[[notationSubPatterns]].
5. Assert: `notationSubPatterns` is a Record (see 15.2.3).
6. Let `notation` be `numberFormat`.[[Notation]].
7. If `notation` is "scientific" or `notation` is "engineering", then
   a. Return `notationSubPatterns`.[[scientific]].
8. Else if `exponent` is not 0, then
   a. Assert: `notation` is "compact".
   b. Let `compactDisplay` be `numberFormat`.[[CompactDisplay]].
   c. Let `compactPatterns` be `notationSubPatterns`.[[compact]].[[<compactDisplay>]].
   d. Return `compactPatterns`.[[<exponent>]].
9. Else,
   a. Return "(number)".
15.5.13 ComputeExponent (numberFormat, x)

The abstract operation ComputeExponent computes an exponent (power of ten) by which to scale \( x \) according to the number formatting settings. It handles cases such as 999 rounding up to 1000, requiring a different exponent.

1. If \( x = 0 \), then
   a. Return 0.
2. If \( x < 0 \), then
   a. Let \( x = -x \).
3. Let magnitude be the base 10 logarithm of \( x \) rounded down to the nearest integer.
4. Let exponent be \( \text{ComputeExponentForMagnitude}(\text{numberFormat}, \text{magnitude}) \).
5. Let \( x \) be \( x \times 10^{-\text{exponent}} \).
6. Let formatNumberResult be \( \text{FormatNumericToString}(\text{numberFormat}, x) \).
7. If formatNumberResult.\\[[\text{RoundedNumber}]\] = 0, then
   a. Return exponent.
8. Let newMagnitude be the base 10 logarithm of formatNumberResult.\\[[\text{RoundedNumber}]\] rounded down to the nearest integer.
9. If newMagnitude is magnitude - exponent, then
   a. Return exponent.
10. Return \( \text{ComputeExponentForMagnitude}(\text{numberFormat}, \text{magnitude} + 1) \).

15.5.14 ComputeExponentForMagnitude (numberFormat, magnitude)

The abstract operation ComputeExponentForMagnitude computes an exponent by which to scale a number of the given magnitude (power of ten of the most significant digit) according to the locale and the desired notation (scientific, engineering, or compact).

1. Let notation be numberFormat.\\[[\text{Notation}]\].
2. If notation is "standard", then
   a. Return 0.
3. Else if notation is "scientific", then
   a. Return magnitude.
4. Else if notation is "engineering", then
   a. Let thousands be the greatest integer that is not greater than \( \text{magnitude} / 3 \).
   b. Return thousands \( \times 3 \).
5. Else,
   a. Assert: notation is "compact".
   b. Let exponent be an implementation- and locale-dependent (ILD) integer by which to scale a number of the given magnitude in compact notation for the current locale.
   c. Return exponent.

15.5.15 Runtime Semantics: StringIntlMV

The syntax-directed operation StringIntlMV takes no arguments.

**NOTE** The conversion of a StringNumericLiteral to a Number value is similar overall to the determination of the NumericValue of a NumericLiteral (see 12.9.3), but some of the details are different.

It is defined piecewise over the following productions:
StringNumericLiteral ::: StrWhiteSpace

1. Return 0.

StringNumericLiteral ::: StrWhiteSpace StrNumericLiteral StrWhiteSpace

1. Return StringIntlMV of StrNumericLiteral.

StringNumericLiteral ::: NonDecimalIntegerLiteral

1. Return MV of NonDecimalIntegerLiteral.

StrDecimalLiteral ::: - StrUnsignedDecimalLiteral

1. Let \( a \) be StringIntlMV of StrUnsignedDecimal Literal.
2. If \( a \) is 0, return negative-zero.
3. If \( a \) is positive-infinity, return negative-infinity.
4. Return \(-a\).

StrUnsignedDecimalLiteral ::: Infinity

1. Return positive-infinity.

StrUnsignedDecimalLiteral ::: DecimalDigits DecimalDigits StrUnsignedDecimalLiteral

1. Let \( b \) be MV of the first \( DecimalDigits \).
2. If the second \( DecimalDigits \) is present, then
   a. Let \( b \) be MV of the second \( DecimalDigits \).
   b. Let \( n \) be the number of code points in the second \( DecimalDigits \).
3. Else,
   a. Let \( b \) be 0.
   b. Let \( n \) be 0.
4. If \( ExponentPart \) is present, let \( e \) be MV of \( ExponentPart \). Otherwise, let \( e \) be 0.
5. Return \((a + (b \times 10^{-n})) \times 10^e\).

StrUnsignedDecimalLiteral ::: DecimalDigits ExponentPart

1. Let \( b \) be MV of \( DecimalDigits \).
2. If \( ExponentPart \) is present, let \( e \) be MV of \( ExponentPart \). Otherwise, let \( e \) be 0.
3. Let \( n \) be the number of code points in \( DecimalDigits \).
4. Return \( b \times 10^e \cdot 10^{-n} \).

StrUnsignedDecimalLiteral ::: DecimalDigits ExponentPart

1. Let \( a \) be MV of \( DecimalDigits \).
2. If \( ExponentPart \) is present, let \( e \) be MV of \( ExponentPart \). Otherwise, let \( e \) be 0.
3. Return \( a \times 10^e \).

15.5.16 ToIntlMathematicalValue ( value )

The abstract operation ToIntlMathematicalValue takes argument \( value \). It returns \( value \) converted to an Intl mathematical value, which is a mathematical value together with positive-infinity, negative-infinity, not-a-number, and negative-zero. This abstract operation is similar to 7.1.3, but a mathematical value can be returned instead of a Number or BigInt, so that exact decimal values can be represented. The following steps are taken:
1. Let `primValue` be `ToPrimitive(value, number)`.
2. If `Type(primValue)` is `BigInt`, return `ℝ(primValue)`.
3. If `Type(primValue)` is `String`, then
   a. Let `str` be `primValue`.
4. Else,
   a. Let `x` be `ToNumber(primValue)`.
   b. If `x` is `-0𝔽`, return negative-zero.
   c. Let `str` be `Number::toString(x, 10)`.
5. Let `text` be `StringToCodePoints(str)`.
6. Let `literal` be `ParseText(text, StringNumericLiteral)`.
7. If `literal` is a List of errors, return `not-a-number`.
8. Let `intlMV` be the `StringToIntMV` of `literal`.
9. If `intlMV` is a mathematical value, then
   a. Let `rounded` be `RoundMVResult(abs(intlMV))`.
   b. If `rounded` is `+∞𝔽` and `intlMV < 0`, return negative-infinity.
   c. If `rounded` is `+∞𝔽`, return positive-infinity.
   d. If `rounded` is `+0𝔽` and `intlMV < 0`, return negative-zero.
   e. If `rounded` is `+0𝔽`, return 0.
10. Return `intlMV`.

15.5.17 GetUnsignedRoundingMode ( `roundingMode, isNegative` )

The abstract operation GetUnsignedRoundingMode returns the rounding mode that should be applied to the absolute value of a number to produce the same result as if `roundingMode`, one of the String values in the `Identifier` column of Table 13, were applied to the signed value of the number (negative if the boolean `isNegative` is `true`, or positive otherwise). The following steps are taken:

1. If `isNegative` is `true`, return the specification type in the third column of Table 15 where the first column is `roundingMode` and the second column is "negative".
2. Else, return the specification type in the third column of Table 15 where the first column is `roundingMode` and the second column is "positive".

Table 15: Conversion from rounding mode to unsigned rounding mode

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Sign</th>
<th>Unsigned Rounding Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;ceil&quot;</td>
<td>positive</td>
<td>infinity</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>zero</td>
</tr>
<tr>
<td>&quot;floor&quot;</td>
<td>positive</td>
<td>zero</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>infinity</td>
</tr>
<tr>
<td>&quot;expand&quot;</td>
<td>positive</td>
<td>infinity</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>infinity</td>
</tr>
<tr>
<td>&quot;trunc&quot;</td>
<td>positive</td>
<td>zero</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>zero</td>
</tr>
</tbody>
</table>
Table 15 (continued)

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Sign</th>
<th>Unsigned Rounding Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;halfCeil&quot;</td>
<td>positive</td>
<td>half-infinity</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>half-zero</td>
</tr>
<tr>
<td>&quot;halfFloor&quot;</td>
<td>positive</td>
<td>half-zero</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>half-infinity</td>
</tr>
<tr>
<td>&quot;halfExpand&quot;</td>
<td>positive</td>
<td>half-infinity</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>half-infinity</td>
</tr>
<tr>
<td>&quot;halfTrunc&quot;</td>
<td>positive</td>
<td>half-zero</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>half-zero</td>
</tr>
<tr>
<td>&quot;halfEven&quot;</td>
<td>positive</td>
<td>half-even</td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>half-even</td>
</tr>
</tbody>
</table>

15.5.18 ApplyUnsignedRoundingMode ( x, r1, r2, unsignedRoundingMode )

The abstract operation ApplyUnsignedRoundingMode considers x (a mathematical value), bracketed below by r1 (a mathematical value) and above by r2 (a mathematical value), and returns either r1 or r2 according to unsignedRoundingMode (a specification type from the Unsigned Rounding Mode column of Table 15 or undefined). The following steps are taken:

1. If x is equal to r1, return r1.
2. Assert: r1 < x < r2.
3. Assert: unsignedRoundingMode is not undefined.
4. If unsignedRoundingMode is zero, return r1.
5. If unsignedRoundingMode is infinity, return r2.
6. Let d1 be x – r1.
7. Let d2 be r2 – x.
8. If d1 < d2, return r1.
9. If d2 < d1, return r2.
10. Assert: d1 is equal to d2.
11. If unsignedRoundingMode is half-zero, return r1.
12. If unsignedRoundingMode is half-infinity, return r2.
13. Assert: unsignedRoundingMode is half-even.
14. Let cardinality be (r1 / (r2 – r1)) modulo 2.
15. If cardinality is 0, return r1.

