

# Package ‘affiner’

January 28, 2026

**Type** Package

**Title** A Finer Way to Render 3D Illustrated Objects in 'grid' Using Affine Transformations

**Version** 0.2.1

**Description** Dilate, permute, project, reflect, rotate, shear, and translate 2D and 3D points. Supports parallel projections including oblique projections such as the cabinet projection as well as axonometric projections such as the isometric projection. Use 'grid's ``affine transformation" feature to render illustrated flat surfaces.

**URL** <https://trevorldavis.com/R/affiner/>

**BugReports** <https://github.com/trevorld/affiner/issues>

**License** MIT + file LICENSE

**Depends** R (>= 3.6.0)

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withr

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|                 |                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------|
| affiner-package | <i>affiner: A Finer Way to Render 3D Illustrated Objects in 'grid' Using Affine Transformations</i> |
|-----------------|-----------------------------------------------------------------------------------------------------|

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Description

Dilate, permute, project, reflect, rotate, shear, and translate 2D and 3D points. Supports parallel projections including oblique projections such as the cabinet projection as well as axonometric projections such as the isometric projection. Use 'grid's "affine transformation" feature to render illustrated flat surfaces.

Package options

The following affiner function arguments may be set globally via `base::options()`:

**affiner\_angular\_unit** The default for the unit argument used by `angle()` and `as_angle()`. The default for this option is "degrees".

**affiner\_grid\_unit** The default for the unit argument used by `affine_settings()`. The default for this option is "inches".

The following cli options may also be of interest:

**cli.unicode** Whether UTF-8 character support should be assumed. Along with `l10n_info()` used to determine the default of the use\_unicode argument of `format.angle()` and `print.angle()`.

Author(s)

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See Also

- Useful links:
- <https://trevorldavis.com/R/affiner/>
  - Report bugs at <https://github.com/trevorld/affiner/issues>

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|             |                               |
|-------------|-------------------------------|
| abs.Coord1D | <i>Compute Euclidean norm</i> |
|-------------|-------------------------------|

---

## Description

abs() computes the Euclidean norm for [Coord2D](#) class objects and [Coord3D](#) class objects.

## Usage

```
## S3 method for class 'Coord1D'
abs(x)

## S3 method for class 'Coord2D'
abs(x)

## S3 method for class 'Coord3D'
abs(x)
```

## Arguments

x                      A [Coord2D](#) class object or [Coord2D](#) class object.

## Value

A numeric vector

## Examples

```
z <- complex(real = 1:4, imaginary = 1:4)
p <- as_coord2d(z)
abs(p) # Euclidean norm
# Less efficient ways to calculate same Euclidean norms
sqrt(p * p) # `*` dot product
distance2d(p, as_coord2d(0, 0, 0))

# In {base} R `abs()` calculates Euclidean norm of complex numbers
all.equal(abs(p), abs(z))
all.equal(Mod(p), Mod(z))

p3 <- as_coord3d(x = 1:4, y = 1:4, z = 1:4)
abs(p3)
```

---

|            |                                   |
|------------|-----------------------------------|
| affineGrob | <i>Affine transformation grob</i> |
|------------|-----------------------------------|

---

## Description

`affineGrob()` is a grid grob function to facilitate using the group affine transformation features introduced in R 4.2.

## Usage

```
affineGrob(
  grob,
  vp_define = NULL,
  transform = NULL,
  vp_use = NULL,
  name = NULL,
  gp = grid::gpar(),
  vp = NULL
)

grid.affine(...)
```

## Arguments

|                        |                                                                                                                                                                                                                                                                                                                                                              |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>grob</code>      | A grid grob to perform affine transformations on. Passed to <code>grid::defineGrob()</code> as its <code>src</code> argument.                                                                                                                                                                                                                                |
| <code>vp_define</code> | <code>grid::viewport()</code> to define grid group in. Passed to <code>grid::defineGrob()</code> as its <code>vp</code> argument. This will cumulative with the current viewport and the <code>vp</code> argument (if any), if this cumulative viewport falls outside the graphics device drawing area this grob may be clipped on certain graphics devices. |
| <code>transform</code> | An affine transformation function. If NULL default to <code>grid::viewportTransform()</code> . Passed to <code>grid::useGrob()</code> as its <code>transform</code> argument.                                                                                                                                                                                |
| <code>vp_use</code>    | <code>grid::viewport()</code> passed to <code>grid::useGrob()</code> as its <code>vp</code> argument.                                                                                                                                                                                                                                                        |
| <code>name</code>      | A character identifier (for grid).                                                                                                                                                                                                                                                                                                                           |
| <code>gp</code>        | A <code>grid::gpar()</code> object.                                                                                                                                                                                                                                                                                                                          |
| <code>vp</code>        | A <code>grid::viewport()</code> object (or NULL).                                                                                                                                                                                                                                                                                                            |
| <code>...</code>       | Passed to <code>affineGrob()</code>                                                                                                                                                                                                                                                                                                                          |

## Details

Not all graphics devices provided by `grDevices` or other R packages support the **affine transformation feature introduced in R 4.2**. If `isTRUE(getRversion() >= '4.2.0')` then the active graphics device should support this feature if `isTRUE(grDevices::dev.capabilities()$transformations)`. In particular the following graphics devices should support the affine transformation feature:

- R's `grDevices::pdf()` device
- R's 'cairo' devices e.g. `grDevices::cairo_pdf()`, `grDevices::png(type = 'cairo')`, `grDevices::svg()`, `grDevices::x11(type = 'cairo')`, etc. If `isTRUE(capabilities('cairo'))` then R was compiled with support for the 'cairo' devices .
- R's 'quartz' devices (since R 4.3.0) e.g. `grDevices::quartz()`, `grDevices::png(type = 'quartz')`, etc. If `isTRUE(capabilities('aqua'))` then R was compiled with support for the 'quartz' devices (generally only TRUE on macOS systems).
- ragg's devices (since v1.3.0) e.g. `ragg::agg_png()`, `ragg::agg_capture()`, etc.

### Value

A `grid::gTree()` (grob) object of class "affine". As a side effect `grid.affine()` draws to the active graphics device.

### See Also

See `affine_settings()` for computing good transform and `vp_use` settings. See <https://www.stat.auckland.ac.nz/~paul/Reports/GraphicsEngine/groups/groups.html> for more information about the group affine transformation feature. See `isocubeGrob()` which wraps this function to render isometric cubes.

### Examples

```
if (require("grid")) {
  grob <- grobTree(rectGrob(gp = gpar(fill = "blue", col = NA)),
                  circleGrob(gp=gpar(fill="yellow", col = NA)),
                  textGrob("RSTATS", gp=gpar(fontsize=32)))
  grid.newpage()
  pushViewport(viewport(width=unit(4, "in"), height=unit(2, "in")))
  grid.draw(grob)
  popViewport()
}

if (require("grid") &&
    getRversion() >= "4.2.0" &&
    isTRUE(dev.capabilities()$transformations)) {
  # Only works if active graphics device supports affine transformations
  # such as `png(type="cairo")` on R 4.2+
  vp_define <- viewport(width=unit(2, "in"), height=unit(2, "in"))
  affine <- affineGrob(grob, vp_define=vp_define)
  grid.newpage()
  pushViewport(viewport(width=unit(4, "in"), height=unit(2, "in")))
  grid.draw(affine)
  popViewport()
}

if (require("grid") &&
    getRversion() >= "4.2.0" &&
    isTRUE(dev.capabilities()$transformations)) {
  # Only works if active graphics device supports affine transformations
  # such as `png(type="cairo")` on R 4.2+
  settings <- affine_settings(xy = list(x = c(3/3, 2/3, 0/3, 1/3),
```

```

                                y = c(2/3, 1/3, 1/3, 2/3)),
                                unit = "snpc")
affine <- affineGrob(grob,
                    vp_define = vp_define,
                    transform = settings$transform,
                    vp_use = settings$vp)
grid.newpage()
grid.draw(affine)
}

```

---

|                 |                            |
|-----------------|----------------------------|
| affiner_options | <i>Get affiner options</i> |
|-----------------|----------------------------|

---

## Description

`affiner_options()` returns the affiner package's global options.

## Usage

```
affiner_options(..., default = FALSE)
```

## Arguments

|                      |                                                                                                                                        |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <code>...</code>     | affiner package options using <code>name = value</code> . The return list will use any of these instead of the current/default values. |
| <code>default</code> | If TRUE return the default values instead of current values.                                                                           |

## Value

A list of option values. Note this function **does not** set option values itself but this list can be passed to `options()`, `withr::local_options()`, or `withr::with_options()`.

## See Also

[affiner](#) for a high-level description of relevant global options.

## Examples

```

affiner_options()

affiner_options(default = TRUE)

affiner_options(affiner_angular_unit = "pi-radians")

```

---

|                 |                                                                                          |
|-----------------|------------------------------------------------------------------------------------------|
| affine_settings | <i>Compute grid affine transformation feature viewports and transformation functions</i> |
|-----------------|------------------------------------------------------------------------------------------|

---

## Description

`affine_settings()` computes grid group affine transformation feature viewport and transformation function settings given the (x,y) coordinates of the corners of the affine transformed "viewport" one wishes to draw in.

## Usage

```
affine_settings(
  xy = data.frame(x = c(0, 0, 1, 1), y = c(1, 0, 0, 1)),
  unit = getOption("affiner_grid_unit", "inches")
)
```

## Arguments

|                   |                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>xy</code>   | An R object with named elements <code>x</code> and <code>y</code> representing the (x,y) coordinates of the affine transformed "viewport" one wishes to draw in. The (x,y) coordinates of the "viewport" should be in "upper left", "lower left", "lower right", and "upper right" order (this ordering should be from the perspective of <b>before</b> the "affine transformation" of the "viewport"). |
| <code>unit</code> | Which <code>grid::unit()</code> to assume the xy "x" and "y" coordinates are expressed in.                                                                                                                                                                                                                                                                                                              |

## Value

A named list with the following group affine transformation feature viewport and functions settings:

**transform** An affine transformation function to pass to `affineGrob()` or `useGrob()`. If `getRversion()` is less than "4.2.0" will instead be NULL.

**vp** A `grid::viewport()` object to pass to `affineGrob()` or `useGrob()`.

**sx** x-axis sx factor

**flipX** whether the affine transformed "viewport" is "flipped" horizontally

**x** x-coordinate for viewport

**y** y-coordinate for viewport

**width** Width of viewport

**height** Height of viewport

**default.units** Default `grid::unit()` for viewport

**angle** angle for viewport

## Usage in other packages

To avoid taking a dependency on `affiner` you may copy the source of `affine_settings()` into your own package under the permissive Unlicense. Either use `usethis::use_standalone("trevorld/affiner", "standalone-affine-settings.r")` or copy the file `standalone-affine-settings.r` into your R directory and add `grid` to the Imports of your DESCRIPTION file.

## See Also

Intended for use with `affineGrob()` and `grid::useGrob()`. See <https://www.stat.auckland.ac.nz/~paul/Reports/GraphicsEngine/groups/groups.html> for more information about the group affine transformation feature.

## Examples

```
if (require("grid")) {
  grob <- grobTree(rectGrob(gp = gpar(fill = "blue", col = NA)),
                  circleGrob(gp=gpar(fill="yellow", col = NA)),
                  textGrob("RSTATS", gp=gpar(fontsize=32)))

  grid.newpage()
  pushViewport(viewport(width=unit(4, "in"), height=unit(2, "in")))
  grid.draw(grob)
  popViewport()
}

if (require("grid") &&
    getRversion() >= "4.2.0" &&
    isTRUE(dev.capabilities()$transformations)) {
  # Only works if active graphics device supports affine transformations
  # such as `png(type="cairo")` on R 4.2+
  vp_define <- viewport(width=unit(2, "in"), height=unit(2, "in"))
  settings <- affine_settings(xy = list(x = c(1/3, 0/3, 2/3, 3/3),
                                          y = c(2/3, 1/3, 1/3, 2/3)),
                             unit = "snpc")

  affine <- affineGrob(grob,
                      vp_define=vp_define,
                      transform = settings$transform,
                      vp_use = settings$vp)

  grid.newpage()
  grid.draw(affine)
}

if (require("grid") &&
    getRversion() >= "4.2.0" &&
    isTRUE(dev.capabilities()$transformations)) {
  # Only works if active graphics device supports affine transformations
  # such as `png(type="cairo")` on R 4.2+
  settings <- affine_settings(xy = list(x = c(3/3, 2/3, 0/3, 1/3),
                                          y = c(2/3, 1/3, 1/3, 2/3)),
                             unit = "snpc")

  affine <- affineGrob(grob,
                      vp_define=vp_define,
                      transform = settings$transform,
                      vp_use = settings$vp)
```

```

    grid.newpage()
    grid.draw(affine)
}

```

---

angle

*Angle vectors*


---

### Description

angle() creates angle vectors with user specified angular unit. around [as\\_angle\(\)](#) for those angular units.

