

# Package ‘vctrs’

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**Title** Vector Helpers

**Version** 0.3.0

**Description** Defines new notions of prototype and size that are used to provide tools for consistent and well-founded type-coercion and size-recycling, and are in turn connected to ideas of type- and size-stability useful for analysing function interfaces.

**License** GPL-3

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df\_ptype2

*Coercion between two data frames***Description**

df\_ptype2() and df\_cast() are the two functions you need to call from vec\_ptype2() and vec\_cast() methods for data frame subclasses. See [?howto-faq-coercion-data-frame](#). Their main job is to determine the common type of two data frames, adding and coercing columns as needed, or throwing an incompatible type error when the columns are not compatible.

**Usage**

```
df_ptype2(x, y, ..., x_arg = "", y_arg = "")
df_cast(x, to, ..., x_arg = "", to_arg = "")
tib_ptype2(x, y, ..., x_arg = "", y_arg = "")
tib_cast(x, to, ..., x_arg = "", to_arg = "")
```

**Arguments**

|   |  |
|---|--|
| <code>x</code> , <code>y</code> , <code>to</code> | Subclasses of data frame.  |
| <code>...</code>                                  | These dots are for future extensions and must be empty.  |
| <code>x_arg</code>                                | Argument names for <code>x</code> and <code>y</code> . These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ).  |
| <code>y_arg</code>                                | Argument names for <code>x</code> and <code>y</code> . These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ).  |
| <code>to_arg</code>                               | Argument names for <code>x</code> and <code>to</code> . These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ). |

**Value**

- When `x` and `y` are not compatible, an error of class `vecrs_error_incompatible_type` is thrown.
- When `x` and `y` are compatible, `df_ptype2()` returns the common type as a bare data frame. `tib_ptype2()` returns the common type as a bare tibble.

---

faq-error-incompatible-attributes

*FAQ - Error/Warning: Some attributes are incompatible*

---

**Description**

This error occurs when [vec\\_ptype2\(\)](#) or [vec\\_cast\(\)](#) are supplied vectors of the same classes with different attributes. In this case, `vecrs` doesn't know how to combine the inputs.

To fix this error, the maintainer of the class should implement self-to-self coercion methods for [vec\\_ptype2\(\)](#) and [vec\\_cast\(\)](#).

**Implementing coercion methods**

- For an overview of how these generics work and their roles in `vecrs`, see [?theory-faq-coercion](#).
- For an example of implementing coercion methods for simple vectors, see [?howto-faq-coercion](#).
- For an example of implementing coercion methods for data frame subclasses, see [?howto-faq-coercion-data-frame](#).
- For a tutorial about implementing `vecrs` classes from scratch, see `vignette("s3-vector")`.

## Description

This guide illustrates how to implement `vec_ptype2()` and `vec_cast()` methods for existing classes. Related topics:

- For an overview of how these generics work and their roles in vctrs, see [?theory-faq-coercion](#).
- For an example of implementing coercion methods for data frame subclasses, see [?howto-faq-coercion-data-frame](#).
- For a tutorial about implementing vctrs classes from scratch, see `vignette("s3-vector")`

### The natural number class:

We'll illustrate how to implement coercion methods with a simple class that represents natural numbers. In this scenario we have an existing class that already features a constructor and methods for `print()` and `subset`.

```
#' @export
new_natural <- function(x) {
  if (is.numeric(x) || is.logical(x)) {
    stopifnot(is_whole(x))
    x <- as.integer(x)
  } else {
    stop("Can't construct natural from unknown type.")
  }
  structure(x, class = "my_natural")
}
is_whole <- function(x) {
  all(x %% 1 == 0 | is.na(x))
}

#' @export
print.my_natural <- function(x, ...) {
  cat("<natural>\n")
  x <- unclass(x)
  NextMethod()
}
#' @export
`[.my_natural` <- function(x, i, ...) {
  new_natural(NextMethod())
}

new_natural(1:3)
#> <natural>
#> [1] 1 2 3
new_natural(c(1, NA))
#> <natural>
#> [1] 1 NA
```

### Roxygen workflow:

To implement methods for generics, first import the generics in your namespace and redocument:

```
#' @importFrom vctrs vec_ptype2 vec_cast
NULL
```

Note that for each batches of methods that you add to your package, you need to export the methods and redocument immediately, even during development. Otherwise they won't be in scope when you run unit tests e.g. with `testthat`.

Implementing double dispatch methods is very similar to implementing regular S3 methods. In these examples we are using `roxygen2` tags to register the methods, but you can also register the methods manually in your `NAMESPACE` file or lazily with `s3_register()`.

### Implementing `vec_ptype2()`:

*The self-self method:*

The first method to implement is the one that signals that your class is compatible with itself:

```
#' @export
vec_ptype2.my_natural.my_natural <- function(x, y, ...) {
  x
}
```

```
vec_ptype2(new_natural(1), new_natural(2:3))
#> <natural>
#> integer(0)
```

`vec_ptype2()` implements a fallback to try and be compatible with simple classes, so it may seem that you don't need to implement the self-self coercion method. However, you must implement it explicitly because this is how `vctrs` knows that a class that is implementing `vctrs` methods (for instance this disable fallbacks to `base::c()`). Also, it makes your class a bit more efficient.

*The parent and children methods:*

Our natural number class is conceptually a parent of `<logical>` and a child of `<integer>`, but the class is not compatible with `logical`, `integer`, or double vectors yet:

```
vec_ptype2(TRUE, new_natural(2:3))
#> Error: Can't combine <logical> and <my_natural>.
```

```
vec_ptype2(new_natural(1), 2:3)
#> Error: Can't combine <my_natural> and <integer>.
```

We'll specify the twin methods for each of these classes, returning the richer class in each case.

```
#' @export
vec_ptype2.my_natural.logical <- function(x, y, ...) {
  # The order of the classes in the method name follows the order of
  # the arguments in the function signature, so `x` is the natural
  # number and `y` is the logical
  x
}
#' @export
vec_ptype2.logical.my_natural <- function(x, y, ...) {
  # In this case `y` is the richer natural number
  y
}
```

Between a natural number and an integer, the latter is the richer class:

```
#' @export
vec_ptype2.my_natural.integer <- function(x, y, ...) {
  y
}
```

```

}
#' @export
vec_ptype2.integer.my_natural <- function(x, y, ...) {
  x
}

```

We no longer get common type errors for logical and integer:

```

vec_ptype2(TRUE, new_natural(2:3))
#> <natural>
#> integer(0)

```

```

vec_ptype2(new_natural(1), 2:3)
#> integer(0)

```

We are not done yet. Pairwise coercion methods must be implemented for all the connected nodes in the coercion hierarchy, which include double vectors further up. The coercion methods for grand-parent types must be implemented separately:

```

#' @export
vec_ptype2.my_natural.double <- function(x, y, ...) {
  y
}
#' @export
vec_ptype2.double.my_natural <- function(x, y, ...) {
  x
}

```

#### *Incompatible attributes:*

Most of the time, inputs are incompatible because they have different classes for which no `vec_ptype2()` method is implemented. More rarely, inputs could be incompatible because of their attributes. In that case incompatibility is signalled by calling `stop_incompatible_type()`. In the following example, we implement a self-self `ptype2` method for a hypothetical subclass of `<factor>` that has stricter combination semantics. The method throws when the levels of the two factors are not compatible.

```

#' @export
vec_ptype2.my_strict_factor.my_strict_factor <- function(x, y, ..., x_arg = "", y_arg = "") {
  if (!setequal(levels(x), levels(y))) {
    stop_incompatible_type(x, y, x_arg = x_arg, y_arg = y_arg)
  }

  x
}

```

Note how the methods need to take `x_arg` and `y_arg` parameters and pass them on to `stop_incompatible_type()`. These argument tags help create more informative error messages when the common type determination is for a column of a data frame. They are part of the generic signature but can usually be left out if not used.

#### **Implementing `vec_cast()`:**

Corresponding `vec_cast()` methods must be implemented for all `vec_ptype2()` methods. The general pattern is to convert the argument `x` to the type of `to`. The methods should validate the values in `x` and make sure they conform to the values of `to`.

Please note that for historical reasons, the order of the classes in the method name is in reverse order of the arguments in the function signature. The first class represents `to`, whereas the second class represents `x`.

The self-self method is easy in this case, it just returns the target input:

```
#' @export
vec_cast.my_natural.my_natural <- function(x, to, ...) {
  x
}
```

The other types need to be validated. We perform input validation in the `new_natural()` constructor, so that's a good fit for our `vec_cast()` implementations.

```
#' @export
vec_cast.my_natural.logical <- function(x, to, ...) {
  # The order of the classes in the method name is in reverse order
  # of the arguments in the function signature, so `to` is the natural
  # number and `x` is the logical
  new_natural(x)
}
vec_cast.my_natural.integer <- function(x, to, ...) {
  new_natural(x)
}
vec_cast.my_natural.double <- function(x, to, ...) {
  new_natural(x)
}
```

With these methods, `vctrs` is now able to combine logical and natural vectors. It properly returns the richer type of the two, a natural vector:

```
vec_c(TRUE, new_natural(1), FALSE)
#> <natural>
#> [1] 1 1 0
```

Because we haven't implemented conversions *from* natural, it still doesn't know how to combine natural with the richer integer and double types:

```
vec_c(new_natural(1), 10L)
#> Error: Can't convert <my_natural> to <integer>.
vec_c(1.5, new_natural(1))
#> Error: Can't convert <my_natural> to <double>.
```

This is quick work which completes the implementation of coercion methods for `vctrs`:

```
#' @export
vec_cast.logical.my_natural <- function(x, to, ...) {
  # In this case `to` is the logical and `x` is the natural number
  attributes(x) <- NULL
  as.logical(x)
}
#' @export
vec_cast.integer.my_natural <- function(x, to, ...) {
  attributes(x) <- NULL
  as.integer(x)
}
#' @export
vec_cast.double.my_natural <- function(x, to, ...) {
  attributes(x) <- NULL
  as.double(x)
}
```

And we now get the expected combinations.

```
vec_c(new_natural(1), 10L)
#> [1] 1 10
```

```
vec_c(1.5, new_natural(1))
#> [1] 1.5 1.0
```

---

howto-faq-coercion-data-frame

*FAQ - How to implement ptype2 and cast methods? (Data frames)*

---

## Description

This guide provides a practical recipe for implementing `vec_ptype2()` and `vec_cast()` methods for coercions of data frame subclasses. Related topics:

- For an overview of the coercion mechanism in `vctrs`, see [?theory-faq-coercion](#).
- For an example of implementing coercion methods for simple vectors, see [?howto-faq-coercion](#).