15.5.19 PartitionNumberRangePattern ( numberFormat, x, y )

The abstract operation PartitionNumberRangePattern creates the parts for a localized number range according to x (which must be an Intl mathematical value), y (which must be an Intl mathematical value), and the formatting options of numberFormat (which must be an object initialized as NumberFormat). The following steps are taken:

1. If x is not-a-number or y is not-a-number, throw a RangeError exception.
2. Let result be a new empty List.
3. Let \( xResult \) be \( \text{PartitionNumberPattern}(\text{numberFormat}, x) \).
4. Let \( yResult \) be \( \text{PartitionNumberPattern}(\text{numberFormat}, y) \).
5. If \( \text{FormatNumeric}(\text{numberFormat}, x) \) is equal to \( \text{FormatNumeric}(\text{numberFormat}, y) \), then
   a. Let \( \text{appxResult} \) be \( \text{FormatApproximately}(\text{numberFormat}, xResult) \).
   b. For each element \( r \) in \( \text{appxResult} \), do
      i. Set \( r.\text{[Source]} \) to "shared".
   c. Return \( \text{appxResult} \).
6. For each element \( r \) in \( xResult \), do
   a. Append a new \( \text{Record} \) \{ \( [\text{Type}] \), \( [\text{Value}] \), \( [\text{Source}] \) \} as the last element of \( \text{result} \).
7. Let \( \text{rangeSeparator} \) be an ILND String value used to separate two numbers.
8. Append a new \( \text{Record} \) \{ \( [\text{Type}] \), \( [\text{Value}] \), \( [\text{Source}] \) \} element to \( \text{result} \).
9. For each element \( r \) in \( yResult \), do
   a. Append a new \( \text{Record} \) \{ \( [\text{Type}] \), \( [\text{Value}] \), \( [\text{Source}] \) \} as the last element of \( \text{result} \).
10. Return \( \text{CollapseNumberRange}(.\text{result}) \).

### 15.5.20 FormatApproximately (\( numberFormat, result \))

The FormatApproximately abstract operation modifies \( \text{result} \), which must be a \( \text{List} \) of \( \text{Record} \) values as described in \( \text{PartitionNumberPattern} \), by adding a new \( \text{Record} \) for the approximately sign, which may depend on \( \text{numberFormat} \) (which must be an object initialized as NumberFormat). The following steps are taken:

1. Let \( \text{approximatelySign} \) be an ILND String value used to signify that a number is approximate.
2. If \( \text{approximatelySign} \) is not empty, insert a new \( \text{Record} \) \{ \( [\text{Type}] \), \( [\text{Value}] \), \( [\text{Source}] \) \} at an ILND index in \( \text{result} \). For example, if \( \text{numberFormat} \) has \( [\text{Locale}] \) "en-US" and \( [\text{NumberingSystem}] \) "latn" and \( [\text{Style}] \) "decimal", the new \( \text{Record} \) might be inserted before the first element of \( \text{result} \).
3. Return \( \text{result} \).

### 15.5.21 CollapseNumberRange (\( result \))

The CollapseNumberRange abstract operation modifies \( \text{result} \) (which must be a \( \text{List} \) of \{ \( [\text{Type}] \), \( [\text{Value}] \), \( [\text{Source}] \) \} \( \text{Records} \) as constructed within \( \text{PartitionNumberRangePattern} \) by removing redundant information and resolving internal inconsistency, and returns the resulting \( \text{List} \). The algorithm is implementation dependent, but must not introduce ambiguity that would cause the result of \( \text{Intl.NumberFormat.prototype.formatRange(}\text{start, end}) \) with arguments \( \text{List} \) « \( \text{start1, end1} \) » to equal the result with arguments \( \text{List} \) « \( \text{start2, end2} \) » if the results for those same arguments \( \text{Lists} \) would not be equal with a trivial implementation of CollapseNumberRange that always returns \( \text{result} \) unmodified.

For example, an implementation may remove the \( \text{Record} \) representing a currency symbol after a range separator to convert a \( \text{results List} \) representing "$3–$5" into one representing "$3–5".

An implementation may also modify \( \text{Record} \) \( [\text{Value}] \) fields for grammatical correctness; for example, converting a \( \text{results List} \) representing "0.5 miles–1 mile" into one representing "0.5–1 miles".

Returning \( \text{result} \) unmodified is guaranteed to be a correct implementation of CollapseNumberRange.

### 15.5.22 FormatNumericRange (\( numberFormat, x, y \))

The FormatNumericRange abstract operation is called with arguments \( \text{numberFormat} \) (which must be an object initialized as a NumberFormat), \( x \) (which must be an Intl mathematical value), and \( y \) (which must be an Intl mathematical value greater than or equal to \( x \)), and performs the following steps:
1. Let parts be ? PartitionNumberRangePattern(numberFormat, x, y).
2. Let result be the empty String.
3. For each element part in parts, do
   a. Set result to the string-concatenation of result and part.[[Value]].
4. Return result.

15.5.23 FormatNumericRangeToParts (numberFormat, x, y)

The FormatNumericRangeToParts abstract operation is called with arguments numberFormat (which must be an object initialized as a NumberFormat), x (which must be an Intl mathematical value), and y (which must be an Intl mathematical value greater than or equal to x), and performs the following steps:

1. Let parts be ? PartitionNumberRangePattern(numberFormat, x, y).
2. Let result be ! ArrayCreate(0).
3. Let n be 0.
4. For each element part in parts, do
   a. Let O be OrdinaryObjectCreate(%Object.prototype%).
   b. Perform ! CreateDataPropertyOrThrow(O, "type", part.[[Type]]).
   c. Perform ! CreateDataPropertyOrThrow(O, "value", part.[[Value]]).
   d. Perform ! CreateDataPropertyOrThrow(O, "source", part.[[Source]]).
   e. Perform ! CreateDataPropertyOrThrow(result, ! ToString(n), O).
   f. Increment n by 1.
5. Return result.

16 PluralRules Objects

16.1 The Intl.PluralRules Constructor

The PluralRules constructor is the %PluralRules% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

16.1.1 Intl.PluralRules ([ locales [, options ] ])

When the Intl.PluralRules function is called with optional arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let pluralRules be ? OrdinaryCreateFromConstructor(NewTarget, "%PluralRules.prototype%", « ! [InitializedPluralRules], [Locale], [Type], [MinimumIntegerDigits], [MinimumFractionDigits],
   [[MaximumFractionDigits]], [MinimumSignificantDigits], [MaximumSignificantDigits],
   [RoundingType], [RoundingMode], [RoundingIncrement], [TrailingZeroDisplay] »).

16.1.2 InitializePluralRules (pluralRules, locales, options)

The abstract operation InitializePluralRules accepts the arguments pluralRules (which must be an object), locales, and options. It initializes pluralRules as a PluralRules object. The following steps are taken:
1. Let `requestedLocales` be ? `CanonicalizeLocaleList(locales)`.
2. Set `options` to ? `CoerceOptionsToObject(options)`.
3. Let `opt` be a new `Record`.
5. Set `opt.[[localeMatcher]]` to `matcher`.
7. Set `pluralRules.[[Type]]` to `t`.
8. Perform ? `SetNumberFormatDigitOptions(pluralRules, options, +0_F, 3_F, "standard")`.
9. Let `localeData` be `%PluralRules%.[[LocaleData]]`.
10. Let `r` be `ResolveLocale(%PluralRules%.[[AvailableLocales]], requestedLocales, opt, %PluralRules%. [[RelevantExtensionKeys]], localeData)`.
11. Set `pluralRules.[[Locale]]` to `r.[[locale]]`.
12. Return `pluralRules`.


The Intl.PluralRules constructor has the following properties:

16.2.1 Intl.PluralRules.prototype

The value of Intl.PluralRules.prototype is %PluralRules.prototype%.

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

16.2.2 Intl.PluralRules.supportedLocalesOf(locales [, options ])

When the `supportedLocalesOf` method is called with arguments `locales` and `options`, the following steps are taken:

1. Let `availableLocales` be %PluralRules%.[[AvailableLocales]].
2. Let `requestedLocales` be ? `CanonicalizeLocaleList(locales)`.

16.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1.

The value of the [[RelevantExtensionKeys]] internal slot is « ».

NOTE 1 Unicode Technical Standard #35 describes no locale extension keys that are relevant to the pluralization process.

The value of the [[LocaleData]] internal slot is implementation-defined within the constraints described in 9.1.

NOTE 2 It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).
16.3 Properties of the Intl.PluralRules Prototype Object

The Intl.PluralRules prototype object is itself an ordinary object. %PluralRules.prototype% is not an Intl.PluralRules instance and does not have an [[InitializedPluralRules]] internal slot or any of the other internal slots of Intl.PluralRules instance objects.

16.3.1 Intl.PluralRules.prototype.constructor

The initial value of Intl.PluralRules.prototype.constructor is %PluralRules%.

16.3.2 Intl.PluralRules.prototype @@toStringTag

The initial value of the @@toStringTag property is the String value "Intl.PluralRules".