### Usage

```
angle(x = numeric(), unit = getOption("affiner_angular_unit", "degrees"))
```

```
degrees(x)
```

```
gradians(x)
```

```
pi_radians(x)
```

```
radians(x)
```

```
turns(x)
```

### Arguments

- |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x    | An angle vector or an object to convert to it (such as a numeric vector)                                                                                                                                                                                                                                                                                                                                                                                                                  |
| unit | <p>A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"):</p> <ul style="list-style-type: none"> <li>• "deg" or "degree"</li> <li>• "half-revolution", "half-turn", or "pi-radian"</li> <li>• "gon", "grad", "grade", or "gradian"</li> <li>• "rad" or "radian"</li> <li>• "rev", "revolution", "tr", or "turn"</li> </ul> |

### Value

A numeric vector of class "angle". Its "unit" attribute is a standardized string of the specified angular unit.

### See Also

[as\\_angle\(\)](#), [angular\\_unit\(\)](#), and [angle-methods](#). <https://en.wikipedia.org/wiki/Angle#Units> for more information about angular units.

**Examples**

```
# Different representations of the "same" angle
angle(180, "degrees")
angle(pi, "radians")
angle(0.5, "turns")
angle(200, "gradians")
pi_radians(1)

a1 <- angle(180, "degrees")
angular_unit(a1)
is_angle(a1)
as.numeric(a1, "radians")
cos(a1)

a2 <- as_angle(a1, "radians")
angular_unit(a2)
is_congruent(a1, a2)
```

angle-methods

*Implemented base methods for angle vectors***Description**

We implemented methods for several base generics for the `angle()` vectors.

**Usage**

```
## S3 method for class 'angle'
as.double(x, unit = angular_unit(x), ...)

## S3 method for class 'angle'
as.complex(x, modulus = 1, ...)

## S3 method for class 'angle'
format(x, unit = angular_unit(x), ..., use_unicode = is_utf8_output())

## S3 method for class 'angle'
print(x, unit = angular_unit(x), ..., use_unicode = is_utf8_output())

## S3 method for class 'angle'
abs(x)
```

**Arguments**

|                   |                                                                                                                                                                                                                       |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>    | <code>angle()</code> vector                                                                                                                                                                                           |
| <code>unit</code> | A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"): |

|             |                                                                                                                                                                                                                                                              |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | <ul style="list-style-type: none"> <li>• "deg" or "degree"</li> <li>• "half-revolution", "half-turn", or "pi-radian"</li> <li>• "gon", "grad", "grade", or "gradian"</li> <li>• "rad" or "radian"</li> <li>• "rev", "revolution", "tr", or "turn"</li> </ul> |
| ...         | Passed to <code>print.default()</code>                                                                                                                                                                                                                       |
| modulus     | Numeric vector representing the complex numbers' modulus                                                                                                                                                                                                     |
| use_unicode | If TRUE use Unicode symbols as appropriate.                                                                                                                                                                                                                  |

### Details

- Mathematical `Ops` (in particular `+` and `-`) for two angle vectors will (if necessary) set the second vector's `angular_unit()` to match the first.
- `as.numeric()` takes a unit argument which can be used to convert angles into other angular units e.g. `angle(x, "degrees") |> as.numeric("radians")` to cast a numeric vector `x` from degrees to radians.
- `abs()` will calculate the angle modulo full turns.
- Use `is_congruent()` to test if two angles are congruent instead of `==` or `all.equal()`.
- Not all implemented methods are documented here and since `angle()` is a `numeric()` class many other S3 generics besides the explicitly implemented ones should also work with it.

### Value

Typical values as usually returned by these base generics.

### Examples

```
# Two "congruent" angles
a1 <- angle(180, "degrees")
a2 <- angle(pi, "radians")

print(a1)
print(a1, unit = "radians")
print(a1, unit = "pi-radians")

cos(a1)
sin(a1)
tan(a1)

# mathematical operations will coerce second `angle()` object to
# same `angular_unit()` as the first one
a1 + a2
a1 - a2

as.numeric(a1)
as.numeric(a1, "radians")
as.numeric(a1, "turns")
```

```
# Use `is_congruent()` to check if two angles are "congruent"
a1 == a2
isTRUE(all.equal(a1, a2))
is_congruent(a1, a2)
is_congruent(a1, a2, mod_turns = FALSE)
a3 <- angle(-180, "degrees") # Only congruent modulus full turns
a1 == a3
isTRUE(all.equal(a1, a2))
is_congruent(a1, a3)
is_congruent(a1, a3, mod_turns = FALSE)
```

---

angular\_unit

*Get/set angular unit of angle vectors*


---

### Description

angular\_unit() gets/sets the angular unit of [angle\(\)](#) vectors.

### Usage

```
angular_unit(x)
```

```
angular_unit(x) <- value
```

### Arguments

x                    An [angle\(\)](#) vector

value                A string of the desired angular unit. See [angle\(\)](#) for supported strings.

### Value

angular\_unit() returns a string of x's angular unit.

### Examples

```
a <- angle(seq(0, 360, by = 90), "degrees")
angular_unit(a)
print(a)
angular_unit(a) <- "turns"
angular_unit(a)
print(a)
```

as\_angle

*Cast to angle vector***Description**

as\_angle() casts to an [angle\(\)](#) vector

**Usage**

```
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'angle'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'character'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'complex'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'Coord2D'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'Coord3D'
as_angle(
  x,
  unit = getOption("affiner_angular_unit", "degrees"),
  type = c("azimuth", "inclination"),
  ...
)

## S3 method for class 'Line2D'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)

## S3 method for class 'Plane3D'
as_angle(
  x,
  unit = getOption("affiner_angular_unit", "degrees"),
  type = c("azimuth", "inclination"),
  ...
)

## S3 method for class 'numeric'
as_angle(x, unit = getOption("affiner_angular_unit", "degrees"), ...)
```

**Arguments**

x                      An R object to convert to a [angle\(\)](#) vector

|      |                                                                                                                                                                                                                                                              |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| unit | A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"):                                        |
|      | <ul style="list-style-type: none"> <li>• "deg" or "degree"</li> <li>• "half-revolution", "half-turn", or "pi-radian"</li> <li>• "gon", "grad", "grade", or "gradian"</li> <li>• "rad" or "radian"</li> <li>• "rev", "revolution", "tr", or "turn"</li> </ul> |
| ...  | Further arguments passed to or from other methods                                                                                                                                                                                                            |
| type | Use "azimuth" to calculate the azimuthal angle and "inclination" to calculate the inclination angle aka polar angle.                                                                                                                                         |

**Value**

An [angle\(\)](#) vector

**Examples**

```
as_angle(angle(pi, "radians"), "pi-radians")
as_angle(complex(real = 0, imaginary = 1), "degrees")
as_angle(as_coord2d(x = 0, y = 1), "turns")
as_angle(200, "gradians")
```

---

|            |                               |
|------------|-------------------------------|
| as_coord1d | <i>Cast to coord1d object</i> |
|------------|-------------------------------|

---

**Description**

as\_coord1d() casts to a [Coord1D](#) class object

**Usage**

```
as_coord1d(x, ...)

## S3 method for class 'character'
as_coord1d(x, ...)

## S3 method for class 'Coord2D'
as_coord1d(
  x,
  permutation = c("xy", "yx"),
  ...,
  line = as_line2d("x-axis"),
  scale = 0
)
```

```
## S3 method for class 'data.frame'
as_coord1d(x, ...)

## S3 method for class 'list'
as_coord1d(x, ...)

## S3 method for class 'matrix'
as_coord1d(x, ...)

## S3 method for class 'numeric'
as_coord1d(x, ...)

## S3 method for class 'Coord1D'
as_coord1d(x, ...)

## S3 method for class 'Point1D'
as_coord1d(x, ...)
```

### Arguments

|             |                                                                                                                                                                                                               |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x           | An object that can be cast to a <a href="#">Coord1D</a> class object such as a numeric vector of x-coordinates.                                                                                               |
| ...         | Further arguments passed to or from other methods                                                                                                                                                             |
| permutation | Either "xy" (no permutation) or "yx" (permute x and y axes)                                                                                                                                                   |
| line        | A <a href="#">Line2D</a> object of length one representing the line you wish to reflect across or project to or an object coercible to one by <code>as_line2d(line, ...)</code> such as "x-axis" or "y-axis". |
| scale       | Oblique projection scale factor. A degenerate 0 value indicates an orthogonal projection.                                                                                                                     |

### Value

A [Coord1D](#) class object

### Examples

```
as_coord1d(x = rnorm(10))
```

---

|            |                               |
|------------|-------------------------------|
| as_coord2d | <i>Cast to coord2d object</i> |
|------------|-------------------------------|

---

### Description

`as_coord2d()` casts to a [Coord2D](#) class object

**Usage**

```

as_coord2d(x, ...)

## S3 method for class 'angle'
as_coord2d(x, radius = 1, ...)

## S3 method for class 'character'
as_coord2d(x, ...)

## S3 method for class 'complex'
as_coord2d(x, ...)

## S3 method for class 'Coord3D'
as_coord2d(
  x,
  permutation = c("xyz", "xzy", "yxz", "yzx", "zyx", "zxy"),
  ...,
  plane = as_plane3d("xy-plane"),
  scale = 0,
  alpha = angle(45, "degrees")
)

## S3 method for class 'data.frame'
as_coord2d(x, ...)

## S3 method for class 'list'
as_coord2d(x, ...)

## S3 method for class 'matrix'
as_coord2d(x, ...)

## S3 method for class 'numeric'
as_coord2d(x, y = rep_len(0, length(x)), ...)

## S3 method for class 'Coord2D'
as_coord2d(x, ...)

```

**Arguments**

|             |                                                                                                                                                                                                                                                                                     |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x           | An object that can be cast to a <a href="#">Coord2D</a> class object such as a matrix or data frame of coordinates.                                                                                                                                                                 |
| ...         | Further arguments passed to or from other methods                                                                                                                                                                                                                                   |
| radius      | A numeric vector of radial distances.                                                                                                                                                                                                                                               |
| permutation | Either "xyz" (no permutation), "xzy" (permute y and z axes), "yxz" (permute x and y axes), "yzx" (x becomes z, y becomes x, z becomes y), "zxy" (x becomes y, y becomes z, z becomes x), "zyx" (permute x and z axes). This permutation is applied before the (oblique) projection. |

|       |                                                                                                                                                                                                                                                                      |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| plane | A <a href="#">Plane3D</a> class object representing the plane you wish to project to or an object coercible to one using <code>as_plane3d(plane, ...)</code> such as "xy-plane", "xz-plane", or "yz-plane".                                                          |
| scale | Oblique projection foreshortening scale factor. A (degenerate) 0 value indicates an orthographic projection. A value of 0.5 is used by a “cabinet projection” while a value of 1.0 is used by a “cavalier projection”.                                               |
| alpha | Oblique projection angle (the angle the third axis is projected going off at). An <a href="#">angle()</a> object or one coercible to one with <code>as_angle(alpha, ...)</code> . Popular angles are 45 degrees, 60 degrees, and <code>arctangent(2)</code> degrees. |
| y     | Numeric vector of y-coordinates to be used.                                                                                                                                                                                                                          |

**Value**

A [Coord2D](#) class object

**Examples**

```
df <- data.frame(x = sample.int(10, 3),
                 y = sample.int(10, 3))
as_coord2d(df)
as_coord2d(complex(real = 3, imaginary = 2))
as_coord2d(angle(90, "degrees"), radius = 2)
as_coord2d(as_coord3d(1, 2, 2), alpha = degrees(90), scale = 0.5)
```

---

|            |                               |
|------------|-------------------------------|
| as_coord3d | <i>Cast to coord3d object</i> |
|------------|-------------------------------|

