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# 1 Overview

CeTZ, ein Typst Zeichenpaket, is a drawing package for Typst. Its API is similar to Processing but with relative coordinates and anchors from TikZ. You also won't have to worry about accidentally drawing over other content as the canvas will automatically resize. And remember: up is positive!

## 2 Getting Started

### 2.1 Usage

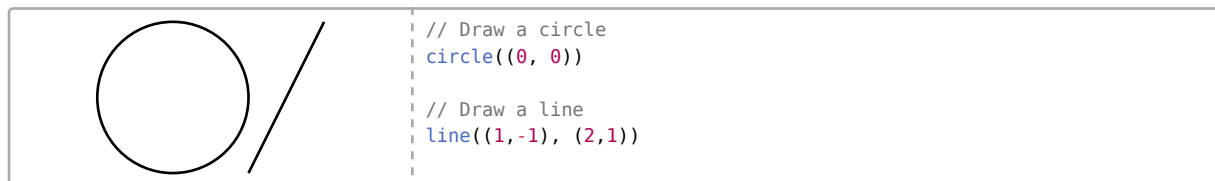
This is the minimal starting point in a .typ file:

```
#import "@preview/cetz:0.4.2"
#cetx.canvas({
  import cetx.draw: *
  ...
})
```

Note that draw functions are imported inside the scope of the canvas block. This is recommended as some draw functions override Typst's functions such as `line`.

### 2.2 Examples

From this point on only the code inside the canvas block will be shown in examples unless specified otherwise.



## 3 Basics

The following chapters are about the basic and core concepts of CeTZ. They are recommended reading for basic usage.

### 3.1 Custom Types

Many CeTZ functions expect data in certain formats which we will call types. Note that these are actually made up of Typst primitives.

**coordinate** A position on the canvas specified by any coordinate system. See [Coordinate Systems](#).

**number** Any of `float`, `int` or `length`

**style** Represents options passed to draw functions that affect how elements are drawn. They are normally taken in the form of named arguments to the draw functions or sometimes can be a dictionary for a single argument.

### 3.2 The Canvas

The `canvas` function is what handles all of the logic and processing in order to produce drawings. It's usually called with a code block `{ ... }` as argument. The content of the curly braces is the body of the canvas. Import all the draw functions you need at the top of the body:

```
#cetx.canvas({
  import cetx.draw: *
})
```

You can now call the draw functions within the body and they'll produce some graphics! Typst will evaluate the code block and pass the result to the canvas function for rendering.

The canvas does not have typical width and height parameters. Instead its size will grow and shrink to fit the drawn graphic.

By default 1 coordinate unit is 1 cm, this can be changed by setting the `length:` parameter.

### 3.3 Styling

You can style draw elements by passing the relevant named arguments to their draw functions. All elements that draw something have stroke and fill styling unless said otherwise.

**fill** `color` or `none` (default: none)

How to fill the drawn element.

**stroke** `none` or `auto` or `length` or `color` or `dictionary` or `stroke` (default: black)

How to stroke the border or the path of the draw element. See Typst's line documentation for more details.

## 4 API

### 4.1 Canvas

**canvas**

```
canvas(  
  length: length,  
  x: number vector,  
  y: number vector,  
  z: number vector,  
  baseline: none number coordinate,  
  debug: bool,  
  background: none color,  
  stroke: none stroke,  
  padding: none number array dictionary,  
  body none array element  
) → content
```

Sets up a canvas for drawing on.

#### Parameters

- **length** `length`

Used to specify what 1 coordinate unit is. Note that ratios are no longer supported! You can wrap the canvas into a `layout(ly => canvas(length: ly.width * <ratio>, ...))`.

- **baseline** `none` `number` `coordinate`

Specifies the coordinate to use as the baseline. Setting this the canvas behaves like a box element instead of a block.

- **body** `none` `array` `element`

A code block in which functions from the draw module have been called.

- **background** `none` `color`

A color to be used for the background of the canvas.

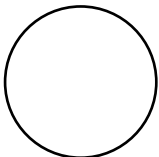
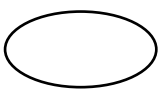
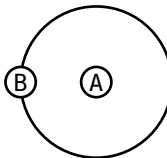
- **stroke** `none` `stroke`  
Stroke style to apply to the canvas top-level element (box or block)
- **padding** `none` `number` `array` `dictionary`  
How much padding to add to the canvas. `none` applies no padding. A number applies padding to all sides equally. A dictionary applies padding following Typst's `pad` function: <https://typst.app/docs/reference/layout/pad/>. An array follows CSS like padding: (y, x), (top, x, bottom) or (top, right, bottom, left).
- **x** `number` `vector`  
Sets up the x vector of the coordinate system to (x, 0, 0) or to the given vector.
- **y** `number` `vector`  
Sets up the y vector of the coordinate system to (0, y, 0) or to the given vector.
- **z** `number` `vector`  
Sets up the z vector of the coordinate system to (0, 0, z) or to the given vector.
- **debug** `bool`  
Shows the bounding boxes of each element when true.

## 4.2 Shapes

### circle

```
circle(
  ..points-style coordinate style,
  name: none str,
  anchor: none str
)
```

Draws a circle or ellipse.

	<pre>// Draw a circle with center (0, 0) circle((0, 0))</pre>
	<pre>// Draw an ellipse circle((2, 0), radius: (1, 0.5))</pre>
	<pre>let (a, b) = ((2, 1), (1, 1))  // Draw a circle with its center at (2, 1), going // through point (1, 1) circle(a, b)  // Show both points set-style(content: (frame: "circle", padding: 1pt, fill: white)) content(a, [A]); content(b, [B])</pre>

If given two coordinates, the distance between them is used as radius. If given a single coordinate, the radius can be set via the `radius (style)` argument.

### Styling

**Root:** `circle`

## Anchors

Supports border and path anchors. The "center" anchor is the default.

## Parameters

- **..points-style** coordinate style

The position to place the circle on.

- **name** none str

- **anchor** none str

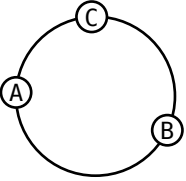
- **radius** number array

A number that defines the size of the circle's radius. Can also be set to a tuple of two numbers to define the radii of an ellipse, the first number is the x radius and the second is the y radius.

## circle-through

```
circle-through(  
  a coordinate,  
  b coordinate,  
  c coordinate,  
  name: none str,  
  anchor: none str,  
  ..style style  
)
```

Draws a circle through three coordinates.

	<pre>let (a, b, c) = ((0, 0), (2, -0.5), (1, 1))  // Draw a circle through 3 points circle-through(a, b, c, name: "c")  // Show the points set-style(content: (frame: "circle", padding: 1pt, fill: white)) content(a, [A]); content(b, [B]); content(c, [C])</pre>
---	---

## Styling

**Root:** circle

circle-through has the same styling as circle except for radius as the circle's radius is calculated by the given coordinates.

## Anchors

Supports the same anchors as circle as well as:

- a** Coordinate a
- b** Coordinate b
- c** Coordinate c

## Parameters

- **a** coordinate

Coordinate a.

- **b** coordinate

Coordinate b.

- **c** coordinate

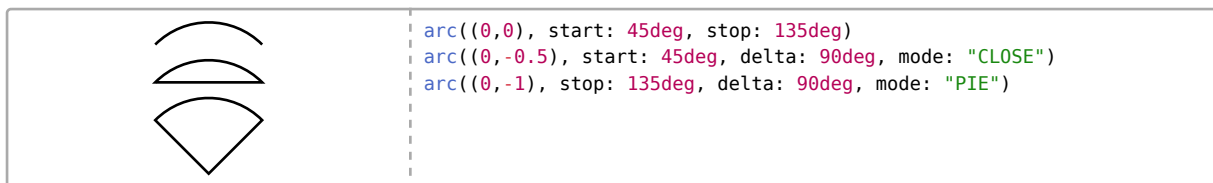
Coordinate c.

- **name** `none` `str`
- **anchor** `none` `str`
- **..style** `style`

## arc

```
arc(
    position coordinate,
    start: auto angle,
    stop: auto angle,
    delta: auto angle,
    name: none str,
    anchor: none str,
    ..style style
)
```

Draws a circular segment.



Note that two of the three angle arguments (start, stop and delta) must be set. The current position ( ) gets updated to the arc's end coordinate (anchor arc-end).

## Styling

**Root:** arc

## Anchors

Supports border and path anchors.

**arc-start** The position at which the arc's curve starts, this is the default.

**arc-end** The position of the arc's curve end.

**arc-center** The midpoint of the arc's curve.

**center** The center of the arc, this position changes depending on if the arc is closed or not.

**chord-center** Center of chord of the arc drawn between the start and end point.

**origin** The origin of the arc's circle.

## Parameters

- **position** `coordinate`

Position to place the arc at.

- **start** `auto` `angle`

The angle at which the arc should start. Remember that 0deg points directly towards the right and 90deg points up.

- **stop** `auto` `angle`

The angle at which the arc should stop.

- **delta** `auto` `angle`

The change in angle away start or stop.

- **name** `none` `str`

- **anchor** `none` `str`



- **..style** `style`

- **radius** `number` `array`

The radius of the arc. An elliptical arc can be created by passing a tuple of numbers where the first element is the x radius and the second element is the y radius.

- **mode** `str`

The options are: "OPEN" no additional lines are drawn so just the arc is shown; "CLOSE" a line is drawn from the start to the end of the arc creating a circular segment; "PIE" lines are drawn from the start and end of the arc to the origin creating a circular sector.

- **update-position** `bool`

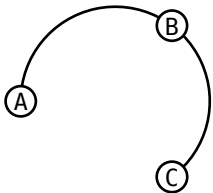
Update the current canvas position to the arc's end point (anchor "arc-end"). This overrides the default of true, that allows chaining of (arc) elements.

## arc-through

```
arc-through(
  a coordinate,
  b coordinate,
  c coordinate,
  name: none str,
  ..style style
)
```

Draws an arc that passes through three points a, b and c.

Note that all three points must not lie on a straight line, otherwise the function fails.



```
let (a, b, c) = ((0, 1), (2, 2), (2, 0))

// Draw an arc through 3 points
arc-through(a, b, c)

// Show the points
set-style(content: (frame: "circle", padding: 1pt, fill: white))
content(a, [A]); content(b, [B]); content(c, [C])
```

## Styling

**Root:** arc

Uses the same styling as arc.

## Anchors

For anchors see arc.

## Parameters

- **a** `coordinate`

Start position of the arc

- **b** `coordinate`

Position the arc passes through

- **c** `coordinate`

End position of the arc

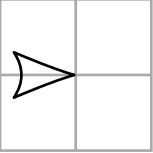
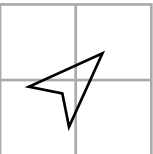
- **name** `none` `str`

- **..style** `style`

## mark

```
mark(  
    from coordinate,  
    to coordinate angle,  
    ..style str style  
)
```

Draws a single mark pointing towards a target coordinate.

	<pre>// Show a grid grid((-1, -1), (1, 1), stroke: gray)  // Draw a mark with its tip at (0, 0) pointing to (1, 0) mark((0, 0), (1, 0), symbol: "&gt;", scale: 4)</pre>
	<pre>// Show a grid grid((-1, -1), (1, 1), stroke: gray)  // Draw a mark with its center at (0, 0) pointing to (1, 1) mark((0, 0), (1, 1), symbol: "&gt;&gt;", anchor: "center", scale: 5)</pre>

Note: To place a mark centered at the first coordinate (from) use the marks anchor: "center" style.

## Styling

**Root:** mark

You can directly use the styling from mark styling.


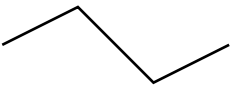
## Parameters

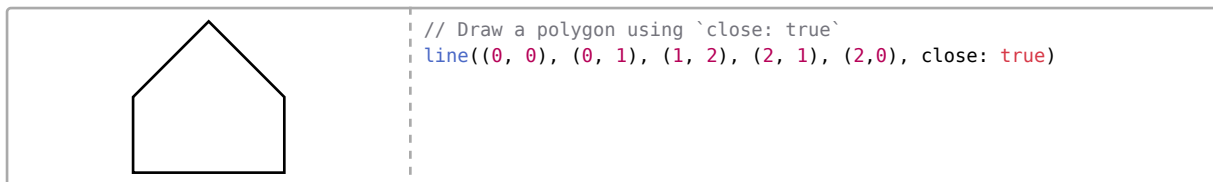
- **from** coordinate  
The position to place the mark.
- **to** coordinate angle  
The position or angle the mark should point towards.
- **..style** str style  
If the third positional argument is of type string, it is treated as mark name (e.g. ">") and overrules style keys such as mark.symbol or mark.end

## line

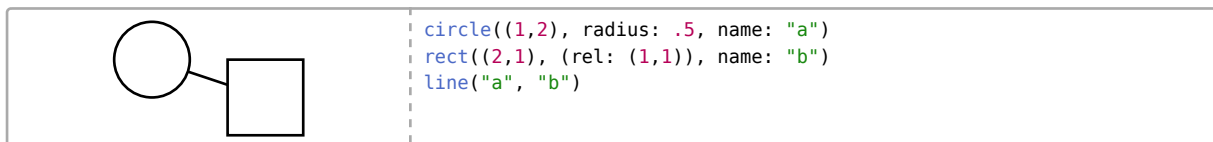
```
line(  
    ..pts-style coordinate style,  
    close: bool,  
    name: none str  
)
```

Draws a line, more than two points can be given to create a line-strip.

	<pre>// Draw a line between two points line((0, 0), (1.5, 1))</pre>
	<pre>// Draw a line between more than two points line((0, 0), (1, 0.5), (2, -0.5), (3, 0))</pre>



If the first or last coordinates are given as the name of an element, that has a "default" anchor, the intersection of that element's border and a line from the first or last two coordinates given is used as coordinate. This is useful to span a line between the borders of two elements.



## Styling

**Root:** line

Supports mark styling.

## Aliases

Supports path anchors.

**centroid** The centroid anchor is calculated for *closed non self-intersecting* polygons if all vertices share the same z value.

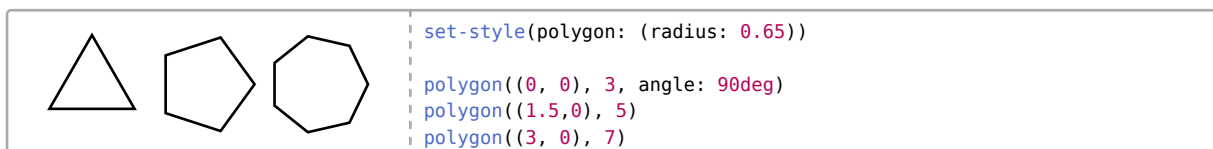
## Parameters

- **..pts-style** coordinate style  
Positional two or more coordinates to draw lines between. Accepts style key-value pairs.
- **close** bool  
If true, the line-strip gets closed to form a polygon
- **name** none str

## poly

```
poly(
  origin coordinate,
  sides int,
  angle: angle,
  name: none str,
  anchor: ,
  ..style
)
```

Draws a regular polygon.