Coercion of data frames occurs when different data frame classes are combined in some way. The two main methods of combination are currently row-binding with `vec_rbind()` and col-binding with `vec_cbind()` (which are in turn used by a number of `dplyr` and `tidyr` functions). These functions take multiple data frame inputs and automatically coerce them to their common type.

`vctrs` is generally strict about the kind of automatic coercions that are performed when combining inputs. In the case of data frames we have decided to be a bit less strict for convenience. Instead of throwing an incompatible type error, we fall back to a base data frame or a tibble if we don't know how to combine two data frame subclasses. It is still a good idea to specify the proper coercion behaviour for your data frame subclasses as soon as possible.

We will see two examples in this guide. The first example is about a data frame subclass that has no particular attributes to manage. In the second example, we implement coercion methods for a tibble subclass that includes potentially incompatible attributes.

### Roxygen workflow:

To implement methods for generics, first import the generics in your namespace and redocument:

```
#' @importFrom vctrs vec_ptype2 vec_cast
NULL
```

Note that for each batches of methods that you add to your package, you need to export the methods and redocument immediately, even during development. Otherwise they won't be in scope when you run unit tests e.g. with `testthat`.

Implementing double dispatch methods is very similar to implementing regular S3 methods. In these examples we are using `roxygen2` tags to register the methods, but you can also register the methods manually in your `NAMESPACE` file or lazily with `s3_register()`.

### Parent methods:

Most of the common type determination should be performed by the parent class. In `vctrs`, double dispatch is implemented in such a way that you need to call the methods for the parent class manually. For `vec_ptype2()` this means you need to call `df_ptype2()` (for data frame subclasses) or `tib_ptype2()` (for tibble subclasses). Similarly, `df_cast()` and `tib_cast()` are the workhorses for `vec_cast()` methods of subtypes of `data.frame` and `tbl_df`. These functions take the union of the columns in `x` and `y`, and ensure shared columns have the same type.

These functions are much less strict than `vec_ptype2()` and `vec_cast()` as they accept any subclass of data frame as input. They always return a `data.frame` or a `tbl_df`. You will probably want to write similar functions for your subclass to avoid repetition in your code. You may want to export them as well if you are expecting other people to derive from your class.

#### A `data.table` example:

This example is the actual implementation of `vctrs` coercion methods for `data.table`. This is a simple example because we don't have to keep track of attributes for this class or manage incompatibilities. See the `tibble` section for a more complicated example.

We first create the `dt_ptype2()` and `dt_cast()` helpers. They wrap around the parent methods `df_ptype2()` and `df_cast()`, and transform the common type or converted input to a data table. You may want to export these helpers if you expect other packages to derive from your data frame class.

These helpers should always return data tables. To this end we use the conversion generic `as.data.table()`. Depending on the tools available for the particular class at hand, a constructor might be appropriate as well.

```
dt_ptype2 <- function(x, y, ...) {
  as.data.table(df_ptype2(x, y, ...))
}
dt_cast <- function(x, to, ...) {
  as.data.table(df_cast(x, to, ...))
}
```

We start with the self-self method:

```
#' @export
vec_ptype2.data.table.data.table <- function(x, y, ...) {
  dt_ptype2(x, y, ...)
}
```

Between a data frame and a data table, we consider the richer type to be data table. This decision is not based on the value coverage of each data structures, but on the idea that data tables have richer behaviour. Since data tables are the richer type, we call `dt_ptype2()` from the `vec_ptype2()` method. It always returns a data table, no matter the order of arguments:

```
#' @export
vec_ptype2.data.table.data.frame <- function(x, y, ...) {
  dt_ptype2(x, y, ...)
}
#' @export
vec_ptype2.data.frame.data.table <- function(x, y, ...) {
  dt_ptype2(x, y, ...)
}
```

The `vec_cast()` methods follow the same pattern, but note how the method for coercing to data frame uses `df_cast()` rather than `dt_cast()`.

Also, please note that for historical reasons, the order of the classes in the method name is in reverse order of the arguments in the function signature. The first class represents `to`, whereas the second class represents `x`.

```
#' @export
vec_cast.data.table.data.table <- function(x, to, ...) {
  dt_cast(x, to, ...)
}
#' @export
```

```

vec_cast.data.table.data.frame <- function(x, to, ...) {
  # `x` is a data.frame to be converted to a data.table
  dt_cast(x, to, ...)
}
#' @export
vec_cast.data.frame.data.table <- function(x, to, ...) {
  # `x` is a data.table to be converted to a data.frame
  df_cast(x, to, ...)
}

```

With these methods `vctrs` is now able to combine data tables with data frames:

```

vec_cbind(data.frame(x = 1:3), data.table(y = "foo"))
#>   x y
#> 1: 1 foo
#> 2: 2 foo
#> 3: 3 foo

```

### A tibble example:

In this example we implement coercion methods for a tibble subclass that carries a colour as a scalar metadata:

```

# User constructor
my_tibble <- function(colour = NULL, ...) {
  new_my_tibble(tibble::tibble(...), colour = colour)
}
# Developer constructor
new_my_tibble <- function(x, colour = NULL) {
  stopifnot(is.data.frame(x))
  tibble::new_tibble(
    x,
    colour = colour,
    class = "my_tibble",
    nrow = nrow(x)
  )
}

df_colour <- function(x) {
  if (inherits(x, "my_tibble")) {
    attr(x, "colour")
  } else {
    NULL
  }
}

#'@export
print.my_tibble <- function(x, ...) {
  cat(sprintf("<%s: %s>\n", class(x)[[1]], df_colour(x)))
  cli::cat_line(format(x)[-1])
}

```

This subclass is very simple. All it does is modify the header.

```

red <- my_tibble("red", x = 1, y = 1:2)
red

```

```

#> <my_tibble: red>
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2

red[2]
#> <my_tibble: red>
#>       y
#>   <int>
#> 1     1
#> 2     2

green <- my_tibble("green", z = TRUE)
green
#> <my_tibble: green>
#>       z
#>   <lgl>
#> 1 TRUE

```

Combinations do not work properly out of the box, instead `vctrs` falls back to a bare tibble:

```

vec_rbind(red, tibble::tibble(x = 10:12))
#> # A tibble: 5 x 2
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2
#> 3    10    NA
#> 4    11    NA
#> 5    12    NA

```

Instead of falling back to a data frame, we would like to return a `<my_tibble>` when combined with a data frame or a tibble. Because this subclass has more metadata than normal data frames (it has a colour), it is a *supertype* of tibble and data frame, i.e. it is the richer type. This is similar to how a grouped tibble is a more general type than a tibble or a data frame. Conceptually, the latter are pinned to a single constant group.

The coercion methods for data frames operate in two steps:

- They check for compatible subclass attributes. In our case the tibble colour has to be the same, or be undefined.
- They call their parent methods, in this case `tib_ptype2()` and `tib_cast()` because we have a subclass of tibble. This eventually calls the data frame methods `df_ptype2()` and `tib_ptype2()` which match the columns and their types.

This process should usually be wrapped in two functions to avoid repetition. Consider exporting these if you expect your class to be derived by other subclasses.

We first implement a helper to determine if two data frames have compatible colours. We use the `df_colour()` accessor which returns `NULL` when the data frame colour is undefined.

```

has_compatible_colours <- function(x, y) {
  x_colour <- df_colour(x) %||% df_colour(y)
  y_colour <- df_colour(y) %||% x_colour
  identical(x_colour, y_colour)
}

```

Next we implement the coercion helpers. If the colours are not compatible, we call `stop_incompatible_cast()` or `stop_incompatible_type()`. These strict coercion semantics are justified because in this class colour is a *data* attribute. If it were a non essential *detail* attribute, like the timezone in a datetime, we would just standardise it to the value of the left-hand side.

In simpler cases (like the `data.table` example), these methods do not need to take the arguments suffixed in `_arg`. Here we do need to take these arguments so we can pass them to the `stop_` functions when we detect an incompatibility. They also should be passed to the parent methods.

```

#' @export
my_tib_cast <- function(x, to, ..., x_arg = "", to_arg = "") {
  out <- tib_cast(x, to, ..., x_arg = x_arg, to_arg = to_arg)

  if (!has_compatible_colours(x, to)) {
    stop_incompatible_cast(
      x,
      to,
      x_arg = x_arg,
      to_arg = to_arg,
      details = "Can't combine colours."
    )
  }

  colour <- df_colour(x) %||% df_colour(to)
  new_my_tibble(out, colour = colour)
}

#' @export
my_tib_ptype2 <- function(x, y, ..., x_arg = "", y_arg = "") {
  out <- tib_ptype2(x, y, ..., x_arg = x_arg, y_arg = y_arg)

  if (!has_compatible_colours(x, y)) {
    stop_incompatible_type(
      x,
      y,
      x_arg = x_arg,
      y_arg = y_arg,
      details = "Can't combine colours."
    )
  }

  colour <- df_colour(x) %||% df_colour(y)
  new_my_tibble(out, colour = colour)
}

```

Let's now implement the coercion methods, starting with the self-self methods.

```

#' @export
vec_ptype2.my_tibble.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}

#' @export
vec_cast.my_tibble.my_tibble <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}

```

We can now combine compatible instances of our class!

```
vec_rbind(red, red)
#> <my_tibble: red>
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2
#> 3     1     1
#> 4     1     2
```

```
vec_rbind(green, green)
#> <my_tibble: green>
#>       z
#>   <lgl>
#> 1 TRUE
#> 2 TRUE
```

```
vec_rbind(green, red)
#> Error: Can't combine `..1` <my_tibble> and `..2` <my_tibble>.
#> Can't combine colours.
```

The methods for combining our class with tibbles follow the same pattern. For `ptype2` we return our class in both cases because it is the richer type:

```
#' @export
vec_ptype2.my_tibble.tbl_df <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
#' @export
vec_ptype2.tbl_df.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
```

For cast are careful about returning a tibble when casting to a tibble. Note the call to `vctrs::tib_cast()`:

```
#' @export
vec_cast.my_tibble.tbl_df <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}
#' @export
vec_cast.tbl_df.my_tibble <- function(x, to, ...) {
  tib_cast(x, to, ...)
}
```

From this point, we get correct combinations with tibbles:

```
vec_rbind(red, tibble::tibble(x = 10:12))
#> <my_tibble: red>
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2
#> 3    10    NA
#> 4    11    NA
#> 5    12    NA
```

However we are not done yet. Because the coercion hierarchy is different from the class hierarchy, there is no inheritance of coercion methods. We're not getting correct behaviour for data frames yet because we haven't explicitly specified the methods for this class:

```
vec_rbind(red, data.frame(x = 10:12))
#> # A tibble: 5 x 2
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2
#> 3    10    NA
#> 4    11    NA
#> 5    12    NA
```

Let's finish up the boiler plate:

```
#' @export
vec_ptype2.my_tibble.data.frame <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}
#' @export
vec_ptype2.data.frame.my_tibble <- function(x, y, ...) {
  my_tib_ptype2(x, y, ...)
}

#' @export
vec_cast.my_tibble.data.frame <- function(x, to, ...) {
  my_tib_cast(x, to, ...)
}
#' @export
vec_cast.data.frame.my_tibble <- function(x, to, ...) {
  df_cast(x, to, ...)
}
}
```

This completes the implementation:

```
vec_rbind(red, data.frame(x = 10:12))
#> <my_tibble: red>
#>       x     y
#>   <dbl> <int>
#> 1     1     1
#> 2     1     2
#> 3    10    NA
#> 4    11    NA
#> 5    12    NA
```

## Description

### Promotion monoid:

Promotions (i.e. automatic coercions) should always transform inputs to their richer type to avoid losing values of precision. `vec_ptype2()` returns the *richer* type of two vectors, or throws an incompatible type error if none of the two vector types include the other. For example, the richer type of integer and double is the latter because double covers a larger range of values than integer. `vec_ptype2()` is a **monoid** over vectors, which in practical terms means that it is a well behaved operation for **reduction**. Reduction is an important operation for promotions because that is how the richer type of multiple elements is computed. As a monoid, `vec_ptype2()` needs an identity element, i.e. a value that doesn't change the result of the reduction. `vctrs` has two identity values, `NULL` and **unspecified** vectors.