---

**Description**

`as_coord3d()` casts to a [Coord3D](#) class object

**Usage**

```
as_coord3d(x, ...)

## S3 method for class 'angle'
as_coord3d(x, radius = 1, inclination = NULL, z = NULL, ...)

## S3 method for class 'character'
as_coord3d(x, ...)

## S3 method for class 'data.frame'
as_coord3d(x, ..., z = NULL)

## S3 method for class 'list'
as_coord3d(x, ..., z = NULL)
```

```
## S3 method for class 'matrix'
as_coord3d(x, ...)

## S3 method for class 'numeric'
as_coord3d(x, y = rep_len(0, length(x)), z = rep_len(0, length(x)), ...)

## S3 method for class 'Coord3D'
as_coord3d(x, ...)

## S3 method for class 'Coord2D'
as_coord3d(x, z = rep_len(0, length(x)), ...)
```

### Arguments

|             |                                                                                                                                                                                   |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x           | An object that can be cast to a <a href="#">Coord3D</a> class object such as a matrix or data frame of coordinates.                                                               |
| ...         | Further arguments passed to or from other methods                                                                                                                                 |
| radius      | A numeric vector. If inclination is not NULL represents spherical distances of spherical coordinates and if z is not NULL represents radial distances of cylindrical coordinates. |
| inclination | Spherical coordinates inclination angle aka polar angle. x represents the azimuth aka azimuthal angle.                                                                            |
| z           | Numeric vector of z-coordinates to be used                                                                                                                                        |
| y           | Numeric vector of y-coordinates to be used if <code>hasName(x, "z")</code> is FALSE.                                                                                              |

### Value

A [Coord3D](#) class object

### Examples

```
as_coord3d(x = 1, y = 2, z = 3)
df <- data.frame(x = sample.int(10, 3),
                 y = sample.int(10, 3),
                 z = sample.int(10, 3))
as_coord3d(df)
# Cylindrical coordinates
as_coord3d(degrees(90), z = 1, radius = 1)
# Spherical coordinates
as_coord3d(degrees(90), inclination = degrees(90), radius = 1)
```

---

as\_line2d

---

*Cast to Line2D object*


---

### Description

`as_line2d()` casts to a [Line2D](#) object.

**Usage**

```

as_line2d(...)

## S3 method for class 'numeric'
as_line2d(a, b, c, ...)

## S3 method for class 'angle'
as_line2d(theta, p1 = as_coord2d("origin"), ...)

## S3 method for class 'character'
as_line2d(x, ...)

## S3 method for class 'Coord2D'
as_line2d(normal, p1 = as_coord3d("origin"), p2, ...)

## S3 method for class 'Line2D'
as_line2d(line, ...)

## S3 method for class 'Point1D'
as_line2d(point, b = 0, ...)

```

**Arguments**

|         |                                                                                                                                               |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| ...     | Passed to other function such as <code>as_coord2d()</code> .                                                                                  |
| a, b, c | Numeric vectors that parameterize the line via the equation $a * x + b * y + c = 0$ . Note if $y = m * x + b$ then $m * x + 1 * y + -b = 0$ . |
| theta   | Angle of the line represented by an <a href="#">angle()</a> vector.                                                                           |
| p1      | Point on the line represented by a <a href="#">Coord2D</a> class object.                                                                      |
| x       | A (character) vector to be cast to a <a href="#">Line2D</a> object                                                                            |
| normal  | Normal vector to the line represented by a <a href="#">Coord2D</a> class object. p2 should be missing.                                        |
| p2      | Another point on the line represented by a <a href="#">Coord2D</a> class object.                                                              |
| line    | A <a href="#">Line2D</a> object                                                                                                               |
| point   | A <a href="#">Point1D</a> object                                                                                                              |

**Examples**

```

p1 <- as_coord2d(x = 5, y = 10)
p2 <- as_coord2d(x = 7, y = 12)
theta <- degrees(45)
as_line2d(theta, p1)
as_line2d(p1, p2)

```

---

|            |                               |
|------------|-------------------------------|
| as_plane3d | <i>Cast to Plane3D object</i> |
|------------|-------------------------------|

---

## Description

as\_plane3d() casts to a [Plane3D](#) object.

## Usage

```
as_plane3d(...)

## S3 method for class 'numeric'
as_plane3d(a, b, c, d, ...)

## S3 method for class 'character'
as_plane3d(x, ...)

## S3 method for class 'Coord3D'
as_plane3d(normal, p1 = as_coord3d("origin"), p2, p3, ...)

## S3 method for class 'Plane3D'
as_plane3d(plane, ...)

## S3 method for class 'Point1D'
as_plane3d(point, b = 0, c = 0, ...)

## S3 method for class 'Line2D'
as_plane3d(line, c = 0, ...)
```

## Arguments

|            |                                                                                                                |
|------------|----------------------------------------------------------------------------------------------------------------|
| ...        | Passed to other function such as as_coord2d().                                                                 |
| a, b, c, d | Numeric vectors that parameterize the plane via the equation $a * x + b * y + c * z + d = 0$ .                 |
| x          | A (character) vector to be cast to a <a href="#">Plane3D</a> object                                            |
| normal     | Normal vector to the plane represented by a <a href="#">Coord3D</a> class object. p2 and p3 should be missing. |
| p1         | Point on the plane represented by a <a href="#">Coord3D</a> class object.                                      |
| p2, p3     | Points on the plane represented by <a href="#">Coord3D</a> class objects. normal should be missing.            |
| plane      | A <a href="#">Plane3D</a> object                                                                               |
| point      | A <a href="#">Point1D</a> object                                                                               |
| line       | A <a href="#">Line2D</a> object                                                                                |

---

|            |                               |
|------------|-------------------------------|
| as_point1d | <i>Cast to Point1D object</i> |
|------------|-------------------------------|

---

### Description

as\_point1d() casts to a [Point1D](#) object.

### Usage

```
as_point1d(...)

## S3 method for class 'numeric'
as_point1d(a, b, ...)

## S3 method for class 'character'
as_point1d(x, ...)

## S3 method for class 'Coord1D'
as_point1d(normal, ...)

## S3 method for class 'Point1D'
as_point1d(point, ...)
```

### Arguments

|        |                                                                                                                    |
|--------|--------------------------------------------------------------------------------------------------------------------|
| ...    | Passed to other function such as as_coord2d().                                                                     |
| a, b   | Numeric vectors that parameterize the point via the equation $a * x + b = 0$ . Note this means that $x = -b / a$ . |
| x      | A (character) vector to be cast to a <a href="#">Point1D</a> object                                                |
| normal | <a href="#">Coord1D</a> class object.                                                                              |
| point  | A <a href="#">Point1D</a> object                                                                                   |

### Examples

```
p1 <- as_point1d(a = 1, b = 0)
```

---

|                |                                                |
|----------------|------------------------------------------------|
| as_transform1d | <i>Cast to 1D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

### Description

as\_transform1d() casts to a [transform1d\(\)](#) affine transformation matrix

**Usage**

```
as_transform1d(x, ...)

## S3 method for class 'transform1d'
as_transform1d(x, ...)

## Default S3 method:
as_transform1d(x, ...)
```

**Arguments**

`x`                      An object that can be cast to a  
`...`                    Further arguments passed to or from other methods

**Value**

A [transform1d\(\)](#) object

**Examples**

```
m <- diag(2L)
as_transform1d(m)
```

---

|                |                                                |
|----------------|------------------------------------------------|
| as_transform2d | <i>Cast to 2D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

**Description**

as\_transform2d() casts to a [transform2d\(\)](#) affine transformation matrix

**Usage**

```
as_transform2d(x, ...)

## S3 method for class 'transform2d'
as_transform2d(x, ...)

## Default S3 method:
as_transform2d(x, ...)
```

**Arguments**

`x`                      An object that can be cast to a  
`...`                    Further arguments passed to or from other methods

**Value**

A [transform2d\(\)](#) object

## Examples

```
m <- diag(3L)
as_transform2d(m)
```

---

|                |                                                |
|----------------|------------------------------------------------|
| as_transform3d | <i>Cast to 3D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

## Description

as\_transform3d() casts to a [transform3d\(\)](#) affine transformation matrix

## Usage

```
as_transform3d(x, ...)
```

## S3 method for class 'transform3d'

```
as_transform3d(x, ...)
```

## Default S3 method:

```
as_transform3d(x, ...)
```

## Arguments

|     |                                                   |
|-----|---------------------------------------------------|
| x   | An object that can be cast to a                   |
| ... | Further arguments passed to or from other methods |

## Value

A [transform3d\(\)](#) object

## Examples

```
m <- diag(4L)
as_transform3d(m)
```

---

|                 |                                    |
|-----------------|------------------------------------|
| bounding_ranges | <i>Compute axis-aligned ranges</i> |
|-----------------|------------------------------------|

---

### Description

`range()` computes axis-aligned ranges for [Coord1D](#), [Coord2D](#), and [Coord3D](#) class objects.

### Usage

```
## S3 method for class 'Coord1D'
range(..., na.rm = FALSE)

## S3 method for class 'Coord2D'
range(..., na.rm = FALSE)

## S3 method for class 'Coord3D'
range(..., na.rm = FALSE)
```

### Arguments

|                    |                                                                                          |
|--------------------|------------------------------------------------------------------------------------------|
| <code>...</code>   | <a href="#">Coord1D</a> , <a href="#">Coord2D</a> , or <a href="#">Coord3D</a> object(s) |
| <code>na.rm</code> | logical, indicating if NA's should be omitted                                            |

### Value

Either a [Coord1D](#), [Coord2D](#), or [Coord3D](#) object of length two. The first element will have the minimum x/y(/z) coordinates and the second element will have the maximum x/y(/z) coordinates of the axis-aligned ranges.

### Examples

```
range(as_coord2d(rnorm(5), rnorm(5)))
range(as_coord3d(rnorm(5), rnorm(5), rnorm(5)))
```

---

|          |                                         |
|----------|-----------------------------------------|
| centroid | <i>Compute centroids of coordinates</i> |
|----------|-----------------------------------------|

---

### Description

`mean()` computes centroids for [Coord1D](#), [Coord2D](#), and [Coord3D](#) class objects

**Usage**

```
## S3 method for class 'Coord1D'
mean(x, ...)

## S3 method for class 'Coord2D'
mean(x, ...)

## S3 method for class 'Coord3D'
mean(x, ...)
```

**Arguments**

x                    A [Coord1D](#), [Coord2D](#), or [Coord3D](#) object  
 ...                  Passed to `base::mean()`

**Value**

A [Coord1D](#), [Coord2D](#), or [Coord3D](#) class object of length one

**Examples**

```
p <- as_coord2d(x = 1:4, y = 1:4)
print(mean(p))
print(sum(p) / length(p)) # less efficient alternative

p <- as_coord3d(x = 1:4, y = 1:4, z = 1:4)
print(mean(p))
```

---

convex\_hull2d

---

*Compute 2D convex hulls*


---

**Description**

`convex_hull2d()` is a S3 generic for computing the convex hull of an object. There is an implemented method supporting [Coord2D](#) class objects using `grDevices::chull()` to compute the convex hull.

**Usage**

```
convex_hull2d(x, ...)

## S3 method for class 'Coord2D'
convex_hull2d(x, ...)
```

**Arguments**

x                    An object representing object to compute convex hull of such as a [Coord2D](#) class object.  
 ...                  Further arguments passed to or from other methods.

**Value**

An object of same class as `x` representing just the subset of points on the convex hull. The method for [Coord2D](#) class objects returns these points in counter-clockwise order.

**Examples**

```
p <- as_coord2d(x = rnorm(25), y = rnorm(25))
print(convex_hull2d(p))

# Equivalent to following calculation using `grDevices::chull()`
all.equal(convex_hull2d(p),
          p[rev(grDevices::chull(as.list(p)))])
```

Coord1D

*1D coordinate vector R6 Class***Description**

Coord1D is an [R6::R6Class\(\)](#) object representing two-dimensional points represented by Cartesian Coordinates.

**Active bindings**

- `xw` A two-column matrix representing the homogeneous coordinates. The first column is the "x" coordinates and the second column is all ones.
- `x` A numeric vector of x-coordinates.

**Methods****Public methods:**

- [Coord1D\\$new\(\)](#)
- [Coord1D\\$print\(\)](#)
- [Coord1D\\$project\(\)](#)
- [Coord1D\\$reflect\(\)](#)
- [Coord1D\\$scale\(\)](#)
- [Coord1D\\$translate\(\)](#)
- [Coord1D\\$transform\(\)](#)
- [Coord1D\\$clone\(\)](#)

**Method** `new()`:*Usage:*

```
Coord1D$new(xw)
```

*Arguments:*

- `xw` A matrix with three columns representing (homogeneous) coordinates. The first column represents x coordinates and the last column is all ones. Column names should be "x" and "w".