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

16.3.3 Intl.PluralRules.prototype.select ( value )

When the select method is called with an argument value, the following steps are taken:

1. Let pr be the this value.
2. Perform ? RequireInternalSlot(pr, [[InitializedPluralRules]]).
3. Let n be ? ToNumber(value).
4. Return ! ResolvePlural(pr, n).[[PluralCategory]].

16.3.4 Intl.PluralRules.prototype.selectRange ( start, end )

When the selectRange method is called with arguments start and end, the following steps are taken:

1. Let pr be the this value.
2. Perform ? RequireInternalSlot(pr, [[InitializedPluralRules]]).
3. If start is undefined or end is undefined, throw a TypeError exception.
4. Let x be ? ToNumber(start).
5. Let y be ? ToNumber(end).

16.3.5 Intl.PluralRules.prototype.resolvedOptions ( )

This function provides access to the locale and options computed during initialization of the object.

1. Let pr be the this value.
2. Perform ? RequireInternalSlot(pr, [[InitializedPluralRules]]).
3. Let options be OrdinaryObjectCreate(%Object.prototype%).
4. For each row of Table 16, except the header row, in table order, do
   a. Let p be the Property value of the current row.
   b. Let v be the value of pr’s internal slot whose name is the Internal Slot value of the current row.
   c. If v is not undefined, then
      i. Perform ! CreateDataPropertyOrThrow(options, p, v).
5. Let `pluralCategories` be a List of Strings containing all possible results of `PluralRuleSelect` for the selected locale `pr.[[Locale]]`.
6. Perform `CreateDataProperty(options, "pluralCategories", CreateArrayFromList(pluralCategories))`.
7. If `pr.[[RoundingType]]` is morePrecision, then
   a. Perform `CreateDataPropertyOrThrow(options, "roundingPriority", "morePrecision")`.
8. Else if `pr.[[RoundingType]]` is lessPrecision, then
   a. Perform `CreateDataPropertyOrThrow(options, "roundingPriority", "lessPrecision")`.
9. Else,
   a. Perform `CreateDataPropertyOrThrow(options, "roundingPriority", "auto")`.
10. Return `options`.

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[Type]]</td>
<td>&quot;type&quot;</td>
</tr>
<tr>
<td>[[MinimumIntegerDigits]]</td>
<td>&quot;minimumIntegerDigits&quot;</td>
</tr>
<tr>
<td>[[MinimumFractionDigits]]</td>
<td>&quot;minimumFractionDigits&quot;</td>
</tr>
<tr>
<td>[[MaximumFractionDigits]]</td>
<td>&quot;maximumFractionDigits&quot;</td>
</tr>
<tr>
<td>[[MinimumSignificantDigits]]</td>
<td>&quot;minimumSignificantDigits&quot;</td>
</tr>
<tr>
<td>[[MaximumSignificantDigits]]</td>
<td>&quot;maximumSignificantDigits&quot;</td>
</tr>
<tr>
<td>[[RoundingMode]]</td>
<td>&quot;roundingMode&quot;</td>
</tr>
<tr>
<td>[[RoundingIncrement]]</td>
<td>&quot;roundingIncrement&quot;</td>
</tr>
<tr>
<td>[[TrailingZeroDisplay]]</td>
<td>&quot;trailingZeroDisplay&quot;</td>
</tr>
</tbody>
</table>

### 16.4 Properties of Intl.PluralRules Instances

Intl.PluralRules instances are ordinary objects that inherit properties from `%PluralRules.prototype%`. Intl.PluralRules instances have an `[[InitializedPluralRules]]` internal slot.

Intl.PluralRules instances also have several internal slots that are computed by the constructor:

- `[[Locale]]` is a String value with the language tag of the locale whose localization is used by the plural rules.
- `[[Type]]` is one of the String values "cardinal" or "ordinal", identifying the plural rules used.
- `[[MinimumIntegerDigits]]` is a non-negative integer Number value indicating the minimum integer digits to be used.
- `[[MinimumFractionDigits]]` and `[[MaximumFractionDigits]]` are non-negative integer Number values indicating the minimum and maximum fraction digits to be used. Numbers will be rounded or padded with trailing zeroes if necessary.
- `[[MinimumSignificantDigits]]` and `[[MaximumSignificantDigits]]` are positive integer Number values indicating the minimum and maximum fraction digits to be used. Either none or both of these properties are present; if they are, they override minimum and maximum integer and fraction digits.
- `[[RoundingType]]` is one of the values fractionDigits, significantDigits, morePrecision, or lessPrecision, indicating which rounding strategy to use, as discussed in 15.4.
- `[[RoundingMode]]` is one of the String values in the Identifier column of Table 13, specifying which rounding mode to use.
• [[RoundingIncrement]] is an integer-valued Number that evenly divides 10, 100, 1000, or 10000 into tenths, fifths, quarters, or halves. It indicates the increment at which rounding should take place relative to the calculated rounding magnitude. For example, if [[MaximumFractionDigits]] is 2 and [[RoundingIncrement]] is 5, then the number is rounded to the nearest 0.05 ("nickel rounding").

• [[TrailingZeroDisplay]] is one of the String values "auto" or "stripIfInteger", indicating whether to strip trailing zeros if the formatted number is an integer (i.e., has no non-zero fraction digit).

16.5 Abstract Operations for PluralRules Objects

16.5.1 GetOperands (s)

The abstract operation GetOperands takes argument s (a decimal String). It extracts numeric features from s that correspond with the operands of Unicode Technical Standard #35 Part 3 Numbers, Section 5.1.1 Operands. It performs the following steps when called:

1. Let n be !ToNumber(s).
2. Assert: n is finite.
3. Let dp be StringIndexOf(s, ".", 0).
4. If dp = -1, then
   a. Let intPart be n.
   b. Let fracSlice be "".
5. Else,
   a. Let intPart be the substring of s from 0 to dp.
   b. Let fracSlice be the substring of s from dp + 1.
6. Let i be abs(!ToNumber(intPart)).
7. Let fracDigitCount be the length of fracSlice.
8. Let f be !ToNumber(fracSlice).
9. Let significantFracSlice be the value of fracSlice stripped of trailing "0".
10. Let significantFracDigitCount be the length of significantFracSlice.
11. Let significantFrac be !ToNumber(significantFracSlice).
12. Return a new Record { [[Number]]: abs(n), [[IntegerDigits]]: i, [[FractionDigits]]: f, [[NumberOfFractionDigits]]: fracDigitCount, [[FractionDigitsWithoutTrailing]]: significantFrac, [[NumberOfFractionDigitsWithoutTrailing]]: significantFracDigitCount }.

Table 17: Plural Rules Operands Record Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>UTS #35 Operand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Number]]</td>
<td>Number</td>
<td>n</td>
<td>Absolute value of the source number</td>
</tr>
<tr>
<td>[[IntegerDigits]]</td>
<td>Number</td>
<td>i</td>
<td>integer part of [[Number]].</td>
</tr>
<tr>
<td>[[FractionDigits]]</td>
<td>Number</td>
<td>f</td>
<td>Visible fraction digits in [[Number]], with trailing zeroes, as an integer having [[NumberOfFractionDigits]] digits.</td>
</tr>
<tr>
<td>[[NumberOfFractionDigits]]</td>
<td>Number</td>
<td>v</td>
<td>Number of visible fraction digits in [[Number]], with trailing zeroes.</td>
</tr>
</tbody>
</table>
### Table 17 (continued)

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>UTS #35 Operand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[FractionDigitsWithoutTrailing]]</td>
<td>Number</td>
<td>t</td>
<td>Visible fraction digits in [[Number]], <em>without</em> trailing zeroes, as an integer having [[NumberOfFractionDigitsWithoutTrailing]] digits.</td>
</tr>
<tr>
<td>[[NumberOfFractionDigitsWithoutTrailing]]</td>
<td>Number</td>
<td>w</td>
<td>Number of visible fraction digits in [[Number]], <em>without</em> trailing zeroes.</td>
</tr>
</tbody>
</table>

#### 16.5.2 PluralRuleSelect (locale, type, n, operands)

The implementation-defined abstract operation PluralRuleSelect takes arguments `locale` (a String), `type` (a String), `n` (a finite Number), and `operands` (a Plural Rules Operands Record derived from formatting `n`). It returns the String from « "zero", "one", "two", "few", "many", "other" » that best categorizes the operands representation of `n` according to the rules for `locale` and `type`.

#### 16.5.3 ResolvePlural (pluralRules, n)

When the ResolvePlural abstract operation is called with arguments `pluralRules` (which must be an object initialized as a PluralRules) and `n` (which must be a Number value), it returns a Record with two string-valued fields describing `n` according to the effective locale and the options of `pluralRules`: `[[PluralCategory]]` characterizing its plural category, and `[[FormattedString]]` containing its formatted representation. The following steps are taken:

1. Assert: `Type(pluralRules)` is Object.
2. Assert: `pluralRules` has an `[[InitializedPluralRules]]` internal slot.
3. Assert: `Type(n)` is Number.
4. If `n` is not a finite Number, then
   a. Return "other".
5. Let `locale` be `pluralRules.[[Locale]]`.
6. Let `type` be `pluralRules.[[Type]]`.
7. Let `res` be `FormatNumericToString(pluralRules, n)`.
8. Let `s` be `res.[[FormattedString]]`.
9. Let `operands` be `GetOperands(s)`.
10. Let `p` be `PluralRuleSelect(locale, type, n, operands)`.
11. Return the Record { `[[PluralCategory]]`: `p`, `[[FormattedString]]`: `s` }.