### The NULL identity:

As an identity element that shouldn't influence the determination of the common type of a set of vectors, `NULL` is promoted to any type:

```
vec_ptype2(NULL, "")
#> character(0)
vec_ptype2(1L, NULL)
#> integer(0)
```

The common type of `NULL` and `NULL` is the identity `NULL`:

```
vec_ptype2(NULL, NULL)
#> NULL
```

This way the result of `vec_ptype2(NULL, NULL)` does not influence subsequent promotions:

```
vec_ptype2(
  vec_ptype2(NULL, NULL),
  ""
)
#> character(0)
```

### Unspecified vectors:

In the `vctrs` coercion system, logical vectors of missing values are also automatically promoted to the type of any other vector, just like `NULL`. We call these vectors **unspecified**. The special coercion semantics of unspecified vectors serve two purposes:

1. It makes it possible to assign vectors of `NA` inside any type of vectors, even when they are not coercible with logical:
 

```
x <- letters[1:5]
vec_assign(x, 1:2, c(NA, NA))
#> [1] NA NA "c" "d" "e"
```
2. We can't put `NULL` in a data frame, so we need an identity element that behaves more like a vector. Logical vectors of `NA` seem a natural fit for this.

Unspecified vectors are thus promoted to any other type, just like `NULL`:

```
vec_ptype2(NA, "")
#> character(0)
vec_ptype2(1L, c(NA, NA))
#> integer(0)
```

### Finalising common types:

`vctrs` has an internal vector type of class `vctrs_unspecified`. Users normally don't see such vectors in the wild, but they do come up when taking the common type of an unspecified vector with another identity value:

```
vec_ptype2(NA, NA)
#> <unspecified> [0]
vec_ptype2(NA, NULL)
#> <unspecified> [0]
vec_ptype2(NULL, NA)
#> <unspecified> [0]
```

We can't return NA here because `vec_ptype2()` normally returns empty vectors. We also can't return NULL because unspecified vectors need to be recognised as logical vectors if they haven't been promoted at the end of the reduction.

```
vec_ptype_finalise(vec_ptype2(NULL, NA))
#> logical(0)
```

See the output of `vec_ptype_common()` which performs the reduction and finalises the type, ready to be used by the caller:

```
vec_ptype_common(NULL, NULL)
#> NULL
vec_ptype_common(NA, NULL)
#> logical(0)
```

Note that **partial** types in `vctrs` make use of the same mechanism. They are finalised with `vec_ptype_finalise()`.

---

list\_of

list\_of S3 class for homogenous lists

---

## Description

A `list_of` object is a list where each element has the same type. Modifying the list with `$`, `[`, and `[[` preserves the constraint by coercing all input items.

## Usage

```
list_of(..., .ptype = NULL)

as_list_of(x, ...)

validate_list_of(x)

is_list_of(x)

## S3 method for class 'vctrs_list_of'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'vctrs_list_of'
vec_cast(x, to, ...)
```

**Arguments**

|                     |   |
|---------------------|---|
| <code>...</code>    | Vectors to coerce.  |
| <code>.ptype</code> | If NULL, the default, the output type is determined by computing the common type across all elements of <code>...</code> .<br>Alternatively, you can supply <code>.ptype</code> to give the output known type. If <code>getOption("vctrs.no_guesses")</code> is TRUE you must supply this value: this is a convenient way to make production code demand fixed types. |
| <code>x</code>      | For <code>as_list_of()</code> , a vector to be coerced to <code>list_of</code> .  |
| <code>y, to</code>  | Arguments to <code>vec_ptype2()</code> and <code>vec_cast()</code> .  |
| <code>x_arg</code>  | Argument names for <code>x</code> and <code>y</code> . These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ).   |
| <code>y_arg</code>  | Argument names for <code>x</code> and <code>y</code> . These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ).   |

**Details**

Unlike regular lists, setting a list element to NULL using `[[` does not remove it.

**Examples**

```
x <- list_of(1:3, 5:6, 10:15)
if (requireNamespace("tibble", quietly = TRUE)) {
  tibble::tibble(x = x)
}

vec_c(list_of(1, 2), list_of(FALSE, TRUE))
```

---

name\_spec

*Name specifications*

---

**Description**

A name specification describes how to combine an inner and outer names. This sort of name combination arises when concatenating vectors or flattening lists. There are two possible cases:

- Named vector:  
`vec_c(outer = c(inner1 = 1, inner2 = 2))`
- Unnamed vector:  
`vec_c(outer = 1:2)`

In `r-lib` and tidyverse packages, these cases are errors by default, because there's no behaviour that works well for every case. Instead, you can provide a name specification that describes how to combine the inner and outer names of inputs. Name specifications can refer to:

- `outer`: The external name recycled to the size of the input vector.
- `inner`: Either the names of the input vector, or a sequence of integer from 1 to the size of the vector if it is unnamed.

## Arguments

`name_spec`, `.name_spec`

A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like `outer = c(inner = 1)`, or when they have length greater than 1: `outer = 1:2`. By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be:

- A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.
- An anonymous function as a purrr-style formula.
- A glue specification of the form `"{outer}_{inner}"`.

See the [name specification topic](#).

## Examples

```
# By default, named inputs must be length 1:
vec_c(name = 1)      # ok
try(vec_c(name = 1:3)) # bad

# They also can't have internal names, even if scalar:
try(vec_c(name = c(internal = 1))) # bad

# Pass a name specification to work around this. A specification
# can be a glue string referring to `outer` and `inner`:
vec_c(name = 1:3, other = 4:5, .name_spec = "{outer}")
vec_c(name = 1:3, other = 4:5, .name_spec = "{outer}_{inner}")

# They can also be functions:
my_spec <- function(outer, inner) paste(outer, inner, sep = "_")
vec_c(name = 1:3, other = 4:5, .name_spec = my_spec)

# Or purrr-style formulas for anonymous functions:
vec_c(name = 1:3, other = 4:5, .name_spec = ~ paste0(.x, .y))
```

---

theory-faq-coercion    *FAQ - How does coercion work in vctrs?*

---

## Description

This is an overview of the usage of `vec_ptype2()` and `vec_cast()` and their role in the vctrs coercion mechanism. Related topics:

- For an example of implementing coercion methods for simple vectors, see [?howto-faq-coercion](#).
- For an example of implementing coercion methods for data frame subclasses, see [?howto-faq-coercion-data-frame](#).
- For a tutorial about implementing vctrs classes from scratch, see `vignette("s3-vector")`.

### Combination mechanism in vctrs:

The coercion system in vctrs is designed to make combination of multiple inputs consistent and extensible. Combinations occur in many places, such as row-binding, joins, subset-assignment, or grouped summary functions that use the split-apply-combine strategy. For example:

```

vec_c(TRUE, 1)
#> [1] 1 1

vec_c("a", 1)
#> Error: Can't combine `..1` <character> and `..2` <double>.

vec_rbind(
  data.frame(x = TRUE),
  data.frame(x = 1, y = 2)
)
#>   x y
#> 1 1 NA
#> 2 1  2

vec_rbind(
  data.frame(x = "a"),
  data.frame(x = 1, y = 2)
)
#> Error: Can't combine `..1$x` <character> and `..2$x` <double>.

```

One major goal of `vctrs` is to provide a central place for implementing the coercion methods that make generic combinations possible. The two relevant generics are `vec_ptype2()` and `vec_cast()`. They both take two arguments and perform **double dispatch**, meaning that a method is selected based on the classes of both inputs.

The general mechanism for combining multiple inputs is:

1. Find the common type of a set of inputs by reducing (as in `base::Reduce()` or `purrr::reduce()`) the `vec_ptype2()` binary function over the set.
2. Convert all inputs to the common type with `vec_cast()`.
3. Initialise the output vector as an instance of this common type with `vec_init()`.
4. Fill the output vector with the elements of the inputs using `vec_assign()`.

The last two steps may require `vec_proxy()` and `vec_restore()` implementations, unless the attributes of your class are constant and do not depend on the contents of the vector. We focus here on the first two steps, which require `vec_ptype2()` and `vec_cast()` implementations.

`vec_ptype2()`:

Methods for `vec_ptype2()` are passed two *prototypes*, i.e. two inputs emptied of their elements. They implement two behaviours:

- If the types of their inputs are compatible, indicate which of them is the richer type by returning it. If the types are of equal resolution, return any of the two.
- Throw an error with `stop_incompatible_type()` when it can be determined from the attributes that the types of the inputs are not compatible.

*Type compatibility:*

A type is **compatible** with another type if the values it represents are a subset or a superset of the values of the other type. The notion of “value” is to be interpreted at a high level, in particular it is not the same as the memory representation. For example, factors are represented in memory with integers but their values are more related to character vectors than to round numbers:

```

# Two factors are compatible
vec_ptype2(factor("a"), factor("b"))
#> factor(0)
#> Levels: a b

```

```
# Factors are compatible with a character
vec_ptype2(factor("a"), "b")
#> character(0)

# But they are incompatible with integers
vec_ptype2(factor("a"), 1L)
#> Error: Can't combine <factor<127a2>> and <integer>.
```

#### *Richness of type:*

Richness of type is not a very precise notion. It can be about richer data (for instance a double vector covers more values than an integer vector), richer behaviour (a `data.table` has richer behaviour than a `data.frame`), or both. If you have trouble determining which one of the two types is richer, it probably means they shouldn't be automatically coercible.