**Method** print():*Usage:*`Coord1D#print(n = NULL, ...)`*Arguments:*`n` Number of coordinates to print. If NULL print all of them.... Passed to `format.default()`.**Method** project():*Usage:*`Coord1D$project(point = as_point1d("origin"), ...)`*Arguments:*`point` A **Point1D** object of length one representing the point you wish to reflect across or project to or an object coercible to one by `as_point1d(point, ...)` such as "origin".... Passed to `project1d()`.**Method** reflect():*Usage:*`Coord1D$reflect(point = as_point1d("origin"), ...)`*Arguments:*`point` A **Point1D** object of length one representing the point you wish to reflect across or project to or an object coercible to one by `as_point1d(point, ...)` such as "origin".... Passed to `reflect1d()`.**Method** scale():*Usage:*`Coord1D$scale(x_scale = 1)`*Arguments:*`x_scale` Scaling factor to apply to x coordinates**Method** translate():*Usage:*`Coord1D$translate(x = as_coord1d(0), ...)`*Arguments:*`x` A **Coord1D** object of length one or an object coercible to one by `as_coord1d(x, ...)`.... Passed to `as_coord1d(x, ...)` if `x` is not a **Coord1D** object**Method** transform():*Usage:*`Coord1D$transform(mat = transform1d())`*Arguments:*`mat` A 2x2 matrix representing a post-multiplied affine transformation matrix. The last **column** must be equal to `c(0, 1)`. If the last **row** is `c(0, 1)` you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 1x1 matrix we'll quietly add a final column/row equal to `c(0, 1)`.

**Method** `clone()`: The objects of this class are cloneable with this method.

*Usage:*

```
Coord1D$clone(deep = FALSE)
```

*Arguments:*

`deep` Whether to make a deep clone.

## Examples

```
p <- as_coord1d(x = rnorm(100, 2))
print(p, n = 10L)
pc <- mean(p) # Centroid
# method chained affine transformation matrices are auto-pre-multiplied
p$
  translate(-pc)$
  reflect("origin")$
  print(n = 10L)
```

---

|         |                                      |
|---------|--------------------------------------|
| Coord2D | <i>2D coordinate vector R6 Class</i> |
|---------|--------------------------------------|

---

## Description

Coord2D is an [R6: `R6Class\(\)`](#) object representing two-dimensional points represented by Cartesian Coordinates.

## Active bindings

`xyw` A three-column matrix representing the homogeneous coordinates. The first two columns are "x" and "y" coordinates and the third column is all ones.

`x` A numeric vector of x-coordinates.

`y` A numeric vector of y-coordinates.

## Methods

### Public methods:

- [Coord2D\\$new\(\)](#)
- [Coord2D\\$permute\(\)](#)
- [Coord2D\\$print\(\)](#)
- [Coord2D\\$project\(\)](#)
- [Coord2D\\$reflect\(\)](#)
- [Coord2D\\$rotate\(\)](#)
- [Coord2D\\$scale\(\)](#)
- [Coord2D\\$shear\(\)](#)
- [Coord2D\\$translate\(\)](#)
- [Coord2D\\$transform\(\)](#)

- [Coord2D\\$clone\(\)](#)

**Method new():***Usage:*`Coord2D$new(xyw)`*Arguments:*

`xyw` A matrix with three columns representing (homogeneous) coordinates. The first two columns represent x and y coordinates and the last column is all ones. Column names should be "x", "y", and "w".

**Method permute():***Usage:*`Coord2D$permute(permutation = c("xy", "yx"))`*Arguments:*

`permutation` Either "xy" (no permutation) or "yx" (permute x and y axes)

**Method print():***Usage:*`Coord2D$print(n = NULL, ...)`*Arguments:*

`n` Number of coordinates to print. If NULL print all of them.

`...` Passed to [format.default\(\)](#).

**Method project():***Usage:*`Coord2D$project(line = as_line2d("x-axis"), ..., scale = 0)`*Arguments:*

`line` A [Line2D](#) object of length one representing the line you wish to reflect across or project to or an object coercible to one by `as_line2d(line, ...)` such as "x-axis" or "y-axis".

`...` Passed to [project2d\(\)](#)

`scale` Oblique projection scale factor. A degenerate 0 value indicates an orthogonal projection.

**Method reflect():***Usage:*`Coord2D$reflect(line = as_line2d("x-axis"), ...)`*Arguments:*

`line` A [Line2D](#) object of length one representing the line you wish to reflect across or project to or an object coercible to one by `as_line2d(line, ...)` such as "x-axis" or "y-axis".

`...` Passed to [reflect2d\(\)](#).

**Method rotate():***Usage:*`Coord2D$rotate(theta = angle(0), ...)`

*Arguments:*

theta An [angle\(\)](#) object of length one or an object coercible to one by `as_angle(theta, ...)`.  
... Passed to [as\\_angle\(\)](#).

**Method** `scale()`:*Usage:*

```
Coord2D$scale(x_scale = 1, y_scale = x_scale)
```

*Arguments:*

x\_scale Scaling factor to apply to x coordinates  
y\_scale Scaling factor to apply to y coordinates

**Method** `shear()`:*Usage:*

```
Coord2D$shear(xy_shear = 0, yx_shear = 0)
```

*Arguments:*

xy\_shear Horizontal shear factor:  $x = x + xy\_shear * y$   
yx\_shear Vertical shear factor:  $y = yx\_shear * x + y$

**Method** `translate()`:*Usage:*

```
Coord2D$translate(x = as_coord2d(0, 0), ...)
```

*Arguments:*

x A [Coord2D](#) object of length one or an object coercible to one by `as_coord2d(x, ...)`.  
... Passed to `as_coord2d(x, ...)` if x is not a [Coord2D](#) object

**Method** `transform()`:*Usage:*

```
Coord2D$transform(mat = transform2d())
```

*Arguments:*

mat A 3x3 matrix representing a post-multiplied affine transformation matrix. The last **column** must be equal to `c(0, 0, 1)`. If the last **row** is `c(0, 0, 1)` you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 2x2 matrix (such as a 2x2 post-multiplied 2D rotation matrix) we'll quietly add a final column/row equal to `c(0, 0, 1)`.

**Method** `clone()`: The objects of this class are cloneable with this method.*Usage:*

```
Coord2D$clone(deep = FALSE)
```

*Arguments:*

deep Whether to make a deep clone.

**Examples**

```
p <- as_coord2d(x = rnorm(100, 2), y = rnorm(100, 2))
print(p, n = 10)
pc <- mean(p) # Centroid
# method chained affine transformation matrices are auto-pre-multiplied
p$
  translate(-pc)$
  shear(x = 1, y = 0)$
  reflect("x-axis")$
  rotate(90, "degrees")$
print(n = 10)
```

Coord3D

*3D coordinate vector R6 Class***Description**

Coord3D is an `R6::R6Class()` object representing three-dimensional points represented by Cartesian Coordinates.

**Active bindings**

`xyzw` A four-column matrix representing the homogeneous coordinates. The first three columns are "x", "y", and "z" coordinates and the fourth column is all ones.

`x` A numeric vector of x-coordinates.

`y` A numeric vector of y-coordinates.

`z` A numeric vector of z-coordinates.

**Methods****Public methods:**

- `Coord3D$new()`
- `Coord3D$permute()`
- `Coord3D$print()`
- `Coord3D$project()`
- `Coord3D$reflect()`
- `Coord3D$rotate()`
- `Coord3D$scale()`
- `Coord3D$shear()`
- `Coord3D$translate()`
- `Coord3D$transform()`
- `Coord3D$clone()`

**Method `new()`:**

*Usage:*

```
Coord3D$new(xyzw)
```

*Arguments:*

`xyzw` A matrix with four columns representing (homogeneous) coordinates. The first three columns represent x, y, and z coordinates and the last column is all ones. Column names should be "x", "y", "z", and "w".

**Method** `permute()`:

*Usage:*

```
Coord3D$permute(permutation = c("xyz", "xzy", "yxz", "yzx", "zyx", "zxy"))
```

*Arguments:*

`permutation` Either "xyz" (no permutation), "xzy" (permute y and z axes), "yxz" (permute x and y axes), "yzx" (x becomes z, y becomes x, z becomes y), "zxy" (x becomes y, y becomes z, z becomes x), "zyx" (permute x and z axes)

**Method** `print()`:

*Usage:*

```
Coord3D$print(n = NULL, ...)
```

*Arguments:*

`n` Number of coordinates to print. If NULL print all of them.

`...` Passed to `format.default()`.

**Method** `project()`:

*Usage:*

```
Coord3D$project(
  plane = as_plane3d("xy-plane"),
  ...,
  scale = 0,
  alpha = angle(45, "degrees")
)
```

*Arguments:*

`plane` A [Plane3D](#) object of length one representing the plane you wish to reflect across or project to or an object coercible to one using `as_plane3d(plane, ...)` such as "xy-plane", "xz-plane", or "yz-plane".

`...` Passed to `project3d()`.

`scale` Oblique projection foreshortening scale factor. A (degenerate) 0 value indicates an orthographic projection. A value of 0.5 is used by a "cabinet projection" while a value of 1.0 is used by a "cavalier projection".

`alpha` Oblique projection angle (the angle the third axis is projected going off at). An `angle()` object or one coercible to one with `as_angle(alpha, ...)`. Popular angles are 45 degrees, 60 degrees, and `arctangent(2)` degrees.

**Method** `reflect()`:

*Usage:*

```
Coord3D$reflect(plane = as_plane3d("xy-plane"), ...)
```

*Arguments:*

plane A [Plane3D](#) object of length one representing the plane you wish to reflect across or project to or an object coercible to one using `as_plane3d(plane, ...)` such as "xy-plane", "xz-plane", or "yz-plane".  
 ... Passed to [reflect3d\(\)](#).

**Method rotate():***Usage:*

```
Coord3D$rotate(axis = as_coord3d("z-axis"), theta = angle(0), ...)
```

*Arguments:*

axis A [Coord3D](#) class object or one that can coerced to one by `as_coord3d(axis, ...)`. The axis represents the axis to be rotated around.  
 theta An [angle\(\)](#) object of length one or an object coercible to one by `as_angle(theta, ...)`.  
 ... Passed to [rotate3d\(\)](#).

**Method scale():***Usage:*

```
Coord3D$scale(x_scale = 1, y_scale = x_scale, z_scale = x_scale)
```

*Arguments:*

x\_scale Scaling factor to apply to x coordinates  
 y\_scale Scaling factor to apply to y coordinates  
 z\_scale Scaling factor to apply to z coordinates

**Method shear():***Usage:*

```
Coord3D$shear(
  xy_shear = 0,
  xz_shear = 0,
  yx_shear = 0,
  yz_shear = 0,
  zx_shear = 0,
  zy_shear = 0
)
```

*Arguments:*

xy\_shear Shear factor:  $x = x + xy\_shear * y + xz\_shear * z$   
 xz\_shear Shear factor:  $x = x + xy\_shear * y + xz\_shear * z$   
 yx\_shear Shear factor:  $y = yx\_shear * x + y + yz\_shear * z$   
 yz\_shear Shear factor:  $y = yx\_shear * x + y + yz\_shear * z$   
 zx\_shear Shear factor:  $z = zx\_shear * x + zy\_shear * y + z$   
 zy\_shear Shear factor:  $z = zx\_shear * x + zy\_shear * y + z$

**Method translate():***Usage:*

```
Coord3D$translate(x = as_coord3d(0, 0, 0), ...)
```

*Arguments:*

**x** A **Coord3D** object of length one or an object coercible to one by `as_coord3d(x, ...)`.  
 ... Passed to `as_coord3d(x, ...)` if **x** is not a **Coord3D** object

**Method** `transform()`:

*Usage:*

```
Coord3D$transform(mat = transform3d())
```

*Arguments:*

**mat** A 4x4 matrix representing a post-multiplied affine transformation matrix. The last **column** must be equal to `c(0, 0, 0, 1)`. If the last **row** is `c(0, 0, 0, 1)` you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 3x3 matrix (such as a 3x3 post-multiplied 3D rotation matrix) we'll quietly add a final column/row equal to `c(0, 0, 0, 1)`.