#### 16.5.4 PluralRuleSelectRange (locale, type, xp, yp)

When the PluralRuleSelectRange abstract operation is called with four arguments, it performs an implementation-dependent algorithm to map the plural category String values `xp` and `yp`, respectively characterizing the start and end of a range, to a resolved String value for the plural form of the range as a whole denoted by `type` (which must be "cardinal" or "ordinal") for the corresponding `locale`, or the String value "other".
16.5.5 ResolvePluralRange (pluralRules, x, y)

When the ResolvePluralRange abstract operation is called with arguments pluralRules (which must be an object initialized as a PluralRules), x (which must be a Number value), and y (which must be a Number value), it returns a String value representing the plural form of the range starting from x and ending at y according to the effective locale and the options of pluralRules. The following steps are taken:

1. Assert: Type(pluralRules) is Object.
2. Assert: pluralRules has an [[InitializedPluralRules]] internal slot.
3. Assert: Type(x) is Number.
4. Assert: Type(y) is Number.
5. If x is NaN or y is NaN, throw a RangeError exception.
6. Let xp be ! ResolvePlural(pluralRules, x).
7. Let yp be ! ResolvePlural(pluralRules, y).
8. If xp.[[FormattedString]] is yp.[[FormattedString]], then
   a. Return xp.[[PluralCategory]].
9. Let locale be pluralRules.[[Locale]].
10. Let type be pluralRules.[[Type]].
11. Return ! PluralRuleSelectRange(locale, type, xp.[[PluralCategory]], yp.[[PluralCategory]]).

17 RelativeTimeFormat Objects

17.1 The Intl.RelativeTimeFormat Constructor

The RelativeTimeFormat constructor is the %RelativeTimeFormat% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

17.1.1 Intl.RelativeTimeFormat ([ locales, options ])

When the Intl.RelativeTimeFormat function is called with optional arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let relativeTimeFormat be ? OrdinaryCreateFromConstructor(NewTarget, "%RelativeTimeFormat.prototype%", « [[InitializedRelativeTimeFormat]], [[Locale]], [[DataLocale]], [[Style]], [[Numeric]], [[NumberFormat]], [[NumberingSystem]], [[PluralRules]] »).

17.1.2 InitializeRelativeTimeFormat (relativeTimeFormat, locales, options)

The abstract operation InitializeRelativeTimeFormat accepts the arguments relativeTimeFormat (which must be an object), locales, and options. It initializes relativeTimeFormat as a RelativeTimeFormat object.

The following algorithm refers to the type nonterminal from UTS 35’s Unicode Locale Identifier grammar. The following steps are taken:

1. Let requestedLocales be ? CanonicalizeLocaleList(locales).
2. Set options to ? CoerceOptionsToObject(options).
3. Let opt be a new Record.
5. Set `opt.[[LocaleMatcher]]` to `matcher`.
6. Let `numberingSystem` be `GetOption(options, "numberingSystem", string, empty, undefined)`.
7. If `numberingSystem` is not `undefined`, then
   a. If `numberingSystem` does not match the Unicode Locale Identifier type nonterminal, throw a `RangeError` exception.
8. Set `opt.[[nu]]` to `numberingSystem`.
9. Let `localeData` be `%RelativeTimeFormat%.[[LocaleData]].
10. Let `r` be `ResolveLocale(%RelativeTimeFormat%.[[AvailableLocales]], requestedLocales, opt, %RelativeTimeFormat%.[[RelevantExtensionKeys]], localeData).
11. Let `locale` be `r.[[locale]]`.
12. Set `relativeTimeFormat.[[Locale]]` to `locale`.
13. Set `relativeTimeFormat.[[DataLocale]]` to `r.[[dataLocale]]`.
14. Set `relativeTimeFormat.[[NumberingSystem]]` to `r.[[nu]]`.
16. Set `relativeTimeFormat.[[Style]]` to `style`.
18. Set `relativeTimeFormat.[[Numeric]]` to `numeric`.
19. Let `relativeTimeFormat.[[NumberFormat]]` be `%NumberFormat%`.
20. Let `relativeTimeFormat.[[PluralRules]]` be `%PluralRules%`.

17.2 Properties of the Intl.RelativeTimeFormat Constructor

The Intl.RelativeTimeFormat constructor has the following properties:

17.2.1 Intl.RelativeTimeFormat.prototype

The value of Intl.RelativeTimeFormat.prototype is %RelativeTimeFormat.prototype%.

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

17.2.2 Intl.RelativeTimeFormat.supportedLocalesOf ( locales [, options ] )

When the supportedLocalesOf method is called with arguments locales and options, the following steps are taken:

1. Let `availableLocales` be %RelativeTimeFormat%.[[AvailableLocales]].
2. Let `requestedLocales` be `CanonicalizeLocaleList(locales)`.
3. Return `SupportedLocales(availableLocales, requestedLocales, options)`.

17.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1.

The value of the [[RelevantExtensionKeys]] internal slot is « "nu" ».

**NOTE 1** Unicode Technical Standard #35 describes one locale extension key that is relevant to relative time formatting: "nu" for numbering system (of formatted numbers).
The value of the [[LocaleData]] internal slot is implementation-defined within the constraints described in 9.1 and the following additional constraints, for all locale values `locale`:

- `[[LocaleData]][[locale]]` has fields "second", "minute", "hour", "day", "week", "month", "quarter", and "year". Additional fields may exist with the previous names concatenated with the strings "-narrow" or "-short". The values corresponding to these fields are Records which contain these two categories of fields:
  - "future" and "past" fields, which are Records with a field for each of the plural categories relevant for `locale`. The value corresponding to those fields is a pattern which may contain "{0}" to be replaced by a formatted number.
  - Optionally, additional fields whose key is the result of `ToString` of a Number, and whose values are literal Strings which are not treated as templates.
- The list that is the value of the "nu" field of any locale field of `[[LocaleData]]` must not include the values "native", "traditio", or "finance".

NOTE 2
It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at https://cldr.unicode.org/).

17.3 Properties of the Intl.RelativeTimeFormat Prototype Object

The Intl.RelativeTimeFormat prototype object is itself an ordinary object. `%RelativeTimeFormat.prototype%` is not an Intl.RelativeTimeFormat instance and does not have an `[[InitializedRelativeTimeFormat]]` internal slot or any of the other internal slots of Intl.RelativeTimeFormat instance objects.

17.3.1 Intl.RelativeTimeFormat.prototype.constructor

The initial value of `Intl.RelativeTimeFormat.prototype.constructor` is `%RelativeTimeFormat%`.

17.3.2 Intl.RelativeTimeFormat.prototype[@@toStringTag]

The initial value of the `@@toStringTag` property is the String value "Intl.RelativeTimeFormat".

This property has the attributes `{ [Writable]: false, [Enumerable]: false, [Configurable]: true }.

17.3.3 Intl.RelativeTimeFormat.prototype.format ( value, unit )

When the `format` method is called with arguments `value` and `unit`, the following steps are taken:

1. Let `relativeTimeFormat` be the this value.
3. Let `value` be ? `ToNumber(value)`.
4. Let `unit` be ? `ToString(unit)`.
5. Return ? `FormatRelativeTime(relativeTimeFormat, value, unit)`.

17.3.4 Intl.RelativeTimeFormat.prototype.formatToParts ( value, unit )

When the `formatToParts` method is called with arguments `value` and `unit`, the following steps are taken:

1. Let `relativeTimeFormat` be the this value.
3. Let `value` be ? `ToNumber(value)`. 

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4. Let \( \text{unit} \) be \( \text{toString(\text{unit})} \).
5. Return \( \text{FormatRelativeTimeToParts(\text{relativeTimeFormat, value, unit})} \).

17.3.5 Intl.RelativeTimeFormat.prototype.resolvedOptions()

This function provides access to the locale and options computed during initialization of the object.

1. Let \( \text{relativeTimeFormat} \) be the this value.
2. Perform \( ? \text{RequireInternalSlot(\text{relativeTimeFormat, [[InitializedRelativeTimeFormat]]})} \).
3. Let \( \text{options} \) be \( \text{ OrdinaryObjectCreate(\%Object.prototype\%)} \).
4. For each row of Table 18, except the header row, in table order, do
   a. Let \( p \) be the Property value of the current row.
   b. Let \( v \) be the value of \( \text{relativeTimeFormat}'s \) internal slot whose name is the Internal Slot value of the current row.
   c. Assert: \( v \) is not undefined.
   d. Perform \( ! \text{CreateDataPropertyOrThrow(\text{options, p, v})} \).
5. Return \( \text{options} \).

Table 18: Resolved Options of RelativeTimeFormat Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[Style]]</td>
<td>&quot;style&quot;</td>
</tr>
<tr>
<td>[[Numeric]]</td>
<td>&quot;numeric&quot;</td>
</tr>
<tr>
<td>[[NumberingSystem]]</td>
<td>&quot;numberingSystem&quot;</td>
</tr>
</tbody>
</table>

17.4 Properties of Intl.RelativeTimeFormat Instances

Intl.RelativeTimeFormat instances are ordinary objects that inherit properties from \%RelativeTimeFormat.prototype\%.

Intl.RelativeTimeFormat instances have an [[InitializedRelativeTimeFormat]] internal slot.