## Styling

**Root:** polygon


## Parameters

- **origin** `coordinate`  
Coordinate to draw the polygon at
- **sides** `int`  
Number of sides of the polygon ( $\geq 3$ )
- **angle** `angle`  
Angle angle to rotate the polygon around its origin
- **name** `none` `str`
- **radius** `number`  
Radius of the polygon

## n-star

```
n-star(  
    origin coordinate,  
    sides int,  
    angle: angle,  
    name: none str,  
    anchor: ,  
    ..style  
)
```

Draws a n-pointed star.

	<pre>set-style(n-star: (radius: 0.65))  n-star((0, 0), 5)  // An 8-pointed star, rotated n-star((1.5, 0), 8, angle: 11.25deg)  // A 6-pointed star showing its inner hexagon n-star((3, 0), 6, show-inner: true)</pre>
---	--

## Styling

Root: nstar

## Parameters

- **origin** `coordinate`  
Coordinate to draw the star's center at.
- **sides** `int`  
Number of points of the star ( $\geq 3$ ).
- **angle** `angle`  
Angle to rotate the star around its origin.
- **name** `none` `str`  
An optional name to identify the shape.
- **radius** `number`  
The radius of the star's outer points.
- **inner-radius** `number` `ratio`  
The radius (if of type ratio, relative to the outer radius) of the star's inner points of the star's inner points.

- **show-inner** `bool`

If true, also draws the inner polygon connecting the star's inner points.

- **fill** `color` `gradient`

The fill color for the star.

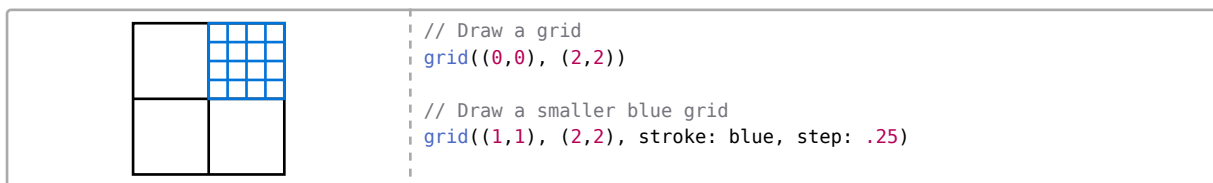
- **stroke** `color` `thickness` `...`

The stroke for the star and the inner polygon.

## grid

```
grid(
  from coordinate,
  to coordinate,
  name: none str,
  ..style style
)
```

Draws a grid between two coordinates



## Styling

**Root:** grid

## Anchors

Supports border anchors.

## Parameters

- **from** `coordinate`

The top left of the grid

- **to** `coordinate`

The bottom right of the grid

- **name** `none` `str`

- **..style** `style`

- **step** `number` `array` `dictionary`

Distance between grid lines. A distance of 1 means to draw a grid line every 1 length units in x- and y-direction. If given a dictionary with x and y keys or a tuple, the step is set per axis.

- **shift** `number` `array` `dictionary`

Offset of the grid lines. Supports an array of the form (x, y) or a dictionary of the form (x: <number>, y: <number>).

- **help-lines** `bool`

If true, force the stroke style to gray + 0.2pt

## content

```
content(
  ..args-style coordinate content style,
  angle: angle coordinate,
```

```

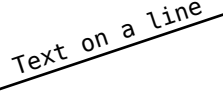
    anchor: none str,
    name: none str
  )

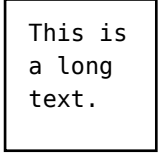
```

Positions Typst content in the canvas. Note that the content itself is not transformed only its position is.

Hello World!	<code>content((0,0), [Hello World!])</code>
--------------	---

To put text on a line you can let the function calculate the angle between its position and a second coordinate by passing it to angle:

	<pre> line((0, 0), (3, 1), name: "line") content(   ("line.start", 50%, "line.end"),   angle: "line.end",   padding: .1,   anchor: "south",   [Text on a line] ) </pre>
---	---

	<pre> // Place content in a rect between two coordinates content(   (0, 0),   (2, 2),   box(     par(justify: false)[This is a long text.],     stroke: 1pt,     width: 100%,     height: 100%,     inset: 1em   ) ) </pre>
--	---

## Styling

**Root:** content

## Anchors

Supports border anchors, the default anchor is set to **center**.

**mid** Content center, from baseline to top bounds

**mid-east** Content center extended to the east

**mid-west** Content center extended to the west

**base** Horizontally centered baseline of the content

**base-east** Baseline height extended to the east

**base-west** Baseline height extended to the west

**text** Position at the content start on the baseline of the content

## Parameters

- **..args-style** coordinate content style

When one coordinate is given as a positional argument, the content will be placed at that position.

When two coordinates are given as positional arguments, the content will be placed inside a rectangle between the two positions. All named arguments are styling and any additional positional arguments will panic.

- **angle** angle coordinate

Rotates the content by the given angle. A coordinate can be given to rotate the content by the angle between it and the first coordinate given in args. This effectively points the right hand side

of the content towards the coordinate. This currently exists because Typst's rotate function does not change the width and height of content.

- **anchor** `none` `str`

- **name** `none` `str`

- **padding** `number` `dictionary`

Sets the spacing around content. Can be a single number to set padding on all sides or a dictionary to specify each side specifically. The dictionary follows Typst's pad function: <https://typst.app/docs/reference/layout/pad/>

- **frame** `str` `none`

Sets the frame style. Can be `{{none}}`, "rect" or "circle" and inherits the stroke and fill style.

- **auto-scale** `bool`

If true, apply current canvas scaling to the content. Defaults to false.

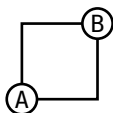
- **wrap** `function` `none`

A function to apply the content body to. Must return content. Example: `text.with(red)` to wrap every content element in a `text(red, <body>)` element.

## rect

```
rect(  
  a coordinate,  
  b coordinate,  
  name: none str,  
  anchor: none str,  
  ..style style  
)
```

Draws a rectangle between two coordinates.



```
// Draw a rect from A(0, 0) to B(1, 1)  
rect((0, 0), (1, 1))  
  
// Show the points  
set-style(content: (frame: "circle", padding: 1pt, fill: white))  
content((0, 0), [A]); content((1, 1), [B])
```



```
rect((0,0), (rel: (1,1)), radius: 0)  
rect((2,0), (rel: (1,1)), radius: 25%)  
rect((4,0), (rel: (1,1)), radius: (north: 50%))  
rect((6,0), (rel: (1,1)), radius: (north-east: 50%))  
rect((8,0), (rel: (1,1)), radius: (south-west: 0, rest: 50%))  
rect((10,0), (rel: (1,1)), radius: (rest: (20%, 50%)))
```

## Styling

**Root:** rect

Ratio values are relative to the rectangle's width and height.

## Anchors

Supports border and path anchors. It's default is the "center" anchor.

## Parameters

- **a** coordinate

Coordinate of the bottom left corner of the rectangle.

- **b** coordinate

Coordinate of the top right corner of the rectangle. You can draw a rectangle with a specified width and height by using relative coordinates for this parameter (rel: (width, height)).

- **name** none str

- **anchor** none str

- **..style** style

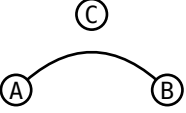
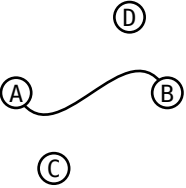
- **radius** number ratio dictionary

The rectangle's corner radius. If set to a single number, that radius is applied to all four corners of the rectangle. If passed a dictionary you can set the radii per corner. The following keys support either a number, ratio or an array of number or ratio for specifying a different x- and y-radius: north, east, south, west, north-west, north-east, south-west and south-east. To set a default value for remaining corners, the rest key can be used.

## bezier

```
bezier(  
  start coordinate,  
  end coordinate,  
  ..ctrl-style coordinate style,  
  name: none str  
)
```

Draws a quadratic or cubic bezier curve

	<pre>let (a, b, c) = ((0, 0), (2, 0), (1, 1)) bezier(a, b, c)  set-style(content: {frame: "circle", padding: 1pt, fill: white}) content(a, [A]); content(b, [B]); content(c, [C])</pre>
	<pre>let (a, b, c, d) = ((0, 0), (2, 0), (.5, -1), (1.5, 1)) bezier(a, b, c, d)  set-style(content: {frame: "circle", padding: 1pt, fill: white}) content(a, [A]); content(b, [B]); content(c, [C]); content(d, [D])</pre>

## Styling

### Root bezier

Supports marks.

### Anchors

Supports path anchors.

**ctrl-n** nth control point where n is an integer starting at 0

## Parameters

- **start** coordinate

Start position



- **end** coordinate

End position (last coordinate)

- **name** none str

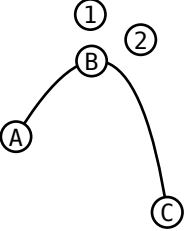
- **..ctrl-style** coordinate style

The first two positional arguments are taken as cubic bezier control points, where the first is the start control point and the second is the end control point. One control point can be given for a quadratic bezier curve instead. Named arguments are for styling.

## bezier-through

```
bezier-through(
  start coordinate,
  pass-through coordinate,
  end coordinate,
  name: none str,
  ..style style
)
```

Draws a cubic bezier curve through a set of three points. See bezier for style and anchor details.



```
let (a, b, c) = ((0, 0), (1, 1), (2, -1))
bezier-through(a, b, c, name: "curve")

// Show the computed control points: 1 and 2
set-style(content: (frame: "circle", padding: 1pt, fill: white))
content(a, [A]); content(b, [B]); content(c, [C])
content("curve.ctrl-1", [2]); content("curve.ctrl-0", [1])
```

## Parameters

- **start** coordinate

The position to start the curve.

- **pass-through** coordinate

The position to pass the curve through.

- **end** coordinate

The position to end the curve.

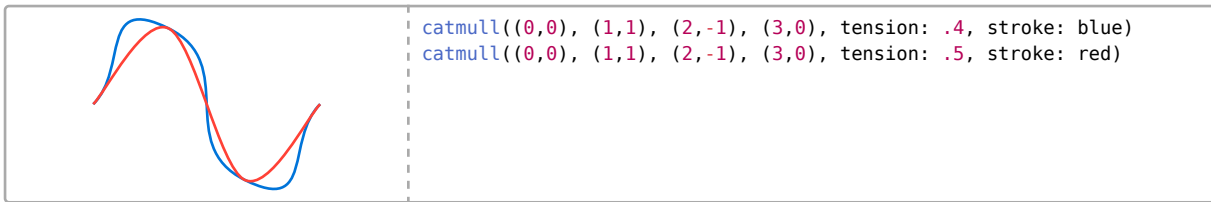
- **name** none str

- **..style** style

## catmull

```
catmull(
  ..pts-style coordinate style,
  close: bool,
  name: none str
)
```

Draws a Catmull-Rom curve through a set of points.



## Styling

**Root:** catmull

Supports marks.

## Anchors

Supports path anchors.

**pt-n** The nth given position (0 indexed so “pt-0” is equal to “start”)

## Parameters

- **..pts-style** coordinate style

Positional arguments should be coordinates that the curve should pass through. Named arguments are for styling.

- **close** bool

Closes the curve with a straight line between the start and end of the curve.

- **name** none str

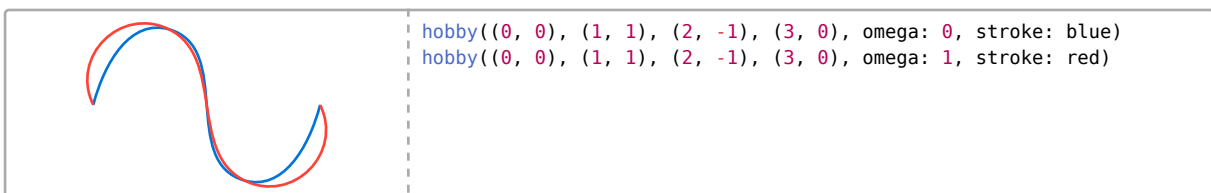
- **tension** float

How tight the curve should fit to the points. The higher the tension the less curvy the curve.

## hobby

```
hobby(
  ..pts-style coordinate style,
  ta: auto array,
  tb: auto array,
  close: bool,
  name: none str
)
```

Draws a Hobby curve through a set of points.



## Styling

**Root** hobby

Supports marks.

## Anchors

Supports path anchors.

**pt-n** The nth given position (0 indexed, so “pt-0” is equal to “start”)

## Parameters

- **..pts-style** coordinate style

Positional arguments are the coordinates to use to draw the curve with, a minimum of two is required. Named arguments are for styling.

- **tb** auto array

Incoming tension at `pts.at(n+1)` from `pts.at(n)` to `pts.at(n+1)`. The number given must be one less than the number of points.

- **ta** auto array

Outgoing tension at `pts.at(n)` from `pts.at(n)` to `pts.at(n+1)`. The number given must be one less than the number of points.

- **close** bool

Closes the curve with a proper smooth curve between the start and end of the curve.

- **name** none str

- **omega** array

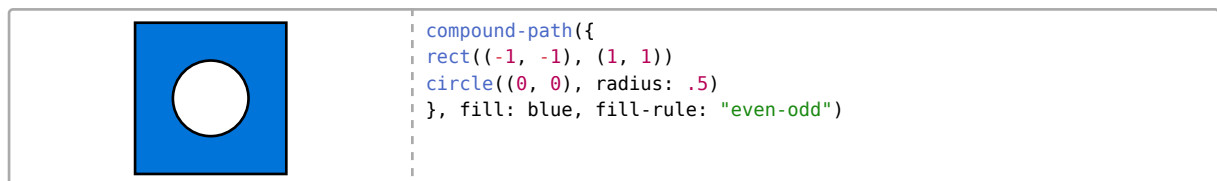
A tuple of floats that describe how curly the curve should be at each endpoint. When the curl is close to zero, the spline approaches a straight line near the endpoints. When the curl is close to one, it approaches a circular arc.

## compound-path

```
compound-path(  
    body elements,  
    name: none str,  
    ..style style  
)
```

Create a new path with each element used as sub-paths. This can be used to create paths with holes.

Unlike `merge-path`, this function groups the shapes as sub-paths instead of concatenating them into a single continuous path.



## anchors

**centroid** Centroid of the *closed and non self-intersecting* shape. Only exists if `close` is true.

Supports path anchors and shapes where all vertices share the same z-value.