Let's look again at what happens when we combine a factor and a character:

```
vec_ptype2(factor("a"), "b")
#> character(0)
```

The `ptype2` method for `<character>` and `<factor<"a">>` returns `<character>` because the former is a richer type. The factor can only contain "a" strings, whereas the character can contain any strings. In this sense, factors are a *subset* of character.

Note that another valid behaviour would be to throw an incompatible type error. This is what a strict factor implementation would do. We have decided to be laxer in `vctrs` because it is easy to inadvertently create factors instead of character vectors, especially with older versions of R where `stringsAsFactors` is still true by default.

#### *Consistency and symmetry on permutation:*

Each `ptype2` method should strive to have exactly the same behaviour when the inputs are permuted. This is not always possible, for example factor levels are aggregated in order:

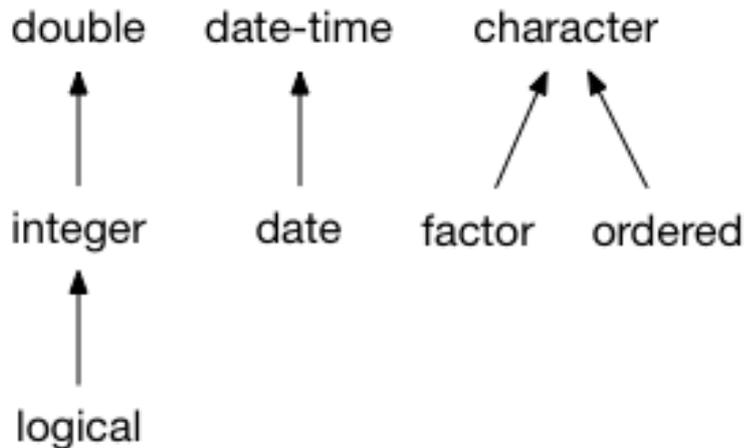
```
vec_ptype2(factor(c("a", "c")), factor("b"))
#> factor(0)
#> Levels: a c b
```

```
vec_ptype2(factor("b"), factor(c("a", "c")))
#> factor(0)
#> Levels: b a c
```

In any case, permuting the input should not return a fundamentally different type or introduce an incompatible type error.

#### *Coercion hierarchy:*

Coercible classes form a coercion (or subtyping) hierarchy. Here is a simplified diagram of the hierarchy for base types. In this diagram the directions of the arrows express which type is richer. They flow from the bottom (more constrained types) to the top (richer types).



As a class implementor, you have two options. The simplest is to create an entirely separate hierarchy. The date and date-time classes are an example of an S3-based hierarchy that is completely separate. Alternatively, you can integrate your class in an existing hierarchy, typically by adding parent nodes on top of the hierarchy (your class is richer), by adding children node at the root of the hierarchy (your class is more constrained), or by inserting a node in the tree. These coercion hierarchies are *implicit*, in the sense that they are implied by the `vec_ptype2()` implementations. There is no structured way to create or modify a hierarchy, instead you need to implement the appropriate coercion methods for all the types in your hierarchy, and diligently return the richer type in each case. The `vec_ptype2()` implementations are not transitive nor inherited, so all pairwise methods between classes lying on a given path must be implemented manually. This is something we might make easier in the future.

`vec_cast()`:

The second generic, `vec_cast()`, is the one that looks at the data and actually performs the conversion. Because it has access to more information than `vec_ptype2()`, it may be stricter and cause an error in more cases. `vec_cast()` has three possible behaviours:

- Determine that the prototypes of the two inputs are not compatible. This must be decided in exactly the same way as for `vec_ptype2()`. Call `stop_incompatible_cast()` if you can determine from the attributes that the types are not compatible.
- Detect incompatible values. Usually this is because the target type is too restricted for the values supported by the input type. For example, a fractional number can't be converted to an integer. The method should throw an error in that case.
- Return the input vector converted to the target type if all values are compatible. Whereas `vec_ptype2()` must return the same type when the inputs are permuted, `vec_cast()` is *directional*. It always returns the type of the right-hand side, or dies trying.

#### Double dispatch:

The dispatch mechanism for `vec_ptype2()` and `vec_cast()` looks like S3 but is actually a custom mechanism. Compared to S3, it has the following differences:

- It dispatches on the classes of the first two inputs.
- There is no inheritance of `ptype2` and `cast` methods. This is because the S3 class hierarchy is not necessarily the same as the coercion hierarchy.
- `NextMethod()` does not work. Parent methods must be called explicitly if necessary.
- The default method is hard-coded.

**Data frames:**

The determination of the common type of data frames with `vec_ptype2()` happens in three steps:

1. Match the columns of the two input data frames. If some columns don't exist, they are created and filled with adequately typed NA values.
2. Find the common type for each column by calling `vec_ptype2()` on each pair of matched columns.
3. Find the common data frame type. For example the common type of a grouped tibble and a tibble is a grouped tibble because the latter is the richer type. The common type of a data table and a data frame is a data table.

`vec_cast()` operates similarly. If a data frame is cast to a target type that has fewer columns, this is an error.

If you are implementing coercion methods for data frames, you will need to explicitly call the parent methods that perform the common type determination or the type conversion described above. These are exported as `df_ptype2()` and `df_cast()`.

*Data frame fallbacks:*

Being too strict with data frame combinations would cause too much pain because there are many data frame subclasses in the wild that don't implement vctrs methods. We have decided to implement a special fallback behaviour for foreign data frames. Incompatible data frames fall back to a base data frame:

```
df1 <- data.frame(x = 1)
df2 <- structure(df1, class = c("foreign_df", "data.frame"))
```

```
vec_rbind(df1, df2)
#> Warning: Can't combine <data.frame> and <foreign_df>; falling back to <data.frame>.
#>   x
#> 1 1
#> 2 1
```

When a tibble is involved, we fall back to tibble:

```
df3 <- tibble::as_tibble(df1)
```

```
vec_rbind(df1, df3)
#> # A tibble: 2 x 1
#>       x
#>   <dbl>
#> 1     1
#> 2     1
```

These fallbacks are not ideal but they make sense because all data frames share a common data structure. This is not generally the case for vectors. For example factors and characters have different representations, and it is not possible to find a fallback time mechanically.

However this fallback has a big downside: implementing vctrs methods for your data frame subclass is a breaking behaviour change. The proper coercion behaviour for your data frame class should be specified as soon as possible to limit the consequences of changing the behaviour of your class in R scripts.

## Description

- `vec_rep()` repeats an entire vector a set number of times.
- `vec_rep_each()` repeats each element of a vector a set number of times.

## Usage

```
vec_rep(x, times)
```

```
vec_rep_each(x, times)
```

## Arguments

|                    |   |
|--------------------|---|
| <code>x</code>     | A vector.   |
| <code>times</code> | For <code>vec_rep()</code> , a single integer for the number of times to repeat the entire vector.<br>For <code>vec_rep_each()</code> , an integer vector of the number of times to repeat each element of <code>x</code> . <code>times</code> will be recycled to the size of <code>x</code> . |

## Details

`vec_rep()` and `vec_rep_each()` work along the size of `x`, rather than its length. For data frames, this means that rows are repeated rather than columns.

## Value

For `vec_rep()`, a vector the same type as `x` with size `vec_size(x) * times`.

For `vec_rep_each()`, a vector the same type as `x` with size `sum(vec_recycle(times, vec_size(x)))`.

## Examples

```
# Repeat the entire vector
vec_rep(1:2, 3)

# Repeat within each vector
vec_rep_each(1:2, 3)
vec_rep_each(1:2, c(3, 4))

df <- data.frame(x = 1:2, y = 3:4)

# `rep()` repeats columns of data frames, and returns lists
rep(df, each = 2)

# `vec_rep()` and `vec_rep_each()` repeat rows, and return data frames
vec_rep(df, 2)
vec_rep_each(df, 2)
```

---

|            |   |
|------------|---|
| vec_assert | <i>Assert an argument has known prototype and/or size</i> |
|------------|---|

---

### Description

- `vec_is()` is a predicate that checks if its input is a vector that conforms to a prototype and/or a size.
- `vec_assert()` throws an error when the input is not a vector or doesn't conform.

### Usage

```
vec_assert(x, ptype = NULL, size = NULL, arg = as_label(substitute(x)))
```

```
vec_is(x, ptype = NULL, size = NULL)
```

### Arguments

|                    |  |
|--------------------|--|
| <code>x</code>     | A vector argument to check.  |
| <code>ptype</code> | Prototype to compare against. If the prototype has a class, its <code>vec_ptype()</code> is compared to that of <code>x</code> with <code>identical()</code> . Otherwise, its <code>typeof()</code> is compared to that of <code>x</code> with <code>==</code> . |
| <code>size</code>  | Size to compare against  |
| <code>arg</code>   | Name of argument being checked. This is used in error messages. The label of the expression passed as <code>x</code> is taken as default.  |

### Value

`vec_is()` returns TRUE or FALSE. `vec_assert()` either throws a typed error (see section on error types) or returns `x`, invisibly.

### Scalars and vectors

Informally, a vector is a collection that makes sense to use as column in a data frame. An object is a vector if one of the following conditions hold:

- A `vec_proxy()` method is implemented for the class of the object.
- The **base type** of the object is atomic: "logical", "integer", "double", "complex", "character", "raw"
- The object is a **data.frame**.
- The base type is "list", and one of:
  - The object is a bare "list" without a "class" attribute.
  - The object explicitly inherits from "list". That is, the "class" attribute contains "list" and `inherits(x, "list")` is TRUE.

Otherwise an object is treated as scalar and cannot be used as a vector. In particular:

- NULL is not a vector.
- S3 lists like `lm` objects are treated as scalars by default.
- Objects of type **expression** are not treated as vectors.

- Support for S4 vectors is currently limited to objects that inherit from an atomic type.
- Subclasses of `data.frame` that *append* their class to the "class" attribute are not treated as vectors. If you inherit from an S3 class, always prepend your class to the "class" attribute for correct dispatch.

### Error types

`vec_is()` never throws. `vec_assert()` throws the following errors:

- If the input is not a vector, an error of class "vctrs\_error\_scalar\_type" is raised.
- If the prototype doesn't match, an error of class "vctrs\_error\_assert\_ptype" is raised.
- If the size doesn't match, an error of class "vctrs\_error\_assert\_size" is raised.

Both errors inherit from "vctrs\_error\_assert".

---

|              |                                  |
|--------------|----------------------------------|
| vec_as_names | <i>Retrieve and repair names</i> |
|--------------|----------------------------------|

---

### Description

`vec_as_names()` takes a character vector of names and repairs it according to the `repair` argument. It is the r-lib and tidyverse equivalent of `base::make.names()`.