Intl.RelativeTimeFormat instances also have several internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used for formatting.
- [[DataLocale]] is a String value with the language tag of the nearest locale for which the implementation has data to perform the formatting operation. It will be a parent locale of [[Locale]].
- [[Style]] is one of the String values "long", "short", or "narrow", identifying the relative time format style used.
- [[Numeric]] is one of the String values "always" or "auto", identifying whether numerical descriptions are always used, or used only when no more specific version is available (e.g., "1 day ago" vs "yesterday").
- [[NumberFormat]] is an Intl.NumberFormat object used for formatting.
- [[NumberingSystem]] is a String value with the "type" given in Unicode Technical Standard #35 for the numbering system used for formatting.
- [[PluralRules]] is an Intl.PluralRules object used for formatting.
17.5 Abstract Operations for RelativeTimeFormat Objects

17.5.1 SingularRelativeTimeUnit ( unit )

1. Assert: Type(unit) is String.
2. If unit is "seconds", return "second".
3. If unit is "minutes", return "minute".
4. If unit is "hours", return "hour".
5. If unit is "days", return "day".
6. If unit is "weeks", return "week".
7. If unit is "months", return "month".
8. If unit is "quarters", return "quarter".
9. If unit is "years", return "year".
10. If unit is not one of "second", "minute", "hour", "day", "week", "month", "quarter", or "year", throw a RangeError exception.
11. Return unit.

17.5.2 PartitionRelativeTimePattern ( relativeTimeFormat, value, unit )

When the PartitionRelativeTimePattern abstract operation is called with arguments relativeTimeFormat, value, and unit it returns a String value representing value (which must be a Number value) according to the effective locale and the formatting options of relativeTimeFormat.

1. Assert: relativeTimeFormat has an [[InitializedRelativeTimeFormat]] internal slot.
2. Assert: Type(value) is Number.
3. Assert: Type(unit) is String.
4. If value is NaN, +∞, or −∞, throw a RangeError exception.
5. Let unit be ? SingularRelativeTimeUnit(unit).
6. Let localeData be %RelativeTimeFormat%.[[LocaleData]].
7. Let dataLocale be relativeTimeFormat.[[DataLocale]].
8. Let fields be localeData.[[<dataLocale>]].
9. Let style be relativeTimeFormat.[[Style]].
10. If style is equal to "short", then
    a. Let entry be the string-concatenation of unit and "-short".
11. Else if style is equal to "narrow", then
    a. Let entry be the string-concatenation of unit and "-narrow".
12. Else,
    a. Let entry be unit.
13. If fields doesn't have a field [[<entry>]], then
    a. Let entry be unit.
14. Let patterns be fields.[[<entry>]].
15. Let numeric be relativeTimeFormat.[[Numeric]].
16. If numeric is equal to "auto", then
    a. Let stringValue be ! ToString(value).
    b. If patterns has a field [[<stringValue>]], then
       i. Let result be patterns.[[<stringValue>]].
       ii. Return a List containing the Record { [[Type]]: "literal", [[Value]]: result }
17. If value is -0 or if value is less than 0, then
    a. Let t be "past".

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18. Else,
   a. Let \( t \) be "future".
19. Let \( p \) be patterns.\[\langle x \rangle\].
20. Let \( f \) be ! \( \text{PartitionNumberPattern}(\text{relativeTimeFormat},[[\text{NumberFormat}]], \text{value}) \).
21. Let \( p \) be ! \( \text{ResolvePlural}(\text{relativeTimeFormat},[[\text{PluralRules}]], \text{value}).[[\text{PluralCategory}]] \).
22. Let \( p \) be ! \( \text{PartitionNumberPattern}(\text{relativeTimeFormat},[[\text{NumberFormat}]], \text{value}).[[\text{PluralCategory}]] \).
23. Return ! \( \text{MakePartsList}(\text{pattern}, \text{unit}, f) \).

### 17.5.3 MakePartsList ( pattern, unit, parts )

The MakePartsList abstract operation is called with arguments \( \text{pattern} \), a pattern String, \( \text{unit} \), a String, and \( \text{parts} \), a List of Records representing a formatted Number.

**NOTE** Example:

1. Return ! \( \text{MakePartsList}("AA\{0\}BB", \"hour\", \{ [[\text{Type}]]: \"integer\", [[\text{Value}]]: \"15\" \} ) \).

   will return a List of Records like

   ```
   «
   \{ [[\text{Type}]]: "literal", [[\text{Value}]]: "AA", [[\text{Unit}]]: empty\},
   \{ [[\text{Type}]]: "integer", [[\text{Value}]]: "15", [[\text{Unit}]]: "hour\"\},
   \{ [[\text{Type}]]: "literal", [[\text{Value}]]: "BB", [[\text{Unit}]]: empty\}
   »
   ```

1. Let \( \text{patternParts} \) be \( \text{PartitionPattern}(\text{pattern}) \).
2. Let \( \text{result} \) be a new empty List.
3. For each \( \text{Record} \{ [[\text{Type}]], [[\text{Value}]] \} \text{patternPart} \) in \( \text{patternParts} \), do
   a. If \( \text{patternPart}.[[\text{Type}]] \) is "literal", then
      i. Append \( \text{Record} \{ [[\text{Type}]]: \"literal\", [[\text{Value}]]: \text{patternPart}.[[\text{Value}]], [[\text{Unit}]]: empty \} \) to \( \text{result} \).
   b. Else,
      i. Assert: \( \text{patternPart}.[[\text{Type}]] \) is "0".
      ii. For each \( \text{Record} \{ [[\text{Type}]], [[\text{Value}]] \} \text{part} \) in \( \text{parts} \), do
           1. Append \( \text{Record} \{ [[\text{Type}]]: \text{part}.[[\text{Type}]], [[\text{Value}]]: \text{part}.[[\text{Value}]], [[\text{Unit}]]: \text{unit} \} \) to \( \text{result} \).
4. Return \( \text{result} \).

### 17.5.4 FormatRelativeTime ( relativeTimeFormat, value, unit )

The FormatRelativeTime abstract operation is called with arguments \( \text{relativeTimeFormat} \) (which must be an object initialized as a RelativeTimeFormat), \( \text{value} \) (which must be a Number value), and \( \text{unit} \) (which must be a String denoting the value unit) and performs the following steps:

1. Let \( \text{parts} \) be ? \( \text{PartitionRelativeTimePattern}(\text{relativeTimeFormat}, \text{value}, \text{unit}) \).
2. Let \( \text{result} \) be an empty String.
3. For each \( \text{Record} \{ [[\text{Type}]], [[\text{Value}]], [[\text{Unit}]] \} \text{part} \) in \( \text{parts} \), do
   a. Set \( \text{result} \) to the string-concatenation of \( \text{result} \) and \( \text{part}.[[\text{Value}]] \).
4. Return \( \text{result} \).

### 17.5.5 FormatRelativeTimeToParts ( relativeTimeFormat, value, unit )

The FormatRelativeTimeToParts abstract operation is called with arguments \( \text{relativeTimeFormat} \) (which must be an object initialized as a RelativeTimeFormat), \( \text{value} \) (which must be a Number value), and \( \text{unit} \) (which
must be a String denoting the value unit) and performs the following steps:

1. Let \( \text{parts} \) be \( \text{PartitionRelativeTimePattern}(\text{relativeTimeFormat}, \text{value}, \text{unit}) \).
2. Let \( \text{result} \) be \( \text{ArrayCreate}(0) \).
3. Let \( n \) be 0.
4. For each \( \text{Record} \{ [[\text{Type}}], [[\text{Value}}], [[\text{Unit}}] \} \text{ part in parts} \), do
   a. Let \( O \) be \( \text{OrdinaryObjectCreate}(%\text{Object.prototype}%). \)
   b. Perform \( \text{CreateDataPropertyOrThrow}(O, "\text{type}", \text{part}.[[\text{Type}}]). \)
   c. Perform \( \text{CreateDataPropertyOrThrow}(O, "\text{value}", \text{part}.[[\text{Value}}]). \)
   d. If \( \text{part}.[[\text{Unit}}] \) is not empty, then
      i. Perform \( \text{CreateDataPropertyOrThrow}(O, "\text{unit}", \text{part}.[[\text{Unit}}]). \)
   e. Perform \( \text{CreateDataPropertyOrThrow}(\text{result}, !\text{ToString}(n), O). \)
   f. Increment \( n \) by 1.
5. Return \( \text{result} \).

18 Segmenter Objects

18.1 The Intl.Segmenter Constructor

The Segmenter constructor is the %Segmenter% intrinsic object and a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

18.1.1 Intl.Segmenter ([ locales [, options ] ])

When the Intl.Segmenter function is called with optional arguments locales and options, the following steps are taken:

1. If NewTarget is undefined, throw a TypeError exception.
2. Let internalSlotsList be « [[InitializedSegmenter]], [[Locale]], [[SegmenterGranularity]] ».
3. Let segmenter be ? OrdinaryCreateFromConstructor(NewTarget, "%Segmenter.prototype%", internalSlotsList).
5. Set options to ? GetOptionsObject(options).
6. Let opt be a new Record.
8. Set opt.[[localeMatcher]] to matcher.
9. Let localeData be %Segmenter%.[[LocaleData]].
10. Let r be ResolveLocale(%Segmenter%.[[AvailableLocales]], requestedLocales, opt, %Segmenter%.[[RelevantExtensionKeys]], localeData).
11. Set segmenter.[[Locale]] to r.[[locale]].
12. Let granularity be ? GetOption(options, "granularity", string, « "grapheme", "word", "sentence" », "grapheme").
13. Set segmenter.[[SegmenterGranularity]] to granularity.