## Parameters

- **body** elements

Elements with paths to be merged together.

- **name** none str

- **..style** style

## merge-path

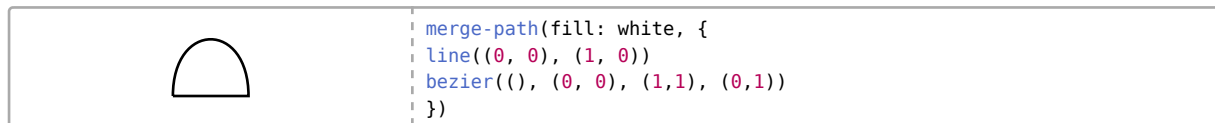
```
merge-path(  
    body elements,
```

```

join: bool,
ignore-marks: bool,
ignore-hidden: bool,
close: bool,
name: none str,
..style style
)

```

Merges two or more paths by concatenating their elements. Anchors and visual styling, such as stroke and fill, are not preserved. When an element's path does not start at the same position the previous element's path ended, a straight line is drawn between them so that the final path is continuous. You must then pay attention to the direction in which element paths are drawn.



Elements hidden via [hide](../grouping/hide) are ignored.

## Anchors

**centroid** Centroid of the *closed and non self-intersecting* shape. Only exists if close is true.

Supports path anchors and shapes where all vertices share the same z-value.

## Parameters

- **body** elements  
Elements with paths to be merged together.
- **join** bool  
Connect all sup-paths with a straight line
- **close** bool  
Close the path with a straight line from the start of the path to its end.
- **ignore-marks** bool  
If true, remove marks from input elements
- **ignore-hidden** bool  
If true, ignore all hidden elements
- **name** none str
- **..style** style

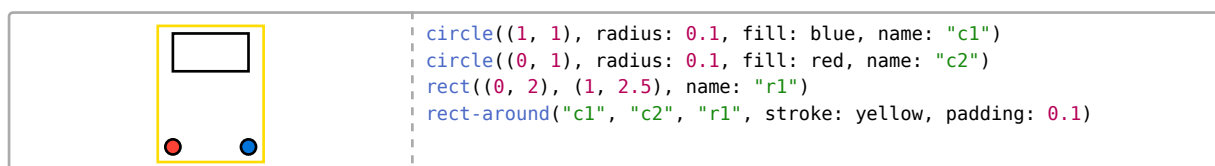
## rect-around

```

rect-around(
  ..pts-style coordinates style
)

```

Draws an axis aligned bounding box around all given points/elements. Everything else (styling, anchors) is similar to the rect shape.



## Styling

The padding attribute can be used to control spacing. Other attributes are forwarded to the rect shape.

## Anchors

The same as for the rect shape.

## Parameters

- **..pts-style** coordinates style

Positional two or more coordinates/elements to calculate bounding box of. Accepts style key-value pairs.

## 4.3 Styling

### set-style

```
set-style(  
  ..style style  
)
```

Set current style

### Parameters

- **..style** style

Style key-value pairs

### fill

```
fill(  
  fill paint  
)
```

Set current fill style

Shorthand for set-style(fill: <fill>)

### Parameters

- **fill** paint

Fill style

### stroke

```
stroke(  
  stroke stroke  
)
```

Set current stroke style

Shorthand for set-style(stroke: <fill>)

### Parameters

- **stroke** stroke

Stroke style

### register-mark

```
register-mark(  
  symbol str,  
  body function,
```


```

mnemonic: none str,
tip: none number coordinate,
base: none number coordinate,
center: none number coordinate,
reverse-tip: none number coordinate,
reverse-base: none number coordinate,
reverse-center: none number coordinate
)

```

Register a custom mark to the canvas

The mark should contain both anchors called **tip** and **base** that are used to determine the marks orientation. If unset both default to (0, 0). An anchor named **center** is used as center of the mark, if present. Otherwise the mid between **tip** and **base** is used.



```

register-mark(":"), style => {
circle((0,0), radius: .5, fill: yellow)
arc((0,0), start: 180deg + 30deg, delta: 180deg - 60deg, anchor:
"origin", radius: .3)
circle((-0.15, 0.15), radius: .1, fill: white)
circle((-0.10, 0.10), radius: .025, fill: black)
circle(( 0.15, 0.15), radius: .1, fill: white)
circle(( 0.20, 0.10), radius: .025, fill: black)

anchor("tip", ( 0.5, 0))
anchor("base", (-0.5, 0))
})

line((0,0), (3,0), mark: (end: ":"))

```

## Parameters

- **symbol** `str`  
Mark name
- **mnemonic** `none str`  
Mark short name
- **body** `function`  
Mark drawing callback, receiving the mark style as argument and returning elements. Format (styles) => elements.
- **tip** `none number coordinate`  
Tip coordinate (if passed a number, the y component is 0)
- **base** `none number coordinate`  
Base coordinate (see tip)
- **center** `none number coordinate`  
Center coordinate (see tip)
- **reverse-tip** `none number coordinate`  
Reversed tip coordinate (see tip)
- **reverse-base** `none number coordinate`  
Reversed base coordinate (see tip)
- **reverse-center** `none number coordinate`  
Reversed center coordinate (see tip)

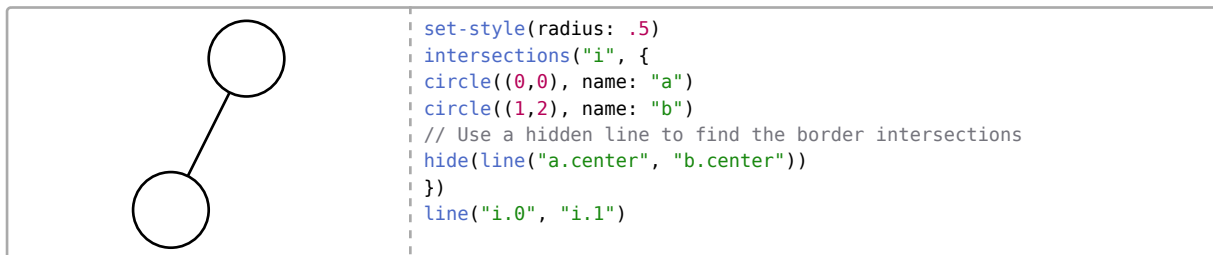
## 4.4 Grouping

### hide

```
hide(  
  body element,  
  bounds: bool  
)
```

Hides an element.

Hidden elements are not drawn to the canvas, are ignored when calculating bounding boxes and discarded by [merge-path](../shapes/merge-path). All other behaviours remain the same as a non-hidden element.



### Parameters

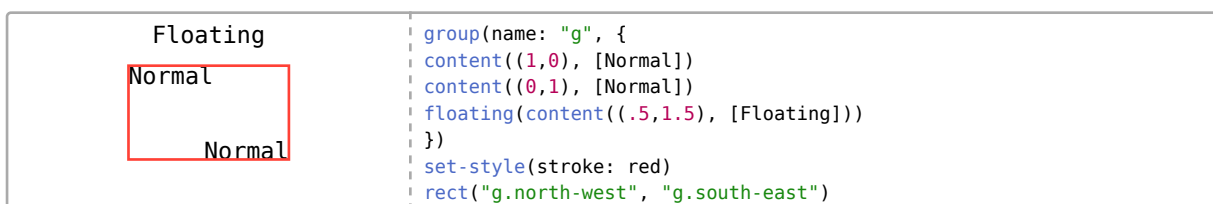
- **body** element  
One or more elements to hide
- **bounds** bool  
If true, respect the bounding box of the hidden elements for resizing the canvas

### floating

```
floating(  
  body element  
)
```

Places an element without affecting bounding boxes.

Floating elements are drawn to the canvas but are ignored when calculating bounding boxes. All other behaviours remain the same.



### Parameters

- **body** element  
One or more elements to place

### intersections

```
intersections(  
  name str,  
  ..elements elements str,  
  samples: int,
```

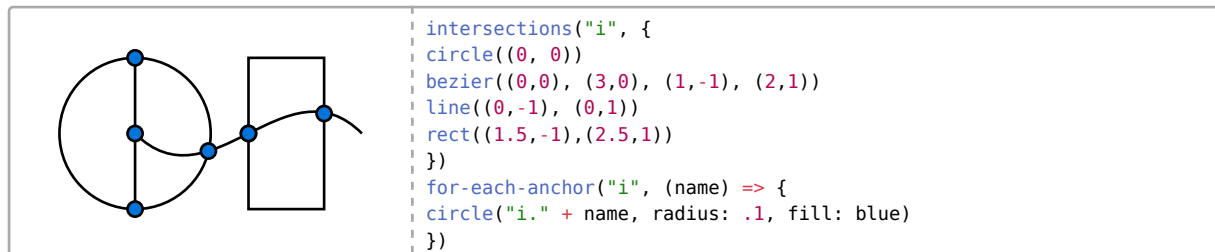
```

    sort: none function,
    ignore-marks: bool
)

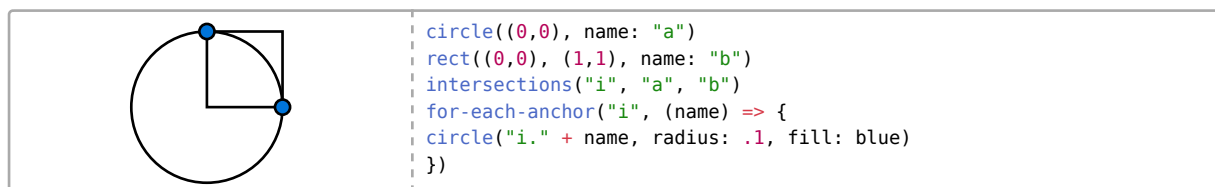
```

Calculates the intersections between multiple paths and creates one anchor per intersection point.

All resulting anchors will be named numerically, starting at 0. i.e., a call `intersections("a", ...)` will generate the anchors "a.0", "a.1", "a.2" to "a.n", depending of the number of intersections.



You can also use named elements:



You can calculate intersections with hidden elements by using `[hide](./hide)`.

that gets called with the list of intersection points.

CeTZ provides the following sorting functions:

- `sorting.points-by-distance(points, reference: (0, 0, 0))`
- `sorting.points-by-angle(points, reference: (0, 0, 0))`

## Parameters

- **name** `str`

Name to prepend to the generated anchors. (Not to be confused with other name arguments that allow the use of anchor coordinates.)

- **..elements** `elements str`

Elements and/or element names to calculate intersections with. Elements referred to by name are (unlike elements passed) not drawn by the intersections function!

- **samples** `int`

Number of samples to use for non-linear path segments. A higher sample count can give more precise results but worse performance.

- **sort** `none function`

A function of the form `(context, array<vector>) -> array<vector>`

- **ignore-marks** `bool`

If true, ignore mark shapes.

## group

```

group(
  body elements function,
  name: none str,

```

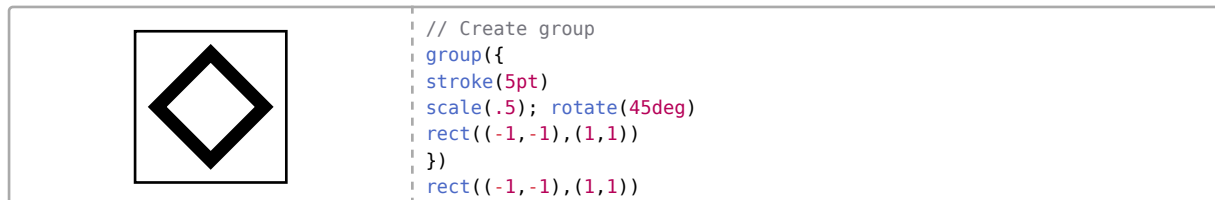


```

    anchor: none str,
    ..style style
)

```

Groups one or more elements together. This element acts as a scope, all state changes such as transformations and styling only affect the elements in the group. Elements after the group are not affected by the changes inside the group.



## Styling

**Root:** group

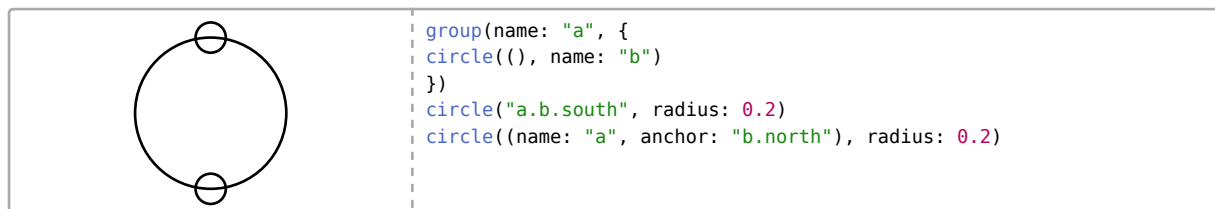
## Anchors

Supports border and path anchors of the axis aligned bounding box of all the child elements of the group.

You can add custom named anchors to the group by using the [anchor](./anchor) element while in the scope of said group, see [anchor](./anchor) for more details.

The default anchor is "center" but this can be overridden by using [anchor](./anchor) to place a new anchor called "default".

When using named elements within a group, you can access the element's anchors outside of the group by using the implicit anchor coordinate. e.g. "a.b.north"



## Parameters

- **body** elements function

Elements to group together. A least one is required. A function that accepts ctx and returns elements is also accepted.

- **anchor** none str

Anchor to position the group and it's children relative to. For translation the difference between the groups "default" anchor and the passed anchor is used.

- **name** none str

- **..style** style

- **padding** none number array dictionary

How much padding to add around the group's bounding box. none applies no padding. A number applies padding to all sides equally. A dictionary applies padding following Typst's pad function: <https://typst.app/docs/reference/layout/pad/>. An array follows CSS like padding: (y, x), (top, x, bottom) or (top, right, bottom, left).

## scope

```
scope(  
  body elements function  
)
```

This element acts as a scope, all state changes such as transformations and styling only affect the elements in the scope. Elements after the scope are not affected by the changes inside the scope. In contrast to group, the scope element does not create a named element itself and “leaks” body elements and anchors to the outside.

## Parameters

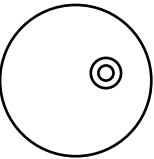

- **body** elements function

Elements to group together. A least one is required. A function that accepts ctx and returns elements is also accepted.

## anchor

```
anchor(  
  name str,  
  position coordinate  
)
```

Creates a new anchor for the current group. The new anchor will be accessible from inside the group by using just the anchor’s name as a coordinate.

	<pre>// Inside a group group(name: "g", {   circle((0,0))   anchor("x", (.4, .1))   circle("x", radius: .2) }) circle("g.x", radius: .1)</pre>
	<pre>// At the root scope anchor("x", (1, 1)) // ... circle("x", radius: .1)</pre>

## Parameters

- **name** str

The name of the anchor

- **position** coordinate

The position of the anchor

## copy-anchors

```
copy-anchors(  
  element str,  
  filter: auto array  
)
```

Copies multiple anchors from one element into the current group. Panics when used outside of a group. Copied anchors will be accessible in the same way anchors created by the anchor element are.