**Method** `clone()`: The objects of this class are cloneable with this method.

*Usage:*

```
Coord3D$clone(deep = FALSE)
```

*Arguments:*

**deep** Whether to make a deep clone.

## Examples

```
p <- as_coord3d(x = rnorm(100, 2), y = rnorm(100, 2), z = rnorm(100, 2))
print(p, n = 10)
pc <- mean(p) # Centroid
# method chained affine transformation matrices are auto-pre-multiplied
p$
  translate(-pc)$
  reflect("xy-plane")$
  rotate("z-axis", degrees(90))$
print(n = 10)
```

---

cross\_product3d

*Compute 3D vector cross product*

---

## Description

`cross_product3d()` computes the cross product of two **Coord3D** class vectors.

## Usage

```
cross_product3d(x, y)
```

**Arguments**

x                    A [Coord3D](#) class vector.  
 y                    A [Coord3D](#) class vector.

**Value**

A [Coord3D](#) class vector

**Examples**

```
x <- as_coord3d(2, 3, 4)
y <- as_coord3d(5, 6, 7)
cross_product3d(x, y)
if (getRversion() >= "4.4.0") {
  crossprod(x, y)
}
```

---

|            |                               |
|------------|-------------------------------|
| distance1d | <i>1D Euclidean distances</i> |
|------------|-------------------------------|

---

**Description**

distance1d() computes 1D Euclidean distances.

**Usage**

```
distance1d(x, y)
```

**Arguments**

x                    Either a [Coord1D](#) or [Point1D](#) class object  
 y                    Either a [Coord1D](#) or [Point1D](#) class object

**Examples**

```
p <- as_coord1d(x = 1:4)
distance1d(p, as_coord1d(0))
```

---

|            |                               |
|------------|-------------------------------|
| distance2d | <i>2D Euclidean distances</i> |
|------------|-------------------------------|

---

**Description**

distance2d() computes 2D Euclidean distances.

**Usage**

```
distance2d(x, y)
```

**Arguments**

|   |                                                                         |
|---|-------------------------------------------------------------------------|
| x | Either a <a href="#">Coord2D</a> or <a href="#">Line2D</a> class object |
| y | Either a <a href="#">Coord2D</a> or <a href="#">Line2D</a> class object |

**Examples**

```
p <- as_coord2d(x = 1:4, y = 1:4)
distance2d(p, as_coord2d(0, 0))
```

---

|            |                               |
|------------|-------------------------------|
| distance3d | <i>3D Euclidean distances</i> |
|------------|-------------------------------|

---

**Description**

distance3d() computes 3D Euclidean distances.

**Usage**

```
distance3d(x, y)
```

**Arguments**

|   |                                                                          |
|---|--------------------------------------------------------------------------|
| x | Either a <a href="#">Coord3D</a> or <a href="#">Plane3D</a> class object |
| y | Either a <a href="#">Coord3D</a> or <a href="#">Plane3D</a> class object |

**Examples**

```
p <- as_coord3d(x = 1:4, y = 1:4, z = 1:4)
distance3d(p, as_coord3d("origin"))
```

graphics

*Plot coordinates, points, lines, and planes***Description**

`plot()` plots `Coord1D` and `Coord2D` class objects while `points()` draws `Coord1D` and `Coord2D` class objects and `lines()` draws `Point1D` and `Line2D` class objects to an existing plot. If the suggested `ggplot2` and `rgl` packages are available we also register `ggplot2::autolayer()` methods for `Coord1D`, `Coord2D`, `Point1D`, and `Line2D` class objects and a `rgl::plot3d()` method for `Coord3D` class objects.

**Usage**

```
## S3 method for class 'Coord1D'
plot(x, ...)

## S3 method for class 'Coord1D'
points(x, ...)

## S3 method for class 'Point1D'
lines(x, ...)

## S3 method for class 'Coord2D'
plot(x, ...)

## S3 method for class 'Coord2D'
points(x, ...)

## S3 method for class 'Line2D'
lines(x, ...)
```

**Arguments**

`x`                    A supported object to plot.  
`...`                Passed to the underlying plot method.

**Value**

Used for its side effect of drawing to the graphics device.

**Examples**

```
c1 <- as_coord2d(x = 0, y = 1:10)
l <- as_line2d(a = 1, b = -1, c = 0) # y = x
c2 <- c1$clone()$reflect(l)
plot(c1, xlim = c(-1, 11), ylim = c(-1, 11),
     main = "2D reflection across a line")
lines(l)
```

```

points(c2, col = "red")

c1 <- as_coord2d(x = 1:10, y = 1:10)
l <- as_line2d(a = -1, b = 0, c = 0) # x = 0
c2 <- c1$clone()$project(l)
if (require("ggplot2", quietly = TRUE,
            include.only = c("ggplot", "autolayer", "labs"))) {
  ggplot() +
    autolayer(c1) +
    autolayer(l) +
    autolayer(c2, color = "red") +
    labs(title = "2D projection onto a line")
}

c1 <- as_coord1d(x = seq.int(-4, -1))
pt <- as_point1d(a = 1, b = 0) # x = 0
c2 <- c1$clone()$reflect(pt)
plot(c1, xlim = c(-5, 5), main = "1D reflection across a point")
lines(pt)
points(c2, col = "red")

# 3D reflection across a plane
c1 <- as_coord3d(x = 1:10, y = 1:10, z = 1:10)
pl <- as_plane3d(a = 0, b = 0, c = -1, d = 2) # z = 2
c2 <- c1$clone()$reflect(pl)
if (require("rgl", quietly = TRUE,
            include.only = c("plot3d", "planes3d", "points3d"))) {
  plot3d(c1, size = 8)
  planes3d(as.data.frame(pl), d = pl$d, color = "grey", alpha = 0.6)
  points3d(as.data.frame(c2), col = "red", size = 8)
}

```

---

|                  |                                      |
|------------------|--------------------------------------|
| has_intersection | <i>Whether two objects intersect</i> |
|------------------|--------------------------------------|

---

## Description

has\_intersection() is an S3 method that returns whether two objects intersect.

## Usage

```

has_intersection(x, y, ...)

## Default S3 method:
has_intersection(x, y, ...)

## S3 method for class 'Point1D'
has_intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

```

```
## S3 method for class 'Line2D'
has_intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Plane3D'
has_intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))
```

### Arguments

|                        |                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------|
| <code>x, y</code>      | The two objects to check if they intersect.                                                    |
| <code>...</code>       | Passed to other methods (or ignored).                                                          |
| <code>tolerance</code> | Numerics with differences smaller than <code>tolerance</code> will be considered “equivalent”. |

### Details

`affiner::has_intersection()` has the same S3 signature and default method as `euclid::has_intersection()` (so it shouldn't matter if one masks the other).

### Value

A logical vector.

### Examples

```
line1 <- as_line2d("x-axis")
line2 <- as_line2d("y-axis")
line3 <- as_line2d(a = 0, b = 1, c = 2) # y + 2 = 0
has_intersection(line1, line1)
has_intersection(line1, line2)
has_intersection(line1, line3)
```

---

|                           |                                         |
|---------------------------|-----------------------------------------|
| <code>intersection</code> | <i>The intersection of two objects.</i> |
|---------------------------|-----------------------------------------|

---

### Description

`intersection()` is an S3 method that returns the intersection of two objects.

### Usage

```
intersection(x, y, ...)

## S3 method for class 'Point1D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Line2D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))
```

```
## S3 method for class 'Plane3D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Coord1D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Coord2D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Coord3D'
intersection(x, y, ..., tolerance = sqrt(.Machine$double.eps))
```

### Arguments

|                        |                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------|
| <code>x, y</code>      | The two objects to compute intersection for.                                                   |
| <code>...</code>       | Passed to other methods (or ignored).                                                          |
| <code>tolerance</code> | Numerics with differences smaller than <code>tolerance</code> will be considered “equivalent”. |

### Details

`affiner::intersection()` has the same S3 signature as `euclid::intersection()` (so it shouldn't matter if one masks the other).

### Value

A list of the object intersections (or NULL if no intersection).

### Examples

```
line1 <- as_line2d("x-axis")
line2 <- as_line2d("y-axis")
line3 <- as_line2d(a = 0, b = 1, c = 2) # y + 2 = 0
intersection(line1, line1)
intersection(line1, line2)
intersection(line1, line3)
```

---

inverse-trigonometric-functions

*Angle vector aware inverse trigonometric functions*

---

### Description

`arcsine()`, `arccosine()`, `arctangent()`, `arcsecant()`, `arccosecant()`, and `arccotangent()` are inverse trigonometric functions that return [angle\(\)](#) vectors with a user chosen angular unit.

**Usage**

```

arcsine(
  x,
  unit = getOption("affiner_angular_unit", "degrees"),
  tolerance = sqrt(.Machine$double.eps)
)

arccosine(
  x,
  unit = getOption("affiner_angular_unit", "degrees"),
  tolerance = sqrt(.Machine$double.eps)
)

arctangent(x, unit = getOption("affiner_angular_unit", "degrees"), y = NULL)

arcsecant(x, unit = getOption("affiner_angular_unit", "degrees"))

arccosecant(x, unit = getOption("affiner_angular_unit", "degrees"))

arccotangent(x, unit = getOption("affiner_angular_unit", "degrees"))

```

**Arguments**

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>         | A numeric vector                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <code>unit</code>      | <p>A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"):</p> <ul style="list-style-type: none"> <li>• "deg" or "degree"</li> <li>• "half-revolution", "half-turn", or "pi-radian"</li> <li>• "gon", "grad", "grade", or "gradian"</li> <li>• "rad" or "radian"</li> <li>• "rev", "revolution", "tr", or "turn"</li> </ul> |
| <code>tolerance</code> | If <code>x</code> greater than 1 (or less than -1) but is within a tolerance of 1 (or -1) then it will be treated as 1 (or -1)                                                                                                                                                                                                                                                                                                                                                            |
| <code>y</code>         | A numeric vector or NULL. If NULL (default) we compute the 1-argument arc-tangent else we compute the 2-argument arctangent. For positive coordinates ( <code>x</code> , <code>y</code> ) then <code>arctangent(x = y/x) == arctangent(x = x, y = y)</code> .                                                                                                                                                                                                                             |

**Value**

An `angle()` vector

**Examples**

```

arccosine(-1, "degrees")
arcsine(0, "turns")
arctangent(0, "gradians")

```

```

arccosecant(-1, "degrees")
arcsecant(1, "degrees")
arccotangent(1, "half-turns")

# `base::atan2(y, x)` computes the angle of the vector from origin to (x, y)
as_angle(as_coord2d(x = 1, y = 1), "degrees")

```

---

isocubeGrob

*Isometric cube grob*


---

## Description

`isometricCube()` is a grid grob function to render isometric cube faces by automatically wrapping around `affineGrob()`.

## Usage

```

isocubeGrob(
  top,
  right,
  left,
  gp_border = grid::gpar(col = "black", lwd = 12),
  name = NULL,
  gp = grid::gpar(),
  vp = NULL
)

grid.isocube(...)

```

## Arguments

|                        |                                                                                                                                               |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <code>top</code>       | A grid grob object to use as the top side of the cube. <code>ggplot2</code> objects will be coerced by <code>ggplot2::ggplotGrob()</code> .   |
| <code>right</code>     | A grid grob object to use as the right side of the cube. <code>ggplot2</code> objects will be coerced by <code>ggplot2::ggplotGrob()</code> . |
| <code>left</code>      | A grid grob object to use as the left side of the cube. <code>ggplot2</code> objects will be coerced by <code>ggplot2::ggplotGrob()</code> .  |
| <code>gp_border</code> | A <code>grid::gpar()</code> object for the <code>polygonGrob()</code> used to draw borders around the cube faces.                             |
| <code>name</code>      | A character identifier (for grid).                                                                                                            |
| <code>gp</code>        | A <code>grid::gpar()</code> object.                                                                                                           |
| <code>vp</code>        | A <code>grid::viewport()</code> object (or <code>NULL</code> ).                                                                               |
| <code>...</code>       | Passed to <code>isocubeGrob()</code>                                                                                                          |

## Details

Any `ggplot2` objects are coerced to grobs by `ggplot2::ggplotGrob()`. Depending on what you'd like to do you may want to instead manually convert a `ggplot2` object `gg` to a grob with `gtable::gtable_filter(ggplot2::ggplotGrob(gg), "panel")`.