`vctrs` deals with a few levels of name repair:

- `minimal` names exist. The `names` attribute is not `NULL`. The name of an unnamed element is "" and never `NA`. For instance, `vec_as_names()` always returns minimal names and data frames created by the `tibble` package have names that are, at least, minimal.
- `unique` names are minimal, have no duplicates, and can be used where a variable name is expected. Empty names, `...`, and `..` followed by a sequence of digits are banned.
  - All columns can be accessed by name via `df[["name"]]` and `df$name`` and `with(df, `name`)`.
- `universal` names are unique and syntactic (see Details for more).
  - Names work everywhere, without quoting: `df$name` and `with(df, name)` and `lm(name1 ~ name2, data = df)` and `dplyr::select(df, name)` all work.

`universal` implies `unique`, `unique` implies `minimal`. These levels are nested.

### Usage

```
vec_as_names(
  names,
  ...,
  repair = c("minimal", "unique", "universal", "check_unique"),
  repair_arg = "",
  quiet = FALSE
)
```

**Arguments**

|            |  |
|------------|--|
| names      | A character vector.  |
| ...        | These dots are for future extensions and must be empty.  |
| repair     | <p>Either a string or a function. If a string, it must be one of "check_unique", "minimal", "unique", or "universal". If a function, it is invoked with a vector of minimal names and must return minimal names, otherwise an error is thrown.</p> <ul style="list-style-type: none"> <li>• Minimal names are never NULL or NA. When an element doesn't have a name, its minimal name is an empty string.</li> <li>• Unique names are unique. A suffix is appended to duplicate names to make them unique.</li> <li>• Universal names are unique and syntactic, meaning that you can safely use the names as variables without causing a syntax error.</li> </ul> <p>The "check_unique" option doesn't perform any name repair. Instead, an error is raised if the names don't suit the "unique" criteria.</p> |
| repair_arg | If specified and repair = "check_unique", any errors will include a hint to set the repair_arg.  |
| quiet      | By default, the user is informed of any renaming caused by repairing the names. This only concerns unique and universal repairing. Set quiet to TRUE to silence the messages.  |

**minimal names**

minimal names exist. The names attribute is not NULL. The name of an unnamed element is "" and never NA.

Examples:

```
Original names of a vector with length 3: NULL
minimal names: "" "" ""
```

```
Original names: "x" NA
minimal names: "x" ""
```

**unique names**

unique names are minimal, have no duplicates, and can be used (possibly with backticks) in contexts where a variable is expected. Empty names, ..., and .. followed by a sequence of digits are banned. If a data frame has unique names, you can index it by name, and also access the columns by name. In particular, df[["name"]] and df\$name and also with(df, `name`) always work.

There are many ways to make names unique. We append a suffix of the form ...j to any name that is "" or a duplicate, where j is the position. We also change ..# and ... to ...#.

Example:

```
Original names: "" "x" "" "y" "x" "..2" "...
unique names: "...1" "x...2" "...3" "y" "x...5" "...6" "...7"
```

Pre-existing suffixes of the form ...j are always stripped, prior to making names unique, i.e. reconstructing the suffixes. If this interacts poorly with your names, you should take control of name repair.

**universal names**

universal names are unique and syntactic, meaning they:

- Are never empty (inherited from unique).
- Have no duplicates (inherited from unique).
- Are not `...` Do not have the form `..i`, where `i` is a number (inherited from unique).
- Consist of letters, numbers, and the dot `.` or underscore `_` characters.
- Start with a letter or start with the dot `.` not followed by a number.
- Are not a [reserved](#) word, e.g., `if` or function or `TRUE`.

If a vector has universal names, variable names can be used "as is" in code. They work well with nonstandard evaluation, e.g., `df$name` works.

`vctrs` has a different method of making names syntactic than `base::make.names()`. In general, `vctrs` prepends one or more dots `.` until the name is syntactic.

Examples:

```
Original names:      ""      "x"    NA      "x"
universal names: ".1" ".x..2" ".3" ".x..4"
```

```
Original names: "(y)" "_z" ".2fa" "FALSE"
universal names: ".y." "._z" ".2fa" ".FALSE"
```

**See Also**

[`rlang::names2\(\)`](#) returns the names of an object, after making them minimal.

The [Names attribute](#) section in the "tidyverse package development principles".

**Examples**

```
# By default, `vec_as_names()` returns minimal names:
vec_as_names(c(NA, NA, "foo"))

# You can make them unique:
vec_as_names(c(NA, NA, "foo"), repair = "unique")

# Universal repairing fixes any non-syntactic name:
vec_as_names(c("_foo", "+"), repair = "universal")
```

---

 vec\_bind

---

*Combine many data frames into one data frame*


---

**Description**

This pair of functions binds together data frames (and vectors), either row-wise or column-wise. Row-binding creates a data frame with common type across all arguments. Column-binding creates a data frame with common length across all arguments.

**Usage**

```
vec_rbind(
  ...,
  .ptype = NULL,
  .names_to = rlang::zap(),
  .name_repair = c("unique", "universal", "check_unique"),
  .name_spec = NULL
)

vec_cbind(
  ...,
  .ptype = NULL,
  .size = NULL,
  .name_repair = c("unique", "universal", "check_unique", "minimal")
)
```

**Arguments**

... Data frames or vectors.  
When the inputs are named:

- `vec_rbind()` assigns names to row names unless `.names_to` is supplied. In that case the names are assigned in the column defined by `.names_to`.
- `vec_cbind()` creates packed data frame columns with named inputs.

NULL inputs are silently ignored. Empty (e.g. zero row) inputs will not appear in the output, but will affect the derived `.ptype`.

`.ptype` If NULL, the default, the output type is determined by computing the common type across all elements of ...  
Alternatively, you can supply `.ptype` to give the output known type. If `getOption("vctrs.no_guess")` is TRUE you must supply this value: this is a convenient way to make production code demand fixed types.

`.names_to`

- By default, input names are [zapped](#).
  - If a string, specifies a column where the input names will be copied. These names are often useful to identify rows with their original input. If a column name is supplied and ... is not named, an integer column is used instead.
  - If NULL, the input names are used as row names.

`.name_repair` One of "unique", "universal", or "check\_unique". See [vec\\_as\\_names\(\)](#) for the meaning of these options.  
With `vec_rbind()`, the repair function is applied to all inputs separately. This is because `vec_rbind()` needs to align their columns before binding the rows, and thus needs all inputs to have unique names. On the other hand, `vec_cbind()` applies the repair function after all inputs have been concatenated together in a final data frame. Hence `vec_cbind()` allows the more permissive minimal names repair.

`.name_spec` A name specification (as documented in [vec\\_c\(\)](#)) for combining the outer inputs names in ... and the inner row names of the inputs. This only has an effect when `.names_to` is set to NULL, which causes the input names to be assigned as row names.

`.size` If, NULL, the default, will determine the number of rows in `vec_cbind()` output by using the standard recycling rules.  
Alternatively, specify the desired number of rows, and any inputs of length 1 will be recycled appropriately.

### Value

A data frame, or subclass of data frame.

If `...` is a mix of different data frame subclasses, `vec_ptype2()` will be used to determine the output type. For `vec_rbind()`, this will determine the type of the container and the type of each column; for `vec_cbind()` it only determines the type of the output container. If there are no non-NULL inputs, the result will be `data.frame()`.

### Invariants

All inputs are first converted to a data frame. The conversion for 1d vectors depends on the direction of binding:

- For `vec_rbind()`, each element of the vector becomes a column in a single row.
- For `vec_cbind()`, each element of the vector becomes a row in a single column.

Once the inputs have all become data frames, the following invariants are observed for row-binding:

- `vec_size(vec_rbind(x,y)) == vec_size(x) + vec_size(y)`
- `vec_ptype(vec_rbind(x,y)) = vec_ptype_common(x,y)`

Note that if an input is an empty vector, it is first converted to a 1-row data frame with 0 columns. Despite being empty, its effective size for the total number of rows is 1.

For column-binding, the following invariants apply:

- `vec_size(vec_cbind(x,y)) == vec_size_common(x,y)`
- `vec_ptype(vec_cbind(x,y)) == vec_cbind(vec_ptype(x),vec_ptype(y))`

### See Also

[vec\\_c\(\)](#) for combining 1d vectors.

### Examples

```
# row binding -----
# common columns are coerced to common class
vec_rbind(
  data.frame(x = 1),
  data.frame(x = FALSE)
)

# unique columns are filled with NAs
vec_rbind(
  data.frame(x = 1),
  data.frame(y = "x")
)

# null inputs are ignored
vec_rbind(
```

```

    data.frame(x = 1),
    NULL,
    data.frame(x = 2)
  )

# bare vectors are treated as rows
vec_rbind(
  c(x = 1, y = 2),
  c(x = 3)
)

# default names will be supplied if arguments are not named
vec_rbind(
  1:2,
  1:3,
  1:4
)

# column binding -----

# each input is recycled to have common length
vec_cbind(
  data.frame(x = 1),
  data.frame(y = 1:3)
)

# bare vectors are treated as columns
vec_cbind(
  data.frame(x = 1),
  y = letters[1:3]
)

# if you supply a named data frame, it is packed in a single column
data <- vec_cbind(
  x = data.frame(a = 1, b = 2),
  y = 1
)
data

# Packed data frames are nested in a single column. This makes it
# possible to access it through a single name:
data$x

# since the base print method is suboptimal with packed data
# frames, it is recommended to use tibble to work with these:
if (rlang::is_installed("tibble")) {
  vec_cbind(x = tibble::tibble(a = 1, b = 2), y = 1)
}

# duplicate names are flagged
vec_cbind(x = 1, x = 2)

```

## Description

Combine all arguments into a new vector of common type.

## Usage

```
vec_c(
  ...,
  .ptype = NULL,
  .name_spec = NULL,
  .name_repair = c("minimal", "unique", "check_unique", "universal")
)
```

## Arguments

- |              |   |
|--------------|---|
| ...          | Vectors to coerce.  |
| .ptype       | <p>If NULL, the default, the output type is determined by computing the common type across all elements of ...</p> <p>Alternatively, you can supply .ptype to give the output known type. If <code>getOption("vctrs.no_guess")</code> is TRUE you must supply this value: this is a convenient way to make production code demand fixed types.</p>  |
| .name_spec   | <p>A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like <code>outer = c(inner = 1)</code>, or when they have length greater than 1: <code>outer = 1:2</code>. By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be:</p> <ul style="list-style-type: none"> <li>• A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.</li> <li>• An anonymous function as a purrr-style formula.</li> <li>• A glue specification of the form <code>"{outer}_{inner}"</code>.</li> </ul> <p>See the <a href="#">name specification topic</a>.</p> |
| .name_repair | How to repair names, see repair options in <code>vec_as_names()</code> . Can also be <code>rlang::zap()</code> to ignore names during concatenation. The names are still used to give informative error messages, e.g. with coercion errors.  |

## Value

A vector with class given by .ptype, and length equal to the sum of the `vec_size()` of the contents of ...