## Parameters

- **element** `str`

The name of the element to copy anchors from.

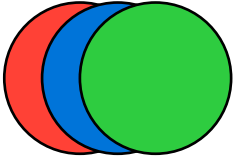
- **filter** `auto` `array`

When set to `auto` all anchors will be copied to the group. An array of anchor names can instead be given so only the anchors that are in the element and the list will be copied over.

## set-ctx

```
set-ctx(  
  callback function  
)
```

An advanced element that allows you to modify the current canvas `{{context}}`. Note: The transformation matrix (`transform`) is rounded after calling the `callback` function and therefore might be not exactly the matrix specified. This is due to rounding errors and should not cause any problems.



```
// Setting a custom transformation matrix  
set-ctx(ctx => {  
  let mat = ((1, 0, .5, 0),  
    (0, 1, 0, 0),  
    (0, 0, 1, 0),  
    (0, 0, 0, 1))  
  ctx.transform = mat  
  return ctx  
})  
circle((z: 0), fill: red)  
circle((z: 1), fill: blue)  
circle((z: 2), fill: green)
```

You can store shared context data under a key in the `ctx.shared-data` dictionary. The `ctx.shared-data` dictionary is not scoped by group or scope elements and can be used for canvas global state.

## Parameters

- **callback** `function`

A function that accepts the context dictionary and only returns a new one.

## get-ctx

```
get-ctx(  
  callback function  
)
```

An advanced element that allows you to read the current `{{context}}` through a callback and return `{{element}}`s based on it.

```
(  
  (1.0, 0.0, 0.0, 0.0),  
  (0.0, 1.0, 0.0, 0.0),  
  (0.0, 0.0, 1.0, 0.0),  
  (0.0, 0.0, 0.0, 1.0),  
)
```

```
// Print the transformation matrix  
get-ctx(ctx => {  
  content(), [#repr(ctx.transform)]  
})
```

## Parameters

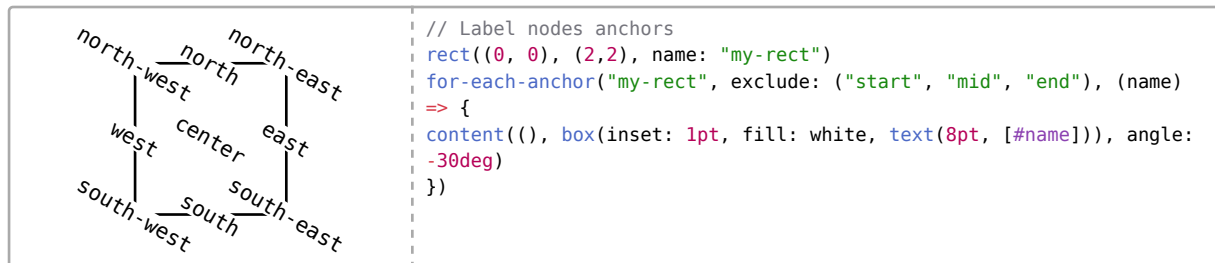
- **callback** `function`

A function that accepts the `{{context}}` and can return elements.

## for-each-anchor

```
for-each-anchor(  
  name str,  
  callback function,  
  exclude: array  
)
```

Iterates through all named anchors of an element and calls a callback for each one.



## Parameters

- **name** str  
The name of the element with the anchors to loop through.
- **callback** function  
A function that takes the anchor name and can return elements.
- **exclude** array  
An array of anchor names to not include in the loop.

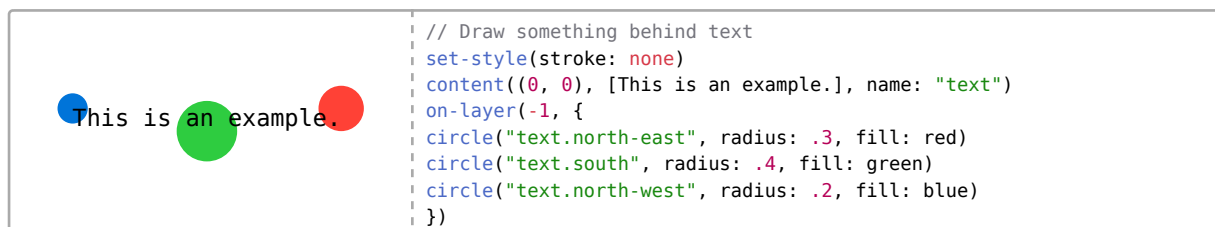
## on-layer

```
on-layer(  
  layer float int,  
  body elements function  
)
```

Places elements on a specific layer.

A layer determines the position of an element in the draw queue. A lower layer is drawn before a higher layer.

Layers can be used to draw behind or in front of other elements, even if the other elements were created before or after. An example would be drawing a background behind a text, but using the text's calculated bounding box for positioning the background.



## Parameters

- **layer** float int  
The layer to place the elements on. Elements placed without on-layer are always placed on layer 0.

- **body** elements function

Elements to draw on the layer specified. A function that accepts ctx and returns elements is also accepted.

## 4.5 Transformation

### set-transform

```
set-transform(
  mat none matrix
)
```

Sets the transformation matrix.

#### Parameters

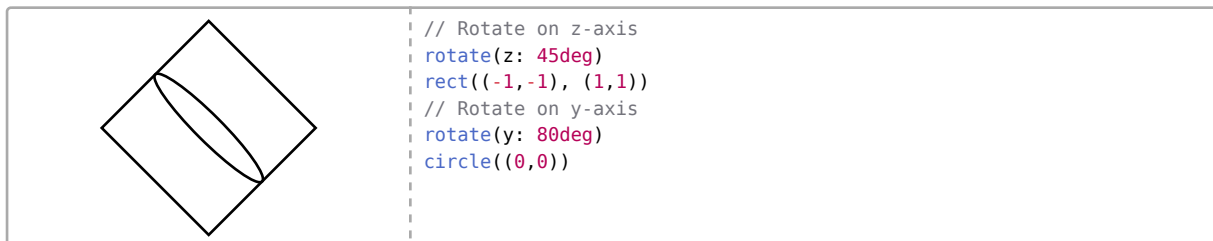
- **mat** none matrix

The 4x4 transformation matrix to set. If none is passed, the transformation matrix is set to the identity matrix (matrix.ident()).

### rotate

```
rotate(
  ..angles angle,
  origin: none coordinate
)
```

Rotates the transformation matrix on the z-axis by a given angle or other axes when specified.



Named arguments of x, y or z can be given to rotate on their respective axis. You can give named arguments of yaw, pitch or roll, too.

#### Parameters

- **..angles** angle

A single angle as a positional argument to rotate on the z-axis by.

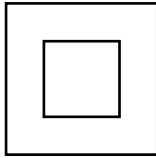
- **origin** none coordinate

Origin to rotate around, or (0, 0, 0) if set to none.

### translate

```
translate(
  ..args vector float length,
  pre: bool
)
```

Translates the transformation matrix by the given vector or dictionary.



```
// Outer rect
rect((0, 0), (2, 2))
// Inner rect
translate(x: .5, y: .5)
rect((0, 0), (1, 1))
```

A translation matrix with the given offsets gets multiplied with the current transformation depending on the value of `pre`.

- `false`: `World = World * Translate`
- `true`: `World = Translate * World`

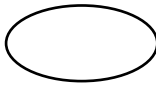
### Parameters

- `..args` `vector` `float` `length`  
A single vector or any combination of the named arguments `x`, `y` and `z` to translate by.
- `pre` `bool`  
Specify matrix multiplication order

### scale

```
scale(
  ..args float ratio,
  origin: none coordinate
)
```

Scales the transformation matrix by the given factor(s).



```
// Scale the y-axis
scale(y: 50%)
circle((0,0))
```

Note that content like text does not scale automatically. See `auto-scale` styling of content for that.

scaling factors. Accepts a single float or ratio value or any combination of the named arguments `x`, `y` and `z` to set per axis scaling factors. A ratio of 100% is the same as the value 1.

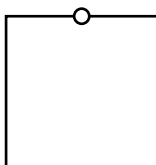
### Parameters

- `..args` `float` `ratio`  
A single value to scale the transformation matrix by or per axis
- `origin` `none` `coordinate`  
Origin to rotate around, or `(0, 0, 0)` if set to none.

### set-origin

```
set-origin(
  origin coordinate
)
```

Sets the given position as the new origin `(0, 0, 0)`



```
// Draw some rect
rect((0,0), (2,2), name: "r")

// Move (0, 0) to the top edge of "r"
set-origin("r.north")
circle((0, 0), radius: .1, fill: white)
```

### Parameters

- **origin** coordinate

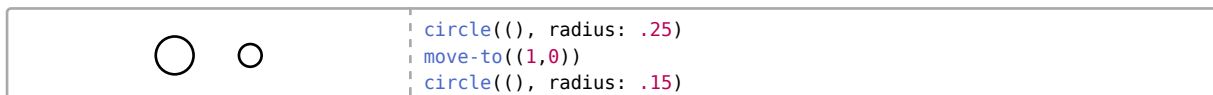
Coordinate to set as new origin (0,0,0)

### move-to

```
move-to(  
  pt coordinate  
)
```

Sets the previous coordinate.

The previous coordinate can be used via () (empty coordinate). It is also used as base for relative coordinates if not specified otherwise.



### Parameters

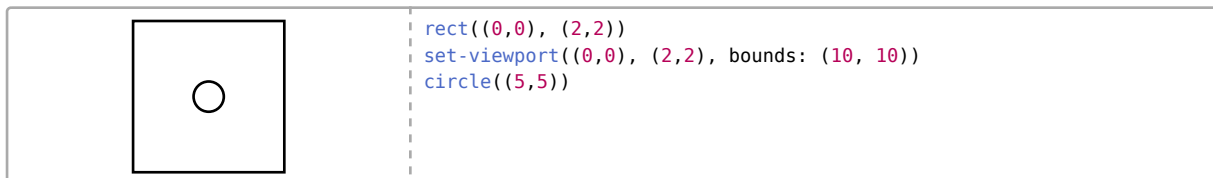
- **pt** coordinate

The coordinate to move to.

### set-viewport

```
set-viewport(  
  from coordinate,  
  to coordinate,  
  bounds: vector  
)
```

Span viewport between two coordinates and set-up scaling and translation



height and depth of the viewport

### Parameters

- **from** coordinate

Bottom left corner coordinate

- **to** coordinate

Top right corner coordinate

- **bounds** vector

Viewport bounds vector that describes the inner width,

## 4.6 Projection

### ortho

```
ortho(  
  x: angle,  
  y: angle,
```

```

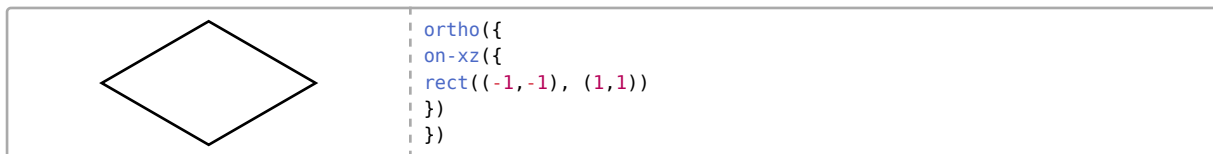
z: angle,
sorted: bool,
cull-face: none str,
reset-transform: bool,
body element
)

```

Set-up an orthographic projection environment.

This is a transformation matrix that rotates elements around the x, the y and the z axis by the parameters given.

By default an isometric projection ( $x \approx 35.264^\circ$ ,  $y = 45^\circ$ ) is set.



or "ccw" for counter-clockwise. Polygons of the specified order will not get drawn.

### Parameters

- **x** angle  
X-axis rotation angle
- **y** angle  
Y-axis rotation angle
- **z** angle  
Z-axis rotation angle
- **sorted** bool  
Sort drawables by maximum distance (front to back)
- **cull-face** none str  
Enable back-face culling if set to "cw" for clockwise
- **reset-transform** bool  
Ignore the current transformation matrix
- **body** element  
Elements to draw

### on-xy

```

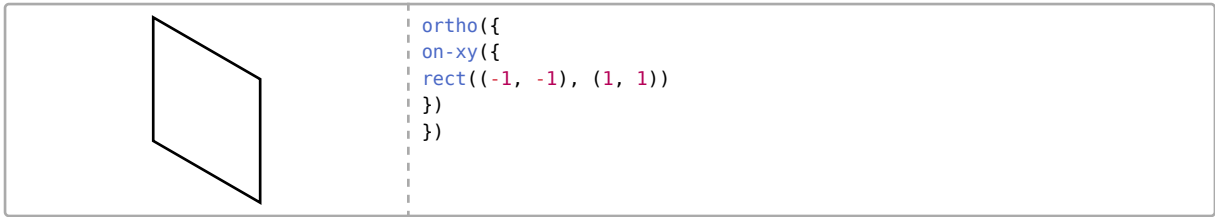
on-xy(
  z: number,
  body element
)

```

Draw elements on the xy-plane with optional z offset.

All vertices of all elements will be changed in the following way:  $(x \ y \ z_{\text{argument}})$ , where  $z_{\text{argument}}$  is the z-value given as argument.





### Parameters

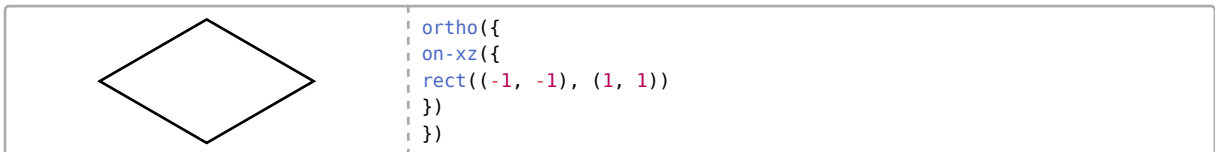
- **z** number  
Z offset for all coordinates
- **body** element  
Elements to draw

### on-xz

```
on-xz(
  y: number,
  body element
)
```

Draw elements on the xz-plane with optional y offset.

All vertices of all elements will be changed in the following way:  $(x \ y_{\text{argument}} \ y)$ , where  $y_{\text{argument}}$  is the y-value given as argument.