18.2 Properties of the Intl.Segmenter Constructor

The Intl.Segmenter constructor has the following properties:
18.2.1 Intl.Segmenter.prototype

The value of `Intl.Segmenter.prototype` is `%Segmenter.prototype%`. This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

18.2.2 Intl.Segmenter.supportedLocalesOf (locales [, options ])

When the `supportedLocalesOf` method is called with arguments `locales` and `options`, the following steps are taken:

1. Let `availableLocales` be `%Segmenter%.[[AvailableLocales]].
2. Let `requestedLocales` be « CanonicalizeLocaleList(locales).»
3. Return « SupportedLocales(availableLocales, requestedLocales, options).»

18.2.3 Internal slots

The value of the [[AvailableLocales]] internal slot is implementation-defined within the constraints described in 9.1.

The value of the [[RelevantExtensionKeys]] internal slot is « ».

NOTE Intl.Segmenter does not have any relevant extension keys.

The value of the [[LocaleData]] internal slot is implementation-defined within the constraints described in 9.1.

18.3 Properties of the Intl.Segmenter Prototype Object

The Intl.Segmenter prototype object is itself an ordinary object. `%Segmenter.prototype%` is not an Intl.Segmenter instance and does not have an [[InitializedSegmenter]] internal slot or any of the other internal slots of Intl.Segmenter instance objects.

18.3.1 Intl.Segmenter.prototype.constructor

The initial value of `Intl.Segmenter.prototype.constructor` is `%Segmenter%`.

18.3.2 Intl.Segmenter.prototype [ @@toStringTag ]

The initial value of the `@@toStringTag` property is the String value "Intl.Segmenter".

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

18.3.3 Intl.Segmenter.prototype.segment (string)

The `Intl.Segmenter.prototype.segment` method is called on an Intl.Segmenter instance with argument `string` to create a Segments instance for the string using the locale and options of the Intl.Segmenter instance. The following steps are taken:

1. Let `segmenter` be the this value.
2. Perform ? RequireInternalSlot(segmenter, [[InitializedSegmenter]]).
3. Let string be ? ToString(string).
4. Return ! CreateSegmentsObject(segmenter, string).

18.3.4 Intl.Segmenter.prototype.resolvedOptions ( )

This function provides access to the locale and options computed during initialization of the object.

1. Let segmenter be the this value.
2. Perform ? RequireInternalSlot(segmenter, [[InitializedSegmenter]]).
3. Let options be OrdinaryObjectCreate(%Object.prototype%).
4. For each row of Table 19, except the header row, in table order, do
   a. Let p be the Property value of the current row.
   b. Let v be the value of segmenter’s internal slot whose name is the Internal Slot value of the current row.
   c. Assert: v is not undefined.
   d. Perform ! CreateDataPropertyOrThrow(options, p, v).
5. Return options.

Table 19: Resolved Options of Segmenter Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Locale]]</td>
<td>&quot;locale&quot;</td>
</tr>
<tr>
<td>[[SegmenterGranularity]]</td>
<td>&quot;granularity&quot;</td>
</tr>
</tbody>
</table>

18.4 Properties of Intl.Segmenter Instances

Intl.Segmenter instances are ordinary objects that inherit properties from %Segmenter.prototype%.

Intl.Segmenter instances have an [[InitializedSegmenter]] internal slot.

Intl.Segmenter instances also have internal slots that are computed by the constructor:

- [[Locale]] is a String value with the language tag of the locale whose localization is used for segmentation.
- [[SegmenterGranularity]] is one of the String values "grapheme", "word", or "sentence", identifying the kind of text element to segment.

18.5 Segments Objects

A Segments instance is an object that represents the segments of a specific string, subject to the locale and options of its constructing Intl.Segmenter instance.

18.5.1 CreateSegmentsObject ( segmenter, string )

The CreateSegmentsObject abstract operation is called with arguments Intl.Segmenter instance segmenter and String value string to create a Segments instance referencing both. The following steps are taken:

1. Let internalSlotsList be « [[SegmentsSegmenter]], [[SegmentsString]] ».
2. Let segments be OrdinaryObjectCreate(%SegmentsPrototype%, internalSlotsList).
3. Set segments.{{SegmentsSegmenter}} to segmenter.
4. Set segments.{{SegmentsString}} to string.
5. Return `segments`.

18.5.2 The `%SegmentsPrototype% Object

The `%SegmentsPrototype% object:

- is the prototype of all Segments objects.
- is an ordinary object.
- has the following properties:

18.5.2.1 `%SegmentsPrototype%.containing (index)`

The `containing` method is called on a Segments instance with argument `index` to return a Segment Data object describing the segment in the string including the code unit at the specified index according to the locale and options of the Segments instance's constructing Intl.Segmenter instance. The following steps are taken:

1. Let `segments` be the `this` value.
2. Perform ? `RequireInternalSlot(segments, [[SegmentsSegmenter]])`.
3. Let `segmenter` be `segments.([[SegmentsSegmenter]])`.
4. Let `string` be `segments.([[SegmentsString]])`.
5. Let `len` be the length of `string`.
6. Let `n` be ? `ToIntegerOrInfinity(index)`.
7. If `n < 0` or `n ≥ len`, return `undefined`.
8. Let `startIndex` be ! `FindBoundary(segmenter, string, n, before)`.
9. Let `endIndex` be ! `FindBoundary(segmenter, string, n, after)`.
10. Return ! `CreateSegmentDataObject(segmenter, string, startIndex, endIndex)`.

18.5.2.2 `%SegmentsPrototype% [ @@iterator ] ( )`

The `@@iterator` method is called on a Segments instance to create a Segment Iterator over its string using the locale and options of its constructing Intl.Segmenter instance. The following steps are taken:

1. Let `segments` be the `this` value.
2. Perform ? `RequireInternalSlot(segments, [[SegmentsSegmenter]])`.
3. Let `segmenter` be `segments.([[SegmentsSegmenter]])`.
4. Let `string` be `segments.([[SegmentsString]])`.
5. Return ! `CreateSegmentIterator(segmenter, string)`.

18.5.3 Properties of Segments Instances

Segments instances are ordinary objects that inherit properties from `%SegmentsPrototype%`.

Segments instances have a `[[SegmentsSegmenter]]` internal slot that references the constructing Intl.Segmenter instance.

Segments instances have a `[[SegmentsString]]` internal slot that references the String value whose segments they expose.

18.6 Segment Iterator Objects

A Segment Iterator is an object that represents a particular iteration over the segments of a specific string.
18.6.1 CreateSegmentIterator (segmenter, string)

The CreateSegmentIterator abstract operation is called with arguments Intl.Segmenter instance `segmenter` and String value `string` to create a Segment Iterator over `string` using the locale and options of `segmenter`. The following steps are taken:

1. Let `internalSlotsList` be « [[IteratingSegmenter]], [[IteratedString]], [[IteratedStringNextSegmentCodeUnitIndex]] ».
2. Let `iterator` be `OrdinaryObjectCreate(%SegmentIteratorPrototype%, internalSlotsList)`.
3. Set `iterator.[[IteratingSegmenter]]` to `segmenter`.
4. Set `iterator.[[IteratedString]]` to `string`.
5. Set `iterator.[[IteratedStringNextSegmentCodeUnitIndex]]` to 0.
6. Return `iterator`.

18.6.2 The %SegmentIteratorPrototype% Object

The `%SegmentIteratorPrototype%` object:

- is the prototype of all Segment Iterator objects.
- is an ordinary object.
- has a `[[Prototype]]` internal slot whose value is the intrinsic object `%Iterator.prototype%`.
- has the following properties:

18.6.2.1 %SegmentIteratorPrototype%.next ( )

The `next` method is called on a Segment Iterator instance to advance it forward one segment and return a `IteratorResult` object either describing the new segment or declaring iteration done. The following steps are taken:

1. Let `iterator` be the `this` value.
2. Perform `? RequireInternalSlot(iterator, [[IteratingSegmenter]])`.
3. Let `segmenter` be `iterator.[[IteratingSegmenter]]`.
4. Let `string` be `iterator.[[IteratedString]]`.
5. Let `startIndex` be `iterator.[[IteratedStringNextSegmentCodeUnitIndex]]`.
6. Let `endIndex` be `! FindBoundary(segmenter, string, startIndex, after)`.
7. If `endIndex` is not finite, then
   a. Return `CreateIterResultObject(undefined, true)`.
8. Set `iterator.[[IteratedStringNextSegmentCodeUnitIndex]]` to `endIndex`.
9. Let `segmentData` be `! CreateSegmentDataObject(segmenter, string, startIndex, endIndex)`.
10. Return `CreateIterResultObject(segmentData, false)`.

18.6.2.2 %SegmentIteratorPrototype% [ @@toStringTag ]

The initial value of the `@@toStringTag` property is the String value "Segmenter String Iterator".

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: true }.

18.6.3 Properties of Segment Iterator Instances

Segment Iterator instances are ordinary objects that inherit properties from `%SegmentIteratorPrototype%`. Segment Iterator instances are initially created with the internal slots described in Table 20.
Table 20: Internal Slots of Segment Iterator Instances

<table>
<thead>
<tr>
<th>Internal Slot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[IteratingSegmenter]]</td>
<td>The Intl.Segmenter instance used for iteration.</td>
</tr>
<tr>
<td>[[IteratedString]]</td>
<td>The String value being iterated upon.</td>
</tr>
<tr>
<td>[[IteratedStringNextSegmentCodeUnitIndex]]</td>
<td>The code unit index in the String value being iterated upon at the start of the next segment.</td>
</tr>
</tbody>
</table>

18.7 Segment Data Objects

A Segment Data object is an object that represents a particular segment from a string.