The vector will have names if the individual components have names (inner names) or if the arguments are named (outer names). If both inner and outer names are present, an error is thrown unless a .name\_spec is provided.

## Invariants

- `vec_size(vec_c(x,y)) == vec_size(x) + vec_size(y)`
- `vec_ptype(vec_c(x,y)) == vec_ptype_common(x,y)`.

**See Also**

[vec\\_cbind\(\)/vec\\_rbind\(\)](#) for combining data frames by rows or columns.

**Examples**

```
vec_c(FALSE, 1L, 1.5)

# Date/times -----
c(Sys.Date(), Sys.time())
c(Sys.time(), Sys.Date())

vec_c(Sys.Date(), Sys.time())
vec_c(Sys.time(), Sys.Date())

# Factors -----
c(factor("a"), factor("b"))
vec_c(factor("a"), factor("b"))

# By default, named inputs must be length 1:
vec_c(name = 1)
try(vec_c(name = 1:3))

# Pass a name specification to work around this:
vec_c(name = 1:3, .name_spec = "{outer}_{inner}")

# See `?name_spec` for more examples of name specifications.
```

---

vec\_cast

---

*Cast a vector to a specified type*


---

**Description**

`vec_cast()` provides directional conversions from one type of vector to another. Along with [vec\\_ptype2\(\)](#), this generic forms the foundation of type coercions in `vctrs`.

**Usage**

```
vec_cast(x, to, ..., x_arg = "", to_arg = "")

vec_cast_common(..., .to = NULL)

## S3 method for class 'logical'
vec_cast(x, to, ...)

## S3 method for class 'integer'
vec_cast(x, to, ...)

## S3 method for class 'double'
vec_cast(x, to, ...)

## S3 method for class 'complex'
```

```
vec_cast(x, to, ...)

## S3 method for class 'raw'
vec_cast(x, to, ...)

## S3 method for class 'character'
vec_cast(x, to, ...)

## S3 method for class 'list'
vec_cast(x, to, ...)
```

### Arguments

|               |   |
|---------------|---|
| x             | Vectors to cast.  |
| to, .to       | Type to cast to. If NULL, x will be returned as is.   |
| ...           | For <code>vec_cast_common()</code> , vectors to cast. For <code>vec_cast()</code> , <code>vec_cast_default()</code> , and <code>vec_restore()</code> , these dots are only for future extensions and should be empty. |
| x_arg, to_arg | Argument names for x and to. These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ).   |

### Value

A vector the same length as x with the same type as to, or an error if the cast is not possible. An error is generated if information is lost when casting between compatible types (i.e. when there is no 1-to-1 mapping for a specific value).

### Implementing coercion methods

- For an overview of how these generics work and their roles in vctrs, see [?theory-faq-coercion](#).
- For an example of implementing coercion methods for simple vectors, see [?howto-faq-coercion](#).
- For an example of implementing coercion methods for data frame subclasses, see [?howto-faq-coercion-data-frame](#).
- For a tutorial about implementing vctrs classes from scratch, see `vignette("s3-vector")`.

### See Also

Call `stop_incompatible_cast()` when you determine from the attributes that an input can't be cast to the target type.

### Examples

```
# x is a double, but no information is lost
vec_cast(1, integer())

# When information is lost the cast fails
try(vec_cast(c(1, 1.5), integer()))
try(vec_cast(c(1, 2), logical()))

# You can suppress this error and get the partial results
allow_lossy_cast(vec_cast(c(1, 1.5), integer()))
allow_lossy_cast(vec_cast(c(1, 2), logical()))

# By default this suppress all lossy cast errors without
```

```
# distinction, but you can be specific about what cast is allowed
# by supplying prototypes
allow_lossy_cast(vec_cast(c(1, 1.5), integer()), to_ptype = integer())
try(allow_lossy_cast(vec_cast(c(1, 2), logical()), to_ptype = integer()))

# No sensible coercion is possible so an error is generated
try(vec_cast(1.5, factor("a")))

# Cast to common type
vec_cast_common(factor("a"), factor(c("a", "b")))
```

---

vec\_chop

*Chopping*


---

### Description

- `vec_chop()` provides an efficient method to repeatedly slice a vector. It captures the pattern of `map(indices, vec_slice, x = x)`. When no indices are supplied, it is generally equivalent to `as.list()`.
- `vec_unchop()` combines a list of vectors into a single vector, placing elements in the output according to the locations specified by indices. It is similar to `vec_c()`, but gives greater control over how the elements are combined. When no indices are supplied, it is identical to `vec_c()`.

If indices selects every value in `x` exactly once, in any order, then `vec_unchop()` is the inverse of `vec_chop()` and the following invariant holds:

$$\text{vec\_unchop}(\text{vec\_chop}(x, \text{indices}), \text{indices}) == x$$

### Usage

```
vec_chop(x, indices = NULL)
```

```
vec_unchop(
  x,
  indices = NULL,
  ptype = NULL,
  name_spec = NULL,
  name_repair = c("minimal", "unique", "check_unique", "universal")
)
```

### Arguments

|                      |   |
|----------------------|---|
| <code>x</code>       | A vector  |
| <code>indices</code> | For <code>vec_chop()</code> , a list of positive integer vectors to slice <code>x</code> with, or <code>NULL</code> . If <code>NULL</code> , <code>x</code> is split into its individual elements, equivalent to using an indices of <code>as.list(vec_seq_along(x))</code> .<br>For <code>vec_unchop()</code> , a list of positive integer vectors specifying the locations to place elements of <code>x</code> in. Each element of <code>x</code> is recycled to the size of the corresponding index vector. The size of <code>indices</code> must match the size of <code>x</code> . If <code>NULL</code> , <code>x</code> is combined in the order it is provided in, which is equivalent to using <code>vec_c()</code> . |

|             |  |
|-------------|--|
| ptype       | If NULL, the default, the output type is determined by computing the common type across all elements of <code>x</code> . Alternatively, you can supply <code>ptype</code> to give the output a known type.   |
| name_spec   | A name specification for combining inner and outer names. This is relevant for inputs passed with a name, when these inputs are themselves named, like <code>outer = c(inner = 1)</code> , or when they have length greater than 1: <code>outer = 1:2</code> . By default, these cases trigger an error. You can resolve the error by providing a specification that describes how to combine the names or the indices of the inner vector with the name of the input. This specification can be: <ul style="list-style-type: none"> <li>• A function of two arguments. The outer name is passed as a string to the first argument, and the inner names or positions are passed as second argument.</li> <li>• An anonymous function as a purrr-style formula.</li> <li>• A glue specification of the form <code>"{outer}_{inner}"</code>.</li> </ul> See the <a href="#">name specification topic</a> . |
| name_repair | How to repair names, see repair options in <code>vec_as_names()</code> . Can also be <code>rlang::zap()</code> to ignore names during concatenation. The names are still used to give informative error messages, e.g. with coercion errors.   |

### Value

- `vec_chop()`: A list of size `vec_size(indices)` or, if `indices == NULL`, `vec_size(x)`.
- `vec_unchop()`: A vector of type `vec_ptype_common(!!!x)`, or `ptype`, if specified. The size is computed as `vec_size_common(!!!indices)` unless the indices are NULL, in which case the size is `vec_size_common(!!!x)`.

### Examples

```
vec_chop(1:5)
vec_chop(1:5, list(1, 1:2))
vec_chop(mtcars, list(1:3, 4:6))

# If `indices` selects every value in `x` exactly once,
# in any order, then `vec_unchop()` inverts `vec_chop()`
x <- c("a", "b", "c", "d")
indices <- list(2, c(3, 1), 4)
vec_chop(x, indices)
vec_unchop(vec_chop(x, indices), indices)

# When unchopping, size 1 elements of `x` are recycled
# to the size of the corresponding index
vec_unchop(list(1, 2:3), list(c(1, 3, 5), c(2, 4)))

# Names are retained, and outer names can be combined with inner
# names through the use of a `name_spec`
lst <- list(x = c(a = 1, b = 2), y = 1)
vec_unchop(lst, list(c(3, 2), c(1, 4)), name_spec = "{outer}_{inner}")

# An alternative implementation of `ave()` can be constructed using
# `vec_chop()` and `vec_unchop()` in combination with `vec_group_loc()`
ave2 <- function(.x, .by, .f, ...) {
  indices <- vec_group_loc(.by)$loc
  chopped <- vec_chop(.x, indices)
```

```

    out <- lapply(chopped, .f, ...)
    vec_unchop(out, indices)
  }

breaks <- warpbreaks$breaks
wool <- warpbreaks$wool

ave2(breaks, wool, mean)

identical(
  ave2(breaks, wool, mean),
  ave(breaks, wool, FUN = mean)
)

```

---

vec\_compare

*Compare two vectors*


---

### Description

Compare two vectors

### Usage

```
vec_compare(x, y, na_equal = FALSE, .ptype = NULL)
```

### Arguments

|          |  |
|----------|--|
| x, y     | Vectors with compatible types and lengths. |
| na_equal | Should NA values be considered equal?      |
| .ptype   | Override to optionally specify common type |

### Value

An integer vector with values -1 for  $x < y$ , 0 if  $x == y$ , and 1 if  $x > y$ . If `na_equal` is `FALSE`, the result will be `NA` if either `x` or `y` is `NA`.

### S3 dispatch

`vec_compare()` is not generic for performance; instead it uses [vec\\_proxy\\_compare\(\)](#) to

### Examples

```

vec_compare(c(TRUE, FALSE, NA), FALSE)
vec_compare(c(TRUE, FALSE, NA), FALSE, na_equal = TRUE)

vec_compare(1:10, 5)
vec_compare(runif(10), 0.5)
vec_compare(letters[1:10], "d")

df <- data.frame(x = c(1, 1, 1, 2), y = c(0, 1, 2, 1))
vec_compare(df, data.frame(x = 1, y = 1))

```

---

|           |  |
|-----------|--|
| vec_count | <i>Count unique values in a vector</i> |
|-----------|--|

---

### Description

Count the number of unique values in a vector. `vec_count()` has two important differences to `table()`: it returns a data frame, and when given multiple inputs (as a data frame), it only counts combinations that appear in the input.