Not all graphics devices provided by `grDevices` or other R packages support the **affine transformation feature introduced in R 4.2**. If `isTRUE(getRversion() >= '4.2.0')` then the active graphics device should support this feature if `isTRUE(grDevices::dev.capabilities()$transformations)`. In particular the following graphics devices should support the affine transformation feature:

- R's `grDevices::pdf()` device
- R's 'cairo' devices e.g. `grDevices::cairo_pdf()`, `grDevices::png(type = 'cairo')`, `grDevices::svg()`, `grDevices::x11(type = 'cairo')`, etc. If `isTRUE(capabilities('cairo'))` then R was compiled with support for the 'cairo' devices.
- R's 'quartz' devices (since R 4.3.0) e.g. `grDevices::quartz()`, `grDevices::png(type = 'quartz')`, etc. If `isTRUE(capabilities('aqua'))` then R was compiled with support for the 'quartz' devices (generally only TRUE on macOS systems).
- ragg's devices (since v1.3.0) e.g. `ragg::agg_png()`, `ragg::agg_capture()`, etc.

## Value

A `grid::gTree()` (grob) object of class "isocube". As a side effect `grid.isocube()` draws to the active graphics device.

## Examples

```
# Only works if active graphics device supports affine transformations
# such as `png(type="cairo")` on R 4.2+
can_run_grid_example <- require("grid", quietly = TRUE) &&
  getRversion() >= "4.2.0" &&
  isTRUE(dev.capabilities()$transformations)
if (can_run_grid_example) {
  grid.newpage()
  gp_text <- gpar(fontsize = 72)
  grid.isocube(top = textGrob("top", gp = gp_text),
               right = textGrob("right", gp = gp_text),
               left = textGrob("left", gp = gp_text))
}
if (can_run_grid_example) {
  colors <- c("#D55E00", "#009E73", "#56B4E9")
  spacings <- c(0.25, 0.2, 0.25)
  texts <- c("pkgname", "left\nface", "right\nface")
  rots <- c(45, 0, 0)
  fontsizes <- c(52, 80, 80)
  sides <- c("top", "left", "right")
  types <- gridpattern::names_polygon_tiling[c(5, 7, 9)]
  l_grobs <- list()
  grid.newpage()
  for (i in 1:3) {
    if (requireNamespace("gridpattern", quietly = TRUE)) {
      bg <- gridpattern::grid.pattern_polygon_tiling(
```

```

        colour = "grey80",
        fill = c(colors[i], "white"),
        type = types[i],
        spacing = spacings[i],
        draw = FALSE)
    } else {
      bg <- rectGrob(gp = gpar(col = NA, fill = colors[i]))
    }
    text <- textGrob(texts[i], rot = rots[i],
      gp = gpar(fontsize = fontsizes[i]))
    l_grobs[[sides[i]]] <- grobTree(bg, text)
  }
  grid.newpage()
  grid.isocube(top = l_grobs$top,
    right = l_grobs$right,
    left = l_grobs$left)
}
# May take more than 5 seconds on CRAN machines
can_run_artsy_example <- can_run_grid_example &&
  require("aRtsy", quietly = TRUE) &&
  require("ggplot2", quietly = TRUE) &&
  requireNamespace("gtable", quietly = TRUE)
if (can_run_artsy_example) {
  gg <- canvas_planet(colorPalette("lava"), threshold = 3) +
    scale_x_continuous(expand = c(0, 0)) +
    scale_y_continuous(expand = c(0, 0))
  grob <- ggplotGrob(gg)
  grob <- gtable::gtable_filter(grob, "panel") # grab just the panel
  grid.newpage()
  grid.isocube(top = grob, left = grob, right = grob,
    gp_border = grid::gpar(col = "darkorange", lwd = 12))
}

```

---

isotoxal\_2ngon\_inner\_radius

*Isotoxal 2n-gon inner radius*


---

## Description

`isotoxal_2ngon_inner_radius()` computes the inner radius of an isotoxal 2n-gon polygon. `star_inner_radius()` is an alias.

## Usage

```

isotoxal_2ngon_inner_radius(
  n,
  outer_radius = 1,
  ...,
  alpha = NULL,

```

```

    beta_ext = NULL,
    d = NULL
)

star_inner_radius(
  n,
  outer_radius = 1,
  ...,
  alpha = NULL,
  beta_ext = NULL,
  d = NULL
)

```

### Arguments

|              |                                                                                                                          |
|--------------|--------------------------------------------------------------------------------------------------------------------------|
| n            | The number of outer vertices.                                                                                            |
| outer_radius | The outer radius of the isotoxal 2n-gon.                                                                                 |
| ...          | Ignored.                                                                                                                 |
| alpha        | The interior angle of an outer vertex. Will be coerced by <a href="#">degrees()</a> .                                    |
| beta_ext     | The exterior angle of an inner vertex. Will be coerced by <a href="#">degrees()</a> .                                    |
| d            | The density aka winding number of the regular star polygon (outline) in which case this star is represented by $ n/d $ . |

### Details

Isotoxal 2n-gon polygons are polygons with:

- 2n vertices alternating between n "outer" vertices evenly spaced on one circle and n "inner" vertices evenly spaced on smaller circle with the same center.
- Each edge of the polygon is of the same length.
- The outer vertices all have the same interior angle alpha and the inner vertices all have the same interior angle beta.
- They are a generalization of (the outlines of) concave simple "star" polygons that also includes convex polygons with an even number of vertices.

### Value

A numeric vector

### See Also

[https://en.wikipedia.org/wiki/Isotoxal\\_figure#Isotoxal\\_polygons](https://en.wikipedia.org/wiki/Isotoxal_figure#Isotoxal_polygons) and [https://en.wikipedia.org/wiki/Star\\_polygon#Isotoxal\\_star\\_simple\\_polygons](https://en.wikipedia.org/wiki/Star_polygon#Isotoxal_star_simple_polygons) for more information on isotoxal polygons.

**Examples**

```
# |8/3| star has outer vertex internal angle 45 degrees
# and inner vertex external angle 90 degrees
isotoxal_2ngon_inner_radius(8, d = 3)
isotoxal_2ngon_inner_radius(8, alpha = 45)
isotoxal_2ngon_inner_radius(8, beta_ext = 90)
```

---

|          |                                                  |
|----------|--------------------------------------------------|
| is_angle | <i>Test whether an object is an angle vector</i> |
|----------|--------------------------------------------------|

---

**Description**

is\_angle() tests whether an object is an angle vector

**Usage**

```
is_angle(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
a <- angle(180, "degrees")
is_angle(a)
is_angle(pi)
```

---

|              |                                               |
|--------------|-----------------------------------------------|
| is_congruent | <i>Test whether two objects are congruent</i> |
|--------------|-----------------------------------------------|

---

**Description**

is\_congruent() is a S3 generic that tests whether two different objects are “congruent”. The is\_congruent() method for [angle\(\)](#) classes tests whether two angles are congruent.

**Usage**

```
is_congruent(x, y, ...)

## S3 method for class 'numeric'
is_congruent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'angle'
is_congruent(
  x,
  y,
  ...,
  mod_turns = TRUE,
  tolerance = sqrt(.Machine$double.eps)
)
```

**Arguments**

|                        |                                                                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <code>x, y</code>      | Two objects to test whether they are “congruent”.                                                                               |
| <code>...</code>       | Further arguments passed to or from other methods.                                                                              |
| <code>tolerance</code> | Angles (coerced to half-turns) or numerics with differences smaller than <code>tolerance</code> will be considered “congruent”. |
| <code>mod_turns</code> | If TRUE angles that are congruent modulo full turns will be considered “congruent”.                                             |

**Value**

A logical vector

**Examples**

```
# Use `is_congruent()` to check if two angles are "congruent"
a1 <- angle(180, "degrees")
a2 <- angle(pi, "radians")
a3 <- angle(-180, "degrees") # Only congruent modulus full turns
a1 == a2
isTRUE(all.equal(a1, a2))
is_congruent(a1, a2)
is_congruent(a1, a2, mod_turns = FALSE)
a1 == a3
isTRUE(all.equal(a1, a3))
is_congruent(a1, a3)
is_congruent(a1, a3, mod_turns = FALSE)
```

---

|            |                                                   |
|------------|---------------------------------------------------|
| is_coord1d | <i>Test whether an object has a Coord1D class</i> |
|------------|---------------------------------------------------|

---

**Description**

is\_coord1d() tests whether an object has a "Coord1D" class

**Usage**

```
is_coord1d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
p <- as_coord1d(x = sample.int(10, 3))
is_coord1d(p)
```

---

|            |                                                   |
|------------|---------------------------------------------------|
| is_coord2d | <i>Test whether an object has a Coord2D class</i> |
|------------|---------------------------------------------------|

---

**Description**

is\_coord2d() tests whether an object has a "Coord2D" class

**Usage**

```
is_coord2d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
p <- as_coord2d(x = sample.int(10, 3), y = sample.int(10, 3))
is_coord2d(p)
```

---

is\_coord3d

*Test whether an object has a Coord3D class*


---

### Description

is\_coord3d() tests whether an object has a "Coord3D" class

### Usage

```
is_coord3d(x)
```

### Arguments

x                      An object

### Value

A logical value

### Examples

```
p <- as_coord3d(x = sample.int(10, 3),
                y = sample.int(10, 3),
                z = sample.int(10, 3))
is_coord3d(p)
```

---

is\_equivalent

*Test whether two objects are equivalent*


---

### Description

is\_equivalent() is a S3 generic that tests whether two different objects are “equivalent”. The is\_equivalent() method for [angle\(\)](#) classes tests whether two angles are congruent. The is\_equivalent() method for [Point1D](#), [Line2D](#), [Plane3D](#) classes tests whether they are the same point/line/plane after standardization.

### Usage

```
is_equivalent(x, y, ...)
```

```
## S3 method for class 'angle'
is_equivalent(
  x,
  y,
  ...,
  mod_turns = TRUE,
```

```

    tolerance = sqrt(.Machine$double.eps)
  )

  ## S3 method for class 'numeric'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Coord1D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Coord2D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Coord3D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Point1D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Line2D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

  ## S3 method for class 'Plane3D'
  is_equivalent(x, y, ..., tolerance = sqrt(.Machine$double.eps))

```

### Arguments

|                        |                                                                                     |
|------------------------|-------------------------------------------------------------------------------------|
| <code>x, y</code>      | Two objects to test whether they are “equivalent”.                                  |
| <code>...</code>       | Further arguments passed to or from other methods.                                  |
| <code>mod_turns</code> | If TRUE angles that are congruent modulo full turns will be considered “congruent”. |
| <code>tolerance</code> | Numerics with differences smaller than tolerance will be considered “equivalent”.   |

### Value

A logical vector

### See Also

[is\\_congruent\(\)](#), [all.equal\(\)](#)

### Examples

```

line1 <- as_line2d(a = 1, b = 2, c = 3) # 1 * x + 2 * y + 3 = 0
line2 <- as_line2d(a = 2, b = 4, c = 6) # 2 * x + 4 * y + 6 = 0
is_equivalent(line1, line2)

```

---

|           |                                                  |
|-----------|--------------------------------------------------|
| is_line2d | <i>Test whether an object has a Line2D class</i> |
|-----------|--------------------------------------------------|

---

**Description**

is\_line2d() tests whether an object has a "Line2D" class

**Usage**

```
is_line2d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
l <- as_line2d(a = 1, b = 2, c = 3)
is_line2d(l)
```

---

|             |                                         |
|-------------|-----------------------------------------|
| is_parallel | <i>Whether two objects are parallel</i> |
|-------------|-----------------------------------------|

---

**Description**

is\_parallel() is a S3 method that tests whether two objects are parallel.

**Usage**

```
is_parallel(x, y, ...)

## S3 method for class 'Line2D'
is_parallel(x, y, ..., tolerance = sqrt(.Machine$double.eps))

## S3 method for class 'Plane3D'
is_parallel(x, y, ..., tolerance = sqrt(.Machine$double.eps))
```

**Arguments**

|           |                                                                                   |
|-----------|-----------------------------------------------------------------------------------|
| x, y      | The two objects to compute if they are parallel.                                  |
| ...       | Passed to other methods (or ignored).                                             |
| tolerance | Numerics with differences smaller than tolerance will be considered “equivalent”. |

**Value**

A logical vector.