### Parameters

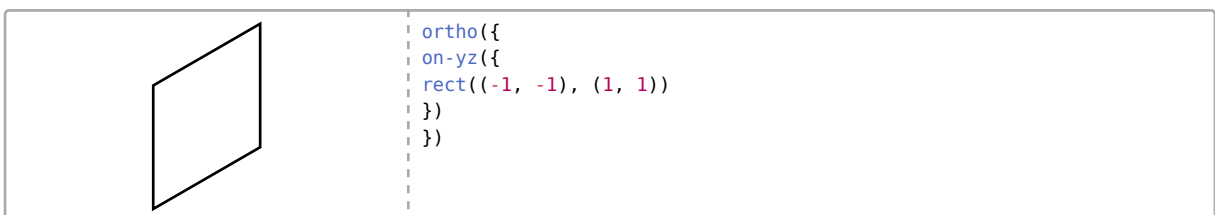
- **y** number  
Y offset for all coordinates
- **body** element  
Elements to draw

### on-yz

```
on-yz(
  x: number,
  body element
)
```

Draw elements on the yz-plane with optional x offset.

All vertices of all elements will be changed in the following way:  $(x_{\text{argument}} \ y \ x)$ , where  $x_{\text{argument}}$  is the x-value given as argument.



## Parameters

- **x** number  
X offset for all coordinates
- **body** element  
Elements to draw

## 4.7 Utility

### assert-version

```
assert-version(  
  min version,  
  max: none version,  
  hint: string  
)
```

Assert that the cetz version of the canvas matches the given version (range).

## Parameters

- **min** version  
Minimum version (current >= min)
- **max** none version  
First unsupported version (current < max)
- **hint** string  
Name of the function/module this assert is called from


### register-coordinate-resolver

```
register-coordinate-resolver(  
  resolver function  
)
```

Push a custom coordinate resolve function to the list of coordinate resolvers. This resolver is scoped to the current context scope!

A coordinate resolver must be a function of the format (context, coordinate) => coordinate. And must *always* return a valid coordinate or panic, in case of an error.

If multiple resolvers are registered, coordinates get passed through all resolvers in reverse registering order. All coordinates get passed to cetz' default coordinate resolvers.



```
register-coordinate-resolver((ctx, c) => {  
  if type(c) == dictionary and "log" in c {  
    c = c.log.map(n => calc.log(n, base: 10))  
  }  
  return c  
})  
  
circle((log: (10, 1e-6)), radius: .25)  
circle((log: (100, 1e-6)), radius: .25)  
circle((log: (1000, 1e-6)), radius: .25)
```

## Parameters

- **resolver** function  
The resolver function, taking a context and a single coordinate and returning a single coordinate

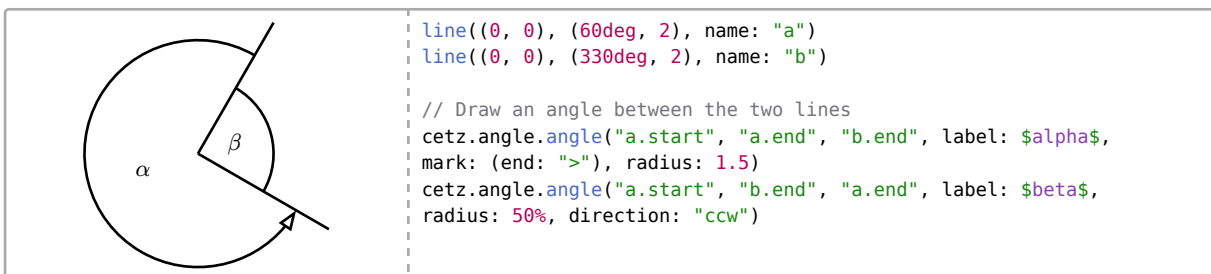
## 4.8 Libraries

### Angle

#### angle

```
angle(  
  origin coordinate,  
  a coordinate,  
  b coordinate,  
  direction: string,  
  label: none content function,  
  name: none str,  
  ..style style  
)
```

Draw an angle counter-clock-wise between a and b through origin origin



### Styling

**Root:** angle

#### Anchors

**a** Point a

**b** Point b

**origin** Origin

**label** Label center

**start** Arc start

**end** Arc end

#### Parameters

- **origin** coordinate

Angle origin

- **a** coordinate

Coordinate of side a, containing an angle between origin and b.

- **b** coordinate

Coordinate of side b, containing an angle between origin and a.

- **direction** string

Direction of the angle. Accepts “ccw” (counter-clockwise), “cw” (clockwise), “near” (inner angle), “far” (outer angle), the first one being the default.

- **label** none content function

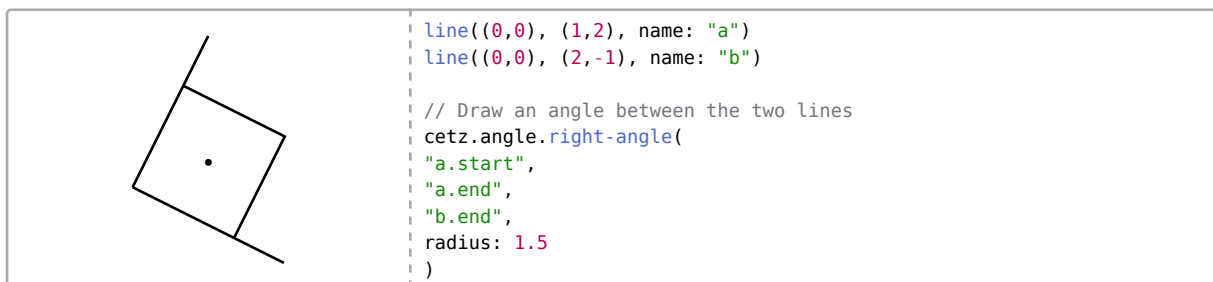
Draw a label at the angles “label” anchor. If label is a function, it gets the angle value passed as argument. The function must be of the format angle => content.

- **name** `none` `str`  
Element name, used for querying anchors.
- **..style** `style`  
Style key-value pairs.
- **radius** `number`  
The radius of the angles arc. If of type `ratio`, it is relative to the smaller distance of either origin to a or origin to b.
- **label-radius** `number` `ratio`  
The radius of the angles label origin. If of type `ratio`, it is relative to `radius`.

### right-angle

```
right-angle(
  origin coordinate,
  a coordinate,
  b coordinate,
  label: none content,
  name: none str,
  ..style style
)
```

Draw a right angle between a and b through origin origin



### Styling

Styling is the same as the `angle` function.

### anchors

anchors are the same as the `angle` function

### Parameters

- **origin** `coordinate`  
Angle origin
- **a** `coordinate`  
Coordinate of side a, containing an angle between origin and b.
- **b** `coordinate`  
Coordinate of side b, containing an angle between origin and a.
- **label** `none` `content`  
Draw a label at the angles "label" anchor.
- **name** `none` `str`  
Element name, used for querying anchors.

- **..style** style

Style key-value pairs.

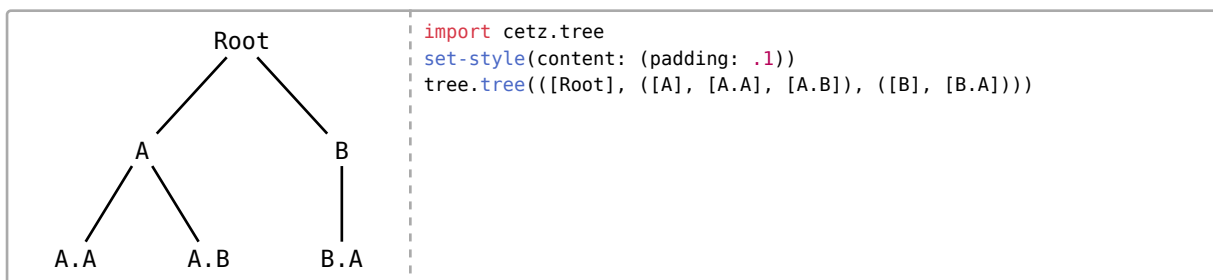
## Tree

### tree

```
tree(
  root array,
  draw-node: auto function,
  draw-edge: none auto function,
  direction: str,
  grow: float,
  spread: float,
  name: none str,
  node-layer: int,
  edge-layer: int,
  measure-content: ,
  anchor: none string
)
```

Lays out and renders tree nodes.

For each node, the tree function creates an anchor of the format "[<child-index>-]<child-index>" (the root is "0", its first child "0-0", second "0-1" and so on) that can be used to query a nodes position on the canvas.



### Parameters

- **root** array

A nested array of content that describes the structure the tree should take. Example: ([root], [child 1], ([child 2], [grandchild 1]))

- **draw-node** auto function

The function to call to draw a node. The function will be passed the node to draw (a dictionary with a content key) and is expected to return elements ((node, parent-node) => elements). The node must be drawn at the (0,0) coordinate. If auto is given, just the node's value will be drawn as content.

- **draw-edge** none auto function

The function to call draw an edge between two nodes. The function will be passed the name of the starting node, the name of the ending node, the start node, the end node, and is expected to return elements ((source-name, target-name, parent-node, child-node) => elements). If auto is given, a straight line will be drawn between nodes.

- **direction** str

A string describing the direction the tree should grow in ("up", "down", "left", "right")

- **grow** float  
Depth grow factor
- **spread** float  
Sibling spread factor
- **name** none str  
The tree element's name
- **node-layer** int  
Layer to draw nodes on
- **edge-layer** int  
Layer to draw edges on
- **anchor** none string  
Name of the anchor to align the tree to. Use the root node anchor ("0") to align the tree to the root nodes position.

## Decorations

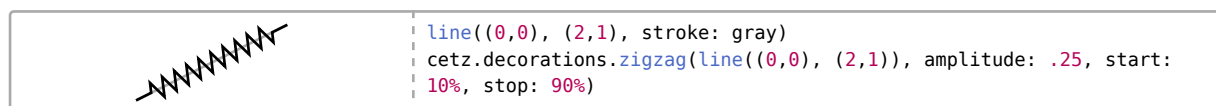
### Path

#### zigzag

```
zigzag(
    target drawable,
    name: none string,
    close: auto bool,
    ..style style
)
```

Draw a zig-zag or saw-tooth wave along a path.

The number of teeth can be controlled via the segments or segment-length style key, and the width via amplitude.



## Styling

**Root:** zigzag

### Parameters

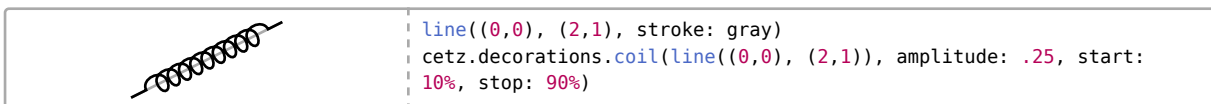
- **target** drawable  
Target path
- **close** auto bool  
Close the path
- **name** none string  
Element name
- **..style** style  
Style
- **factor** ratio  
Triangle mid between its start and end. Setting this to 0% leads to a falling sawtooth shape, while 100% results in a raising sawtooth.

## coil

```
coil(  
    target drawable,  
    close: auto bool,  
    name: none string,  
    ..style style  
)
```

Draw a stretched coil/loop spring along a path

The number of windings can be controlled via the segments or segment-length style key, and the width via amplitude.



## Styling

Root: coil

### Parameters

- **target** drawable

Target path

- **close** auto bool

Close the path

- **name** none string

Element name

- **..style** style

Style

- **factor** ratio

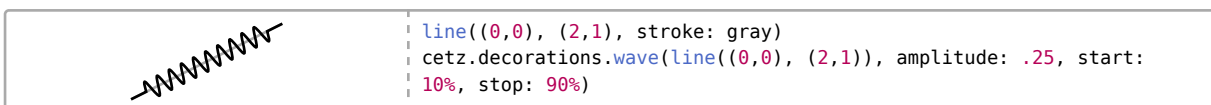
Factor of how much the coil overextends its length to form a curl.

## wave

```
wave(  
    target drawable,  
    close: auto bool,  
    name: none string,  
    ..style style  
)
```

Draw a wave along a path using a catmull-rom curve

The number of phases can be controlled via the segments or segment-length style key, and the width via amplitude.



## Styling

Root: wave

- **tension** (float) = 0.5 Catmull-Rom curve tension, see [Catmull](/api/draw-functions/shapes/catmull)

### Parameters

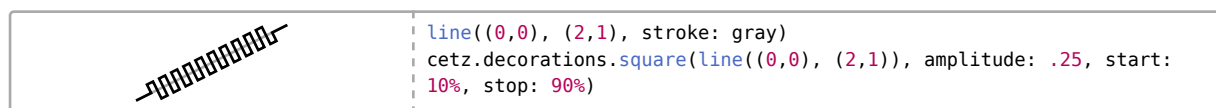
- **target** drawable  
Target path
- **close** auto bool  
Close the path
- **name** none string  
Element name
- **..style** style  
Style

### square

```
square(
    target drawable,
    close: auto bool,
    name: none string,
    ..style style
)
```

Draw a square-wave along a path using a line-strip

The number of phases can be controlled via the segments or segment-length style key, and the width via amplitude.



### Styling

**Root:** square

- **factor** (ratio) = 50% Square-Wave midpoint

### Parameters

- **target** drawable  
Target path
- **close** auto bool  
Close the path
- **name** none string  
Element name
- **..style** style  
Style

### Brace

#### brace

```
brace(
    start coordinate,
    end coordinate,
```

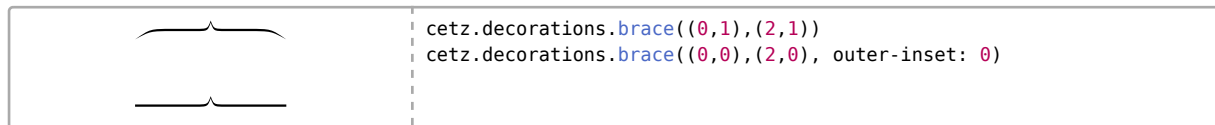


```

    ..style style,
    name: string none
)

```

Draw a curly brace between two points.



## Styling

**Root:** brace

Use the `fill` style for tapered braces and set `stroke` to `none`.

## Anchors

**start** Where the brace starts, same as the `start` parameter.

**end** Where the brace end, same as the `end` parameter.

**spike** Point of the spike, halfway between `start` and `end` and shifted by `amplitude` towards the pointing direction.