18.7.1 CreateSegmentDataObject (segmenter, string, startIndex, endIndex)

The CreateSegmentDataObject abstract operation is called with arguments Intl.Segmenter instance segmenter, String value string, and indices startIndex and endIndex within string to create a Segment Data object describing the segment within string from segmenter that is bounded by the indices. The following steps are taken:

1. Let len be the length of string.
2. Assert: startIndex ≥ 0.
3. Assert: endIndex ≤ len.
4. Assert: startIndex < endIndex.
5. Let result be OrdinaryObjectCreate(%Object.prototype%).
6. Let segment be the substring of string from startIndex to endIndex.
7. Perform ! CreateDataPropertyOrThrow(result, "segment", segment).
8. Perform ! CreateDataPropertyOrThrow(result, "index", F(startIndex)).
9. Perform ! CreateDataPropertyOrThrow(result, "input", string).
10. Let granularity be segmenter.[[SegmenterGranularity]].
11. If granularity is "word", then
    a. Let isWordLike be a Boolean value indicating whether the segment in string is "word-like" according to locale segmenter.[[Locale]].
    b. Perform ! CreateDataPropertyOrThrow(result, "isWordLike", isWordLike).
12. Return result.

NOTE Whether a segment is "word-like" is implementation-dependent, and implementations are recommended to use locale-sensitive tailorings. In general, segments consisting solely of spaces and/or punctuation (such as those terminated with "WORD_NONE" boundaries by ICU [International Components for Unicode, documented at https://unicode-org.github.io/icu-docs/]) are not considered to be "word-like".

18.8 Abstract Operations for Segmenter Objects

18.8.1 FindBoundary (segmenter, string, startIndex, direction)

The FindBoundary abstract operation is called with arguments Intl.Segmenter instance segmenter, String string, integer startIndex, and direction (which must be before or after) to find a segmentation boundary between two code units in string in the specified direction from the code unit at index startIndex according to
the locale and options of `segmenter` and return the immediately following code unit index (which will be infinite if no such boundary exists). The following steps are taken:

1. Let `locale` be `segmenter.[[Locale]]`.  
2. Let `granularity` be `segmenter.[[SegmenterGranularity]]`.  
3. Let `len` be the length of `string`.  
4. If `direction` is before, then  
   a. Assert: `startIndex` ≥ 0.  
   b. Assert: `startIndex` < `len`.  
   c. Search `string` for the last segmentation boundary that is preceded by at most `startIndex` code units from the beginning, using locale `locale` and text element granularity `granularity`.  
   d. If a boundary is found, return the count of code units in `string` preceding it.  
   e. Return 0.  
5. Assert: `direction` is after.  
6. If `len` is 0 or `startIndex` ≥ `len`, return +∞.  
7. Search `string` for the first segmentation boundary that follows the code unit at index `startIndex`, using locale `locale` and text element granularity `granularity`.  
8. If a boundary is found, return the count of code units in `string` preceding it.  
9. Return `len`.  

### 19 Locale Sensitive Functions of the ECMAScript Language Specification

The ECMAScript Language Specification, edition 10 or successor, describes several locale-sensitive functions. An ECMAScript implementation that implements this Internationalization API Specification shall implement these functions as described here.

The Collator, NumberFormat, or DateTimeFormat objects created in the algorithms in this clause are only used within these algorithms. They are never directly accessed by ECMAScript code and need not actually exist within an implementation.

#### 19.1 Properties of the String Prototype Object

##### 19.1.1 String.prototype.localeCompare ( `that` [ , `locales` [ , `options` ] ] )

This definition supersedes the definition provided in es2023, 22.1.3.11.

When the `localeCompare` method is called with argument `that` and optional arguments `locales`, and `options`, the following steps are taken:

1. Let `O` be ? `RequireObjectCoercible(this value)`.  
2. Let `S` be ? `ToString(O)`.  
3. Let `thatValue` be ? `ToString(that)`.  
5. Return `CompareStrings(collator, S, thatValue)`.  

The Collator, NumberFormat, or DateTimeFormat objects created in the algorithms in this clause are only used within these algorithms. They are never directly accessed by ECMAScript code and need not actually exist within an implementation.
The value of the "length" property of the `localeCompare` method is 1.

**NOTE 1** The `localeCompare` method itself is not directly suitable as an argument to `Array.prototype.sort` because the latter requires a function of two arguments.

**NOTE 2** 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.

### 19.1.2 String.prototype.toLocaleLowerCase ([ `locales` ])

This definition supersedes the definition provided in es2023, 22.1.3.25.

This function interprets a String value as a sequence of code points, as described in es2023, 6.1.4. The following steps are taken:

1. Let `O` be `RequireObjectCoercible(this value).`
2. Let `S` be `ToString(O).`

**NOTE** The `toLocaleLowerCase` function is intentionally generic; it does not require that its `this` value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

### 19.1.2.1 TransformCase ( `S, locales, targetCase` )

The abstract operation `TransformCase` takes arguments `S` (a String), `locales` (an ECMAScript language value), and `targetCase` (lower or upper). It interprets `S` as a sequence of UTF-16 encoded code points, as described in es2023, 6.1.4, and returns the result of implementation- and locale-dependent (ILD) transformation into `targetCase` as a new String value. It performs the following steps when called:

1. Let `requestedLocales` be `? CanonicalizeLocaleList(locales).`
2. If `requestedLocales` is not an empty List, then
   a. Let `requestedLocale be requestedLocales[0].`
3. Else,
   a. Let `requestedLocale be ! DefaultLocale().`
4. Let `noExtensionsLocale` be the String value that is `requestedLocale` with any Unicode locale extension sequences (6.2.1) removed.
5. Let `availableLocales` be a List with language tags that includes the languages for which the Unicode Character Database contains language sensitive case mappings. Implementations may add additional language tags if they support case mapping for additional locales.
7. If `locale` is undefined, set `locale` to "und".
8. Let `codePoints` be `StringToCodePoints(S).`
9. If `targetCase` is lower, then
   a. Let `newCodePoints` be a List whose elements are the result of a lowercase transformation of `codePoints` according to an implementation-derived algorithm using `locale` or the Unicode Default Case Conversion algorithm.
10. Else,
   a. Assert: `targetCase` is upper.
b. Let newCodePoints be a List whose elements are the result of an uppercase transformation of codePoints according to an implementation-derived algorithm using locale or the Unicode Default Case Conversion algorithm.


Code point mappings may be derived according to a tailored version of the Default Case Conversion Algorithms of the Unicode Standard. Implementations may use locale-sensitive tailoring defined in the file SpecialCasing.txt of the Unicode Character Database and/or CLDR and/or any other custom tailoring. Regardless of tailoring, a conforming implementation's case transformation algorithm must always yield the same result given the same input code points, locale, and target case.

NOTE The case mapping of some code points may produce multiple code points, and therefore the result may not be the same length as the input. Because both toLocaleUpperCase and toLocaleLowerCase have context-sensitive behaviour, the functions are not symmetrical. In other words, s.toLocaleUpperCase().toLocaleLowerCase() is not necessarily equal to s.toLocaleLowerCase().toLocaleUpperCase() and s.toLocaleLowerCase().toLocaleUpperCase() is not necessarily equal to s.toLocaleUpperCase().

19.1.3 String.prototype.toLocaleUpperCase ([ locales ])

This definition supersedes the definition provided in es2023, 22.1.3.26.

This function interprets a String value as a sequence of code points, as described in es2023, 6.1.4. The following steps are taken:

1. Let O be ? RequireObjectCoercible(this value).
2. Let S be ? ToString(O).

NOTE The toLocaleUpperCase function is intentionally generic; it does not require that its this value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

19.2 Properties of the Number Prototype Object

The following definition(s) refer to the abstract operation thisNumberValue as defined in es2023, 21.1.3.

19.2.1 Number.prototype.toLocaleString ([ locales [, options ] ])

This definition supersedes the definition provided in es2023, 21.1.3.4.

When the toLocaleString method is called with optional arguments locales and options, the following steps are taken:

1. Let x be ? thisNumberValue(this value).
2. Let numberFormat be ? Construct(%NumberFormat%, « locales, options »).
19.3 Properties of the BigInt Prototype Object

The following definition(s) refer to the abstract operation `thisBigIntValue` as defined in es2023, 21.2.3.

19.3.1 BigInt.prototype.toLocaleString ([ locales [, options ]])

This definition supersedes the definition provided in es2023, 21.2.3.2.

When the `toLocaleString` method is called with optional arguments `locales` and `options`, the following steps are taken:

1. Let `x` be `thisBigIntValue(this value)`.
2. Let `numberFormat` be `Construct(%NumberFormat%, « locales, options »)`.
3. Return `FormatNumeric(numberFormat, x)`.

19.4 Properties of the Date Prototype Object

The following definition(s) refer to the abstract operation `thisTimeValue` as defined in es2023, 21.4.4.

19.4.1 Date.prototype.toLocaleString ([ locales [, options ]])

This definition supersedes the definition provided in es2023, 21.4.4.39.

When the `toLocaleString` method is called with optional arguments `locales` and `options`, the following steps are taken:

1. Let `x` be `thisTimeValue(this value)`.
2. If `x` is `NaN`, return "Invalid Date".
3. Let `options` be `ToDateTimeOptions(options, "any", "all")`.
4. Let `dateFormat` be `Construct(%DateTimeFormat%, « locales, options »)`.
5. Return `FormatDateTime(dateFormat, x)`.