**Examples**

```
line1 <- as_line2d("x-axis")
line2 <- as_line2d("y-axis")
line3 <- as_line2d(a = 0, b = 1, c = 2) # y + 2 = 0
is_parallel(line1, line1)
is_parallel(line1, line2)
is_parallel(line1, line3)
```

---

is\_plane3d

*Test whether an object has a Plane3D class*

---

**Description**

is\_plane3d() tests whether an object has a "Plane3D" class

**Usage**

```
is_plane3d(x)
```

**Arguments**

x                      An object

**Value**

A logical value

**Examples**

```
p <- as_plane3d(a = 1, b = 2, c = 3, 4)
is_plane3d(p)
```

---

|            |                                                   |
|------------|---------------------------------------------------|
| is_point1d | <i>Test whether an object has a Point1D class</i> |
|------------|---------------------------------------------------|

---

**Description**

is\_point1d() tests whether an object has a "Point1D" class

**Usage**

```
is_point1d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
p <- as_point1d(a = 1, b = 5)
is_point1d(p)
```

---

|                |                                                |
|----------------|------------------------------------------------|
| is_transform1d | <i>Test if 1D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

**Description**

is\_transform1d() tests if object is a [transform1d\(\)](#) affine transformation matrix

**Usage**

```
is_transform1d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
m <- transform1d(diag(2L))
is_transform1d(m)
is_transform1d(diag(2L))
```

---

|                |                                                |
|----------------|------------------------------------------------|
| is_transform2d | <i>Test if 2D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

**Description**

is\_transform2d() tests if object is a [transform2d\(\)](#) affine transformation matrix

**Usage**

```
is_transform2d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
m <- transform2d(diag(3L))
is_transform2d(m)
is_transform2d(diag(3L))
```

---

|                |                                                |
|----------------|------------------------------------------------|
| is_transform3d | <i>Test if 3D affine transformation matrix</i> |
|----------------|------------------------------------------------|

---

**Description**

is\_transform3d() tests if object is a [transform3d\(\)](#) affine transformation matrix

**Usage**

```
is_transform3d(x)
```

**Arguments**

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

**Value**

A logical value

**Examples**

```
m <- transform3d(diag(4L))
is_transform3d(m)
is_transform3d(diag(4L))
```

Line2D

2D lines R6 Class

**Description**

Line2D is an `R6::R6Class()` object representing two-dimensional lines.

**Public fields**

- a Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .
- b Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .
- c Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .

**Methods****Public methods:**

- `Line2D$new()`
- `Line2D$print()`
- `Line2D$clone()`

**Method new():**

*Usage:*

`Line2D$new(a, b, c)`

*Arguments:*

- a Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .
- b Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .
- c Numeric vector that parameterizes the line via the equation  $a * x + b * y + c = 0$ .

**Method print():**

*Usage:*

`Line2D$print(n = NULL, ...)`

*Arguments:*

- n Number of lines to print. If NULL print all of them.
- ... Passed to `format.default()`.

**Method clone():** The objects of this class are cloneable with this method.

*Usage:*

`Line2D$clone(deep = FALSE)`

*Arguments:*

- deep Whether to make a deep clone.

**Examples**

```
p1 <- as_coord2d(x = 5, y = 10)
p2 <- as_coord2d(x = 7, y = 12)
theta <- degrees(45)
as_line2d(theta, p1)
as_line2d(p1, p2)
```

---

|          |                          |
|----------|--------------------------|
| normal2d | <i>2D normal vectors</i> |
|----------|--------------------------|

---

**Description**

`normal2d()` is an S3 generic that computes a 2D normal vector.

**Usage**

```
normal2d(x, ...)
```

```
## S3 method for class 'Coord2D'
normal2d(x, ..., normalize = TRUE)
```

```
## S3 method for class 'Line2D'
normal2d(x, ..., normalize = TRUE)
```

**Arguments**

|                        |                                                                                   |
|------------------------|-----------------------------------------------------------------------------------|
| <code>x</code>         | Object to compute a 2D normal vector for such as a <a href="#">Line2D</a> object. |
| <code>...</code>       | Passed to or from other methods.                                                  |
| <code>normalize</code> | If TRUE coerce to a normalize vector                                              |

**Value**

A [Coord2D](#) (normal) vector

**Examples**

```
p <- as_coord2d(x = 2, y = 3)
normal2d(p)
normal2d(p, normalize = FALSE)
```

---

|          |                          |
|----------|--------------------------|
| normal3d | <i>3D normal vectors</i> |
|----------|--------------------------|

---

## Description

`normal3d()` is an S3 generic that computes a 3D normal vector.

## Usage

```
normal3d(x, ...)  
  
## S3 method for class 'Coord3D'  
normal3d(x, cross, ..., normalize = TRUE)  
  
## S3 method for class 'character'  
normal3d(x, ..., normalize = TRUE)  
  
## S3 method for class 'Plane3D'  
normal3d(x, ..., normalize = TRUE)
```

## Arguments

|                        |                                                                                                                                    |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>         | Object to compute a 3D normal vector for such as a <a href="#">Plane3D</a> object                                                  |
| <code>...</code>       | Passed to other methods such as <a href="#">as_coord3d()</a> .                                                                     |
| <code>cross</code>     | A <a href="#">Coord3D</a> vector. We'll compute the normal of <code>x</code> and <code>cross</code> by taking their cross product. |
| <code>normalize</code> | If TRUE normalize to a unit vector                                                                                                 |

## Value

A [Coord3D](#) (normal) vector

## Examples

```
normal3d("xy-plane")  
normal3d(as_coord3d(2, 0, 0), cross = as_coord3d(0, 2, 0))
```

Plane3D

*3D planes R6 Class***Description**

Plane3D is an `R6::R6Class()` object representing three-dimensional planes.

**Public fields**

- a Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- b Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- c Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- d Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .

**Methods****Public methods:**

- `Plane3D$new()`
- `Plane3D$print()`
- `Plane3D$clone()`

**Method new():**

*Usage:*

`Plane3D$new(a, b, c, d)`

*Arguments:*

- a Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- b Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- c Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .
- d Numeric vector that parameterizes the plane via the equation  $a * x + b * y + c * z + d = 0$ .

**Method print():**

*Usage:*

`Plane3D$print(n = NULL, ...)`

*Arguments:*

- n Number of lines to print. If NULL print all of them.
- ... Passed to `format.default()`.

**Method clone():** The objects of this class are cloneable with this method.

*Usage:*

`Plane3D$clone(deep = FALSE)`

*Arguments:*

- deep Whether to make a deep clone.

Point1D

*1D points R6 Class***Description**

Point1D is an `R6::R6Class()` object representing one-dimensional points.

**Public fields**

- a Numeric vector that parameterizes the point via the equation  $a * x + b = 0$ .
- b Numeric vector that parameterizes the point via the equation  $a * x + b = 0$ .

**Methods****Public methods:**

- `Point1D$new()`
- `Point1D$print()`
- `Point1D$clone()`

**Method** `new()`:

*Usage:*

`Point1D$new(a, b)`

*Arguments:*

- a Numeric vector that parameterizes the line via the equation  $a * x + b = 0$ .
- b Numeric vector that parameterizes the line via the equation  $a * x + b = 0$ .

**Method** `print()`:

*Usage:*

`Point1D$print(n = NULL, ...)`

*Arguments:*

- n Number of lines to print. If NULL print all of them.
- ... Passed to `format.default()`.

**Method** `clone()`: The objects of this class are cloneable with this method.

*Usage:*

`Point1D$clone(deep = FALSE)`

*Arguments:*

- deep Whether to make a deep clone.

**Examples**

```
p1 <- as_point1d(a = 1, b = 5)
```

---

|                |                                                                      |
|----------------|----------------------------------------------------------------------|
| rotate3d_to_AA | <i>Convert from 3D rotation matrix to axis-angle representation.</i> |
|----------------|----------------------------------------------------------------------|

---

### Description

rotate3d\_to\_AA() converts from (post-multiplied) rotation matrix to an axis-angle representation of 3D rotations.

### Usage

```
rotate3d_to_AA(
  mat = diag(4),
  unit = getOption("affiner_angular_unit", "degrees")
)
```

### Arguments

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mat  | 3D rotation matrix (post-multiplied). If you have a pre-multiplied rotation matrix simply transpose it with <code>t()</code> to get a post-multiplied rotation matrix.                                                                                                                                                                                                                                                                                                             |
| unit | A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"): <ul style="list-style-type: none"> <li>• "deg" or "degree"</li> <li>• "half-revolution", "half-turn", or "pi-radian"</li> <li>• "gon", "grad", "grade", or "gradian"</li> <li>• "rad" or "radian"</li> <li>• "rev", "revolution", "tr", or "turn"</li> </ul> |

### See Also

[https://en.wikipedia.org/wiki/Axis-angle\\_representation](https://en.wikipedia.org/wiki/Axis-angle_representation) for more details about the Axis-angle representation of 3D rotations. `rotate3d()` can be used to convert from an axis-angle representation to a rotation matrix.

### Examples

```
# axis-angle representation of 90 degree rotation about the x-axis
rotate3d_to_AA(rotate3d("x-axis", 90, unit = "degrees"))

# find Axis-Angle representation of first rotating about x-axis 180 degrees
# and then rotating about z-axis 45 degrees
R <- rotate3d("x-axis", 180, unit = "degrees") %*%
  rotate3d("z-axis", 45, unit = "degrees")
AA <- rotate3d_to_AA(R)

# Can use `rotate3d()` to convert back to rotation matrix representation
all.equal(R, do.call(rotate3d, AA))
```

---

|             |                                          |
|-------------|------------------------------------------|
| transform1d | <i>1D affine transformation matrices</i> |
|-------------|------------------------------------------|

---

### Description

transform1d(), reflect1d(), scale2d(), and translate1d() create 1D affine transformation matrix objects.

### Usage

```
transform1d(mat = diag(2L))

project1d(point = as_point1d("origin"), ...)

reflect1d(point = as_point1d("origin"), ...)

scale1d(x_scale = 1)

translate1d(x = as_coord1d(0), ...)
```

### Arguments

|         |                                                                                                                                                                                                                                                                                                                                                                     |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mat     | A 2x2 matrix representing a post-multiplied affine transformation matrix. The last <b>column</b> must be equal to $c(0, 1)$ . If the last <b>row</b> is $c(0, 1)$ you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 1x1 matrix we'll quietly add a final column/row equal to $c(0, 1)$ . |
| point   | A <a href="#">Point1D</a> object of length one representing the point you wish to reflect across or project to or an object coercible to one by <code>as_point1d(point, ...)</code> such as "origin".                                                                                                                                                               |
| ...     | Passed to <a href="#">as_coord1d()</a> .                                                                                                                                                                                                                                                                                                                            |
| x_scale | Scaling factor to apply to x coordinates                                                                                                                                                                                                                                                                                                                            |
| x       | A <a href="#">Coord1D</a> object of length one or an object coercible to one by <code>as_coord1d(x, ...)</code> .                                                                                                                                                                                                                                                   |

### Details

transform1d() User supplied (post-multiplied) affine transformation matrix.

reflect1d() Reflections across a point.

scale1d() Scale the x-coordinates by multiplicative scale factors.

translate1d() Translate the coordinates by a [Coord1D](#) class object parameter.

transform1d() 1D affine transformation matrix objects are meant to be post-multiplied and therefore should **not** be multiplied in reverse order. Note the [Coord1D](#) class object methods auto-pre-multiply affine transformations when "method chaining" so pre-multiplying affine transformation

matrices to do a single cumulative transformation instead of a method chain of multiple transformations will not improve performance as much as it does in other R packages.

To convert a pre-multiplied 1D affine transformation matrix to a post-multiplied one simply compute its transpose using `t()`. To get an inverse transformation matrix from an existing transformation matrix that does the opposite transformations simply compute its inverse using `solve()`.

### Value

A 2x2 post-multiplied affine transformation matrix with classes "transform1d" and "at\_matrix"

### Examples

```
p <- as_coord1d(x = sample(1:10, 3))

# {affiner} affine transformation matrices are post-multiplied
# and therefore should not go in reverse order
mat <- transform1d(diag(2)) %*%
      scale1d(2) %*%
      translate1d(x = -1)
p1 <- p$
      clone()$
      transform(mat)

# The equivalent result applying affine transformations via method chaining
p2 <- p$
      clone()$
      transform(diag(2))$
      scale(2)$
      translate(x = -1)

all.equal(p1, p2)
```

---

transform2d

2D affine transformation matrices

---

### Description

`transform2d()`, `project2d()`, `reflect2d()`, `rotate2d()`, `scale2d()`, `shear2d()`, and `translate2d()` create 2D affine transformation matrix objects.