### Usage

```
vec_count(x, sort = c("count", "key", "location", "none"))
```

### Arguments

|                   |  |
|-------------------|--|
| <code>x</code>    | A vector (including a data frame).   |
| <code>sort</code> | One of "count", "key", "location", or "none". <ul style="list-style-type: none"> <li>"count", the default, puts most frequent values at top</li> <li>"key", orders by the output key column (i.e. unique values of <code>x</code>)</li> <li>"location", orders by location where key first seen. This is useful if you want to match the counts up to other unique/duplicated functions.</li> <li>"none", leaves unordered.</li> </ul> |

### Value

A data frame with columns `key` (same type as `x`) and `count` (an integer vector).

### Examples

```
vec_count(mtcars$vs)
vec_count(iris$Species)

# If you count a data frame you'll get a data frame
# column in the output
str(vec_count(mtcars[c("vs", "am")]))

# Sorting -----

x <- letters[rpois(100, 6)]
# default is to sort by frequency
vec_count(x)

# by can sort by key
vec_count(x, sort = "key")

# or location of first value
vec_count(x, sort = "location")
head(x)

# or not at all
vec_count(x, sort = "none")
```

---

|               |                               |
|---------------|-------------------------------|
| vec_duplicate | <i>Find duplicated values</i> |
|---------------|-------------------------------|

---

### Description

- `vec_duplicate_any()`: detects the presence of duplicated values, similar to `anyDuplicated()`.
- `vec_duplicate_detect()`: returns a logical vector describing if each element of the vector is duplicated elsewhere. Unlike `duplicated()`, it reports all duplicated values, not just the second and subsequent repetitions.
- `vec_duplicate_id()`: returns an integer vector giving the location of the first occurrence of the value.

### Usage

```
vec_duplicate_any(x)
```

```
vec_duplicate_detect(x)
```

```
vec_duplicate_id(x)
```

### Arguments

`x`                    A vector (including a data frame).

### Value

- `vec_duplicate_any()`: a logical vector of length 1.
- `vec_duplicate_detect()`: a logical vector the same length as `x`.
- `vec_duplicate_id()`: an integer vector the same length as `x`.

### Missing values

In most cases, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. This behaviour would be unappealing here, so these functions consider all NAs to be equal. (Similarly, all NaN are also considered to be equal.)

### See Also

[vec\\_unique\(\)](#) for functions that work with the dual of duplicated values: unique values.

### Examples

```
vec_duplicate_any(1:10)
vec_duplicate_any(c(1, 1:10))

x <- c(10, 10, 20, 30, 30, 40)
vec_duplicate_detect(x)
# Note that `duplicated()` doesn't consider the first instance to
# be a duplicate
duplicated(x)
```

```

# Identify elements of a vector by the location of the first element that
# they're equal to:
vec_duplicate_id(x)
# Location of the unique values:
vec_unique_loc(x)
# Equivalent to `duplicated()` :
vec_duplicate_id(x) == seq_along(x)

```

---

|           |                                      |
|-----------|--------------------------------------|
| vec_equal | <i>Test if two vectors are equal</i> |
|-----------|--------------------------------------|

---

### Description

vec\_equal\_na() tests a special case: equality with NA. It is similar to [is.na](#) but:

- Considers the missing element of a list to be NULL.
- Considered data frames and records to be missing if every component is missing. This preserves the invariant that `vec_equal_na(x)` is equal to `vec_equal(x, vec_init(x), na_equal = TRUE)`.

### Usage

```
vec_equal(x, y, na_equal = FALSE, .ptype = NULL)
```

```
vec_equal_na(x)
```

### Arguments

|          |  |
|----------|--|
| x        | Vectors with compatible types and lengths. |
| y        | Vectors with compatible types and lengths. |
| na_equal | Should NA values be considered equal?      |
| .ptype   | Override to optionally specify common type |

### Value

A logical vector the same size as. Will only contain NAs if `na_equal` is FALSE.

### Examples

```

vec_equal(c(TRUE, FALSE, NA), FALSE)
vec_equal(c(TRUE, FALSE, NA), FALSE, na_equal = TRUE)
vec_equal_na(c(TRUE, FALSE, NA))

vec_equal(5, 1:10)
vec_equal("d", letters[1:10])

df <- data.frame(x = c(1, 1, 2, 1, NA), y = c(1, 2, 1, NA, NA))
vec_equal(df, data.frame(x = 1, y = 2))
vec_equal_na(df)

```

---

|          |                            |
|----------|----------------------------|
| vec_init | <i>Initialize a vector</i> |
|----------|----------------------------|

---

**Description**

Initialize a vector

**Usage**

```
vec_init(x, n = 1L)
```

**Arguments**

|   |                                   |
|---|-----------------------------------|
| x | Template of vector to initialize. |
| n | Desired size of result.           |

**Examples**

```
vec_init(1:10, 3)
vec_init(Sys.Date(), 5)
vec_init(mtcars, 2)
```

---

|             |                              |
|-------------|------------------------------|
| vec_is_list | <i>Is the object a list?</i> |
|-------------|------------------------------|

---

**Description**

vec\_is\_list() tests if x is considered a list in the vctrs sense. It returns TRUE if:

- x is a bare list with no class.
- x is a list explicitly inheriting from "list".

**Usage**

```
vec_is_list(x)
```

**Arguments**

|   |            |
|---|------------|
| x | An object. |
|---|------------|

**Details**

Notably, data frames and S3 record style classes like POSIXlt are not considered lists.

If x inherits explicitly from "list", it is also required that the proxy returned by [vec\\_proxy\(\)](#) is a list. If it is not, an error is thrown.

**Examples**

```
vec_is_list(list())
vec_is_list(list_of(1))

vec_is_list(data.frame())
```

---

`vec_match`*Find matching observations across vectors*

---

### Description

`vec_in()` returns a logical vector based on whether `needle` is found in `haystack`. `vec_match()` returns an integer vector giving location of `needle` in `haystack`, or NA if it's not found.

### Usage

```
vec_match(  
  needles,  
  haystack,  
  ...,  
  na_equal = TRUE,  
  needles_arg = "",  
  haystack_arg = ""  
)  
  
vec_in(  
  needles,  
  haystack,  
  ...,  
  na_equal = TRUE,  
  needles_arg = "",  
  haystack_arg = ""  
)
```

### Arguments

`needles`, `haystack`

Vector of `needles` to search for in vector `haystack`. `haystack` should usually be unique; if not `vec_match()` will only return the location of the first match. `needles` and `haystack` are coerced to the same type prior to comparison.

... These dots are for future extensions and must be empty.

`na_equal` If TRUE, missing values in `needles` can be matched to missing values in `haystack`. If FALSE, they propagate, missing values in `needles` are represented as NA in the return value.

`needles_arg`, `haystack_arg`

Argument tags for `needles` and `haystack` used in error messages.

### Details

`vec_in()` is equivalent to `%in%`; `vec_match()` is equivalent to `match()`.

### Value

A vector the same length as `needles`. `vec_in()` returns a logical vector; `vec_match()` returns an integer vector.

**Missing values**

In most cases places in R, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. The exception is in matching functions like `match()` and `merge()`, where an NA will match another NA. By `vec_match()` and `vec_in()` will match NAs; but you can control this behaviour with the `na_equal` argument.

**Examples**

```
hadley <- strsplit("hadley", "")[[1]]
vec_match(hadley, letters)

vowels <- c("a", "e", "i", "o", "u")
vec_match(hadley, vowels)
vec_in(hadley, vowels)

# Only the first index of duplicates is returned
vec_match(c("a", "b"), c("a", "b", "a", "b"))
```

vec\_order

*Order and sort vectors***Description**

Order and sort vectors

**Usage**

```
vec_order(x, direction = c("asc", "desc"), na_value = c("largest", "smallest"))
vec_sort(x, direction = c("asc", "desc"), na_value = c("largest", "smallest"))
```

**Arguments**

|                        |  |
|------------------------|--|
| <code>x</code>         | A vector   |
| <code>direction</code> | Direction to sort in. Defaults to ascending.             |
| <code>na_value</code>  | Should NAs be treated as the largest or smallest values? |

**Value**

- `vec_order()` an integer vector the same size as `x`.
- `vec_sort()` a vector with the same size and type as `x`.

**Examples**

```
x <- round(c(runif(9), NA), 3)
vec_order(x)
vec_sort(x)
vec_sort(x, "desc")

# Can also handle data frames
df <- data.frame(g = sample(2, 10, replace = TRUE), x = x)
vec_order(df)
vec_sort(df)
vec_sort(df, "desc")
```

vec\_ptype

*Find the prototype of a set of vectors***Description**

vec\_ptype() returns the unfinalised prototype of a single vector. vec\_ptype\_common() finds the common type of multiple vectors. vec\_ptype\_show() nicely prints the common type of any number of inputs, and is designed for interactive exploration.

**Usage**

```
vec_ptype(x, ..., x_arg = "")
```

```
vec_ptype_common(..., .ptype = NULL)
```

```
vec_ptype_show(...)
```

**Arguments**

x                    A vector

...                   For vec\_ptype(), these dots are for future extensions and must be empty.  
For vec\_ptype\_common() and vec\_ptype\_show(), vector inputs.

x\_arg                Argument name for x. This is used in error messages to inform the user about the locations of incompatible types.

.ptype                If NULL, the default, the output type is determined by computing the common type across all elements of ...

Alternatively, you can supply .ptype to give the output known type. If `getOption("vctrs.no_guess")` is TRUE you must supply this value: this is a convenient way to make production code demand fixed types.

**Value**

vec\_ptype() and vec\_ptype\_common() return a prototype (a size-0 vector)

**vec\_ptype()**

vec\_ptype() returns [size 0](#) vectors potentially containing attributes but no data. Generally, this is just `vec_slice(x, 0L)`, but some inputs require special handling.

- While you can't slice NULL, the prototype of NULL is itself. This is because we treat NULL as an identity value in the `vec_ptype2()` monoid.
- The prototype of logical vectors that only contain missing values is the special [unspecified](#) type, which can be coerced to any other 1d type. This allows bare NAs to represent missing values for any 1d vector type.

See [internal-faq-ptype2-identity](#) for more information about identity values.

Because it may contain unspecified vectors, the prototype returned by `vec_ptype()` is said to be **unfinalised**. Call `vec_ptype_finalise()` to finalise it. Commonly you will need the finalised prototype as returned by `vec_slice(x, 0L)`.

vec\_ptype\_common()

vec\_ptype\_common() first finds the prototype of each input, then successively calls `vec_ptype2()` to find a common type. It returns a **finalised** prototype.