**content** Point to place content/text at, in front of the spike.

**center** Center of the enclosing rectangle.

## Parameters

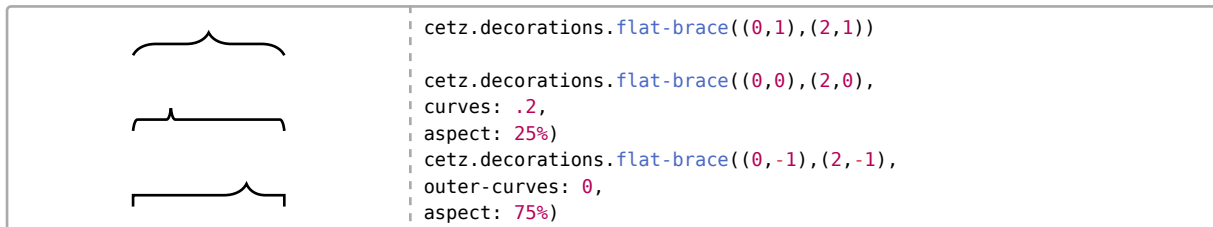
- **start** coordinate  
Start point
- **end** coordinate  
End point
- **name** string none  
Element name used for querying anchors
- **..style** style  
Style key-value pairs
- **amplitude** number  
Sets the height of the brace, from its baseline to its middle tip.
- **thickness** number ratio  
Thickness of tapered braces (if ratio, relative to half the amplitude).
- **pointiness** ratio  
Thickness of the mid-spice
- **taper** bool  
Draw a tapered brace
- **outer-inset** number ratio  
Inset of the outer curve points
- **outer-curvyness** ratio  
Curvyness of the outer curves
- **inner-outset** number ratio  
Inset of the inner tip curve points
- **inner-curvyness** ratio  
Curvyness of the inner tip curves

- **outer-thickness** `number`  
Thickness of the outer tips
- **content-offset** `number`  
Offset of the "content" anchor from the spike of the brace.
- **flip** `bool`  
Mirror the brace along the line between start and end.

### flat-brace

```
flat-brace(
  start coordinate,
  end coordinate,
  flip: bool,
  debug: bool,
  name: str none,
  ..style style
)
```

Draw a flat curly brace between two points.



This mimics the braces from TikZ's [decorations.pathreplacing library]([https://github.com/pgf-tikz/pgf/blob/6e5fd71581ab04351a89553a259b57988bc28140/tex/generic/pgf/libraries/decorations/pgf\\_librarydecorations.pathreplacing.code.tex#L136-L185](https://github.com/pgf-tikz/pgf/blob/6e5fd71581ab04351a89553a259b57988bc28140/tex/generic/pgf/libraries/decorations/pgf_librarydecorations.pathreplacing.code.tex#L136-L185)). In contrast to the brace function, these braces use straight line segments, resulting in better looks for long braces with a small amplitude.

### Styling

**Root:** flat-brace

- **aspect** (ratio) = 50% Determines the fraction of the total length where the spike will be placed.

### Anchors

**start** Where the brace starts, same as the start parameter.

**end** Where the brace end, same as the end parameter.

**spike** Point of the spike's top.

**content** Point to place content/text at, in front of the spike.

**center** Center of the enclosing rectangle.

### Parameters

- **start** `coordinate`  
Start point
- **end** `coordinate`  
End point
- **flip** `bool`  
Flip the brace around

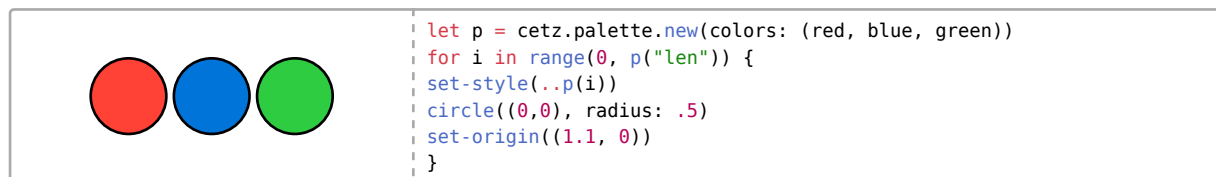
- **name** `str` `none`  
Element name for querying anchors
- **debug** `bool`
- **..style** `style`  
Style key-value pairs
- **amplitude** `number`  
Determines how much the brace rises above the base line.
- **curves** `number` `auto` `array`  
Curviness factor of the brace, a factor of 0 means no curves.
- **outer-curves** `number` `auto` `array`  
Curviness factor of the outer curves of the brace. A factor of 0 means no curves.

## Palette

### new

```
new(
  base: style,
  colors: none array,
  dash: none array
) → function
```

Create a new palette based on a base style



The functions returned by this function have the following named arguments:

You can use a palette for stroking via: `red.with(stroke: true)`.

### Parameters

- **fill** `bool`  
If true, the returned fill color is one of the colors from the `colors` list, otherwise the base styles fill is used.
- **stroke** `bool`  
If true, the returned stroke color is one of the colors from the `colors` list, otherwise the base styles stroke color is used.
- **base** `style`  
Style dictionary to use as base style for the styles generated per color
- **colors** `none` `array`  
List of colors the returned palette should return styles with.
- **dash** `none` `array`  
List of stroke dash patterns the returned palette should return styles with.

## 4.9 Internals

### Complex

#### re

```
re(  
    V complex  
) → float
```

Returns the real part of a complex number.

#### Parameters

- **V** complex  
A complex number.

#### im

```
im(  
    V complex  
) → float
```

Returns the imaginary part of a complex number.

#### Parameters

- **V** complex  
A complex number.

#### mul

```
mul(  
    V complex,  
    W complex  
)
```

Multiplies two complex numbers together and returns the result  $VW$ .

#### Parameters

- **V** complex  
The complex number on the left hand side.
- **W** complex  
The complex number on the right hand side.

#### conj

```
conj(  
    V complex  
) → complex
```

Calculates the conjugate of a complex number.

#### Parameters

- **V** complex  
A complex number.

## dot

```
dot(  
    V complex,  
    W complex  
) → float
```

Calculates the dot product of two complex numbers in  $\mathbb{R}^2$   $V \cdot W$ .

### Parameters

- **V** complex  
The complex number on the left hand side.
- **W** complex  
The complex number on the right hand side.

## normsq

```
normsq(  
    V complex  
) → float
```

Calculates the squared normal of a complex number.

### Parameters

- **V** complex  
The complex number.

## norm

```
norm(  
    V complex  
) → float
```

Calculates the normal of a complex number

### Parameters

- **V** complex  
The complex number.

## scale

```
scale(  
    V complex,  
    t float  
) → complex
```

Multiplies a complex number by a scale factor.

### Parameters

- **V** complex  
The complex number to scale.
- **t** float  
The scale factor.

## **unit**

```
unit(  
  V complex  
) → vector
```

Returns a unit vector in the direction of a complex number.

### **Parameters**

- **V** complex  
The complex number.

## **inv**

```
inv(  
  V complex  
) → complex
```

Inverts a complex number.

### **Parameters**

- **V** complex  
The complex number

## **div**

```
div(  
  V complex,  
  W complex  
) → complex
```

Divides two complex numbers.

### **Parameters**

- **V** complex  
The complex number of the numerator.
- **W** complex  
The complex number of the denominator.

## **add**

```
add(  
  V complex,  
  W complex  
) → complex
```

Adds two complex numbers together.

### **Parameters**

- **V** complex  
The complex number on the left hand side.
- **W** complex  
The complex number on the right hand side.

## **sub**

```
sub(  
  V complex,  
  W complex  
) → complex
```

Subtracts two complex numbers together.

### **Parameters**

- **V** complex  
The complex number on the left hand side.
- **W** complex  
The complex number on the right hand side.

## **arg**

```
arg(  
  V complex  
)
```

Calculates the argument of a complex number.

### **Parameters**

- **V** complex  
The complex number.

## **ang**

```
ang(  
  V complex,  
  W complex  
)
```

Get the signed angle of two complex numbers from V to W.

### **Parameters**

- **V** complex  
A complex number.
- **W** complex  
A complex number.

## **Vector**

### **as-mat**

```
as-mat(  
  v vector,  
  mode: str  
) → matrix
```

Converts a vector to a row or column matrix.

### **Parameters**

- **v** vector  
The vector to convert.

- **mode** `str`

The type of matrix to convert into. Must be one of "row" or "column".

### **as-vec**

```
as-vec(
    v vector,
    init: vector
) → vector
```

Ensures a vector has an exact number of components. This is done by passing another vector `init` that has the required dimension. If the original vector does not have enough dimensions, the values from `init` will be inserted. It is recommended to use a zero vector for `init`.

### **Parameters**

- **v** `vector`

The vector to ensure.

- **init** `vector`

The vector to check the dimension against.

### **len**

```
len(
    v vector
) → float
```

Return length/magnitude of a vector.

### **Parameters**

- **v** `vector`

The vector to find the magnitude of.

### **add**

```
add(
    v1 vector,
    v2 vector
) → vector
```

Adds two vectors of the same dimension

### **Parameters**

- **v1** `vector`

The vector on the left hand side.

- **v2** `vector`

The vector on the right hand side.

### **sub**

```
sub(
    v1 vector,
    v2 vector
) → vector
```

Subtracts two vectors of the same dimension



### Parameters

- **v1** vector

The vector on the left hand side.

- **v2** vector

The vector on the right hand side.

### dist

```
dist(  
    a vector,  
    b vector  
) → float
```

Calculates the distance between two vectors by subtracting the length of vector a from vector b.

### Parameters

- **a** vector

Vector a

- **b** vector

Vector b

### scale

```
scale(  
    v vector,  
    x float  
) → vector
```

Multiplies a vector with scalar x

### Parameters

- **v** vector

The vector to scale.

- **x** float

The scale factor.

### div

```
div(  
    v vector,  
    x float  
)
```

Divides a vector by scalar x

### Parameters

- **v** vector

The vector to be divided.

- **x** float

The inverse scale factor.

## neg

```
neg(  
  v vector  
) → vector
```

Negates each value in a vector

### Parameters

- **v** vector  
The vector to negate.

## norm

```
norm(  
  v vector  
) → vector
```

Normalizes a vector (divide by its length)

### Parameters

- **v** vector  
The vector to normalize.

## element-product

```
element-product(  
  a vector,  
  b vector  
)
```

Multiply two vectors component-wise

### Parameters

- **a** vector  
First vector.
- **b** vector  
Second vector.

## dot

```
dot(  
  v1 vector,  
  v2 vector  
) → float
```

Calculates the dot product between two vectors.

### Parameters

- **v1** vector  
The vector on the left hand side.
- **v2** vector  
The vector on the right hand side.

## cross

```
cross(  
  v1 vector,  
  v2 vector  
) → vector
```

Calculates the cross product of two vectors with a dimension of three.

### Parameters

- **v1** vector  
The vector on the left hand side.
- **v2** vector  
The vector on the right hand side.

## angle2

```
angle2(  
  a vector,  
  b vector  
) → angle
```

Calculates the angle between two vectors and the x-axis in 2d space

### Parameters

- **a** vector  
The vector to measure the angle from.
- **b** vector  
The vector to measure the angle to.

## angle

```
angle(  
  v1 vector,  
  c vector,  
  v2 vector  
)
```

Calculates the angle between three vectors

### Parameters

- **v1** vector  
The vector to measure the angle from.
- **c** vector  
The vector to measure the angle at.
- **v2** vector  
The vector to measure the angle to.

## lerp

```
lerp(  
  v1 vector,  
  v2 vector,  
  t float  
)
```

Linear interpolation between two vectors.

### Parameters

- **v1** vector  
The vector to interpolate from.
- **v2** vector  
The vector to interpolate to.
- **t** float  
The factor to interpolate by. A value of 0 is v1 and a value of 1 is v2.

### Matrix

#### ident

```
ident(  
    size int  
) → matrix
```

Create a (square) identity matrix with dimensions  $\text{size} \times \text{size}$

### Parameters

- **size** int  
Size of the matrix

#### diag

```
diag(  
    ..diag float  
) → matrix
```

Create a square matrix with the diagonal set to the given values

### Parameters

- **..diag** float  
Diagonal values

#### dim

```
dim(  
    m matrix  
) → array
```

Returns the dimension of the given matrix as (m, n)

### Parameters

- **m** matrix  
The matrix

#### column

```
column(  
    mat matrix,  
    n int  
) → vector
```

Returns the n-th column of a matrix as a {{vector}}

### Parameters

- **mat** `matrix`  
Input matrix
- **n** `int`  
The column's index

### round

```
round(  
    mat matrix,  
    precision: int  
) → matrix
```

Rounds each value in the matrix to a precision.

### Parameters

- **mat** `matrix`  
Input matrix
- **precision** `int`  
Rounding precision (digits)

### transform-translate

```
transform-translate(  
    x float,  
    y float,  
    z float  
) → matrix
```

Returns a  $4 \times 4$  translation matrix

### Parameters

- **x** `float`  
The translation in the  $x$  direction.
- **y** `float`  
The translation in the  $y$  direction.
- **z** `float`  
The translation in the  $z$  direction.

### transform-shear-x

```
transform-shear-x(  
    factor float  
) → matrix
```

Returns a  $4 \times 4$  x-shear matrix

### Parameters

- **factor** `float`  
The shear in the  $x$  direction.

### transform-shear-z

```
transform-shear-z(  
    factor float  
) → matrix
```

Returns a  $4 \times 4$  z-shear matrix

#### Parameters

- **factor** float

The shear in the  $z$  direction.

### transform-scale

```
transform-scale(  
    f float array dictionary  
) → matrix
```

Returns a  $4 \times 4$  scale matrix

#### Parameters

- **f** float array dictionary

The scale factor(s) of the matrix. An `{{array}}` of at least 3 `{{float}}`s sets the x, y and z scale factors.

A `{{dictionary}}` sets the scale in the direction of the corresponding x, y and z keys. A single `{{float}}` sets the scale for all directions.

### transform-rotate-dir

```
transform-rotate-dir(  
    dir vector,  
    up vector  
) → matrix
```

Returns a  $4 \times 4$  rotation xyz matrix for a direction and up vector

#### Parameters

- **dir** vector

idk

- **up** vector

idk

### transform-rotate-x

```
transform-rotate-x(  
    angle angle  
) → matrix
```

Returns a  $4 \times 4$   $x$  rotation matrix

#### Parameters

- **angle** angle

The angle to rotate around the  $x$  axis

### **transform-rotate-y**

```
transform-rotate-y(  
  angle angle  
) → matrix
```

Returns a  $4 \times 4$   $y$  rotation matrix

#### **Parameters**

- **angle** angle  
The angle to rotate around the  $y$  axis

### **transform-rotate-z**

```
transform-rotate-z(  
  angle angle  
) → matrix
```

Returns a  $4 \times 4$   $z$  rotation matrix

#### **Parameters**

- **angle** angle  
The angle to rotate around the  $z$  axis

### **transform-rotate-xz**

```
transform-rotate-xz(  
  x angle,  
  z angle  
) → matrix
```

Returns a  $4 \times 4$   $xz$  rotation matrix

#### **Parameters**

- **x** angle  
The angle to rotate around the  $x$  axis
- **z** angle  
The angle to rotate around the  $z$  axis

### **transform-rotate-ypr**

```
transform-rotate-ypr(  
  a angle,  
  b angle,  
  c angle  
) → matrix
```

Returns a  $4 \times 4$  rotation matrix - yaw-pitch-roll

#### **Parameters**

- **a** angle  
Yaw
- **b** angle  
Pitch

- `c angle`

Roll

### **transform-rotate-xyz**

```
transform-rotate-xyz(  
  x angle,  
  y angle,  
  z angle  
) → matrix
```

Returns a  $4 \times 4$  rotation matrix - euler angles

Calculates the product of the three rotation matrices  $R = R_{z(z)}R_{y(y)}R_{x(x)}$

#### **Parameters**

- `x angle`  
Rotation about x
- `y angle`  
Rotation about y
- `z angle`  
Rotation about z

### **mul-mat**

```
mul-mat(  
  ..matrices matrix  
) → matrix
```

Multiplies matrices on top of each other.