19.4.2 Date.prototype.toLocaleDateString ([ locales [, options ]])

This definition supersedes the definition provided in es2023, 21.4.4.38.

When the `toLocaleDateString` method is called with optional arguments `locales` and `options`, the following steps are taken:

1. Let `x` be `thisTimeValue(this value)`.
2. If `x` is `NaN`, return "Invalid Date".
3. Let `options` be `ToDateTimeOptions(options, "date", "date")`.
4. Let `dateFormat` be `Construct(%DateTimeFormat%, « locales, options »)`.
5. Return `FormatDateTime(dateFormat, x)`.

19.4.3 Date.prototype.toLocaleTimeString ([ locales [, options ]])

This definition supersedes the definition provided in es2023, 21.4.4.40.

When the `toLocaleTimeString` method is called with optional arguments `locales` and `options`, the following steps are taken:
1. Let \( x \) be \( \mathtt{thisTimeValue}(\this) \).
2. If \( x \) is \( \mathtt{NaN} \), return \"Invalid Date\".
3. Let \( \text{options} \) be \? \( \mathtt{ToDateTimeOptions}(\text{options}, \"time\", \"time\") \).
4. Let \( \text{timeFormat} \) be \? \( \mathtt{Construct}(\%\text{DateTimeFormat}\%, \:\{\: \text{locales}, \text{options} \}) \).
5. Return \? \( \mathtt{FormatDateTime}(\text{timeFormat}, x) \).

19.5 Properties of the Array Prototype Object

19.5.1 \( \text{Array.prototype.toLocaleString} \) \( ([ \text{locales} [, \text{options}] ]) \)

This definition supersedes the definition provided in es2023, 23.1.3.32.

When the \( \text{toLocaleString} \) method is called with optional arguments \text{locales} and \text{options}, the following steps are taken:

1. Let \( \text{array} \) be \? \( \mathtt{ToObject}(\this) \).
2. Let \( \text{len} \) be \? \( \mathtt{ToLength}(\? \( \mathtt{Get}(\text{array}, \"length\") \)) \).
3. Let \( \text{separator} \) be the implementation-defined list-separator String value appropriate for the host environment’s current locale (such as \"","\n\)
4. Let \( R \) be the empty String.
5. Let \( k \) be 0.
6. Repeat, while \( k < \text{len} \).
   a. If \( k > 0 \), then
      i. Set \( R \) to the string-concatenation of \( R \) and \( \text{separator} \).
   b. Let \( \text{nextElement} \) be \? \( \mathtt{Get}(\text{array}, \!: \mathtt{ToString}(k)) \).
   c. If \( \text{nextElement} \) is not \( \mathtt{undefined} \) or \( \mathtt{null} \), then
      i. Let \( S \) be \? \( \mathtt{Invoke}(\text{nextElement}, \"\text{toLocaleString}\", \:\{\: \text{locales}, \text{options} \}) \).
      ii. Set \( R \) to the string-concatenation of \( R \) and \( S \).
   d. Increase \( k \) by 1.
7. Return \( R \).

NOTE 1  This algorithm’s steps mirror the steps taken in es2023, 23.1.3.32, with the exception that \( \mathtt{Invoke}(\text{nextElement}, \"\text{toLocaleString}\") \) now takes \text{locales} and \text{options} as arguments.

NOTE 2  The elements of the array are converted to Strings using their \( \text{toLocaleString} \) methods, and these Strings are then concatenated, separated by occurrences of an implementation-defined locale-sensitive separator String. This function is analogous to \( \text{toString} \) except that it is intended to yield a locale-sensitive result corresponding with conventions of the host environment’s current locale.

NOTE 3  The \( \text{toLocaleString} \) 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.
Annex A
(informative)

Implementation Dependent Behaviour

The following aspects of the ECMAScript 2023 Internationalization API Specification are implementation dependent:

- In all functionality:
  - Additional values for some properties of `options` arguments (2)
  - The default locale (6.2.4)
  - The default time zone (6.5.3)
  - The set of available locales for each constructor (9.1)
  - The `BestFitMatcher` algorithm (9.2.4)
  - The `BestFitSupportedLocales` algorithm (9.2.9)

- In Collator:
  - Support for the Unicode extensions keys "kf", "kn" and the parallel options properties "caseFirst", "numeric" (10.1.2)
  - The set of supported "co" key values (collations) per locale beyond a default collation (10.2.3)
  - The set of supported "kf" key values (case order) per locale (10.2.3)
  - The set of supported "kn" key values (numeric collation) per locale (10.2.3)
  - The default search sensitivity per locale (10.2.3)
  - The sort order for each supported locale and options combination (10.3.3.1)

- In DateTimeFormat:
  - The `BestFitFormatMatcher` algorithm (11.1.2)
  - The set of supported "ca" key values (calendars) per locale (11.2.3)
  - The set of supported "nu" key values (numbering systems) per locale (11.2.3)
  - The default hourCycle setting per locale (11.2.3)
  - The set of supported date-time formats per locale beyond a core set, including the representations used for each component and the associated patterns (11.2.3)
  - Localized weekday names, era names, month names, day period names, am/pm indicators, and time zone names (11.5.8)
  - The calendric calculations used for calendars other than "gregory", and adjustments for local time zones and daylight saving time (11.5.8)
  - The set of all known registered Zone and Link names of the IANA Time Zone Database and the information about their offsets from UTC and their daylight saving time rules (6.5)

- In DisplayNames:
  - The localized names (12.2.3)

- In ListFormat:
  - The patterns used for formatting values (13.2.3)

- In Locale:
  - Support for the Unicode extensions keys "kf", "kn" and the parallel options properties "caseFirst", "numeric" (14.1.1)

- In NumberFormat:
  - The set of supported "nu" key values (numbering systems) per locale (15.2.3)
  - The patterns used for formatting values as decimal, percent, currency, or unit values per locale, with or without the sign, with or without accounting format for currencies, and in standard, compact, or scientific notation (15.5.6)
  - Localized representations of NaN and Infinity (15.5.6)
  - The implementation of numbering systems not listed in Table 14 (15.5.6)
  - Localized decimal and grouping separators (15.5.6)
  - Localized plus and minus signs (15.5.6)
  - Localized digit grouping schemata (15.5.6)
  - Localized magnitude thresholds for compact notation (15.5.6)
- Localized symbols for compact and scientific notation (15.5.6)
- Localized narrow, short, and long currency symbols and names (15.5.6)
- Localized narrow, short, and long unit symbols (15.5.6)
- In PluralRules:
  - List of Strings representing the possible results of plural selection and their corresponding order per locale. (16.1.2)
- In RelativeTimeFormat:
  - The set of supported "nu" key values (numbering systems) per locale (17.2.3)
  - The patterns used for formatting values (17.2.3)
- In Segmenter:
  - Boundary determination algorithms (18.8.1)
  - Classification of segments as "word-like" (18.7.1)
Annex B
(informative)

Additions and Changes That Introduce Incompatibilities with Prior Editions

- **10.1, 15.1, 11.1** In ECMA-402, 1st Edition, constructors could be used to create Intl objects from arbitrary objects. This is no longer possible in 2nd Edition.
- **11.3.3** In ECMA-402, 1st Edition, the "length" property of the function object \( F \) was set to \(+0_F\). In 2nd Edition, "length" is set to \( 1_F \).
- **10.3.2** In ECMA-402, 7th Edition, the `@@toStringTag` property of `Intl.Collator.prototype` was set to "Object". In 8th Edition, `@@toStringTag` is set to "Intl.Collator".
- **11.3.2** In ECMA-402, 7th Edition, the `@@toStringTag` property of `Intl.DateTimeFormat.prototype` was set to "Object". In 8th Edition, `@@toStringTag` is set to "Intl.DateTimeFormat".
- **15.3.2** In ECMA-402, 7th Edition, the `@@toStringTag` property of `Intl.NumberFormat.prototype` was set to "Object". In 8th Edition, `@@toStringTag` is set to "Intl.NumberFormat".
- **16.3.2** In ECMA-402, 7th Edition, the `@@toStringTag` property of `Intl.PluralRules.prototype` was set to "Object". In 8th Edition, `@@toStringTag` is set to "Intl.PluralRules".
- **8.1.1** In ECMA-402, 7th Edition, the `@@toStringTag` property of `Intl` was not defined. In 8th Edition, `@@toStringTag` is set to "Intl".
- **15.1** In ECMA-402, 8th Edition, the NumberFormat constructor used to throw an error when style is "currency" and maximumFractionDigits was set to a value lower than the default fractional digits for that currency. This behaviour was corrected in the 9th edition, and it no longer throws an error.
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Colophon

This specification is authored on GitHub in a plaintext source format called Ecmarkup. Ecmarkup is an HTML and Markdown dialect that provides a framework and toolset for authoring ECMAScript specifications in plaintext and processing the specification into a full-featured HTML rendering that follows the editorial conventions for this document. Ecmarkup builds on and integrates a number of other formats and technologies including Grammarkdown for defining syntax and Ecmarkdown for authoring algorithm steps. Beginning with the ninth edition, PDF renderings of this specification are produced by augmenting the generated HTML with additional attributes and CSS rules defined by the W3C CSS Paged Media and CSS Generated Content for Paged Media specifications. The augmented HTML is “printed” as a PDF document using a web browser and the Paged.js JavaScript polyfill library.

Prior editions of this specification were authored using Word—the Ecmarkup source text that formed the basis of this edition was produced by converting the ECMAScript 2015 Word document to Ecmarkup using an automated conversion tool.