### Usage

```
transform2d(mat = diag(3L))

permute2d(permutation = c("xy", "yx"))

project2d(line = as_line2d("x-axis"), ..., scale = 0)

reflect2d(line = as_line2d("x-axis"), ...)
```

```

rotate2d(theta = angle(0), ...)

scale2d(x_scale = 1, y_scale = x_scale)

shear2d(xy_shear = 0, yx_shear = 0)

translate2d(x = as_coord2d(0, 0), ...)

```

### Arguments

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mat         | A 3x3 matrix representing a post-multiplied affine transformation matrix. The last <b>column</b> must be equal to $c(0, 0, 1)$ . If the last <b>row</b> is $c(0, 0, 1)$ you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 2x2 matrix (such as a 2x2 post-multiplied 2D rotation matrix) we'll quietly add a final column/row equal to $c(0, 0, 1)$ . |
| permutation | Either "xy" (no permutation) or "yx" (permute x and y axes)                                                                                                                                                                                                                                                                                                                                                                     |
| line        | A <a href="#">Line2D</a> object of length one representing the line you wish to reflect across or project to or an object coercible to one by <code>as_line2d(line, ...)</code> such as "x-axis" or "y-axis".                                                                                                                                                                                                                   |
| ...         | Passed to <a href="#">as_angle()</a> or <a href="#">as_coord2d()</a> .                                                                                                                                                                                                                                                                                                                                                          |
| scale       | Oblique projection scale factor. A degenerate 0 value indicates an orthogonal projection.                                                                                                                                                                                                                                                                                                                                       |
| theta       | An <a href="#">angle()</a> object of length one or an object coercible to one by <code>as_angle(theta, ...)</code> .                                                                                                                                                                                                                                                                                                            |
| x_scale     | Scaling factor to apply to x coordinates                                                                                                                                                                                                                                                                                                                                                                                        |
| y_scale     | Scaling factor to apply to y coordinates                                                                                                                                                                                                                                                                                                                                                                                        |
| xy_shear    | Horizontal shear factor: $x = x + xy\_shear * y$                                                                                                                                                                                                                                                                                                                                                                                |
| yx_shear    | Vertical shear factor: $y = yx\_shear * x + y$                                                                                                                                                                                                                                                                                                                                                                                  |
| x           | A <a href="#">Coord2D</a> object of length one or an object coercible to one by <code>as_coord2d(x, ...)</code> .                                                                                                                                                                                                                                                                                                               |

### Details

`transform2d()` User supplied (post-multiplied) affine transformation matrix.  
`project2d()` Oblique vector projections onto a line parameterized by an oblique projection scale factor. A (degenerate) scale factor of zero results in an orthogonal projection.  
`reflect2d()` Reflections across a line. To "flip" across both the x-axis and the y-axis use `scale2d(-1)`.  
`rotate2d()` Rotations around the origin parameterized by an [angle\(\)](#).  
`scale2d()` Scale the x-coordinates and/or the y-coordinates by multiplicative scale factors.  
`shear2d()` Shear the x-coordinates and/or the y-coordinates using shear factors.  
`translate2d()` Translate the coordinates by a [Coord2D](#) class object parameter.  
`transform2d()` 2D affine transformation matrix objects are meant to be post-multiplied and therefore should **not** be multiplied in reverse order. Note the [Coord2D](#) class object methods auto-pre-multiply affine transformations when "method chaining" so pre-multiplying affine transformation

matrices to do a single cumulative transformation instead of a method chain of multiple transformations will not improve performance as much as it does in other R packages.

To convert a pre-multiplied 2D affine transformation matrix to a post-multiplied one simply compute its transpose using `t()`. To get an inverse transformation matrix from an existing transformation matrix that does the opposite transformations simply compute its inverse using `solve()`.

### Value

A 3x3 post-multiplied affine transformation matrix with classes "transform2d" and "at\_matrix"

### Examples

```
p <- as_coord2d(x = sample(1:10, 3), y = sample(1:10, 3))

# {affiner} affine transformation matrices are post-multiplied
# and therefore should not go in reverse order
mat <- transform2d(diag(3)) %*%
  reflect2d(as_coord2d(-1, 1)) %*%
  rotate2d(90, "degrees") %*%
  scale2d(1, 2) %*%
  shear2d(0.5, 0.5) %*%
  translate2d(x = -1, y = -1)

p1 <- p$
  clone()$
  transform(mat)

# The equivalent result applying affine transformations via method chaining
p2 <- p$
  clone()$
  transform(diag(3L))$
  reflect(as_coord2d(-1, 1))$
  rotate(90, "degrees")$
  scale(1, 2)$
  shear(0.5, 0.5)$
  translate(x = -1, y = -1)

all.equal(p1, p2)
```

### Description

`transform3d()`, `project3d()`, `reflect3d()`, `rotate3d()`, `scale3d()`, `shear3d()`, and `translate3d()` create 3D affine transformation matrix objects.

**Usage**

```

transform3d(mat = diag(4L))

permute3d(permutation = c("xyz", "xzy", "yxz", "yzx", "zyx", "zxy"))

project3d(
  plane = as_plane3d("xy-plane"),
  ...,
  scale = 0,
  alpha = angle(45, "degrees")
)

reflect3d(plane = as_plane3d("xy-plane"), ...)

rotate3d(axis = as_coord3d("z-axis"), theta = angle(0), ...)

scale3d(x_scale = 1, y_scale = x_scale, z_scale = x_scale)

shear3d(
  xy_shear = 0,
  xz_shear = 0,
  yx_shear = 0,
  yz_shear = 0,
  zx_shear = 0,
  zy_shear = 0
)

translate3d(x = as_coord3d(0, 0, 0), ...)

```

**Arguments**

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mat         | A 4x4 matrix representing a post-multiplied affine transformation matrix. The last <b>column</b> must be equal to <code>c(0, 0, 0, 1)</code> . If the last <b>row</b> is <code>c(0, 0, 0, 1)</code> you may need to transpose it to convert it from a pre-multiplied affine transformation matrix to a post-multiplied one. If a 3x3 matrix (such as a 3x3 post-multiplied 3D rotation matrix) we'll quietly add a final column/row equal to <code>c(0, 0, 0, 1)</code> . |
| permutation | Either "xyz" (no permutation), "xzy" (permute y and z axes), "yxz" (permute x and y axes), "yzx" (x becomes z, y becomes x, z becomes y), "zxy" (x becomes y, y becomes z, z becomes x), "zyx" (permute x and z axes)                                                                                                                                                                                                                                                     |
| plane       | A <a href="#">Plane3D</a> object of length one representing the plane you wish to reflect across or project to or an object coercible to one using <code>as_plane3d(plane, ...)</code> such as "xy-plane", "xz-plane", or "yz-plane".                                                                                                                                                                                                                                     |
| ...         | Passed to <a href="#">as_angle()</a> or <a href="#">as_coord3d()</a> .                                                                                                                                                                                                                                                                                                                                                                                                    |
| scale       | Oblique projection foreshortening scale factor. A (degenerate) 0 value indicates an orthographic projection. A value of 0.5 is used by a "cabinet projection" while a value of 1.0 is used by a "cavalier projection".                                                                                                                                                                                                                                                    |

|          |                                                                                                                                                                                                                                                                      |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| alpha    | Oblique projection angle (the angle the third axis is projected going off at). An <a href="#">angle()</a> object or one coercible to one with <code>as_angle(alpha, ...)</code> . Popular angles are 45 degrees, 60 degrees, and <code>arctangent(2)</code> degrees. |
| axis     | A <a href="#">Coord3D</a> class object or one that can coerced to one by <code>as_coord3d(axis, ...)</code> . The axis represents the axis to be rotated around.                                                                                                     |
| theta    | An <a href="#">angle()</a> object of length one or an object coercible to one by <code>as_angle(theta, ...)</code> .                                                                                                                                                 |
| x_scale  | Scaling factor to apply to x coordinates                                                                                                                                                                                                                             |
| y_scale  | Scaling factor to apply to y coordinates                                                                                                                                                                                                                             |
| z_scale  | Scaling factor to apply to z coordinates                                                                                                                                                                                                                             |
| xy_shear | Shear factor: $x = x + xy\_shear * y + xz\_shear * z$                                                                                                                                                                                                                |
| xz_shear | Shear factor: $x = x + xy\_shear * y + xz\_shear * z$                                                                                                                                                                                                                |
| yx_shear | Shear factor: $y = yx\_shear * x + y + yz\_shear * z$                                                                                                                                                                                                                |
| yz_shear | Shear factor: $y = yx\_shear * x + y + yz\_shear * z$                                                                                                                                                                                                                |
| zx_shear | Shear factor: $z = zx\_shear * x + zy\_shear * y + z$                                                                                                                                                                                                                |
| zy_shear | Shear factor: $z = zx\_shear * x + zy\_shear * y + z$                                                                                                                                                                                                                |
| x        | A <a href="#">Coord3D</a> object of length one or an object coercible to one by <code>as_coord3d(x, ...)</code> .                                                                                                                                                    |

## Details

`transform3d()` User supplied (post-multiplied) affine transformation matrix.

`scale3d()` Scale the x-coordinates and/or the y-coordinates and/or the z-coordinates by multiplicative scale factors.

`shear3d()` Shear the x-coordinates and/or the y-coordinates and/or the z-coordinates using shear factors.

`translate3d()` Translate the coordinates by a [Coord3D](#) class object parameter.

`transform3d()` 3D affine transformation matrix objects are meant to be post-multiplied and therefore should **not** be multiplied in reverse order. Note the [Coord3D](#) class object methods auto-pre-multiply affine transformations when "method chaining" so pre-multiplying affine transformation matrices to do a single cumulative transformation instead of a method chain of multiple transformations will not improve performance as much as it does in other R packages.

To convert a pre-multiplied 3D affine transformation matrix to a post-multiplied one simply compute its transpose using `t()`. To get an inverse transformation matrix from an existing transformation matrix that does the opposite transformations simply compute its inverse using `solve()`.

## Value

A 4x4 post-multiplied affine transformation matrix with classes "transform3d" and "at\_matrix"

**Examples**

```

p <- as_coord3d(x = sample(1:10, 3), y = sample(1:10, 3), z = sample(1:10, 3))

# {affiner} affine transformation matrices are post-multiplied
# and therefore should **not** go in reverse order
mat <- transform3d(diag(4L)) %*%
  rotate3d("z-axis", degrees(90)) %*%
  scale3d(1, 2, 1) %*%
  translate3d(x = -1, y = -1, z = -1)
p1 <- p$
  clone()$
  transform(mat)

# The equivalent result applying affine transformations via method chaining
p2 <- p$
  clone()$
  transform(diag(4L))$
  rotate("z-axis", degrees(90))$
  scale(1, 2, 1)$
  translate(x = -1, y = -1, z = -1)

all.equal(p1, p2)

```

---

trigonometric-functions

*Angle vector aware trigonometric functions*


---

**Description**

sine(), cosine(), tangent(), secant(), cosecant(), and cotangent() are [angle\(\)](#) aware trigonometric functions that allow for a user chosen angular unit.

**Usage**

```

sine(x, unit = getOption("affiner_angular_unit", "degrees"))

cosine(x, unit = getOption("affiner_angular_unit", "degrees"))

tangent(x, unit = getOption("affiner_angular_unit", "degrees"))

secant(x, unit = getOption("affiner_angular_unit", "degrees"))

cosecant(x, unit = getOption("affiner_angular_unit", "degrees"))

cotangent(x, unit = getOption("affiner_angular_unit", "degrees"))

```

**Arguments**

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>    | An angle vector or an object to convert to it (such as a numeric vector)                                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>unit</code> | <p>A string of the desired angular unit. Supports the following strings (note we ignore any punctuation and space characters as well as any trailing s's e.g. "half turns" will be treated as equivalent to "halfturn"):</p> <ul style="list-style-type: none"><li>• "deg" or "degree"</li><li>• "half-revolution", "half-turn", or "pi-radian"</li><li>• "gon", "grad", "grade", or "gadian"</li><li>• "rad" or "radian"</li><li>• "rev", "revolution", "tr", or "turn"</li></ul> |

**Value**

A numeric vector

**Examples**

```
sine(pi, "radians")
cosine(180, "degrees")
tangent(0.5, "turns")

a <- angle(0.5, "turns")
secant(a)
cosecant(a)
cotangent(a)
```

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