#### **Parameters**

- `..matrices matrix`  
The matrices to multiply from left to right.

### **mul4x4-vec3**

```
mul4x4-vec3(  
  mat matrix,  
  vec vector,  
  w: float  
) → vector
```

Multiplies a  $4 \times 4$  matrix with a vector of size 3 or 4. The resulting is three dimensional

#### **Parameters**

- `mat matrix`  
The matrix to multiply
- `vec vector`  
The vector to multiply
- `w float`  
The default value for the fourth element of the vector if it is three dimensional.



## mul-vec

```
mul-vec(  
  mat matrix,  
  vec vector  
) → vector
```

Multiplies an  $m \times n$  matrix with an  $m$ th dimensional vector where  $m \leq 4$ . Prefer the use of mul4x4-vec3 when possible as it does not use loops.

### Parameters

- **mat** matrix  
The matrix to multiply
- **vec** vector  
The vector to multiply

## inverse

```
inverse(  
  matrix matrix  
) → matrix
```

Calculates the inverse matrix of any size.

### Parameters

- **matrix** matrix  
The matrix to inverse.

## Coordinate

### resolve-system

```
resolve-system(  
  ctx,  
  c coordinate  
) → str
```

Figures out what system a coordinate belongs to and returns the corresponding string.

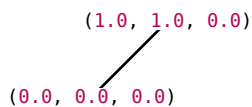
### Parameters

- **c** coordinate  
The coordinate to find the system of.

## resolve

```
resolve(  
  ctx context,  
  ..coordinates coordinate,  
  update: bool  
) → array
```

Resolve a list of coordinates to absolute vectors. Returns an array of the new context</Type> then the resolved coordinate vectors.



```
line((0,0), (1,1), name: "l")
get-ctx(ctx => {
  // Get the vector of coordinate "l.start" and "l.end"
  let (ctx, a, b) = cetz.coordinate.resolve(ctx, "l.start", "l.end")
  content("l.start", [#a], frame: "rect", stroke: none, fill: white)
  content("l.end", [#b], frame: "rect", stroke: none, fill: white)
})
```

## Parameters

- **ctx** context  
Canvas context object
- **..coordinates** coordinate  
List of coordinates
- **update** bool  
Update the context's last position

## Styles

### resolve

```
resolve(
  dict style,
  root: none str array,
  merge: style,
  base: none style
) → style
```

You can use this to combine the style in ctx, the style given by a user for a single element and an element's default style.

base is first merged onto dict without overwriting existing values, and if root is given it is merged onto that key of dict. merge is then merged onto dict but does overwrite existing entries, if root is given it is merged onto that key of dict. Then entries in dict that are {{auto}} inherit values from their nearest ancestor and entries of type {{dictionary}} are merged with their closest ancestor.

```
#let dict = (
  stroke: "black",
  fill: none,
  mark: (stroke: auto, fill: "blue"),
  line: (stroke: auto, mark: auto, fill: "red")
)
#cetz.styles.resolve(dict, merge: (mark: (stroke: "yellow")), root: "line")
```

The following is a more detailed explanation of how the algorithm works to use as a reference if needed. It should be updated whenever changes are made. Remember that dictionaries are recursively merged, if an entry is any other type it is simply updated. (dict + dict = merged dict, value + dict = dict, dict + value = value) First if base is given, it will be merged without overwriting values onto dict. If root is given it will be merged onto that key of dict. Each level of dict is then processed with these steps. If root is given the level with that key will be the first, otherwise the whole of dict is processed.

1. Values on the corresponding level of merge are inserted into the level if the key does not exist on the level or if they are not both dictionaries. If they are both dictionaries their values will be inserted in the same stage at a lower level.

2. If an entry is auto or a dictionary, the tree is travelled back up until an entry with the same key is found. If the current entry is auto the value of the ancestor's entry is copied. Or if the current entry and ancestor entry is a dictionary, they are merged with the current entry overwriting any values in it's ancestors.
3. Each entry that is a dictionary is then resolved from step 1.

```
(
  scale: 1,
  length: 5.67pt,
  width: 4.25pt,
  inset: 1.42pt,
  sep: 2.83pt,
  pos: none,
  offset: 0,
  start: none,
  end: none,
  symbol: none,
  xy-up: (0, 0, 1),
  z-up: (0, 1, 0),
  stroke: (paint: luma(0%), thickness: 1pt, dash: "solid"),
  fill: none,
  slant: none,
  harpoon: false,
  flip: false,
  reverse: false,
  position-samples: 20,
  shorten-to: auto,
  transform-shape: false,
  anchor: "tip",
)

get-ctx(ctx => {
  // Get the current "mark" style
  content((0,0), [#cetz.styles.resolve(ctx.style, root: "mark")])
})
```

## Parameters

- **dict** style  
Current context style from `ctx.style`.
- **merge** style  
Style values overwriting the current style. I.e. inline styles passed with an element: `line(..., stroke: red)`.
- **root** none str array  
Style root element name or list of nested roots (`("my-package", "my-element")`).
- **base** none style  
Style values to merge into dict without overwriting it.

## merge

```
merge(
  bottom,
  top
)
```

Merge two style dictionaries by using cetz' style folding logic.

- bottom (dictionary) Base style dictionary.
- top (dictionary) New style dictionary to merge on top of bottom.

## Process

### element

```
element(
  ctx ctx,
```

```
    element-func function
  )
```

Processes an element's function to get its drawables and bounds. Returns a `dictionary` with the key-values: `ctx` The modified context object, `bounds` The `aabb` of the element's drawables, `drawables` An `array` of the element's `drawable`s.

### Parameters

- **ctx** `ctx`  
The current context object.
- **element-func** `function`  
A function that when passed `ctx`, it should return an element dictionary.

### many

```
many(
  ctx ctx,
  body array
) → dictionary
```

Runs the element function for a list of element functions and aggregates the results.

### Parameters

- **ctx** `ctx`  
The current context object.
- **body** `array`  
The array of element functions to process.

### Drawable

### TAG

```
TAG(
)
```

Tag constants

### apply-transform

```
apply-transform(
  transform matrix,
  drawables drawable
) → drawable
```

Applies a transform to drawables. If a single drawable is given it will be returned in a single element array</Type>.

### Parameters

- **transform** `matrix`  
The transformation matrix.
- **drawables** `drawable`  
The drawables to transform.

## apply-tags

```
apply-tags(  
    drawables drawable array,  
    ..tags str  
) → drawable or array
```

Adds tags to one or more drawables.

### Parameters

- **drawables** drawable array  
A single drawable or an array of drawable.
- **..tags** str  
The list of tags to add to the drawable

### Result

- drawable  
A single drawable
- array  
An array of drawable

## filter-tagged

```
filter-tagged(  
    drawables drawable array,  
    ..tags str  
) → drawable or array
```

Filter out all drawables that have one of the given tags assigned.

### Parameters

- **drawables** drawable array  
A single drawable or an array of drawables.
- **..tags** str  
The list of tags to use as a filter.

### Result

- drawable  
A single drawable
- array  
An array of drawable

## path

```
path(  
    fill: color none,  
    stroke: stroke,  
    fill-rule: str,  
    tags: ,  
    path  
) → drawable
```

Creates a path drawable from path segments.

### Parameters

- **segments** array  
The segments to create the path from.
- **close** bool  
If true the path will be closed.
- **fill** color none  
The color to fill the path with.
- **fill-rule** str  
One of “even-odd” or “non-zero”.
- **stroke** stroke  
The stroke of the path.

### line-strip

```
line-strip(  
    points array,  
    close: bool,  
    fill: none fill,  
    stroke: none stroke,  
    fill-rule: str,  
    tags:  
) → drawable
```

Construct a line-strip from a list of points

### Parameters

- **points** array  
Array of points
- **close** bool
- **fill** none fill
- **stroke** none stroke
- **fill-rule** str

### content

```
content(  
    pos vector,  
    width float,  
    height float,  
    border segment,  
    body content  
) → drawable
```

Creates a content drawable.

### Parameters

- **pos** vector  
The position of the drawable.
- **width** float  
The width of the drawable.

- **height** float  
The height of the drawable.
- **border** segment  
A segment to define the border of the drawable with.
- **body** content  
The content of the drawable.

## ellipse

```
ellipse(
  x float,
  y float,
  z float,
  rx float,
  ry float,
  fill: color none,
  stroke: stroke
) → drawable
```

Creates a path drawable in the shape of an ellipse.

### Parameters

- **x** float  
The  $x$  position of the ellipse.
- **y** float  
The  $y$  position of the ellipse.
- **z** float  
The  $z$  position of the ellipse.
- **rx** float  
The radius of the ellipse in the  $x$  axis.
- **ry** float  
The radius of the ellipse in the  $y$  axis.
- **fill** color none  
The color to fill the ellipse with.
- **stroke** stroke  
The stroke of the ellipse's path.

## arc

```
arc(
  x float,
  y float,
  z float,
  start angle,
  stop angle,
  rx float,
  ry float,
  mode: str,
  fill: color none,
```

```
stroke: stroke
) → drawable
```

Creates a path drawable in the shape of an arc.

### Parameters

- **x** float  
The  $x$  position of the start of the arc.
- **y** float  
The  $y$  position of the start of the arc.
- **z** float  
The  $z$  position of the start of the arc.
- **start** angle  
The angle along an ellipse to start drawing the arc from.
- **stop** angle  
The angle along an ellipse to stop drawing the arc at.
- **rx** float  
The radius of the arc in the  $x$  axis.
- **ry** float  
The radius of the arc in the  $y$  axis.
- **mode** str  
How to draw the arc: "OPEN" leaves the path open, "CLOSED" closes the arc by drawing a straight line between the end of the arc and its start, "PIE" also closes the arc by drawing a line from its end to its origin then to its start.
- **fill** color none  
The color to fill the arc with.
- **stroke** stroke  
The stroke of the arc's path.

### Anchor

#### border

```
border(  
    center vector,  
    x-dist number,  
    y-dist number,  
    drawables drawables,  
    angle angle  
) → none or vector
```

Calculates a border anchor at the given angle by testing for an intersection between a line and the given drawables. Returns none if no intersection is found for better error reporting.

### Parameters

- **center** vector  
The position from which to start the test line.
- **x-dist** number  
The furthest distance the test line should go in the  $x$  direction.



- **y-dist** number

The furthest distance the test line should go in the y direction.

- **drawables** drawables

Drawables to test for an intersection against. Ideally should be of type path but all others are ignored.

- **angle** angle

The angle to check for a border anchor at.

## setup

```
setup(
  callback function auto,
  anchor-names array,
  default: str none,
  transform: matrix none,
  name: str none,
  offset-anchor: str none,
  border-anchors: bool,
  path-anchors: bool,
  radii: none array,
  path: none drawable,
  nested-anchors:
) → array
```

Setup an anchor calculation and handling function for an element. Unifies anchor error checking and calculation of the offset transform.

A tuple of a transformation matrix and function will be returned. The transform is calculated by translating the given transform by the distance between the position of `offset-anchor` and `default`. It can then be used to correctly transform an element's drawables. If either are `none` the calculation won't happen but the transform will still be returned. The function can be used to get the transformed anchors of an element by passing it a string. An empty array can be passed to get the list of valid anchors.

## Parameters

- **callback** function auto

The function to call to get a named anchor's position. The anchor's name will be passed and it should return a `vector</Type>` (`str => vector`). If no named anchors exist on the element `auto` can be given instead of a function.

- **anchor-names** array

A list of valid anchor names. This list will be used to validate an anchor exists before `callback` is used.

- **default** str none

The name of the default anchor, if one exists.

- **transform** matrix none

The current transformation matrix to apply to an anchor's position before returning it. If `offset-anchor` and `default` is set, it will be first translated by the distance between them.

- **name** str none

The name of the element, this is only used in the error message in the event an anchor is invalid.

- **offset-anchor** `str` `none`  
The name of an anchor to offset the transform by.
- **border-anchors** `bool`  
If true, add border anchors.
- **path-anchors** `bool`  
If true, add path anchors.
- **radii** `none` `array`  
Radius tuple used for border anchor calculation.
- **path** `none` `drawable`  
Path used for path and border anchor calculation.

## Mark

### check-mark

```
check-mark(
    style style
) → bool
```

Checks if a mark should be drawn according to the current style.

### Parameters

- **style** `style`  
The current style.

### process-style

```
process-style(
    ctx context,
    style style,
    root str,
    path-length float
)
```

Processes the mark styling. TODO: remember what is actually going on here.

### Parameters

- **ctx** `context`  
The context object.
- **style** `style`  
The current style.
- **root** `str`  
Where the mark is being placed, normally either "start" or "end". Allows different styling for marks in different directions.
- **path-length** `float`  
The length of the path. This is used for relative offsets.

### place-mark-on-path

```
place-mark-on-path(
    ctx context,
    styles style,
    segments drawable,
```

```
    is-end: bool  
) → dictionary
```

Places a mark on the given path. Returns a {{dictionary}} with the following keys:

—

### Parameters

- **drawables** drawable  
The mark drawables.
- **distance** float  
The length to shorten the path by.
- **pos** float  
The position of the mark, can be used to snap the end of the path to after shortening.
- **ctx** context  
The canvas context object.
- **styles** style  
A processed mark styling.
- **segments** drawable  
The path to place the mark on.
- **is-end** bool  
Start from the end of the path

### Result

dictionary

Dictionary with the following keys: pt, distance and drawable.

### place-marks-along-path

```
place-marks-along-path(  
  ctx context,  
  style style,  
  transform matrix,  
  path drawable,  
  add-path: bool  
) → array
```

Places marks along a path. Returns them as an {{array}} of {{drawable}}.

### Parameters

- **ctx** context  
The context object.
- **style** style  
The current mark styling.
- **transform** matrix  
The current transformation matrix.
- **path** drawable  
The path to place the marks on.

- **add-path** `bool`

When true the shortened path will be returned as the first `Drawable` in the `array`

## Bezier

### quadratic-point

```
quadratic-point(
  a vector,
  b vector,
  c vector,
  t float
) → vector
```

Get the point on quadratic bezier at position `t`.