### Examples

```
# Unknown types -----
vec_ptype_show()
vec_ptype_show(NA)
vec_ptype_show(NULL)

# Vectors -----
vec_ptype_show(1:10)
vec_ptype_show(letters)
vec_ptype_show(TRUE)

vec_ptype_show(Sys.Date())
vec_ptype_show(Sys.time())
vec_ptype_show(factor("a"))
vec_ptype_show(ordered("a"))

# Matrices -----
# The prototype of a matrix includes the number of columns
vec_ptype_show(array(1, dim = c(1, 2)))
vec_ptype_show(array("x", dim = c(1, 2)))

# Data frames -----
# The prototype of a data frame includes the prototype of
# every column
vec_ptype_show(iris)

# The prototype of multiple data frames includes the prototype
# of every column that in any data frame
vec_ptype_show(
  data.frame(x = TRUE),
  data.frame(y = 2),
  data.frame(z = "a")
)
```

---

vec\_ptype2.logical      *Find the common type for a pair of vectors*

---

### Description

vec\_ptype2() defines the coercion hierarchy for a set of related vector types. Along with `vec_cast()`, this generic forms the foundation of type coercions in vctrs.

vec\_ptype2() is relevant when you are implementing vctrs methods for your class, but it should not usually be called directly. If you need to find the common type of a set of inputs, call `vec_ptype_common()` instead. This function supports multiple inputs and **finalises** the common type.

**Usage**

```
## S3 method for class 'logical'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'integer'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'double'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'complex'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'character'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'raw'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

## S3 method for class 'list'
vec_ptype2(x, y, ..., x_arg = "", y_arg = "")

vec_ptype2(x, y, ..., x_arg = "", y_arg = "")
```

**Arguments**

|              |  |
|--------------|--|
| x, y         | Vector types.  |
| ...          | These dots are for future extensions and must be empty.  |
| x_arg, y_arg | Argument names for x and y. These are used in error messages to inform the user about the locations of incompatible types (see <a href="#">stop_incompatible_type()</a> ). |

**Implementing coercion methods**

- For an overview of how these generics work and their roles in vctrs, see [?theory-faq-coercion](#).
- For an example of implementing coercion methods for simple vectors, see [?howto-faq-coercion](#).
- For an example of implementing coercion methods for data frame subclasses, see [?howto-faq-coercion-data-frame](#).
- For a tutorial about implementing vctrs classes from scratch, see `vignette("s3-vector")`.

**See Also**

[stop\\_incompatible\\_type\(\)](#) when you determine from the attributes that an input can't be cast to the target type.

**Description**

`vec_recycle(x, size)` recycles a single vector to given size. `vec_recycle_common(...)` recycles multiple vectors to their common size. All functions obey the vctrs recycling rules, described below, and will throw an error if recycling is not possible. See `vec_size()` for the precise definition of size.

**Usage**

```
vec_recycle(x, size, ..., x_arg = "")
```

```
vec_recycle_common(..., .size = NULL)
```

**Arguments**

|                    |   |
|--------------------|---|
| <code>x</code>     | A vector to recycle.  |
| <code>size</code>  | Desired output size.  |
| <code>...</code>   | <ul style="list-style-type: none"> <li>• For <code>vec_recycle_common()</code>, vectors to recycle.</li> <li>– For <code>vec_recycle()</code>, these dots should be empty.</li> </ul> |
| <code>x_arg</code> | Argument name for <code>x</code> . These are used in error messages to inform the user about which argument has an incompatible size.   |
| <code>.size</code> | Desired output size. If omitted, will use the common size from <code>vec_size_common()</code> .   |

**Recycling rules**

The common size of two vectors defines the recycling rules, and can be summarise with the following table:

|   | 1 | m | n |
|---|---|---|---|
| 1 | 1 | m | n |
| m | m | m | X |
| n | n | X | n |

(Note NULLs are handled specially; they are treated like empty arguments and hence don't affect the size)

This is a stricter set of rules than base R, which will usually return output of length  $\max(n_x, n_y)$ , warning if the length of the longer vector is not an integer multiple of the length of the shorter.

We say that two vectors have **compatible size** if they can be recycled to be the same length.

### Examples

```
# Inputs with 1 observation are recycled
vec_recycle_common(1:5, 5)
vec_recycle_common(integer(), 5)
## Not run:
vec_recycle_common(1:5, 1:2)

## End(Not run)

# Data frames and matrices are recycled along their rows
vec_recycle_common(data.frame(x = 1), 1:5)
vec_recycle_common(array(1:2, c(1, 2)), 1:5)
vec_recycle_common(array(1:3, c(1, 3, 1)), 1:5)
```

---

vec\_seq\_along

*Useful sequences*

---

### Description

vec\_seq\_along() is equivalent to [seq\\_along\(\)](#) but uses size, not length. vec\_init\_along() creates a vector of missing values with size matching an existing object.

### Usage

```
vec_seq_along(x)
```

```
vec_init_along(x, y = x)
```

### Arguments

x, y                      Vectors

### Value

- vec\_seq\_along() an integer vector with the same size as x.
- vec\_init\_along() a vector with the same type as x and the same size as y.

### Examples

```
vec_seq_along(mtcars)
vec_init_along(head(mtcars))
```

---

|          |                               |
|----------|-------------------------------|
| vec_size | <i>Number of observations</i> |
|----------|-------------------------------|

---

### Description

vec\_size(x) returns the size of a vector. vec\_is\_empty() returns TRUE if the size is zero, FALSE otherwise.

The size is distinct from the length() of a vector because it generalises to the "number of observations" for 2d structures, i.e. it's the number of rows in matrix or a data frame. This definition has the important property that every column of a data frame (even data frame and matrix columns) have the same size. vec\_size\_common(...) returns the common size of multiple vectors.

list\_sizes() returns an integer vector containing the size of each element of a list. It is nearly equivalent to, but faster than, map\_int(x, vec\_size), with the exception that list\_sizes() will error on non-list inputs, as defined by vec\_is\_list(). list\_sizes() is to vec\_size() as lengths() is to length().

### Usage

```
vec_size(x)
```

```
vec_size_common(..., .size = NULL, .absent = 0L)
```

```
list_sizes(x)
```

```
vec_is_empty(x)
```

### Arguments

|         |   |
|---------|---|
| x, ...  | Vector inputs or NULL.  |
| .size   | If NULL, the default, the output size is determined by recycling the lengths of all elements of ... Alternatively, you can supply .size to force a known size; in this case, x and ... are ignored. |
| .absent | The size used when no input is provided, or when all input is NULL. If left as NULL when no input is supplied, an error is thrown.  |

### Details

There is no vctrs helper that retrieves the number of columns: as this is a property of the [type](#).

vec\_size() is equivalent to NROW() but has a name that is easier to pronounce, and throws an error when passed non-vector inputs.

### Value

An integer (or double for long vectors).

vec\_size\_common() returns .absent if all inputs are NULL or absent, 0L by default.

### Invariants

- `vec_size(dataframe) == vec_size(dataframe[[i]])`
- `vec_size(matrix) == vec_size(matrix[,i,drop = FALSE])`
- `vec_size(vec_c(x,y)) == vec_size(x) + vec_size(y)`

**The size of NULL**

The size of NULL is hard-coded to 0L in `vec_size()`. `vec_size_common()` returns `.absent` when all inputs are NULL (if only some inputs are NULL, they are simply ignored).

A default size of 0 makes sense because sizes are most often queried in order to compute a total size while assembling a collection of vectors. Since we treat NULL as an absent input by principle, we return the identity of sizes under addition to reflect that an absent input doesn't take up any size.

Note that other defaults might make sense under different circumstances. For instance, a default size of 1 makes sense for finding the common size because 1 is the identity of the recycling rules.

**See Also**

`vec_slice()` for a variation of `[]` compatible with `vec_size()`, and `vec_recycle()` to recycle vectors to common length.

**Examples**

```
vec_size(1:100)
vec_size(mtcars)
vec_size(array(dim = c(3, 5, 10)))

vec_size_common(1:10, 1:10)
vec_size_common(1:10, 1)
vec_size_common(integer(), 1)

list_sizes(list("a", 1:5, letters))
```

---

vec\_split

*Split a vector into groups*


---

**Description**

This is a generalisation of `split()` that can split by any type of vector, not just factors. Instead of returning the keys in the character names, they are returned in a separate parallel vector.

**Usage**

```
vec_split(x, by)
```

**Arguments**

|                 |  |
|-----------------|--|
| <code>x</code>  | Vector to divide into groups.                  |
| <code>by</code> | Vector whose unique values defines the groups. |

**Value**

A data frame with two columns and size equal to `vec_size(vec_unique(by))`. The key column has the same type as `by`, and the `val` column is a list containing elements of type `vec_ptype(x)`.

Note for complex types, the default data.frame print method will be suboptimal, and you will want to coerce into a tibble to better understand the output.

## Examples

```
vec_split(mtcars$cyl, mtcars$vs)
vec_split(mtcars$cyl, mtcars[c("vs", "am")])

if (require("tibble")) {
  as_tibble(vec_split(mtcars$cyl, mtcars[c("vs", "am")]))
  as_tibble(vec_split(mtcars, mtcars[c("vs", "am")]))
}
```

---

vec\_unique

*Find and count unique values*

---

## Description

- `vec_unique()`: the unique values. Equivalent to `unique()`.
- `vec_unique_loc()`: the locations of the unique values.
- `vec_unique_count()`: the number of unique values.

## Usage

```
vec_unique(x)
```

```
vec_unique_loc(x)
```

```
vec_unique_count(x)
```

## Arguments

`x` A vector (including a data frame).

## Value

- `vec_unique()`: a vector the same type as `x` containing only unique values.
- `vec_unique_loc()`: an integer vector, giving locations of unique values.
- `vec_unique_count()`: an integer vector of length 1, giving the number of unique values.

## Missing values

In most cases, missing values are not considered to be equal, i.e. `NA == NA` is not `TRUE`. This behaviour would be unappealing here, so these functions consider all `NA`s to be equal. (Similarly, all `NaN` are also considered to be equal.)

## See Also

[vec\\_duplicate](#) for functions that work with the dual of unique values: duplicated values.

**Examples**

```
x <- rpois(100, 8)
vec_unique(x)
vec_unique_loc(x)
vec_unique_count(x)

# `vec_unique()` returns values in the order that encounters them
# use sort = "location" to match to the result of `vec_count()`
head(vec_unique(x))
head(vec_count(x, sort = "location"))

# Normally missing values are not considered to be equal
NA == NA

# But they are for the purposes of considering uniqueness
vec_unique(c(NA, NA, NA, NA, 1, 2, 1))
```

---

%0%

*Default value for empty vectors*

---

**Description**

Use this inline operator when you need to provide a default value for empty (as defined by [vec\\_is\\_empty\(\)](#)) vectors.

**Usage**

```
x %0% y
```

**Arguments**

|   |   |
|---|---|
| x | A vector  |
| y | Value to use if x is empty. To preserve type-stability, should be the same type as x. |

**Examples**

```
1:10 %0% 5
integer() %0% 5
```

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