#### Parameters

- **a** `vector`  
Start point
- **b** `vector`  
End point
- **c** `vector`  
Control point
- **t** `float`  
Position on curve `[0, 1]`

### quadratic-derivative

```
quadratic-derivative(
  a vector,
  b vector,
  c vector,
  t float
) → vector
```

Get the derivative ( $dx/dt$ ) of a quadratic bezier at position `t`.

#### Parameters

- **a** `vector`  
Start point
- **b** `vector`  
End point
- **c** `vector`  
Control point
- **t** `float`  
Position on curve `[0, 1]`

### cubic-point

```
cubic-point(
  a vector,
  b vector,
  c1 vector,
```

```
    c2 vector,  
    t float  
  ) → vector
```

Get the point on a cubic bezier curve at position t.

#### Parameters

- **a** vector  
Start point
- **b** vector  
End point
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **t** float  
Position on curve [0, 1]

#### cubic-derivative

```
cubic-derivative(  
  a vector,  
  b vector,  
  c1 vector,  
  c2 vector,  
  t float  
) → vector
```

Get the derivative (dx/dt) of a cubic bezier at position t.

#### Parameters

- **a** vector  
Start point
- **b** vector  
End point
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **t** float  
Position on curve [0, 1]

#### to-abc

```
to-abc(  
  s vector,  
  e vector,  
  B vector,  
  t float,
```

```
deg: int
) → array
```

Get a bezier curve's ABC coordinates. Returns them as a respective array</Type> of vector</Type>s.

```
/A\ <-- Control point of quadratic bezier
/ | \
/ | \
/_.-B-._\ <-- Point on curve
,' | ',
/ | \
s-----C-----e <-- Point on line between s and e
```

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **B** vector  
Point on curve
- **t** float  
Position on curve [0, 1]
- **deg** int  
Bezier degree (2 or 3)

### quadratic-through-3points

```
quadratic-through-3points(
  s vector,
  B vector,
  e vector
) → bezier
```

Compute the control points for a quadratic bezier through 3 points.

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **B** vector  
A point which the curve passes through

### quadratic-to-cubic

```
quadratic-to-cubic(
  s vector,
  e vector,
  c vector
) → bezier
```

Convert a quadratic bezier to a cubic bezier.

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c** vector  
Control point

### cubic-through-3points

```
cubic-through-3points(  
  s vector,  
  B vector,  
  e vector  
) → bezier
```

Compute the control points for a cubic bezier through 3 points.

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **B** vector  
A point which the curve passes through

### split

```
split(  
  s vector,  
  e vector,  
  c1 vector,  
  c2 vector,  
  t float  
) → array
```

Split a cubic bezier into two cubic beziers at the point **t**. Returns an array</Type> of two bezier</Type>. The first holds the original curve start **s**, and the second holds the original curve end **e**.

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **t** float  
The point on the bezier to split, [0, 1]

### cubic-arclen

```
cubic-arclen(  
  s vector,  
  e vector,  
  c1 vector,  
  c2 vector,  
  samples:  
) → float
```

Get the approximate cubic curve length

#### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2

### cubic-shorten-linear

```
cubic-shorten-linear(  
  s vector,  
  e vector,  
  c1 vector,  
  c2 vector,  
  d float  
) → bezier
```

Shorten the curve by offsetting s and c1 or e and c2 by distance d. If d is positive the curve gets shortened by moving s and c1 closer to e, if d is negative, e and c2 get moved closer to s.

#### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **d** float  
Distance to shorten by

### cubic-t-for-distance

```
cubic-t-for-distance(  
  s vector,  
  e vector,
```



```

    c1 vector,
    c2 vector,
    d float,
    samples:
) → float

```

Approximate bezier interval  $t$  for a given distance  $d$ . If  $d$  is positive, the functions starts from the curve's start  $s$ , if  $d$  is negative, it starts form the curve's end  $e$ .

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **d** float  
The distance along the bezier to find  $t$ .

### cubic-shorten

```

cubic-shorten(
    s vector,
    e vector,
    c1 vector,
    c2 vector,
    d float,
    samples: int
) → bezier

```

Shorten curve by distance  $d$ . This keeps the curvature of the curve by finding new values along the original curve. If  $d$  is positive the curve gets shortened by moving  $s$  closer to  $e$ , if  $d$  is negative,  $e$  is moved closer to  $s$ . The points  $s$  and  $e$  are moved along the curve, keeping the curve's curvature the same (the control points get recalculated).

### Parameters

- **s** vector  
Curve start
- **e** vector  
Curve end
- **c1** vector  
Control point 1
- **c2** vector  
Control point 2
- **d** float  
Distance to shorten by

- **samples** `int`

Maximum of samples/steps to use

### **cubic-extrema**

```
cubic-extrema(
    s vector,
    e vector,
    c1 vector,
    c2 vector
) → array
```

Find cubic curve extrema by calculating the roots of the curve's first derivative. Returns an array</Type> of vector</Type> ordered by distance along the curve from the start to its end.

#### **Parameters**

- **s** `vector`  
Curve start
- **e** `vector`  
Curve end
- **c1** `vector`  
Control point 1
- **c2** `vector`  
Control point 2

### **cubic-aabb**

```
cubic-aabb(
    s vector,
    e vector,
    c1 vector,
    c2 vector
) → array
```

Returns axis aligned bounding box coordinates (bottom-left, top-right) for a cubic bezier curve.

#### **Parameters**

- **s** `vector`  
Curve start
- **e** `vector`  
Curve end
- **c1** `vector`  
Control point 1
- **c2** `vector`  
Control point 2

### **catmull-to-cubic**

```
catmull-to-cubic(
    points array,
    k float,
```

```
    close: bool  
) → array
```

Returns an array of cubic bezier</Type> for a catmull curve through an array of points.

### Parameters

- **points** array  
Array of 2d points
- **k** float  
Strength between 0 and 1
- **close** bool

### line-cubic-intersections

```
line-cubic-intersections(  
    la vector,  
    lb vector,  
    s vector,  
    e vector,  
    c1 vector,  
    c2 vector,  
    ray: bool  
) → array
```

Calculate the intersection points between a 2D cubic-bezier and a straight line. Returns an array of vector</Type>

### Parameters

- **s** vector  
Bezier start point
- **e** vector  
Bezier end point
- **c1** vector  
Bezier control point 1
- **c2** vector  
Bezier control point 2
- **la** vector  
Line start point
- **lb** vector  
Line end point
- **ray** bool  
If set to true, ignore line length

### AABB

#### aabb

```
aabb(  
    pts array,  
    init: aabb  
) → aabb
```

Compute an axis aligned bounding box (aabb) for a list of vectors</Type>.

#### Parameters

- **pts** array  
List of vector</Type>s.
- **init** aabb  
Initial aabb

#### mid

```
mid(  
  bounds aabb  
) → vector
```

Get the mid-point of an AABB as vector.

#### Parameters

- **bounds** aabb  
The AABB to get the mid-point of.

#### corner-points

```
corner-points(  
  bounds aabb,  
  front:  
) → array
```

Get four corner points of the AABB as vectors.

#### Parameters

- **bounds** aabb  
The AABB
- **from** bool  
Return the corner points for the high z component

#### Result

array  
of vectors

#### size

```
size(  
  bounds aabb  
) → vector
```

Get the size of an aabb as vector. This is a vector from the aabb's low to high.

#### Parameters

- **bounds** aabb  
The aabb to get the size of.

#### padded

```
padded(  
  bounds aabb,
```

```
padding none dictionary
) → aabb
```

Pad AABB with padding from dictionary with keys top, left, right and bottom.

### Parameters

- **bounds** aabb  
The AABB to pad.
- **padding** none dictionary  
Padding values

### Hobby

#### hobby-to-cubic-open

```
hobby-to-cubic-open(
  points array,
  ta: auto array,
  tb: auto array,
  rho: auto function,
  omega: auto array
) → array
```

Calculates a bezier spline for an open Hobby curve through a list of points. Returns an `{{array}}` of `{{bezier}}`s

### Parameters

- **points** array  
List of points
- **ta** auto array  
Outgoing tension per point
- **tb** auto array  
Incoming tension per point
- **rho** auto function  
The rho function of the form (float, float) => float
- **omega** auto array  
Tuple of the curl at the start end end of the curve (start, end) as floats

#### hobby-to-cubic-closed

```
hobby-to-cubic-closed(
  points array,
  ta: auto array,
  tb: auto array,
  rho: auto array
) → array
```

Calculates a bezier spline for a closed Hobby curve through a list of points. Returns an `{{array}}` of `{{bezier}}`s.

## Parameters

- **points** array  
List of points
- **ta** auto array  
Outgoing tension per point
- **tb** auto array  
Incoming tension per point
- **rho** auto array  
The rho function of the form (float, b) => float

## hobby-to-cubic

```
hobby-to-cubic(  
  points array,  
  ta: auto array,  
  tb: auto array,  
  rho: auto array,  
  omega: auto array,  
  close: bool  
) → array
```

Calculates a bezier spline for a Hobby curve through a list of points. Returns an `{{array}}` of `{{bezier}}` s.

## Parameters

- **points** array  
List of points
- **ta** auto array  
Outgoing tension per point
- **tb** auto array  
Incoming tension per point
- **rho** auto array  
The rho function of the form (float, float) => float
- **omega** auto array  
Tuple of the curl at the start end end of the curve (start, end) as floats
- **close** bool  
Close the curve

## Intersection

### line-line

```
line-line(  
  p1 vector,  
  p2 vector,  
  p3 vector,  
  p4 vector,  
  ray: bool,  
  eps: float  
) → vector or none
```

Checks for a line-line intersection between the given points and returns its position, otherwise `{{none}}`.

### Parameters

- `p1` vector  
Point 1
- `p2` vector  
Point 2
- `p3` vector  
Point 3
- `p4` vector  
Point 4
- `ray` bool  
If true, handle both lines as infinite rays
- `eps` float  
Epsilon

### Result

- vector  
The intersection point between both lines
- none  
None, if both lines are parallel

### line-cubic

```
line-cubic(  
  la vector,  
  lb vector,  
  s vector,  
  e vector,  
  c1 vector,  
  c2 vector  
) → array
```

Finds the intersections of a line and cubic bezier.

### Parameters

- `s` vector  
Bezier start point
- `e` vector  
Bezier end point
- `c1` vector  
Bezier control point 1
- `c2` vector  
Bezier control point 2
- `la` vector  
Line start point

- **lb** vector

Line end point

- **ray** bool

When true, intersections will be found for the whole line instead of inbetween the given points.

### line-path

```
line-path(
  la vector,
  lb vector,
  path drawable
) → array
```

Finds the intersections of a line and path in 2D. The path should be given as a {{drawable}} of type path.

#### Parameters

- **la** vector

Line start

- **lb** vector

Line end

- **path** drawable

The path.

### path-path

```
path-path(
  a path,
  b path,
  samples: int
) → array
```

Finds the intersections between two path {{drawable}}s in 2D.

#### Parameters

- **a** path

Path a

- **b** path

Path b

- **samples** int

Number of samples to use for bezier curves

### Path Util

#### make-subpath

```
make-subpath(
  origin vector,
  segments array,
  closed: bool
) → subpath
```

Create a new subpath. A path is an array of subpaths.



## Parameters

- **origin** vector  
Origin
- **segments** array  
Segments
- **closed** bool  
Closed

## first-subpath-closed

```
first-subpath-closed(  
  path  
) → boolean
```

Get if the first subpath is closed

## first-subpath-start

```
first-subpath-start(  
  path  
) → vector
```

Get the start position of the first path

## subpath-start

```
subpath-start(  
  subpath  
) → vector
```

Get the start point of a subpath

## subpath-end

```
subpath-end(  
  subpath,  
  ignore-close-flag:  
) → vector
```

Get the end point of a subpath

## last-subpath-end

```
last-subpath-end(  
  path  
) → vector
```

Get the end position of the last path

## bounds

```
bounds(  
  path array  
) → array
```

Calculates the bounding points for a list of path segments

## Parameters

- **path** array  
Path

## segment-lengths

```
segment-lengths(  
    path path,  
    samples: auto int  
) → array
```

Returns an array of arrays with the lengths of all path segments. One sub-array for each subpath and its segments.

### Parameters

- **path** path  
Input path
- **samples** auto int  
Number of samples to use for curves

### Result

array

Array of arrays of floats containing the segment lengths

## length

```
length(  
    segments path,  
    samples: auto int  
) → float
```

Returns the sum of all segment lengths of a path.

### Parameters

- **segments** path  
Path segments
- **samples** auto int  
Number of samples to take for curves

### Result

float

Length

## point-at

```
point-at(  
    path path,  
    distance ratio number,  
    reverse: bool,  
    samples: ,  
    ignore-subpaths: bool  
) → none or dictionary
```

Get information about a point at a given distance on a path.

- point (vector) The point on the path
- previous-point (vector) Point previous to point
- direction (vector) Normalized direction vector
- subpath-index (int) Index of the subpath

- **segment-index** (int) Index of the segment

None is returned, if the path is empty/of length zero.

### Parameters

- **path** path  
The path
- **distance** ratio number  
Distance along the path
- **reverse** bool  
Travel from end to start
- **ignore-subpaths** bool  
If false consider the whole path, including sub-paths

### Result

- 
- dictionary  
Dictionary with the following keys:

### shorten-to

```
shorten-to(
    path Path,
    distance number ratio array,
    reverse: boolean,
    mode: 'CURVED' 'LINEAR',
    samples: auto int,
    snap-to: none array
)
```

Shorten a path on one or both sides

### Parameters

- **path** Path  
Path
- **distance** number ratio array  
Distance to shorten the path by
- **reverse** boolean  
If true, start from the end
- **mode** 'CURVED' 'LINEAR'  
Shortening mode for cubic segments
- **samples** auto int  
Samples to take for measuring cubic segments
- **snap-to** none array  
Optional array of points to try to move the shortened segment to

### normalize

```
normalize(
    path path
) → path
```

Normalize a path:

- Add missing closing segments
- Remove zero-length line segments

### Parameters

- **path** path  
Input path

### Util

#### float-epsilon

```
float-epsilon(  
)
```

Constant to be used as float rounding error

#### float-eq

```
float-eq(  
  a float,  
  b float,  
  epsilon: float  
) → bool
```

Compare two floating point numbers

### Parameters

- **a** float  
First number
- **b** float  
Second number
- **epsilon** float  
Maximum distance between both numbers

#### apply-transform

```
apply-transform(  
  transform matrix function,  
  ..vecs vector  
) → vector or array or dictionary
```

Multiplies vectors by a transformation matrix. If multiple vectors are given they are returned as an array, if only one vector is given only one will be returned, if a dictionary is given they will be returned in the dictionary with the same keys.

### Parameters

- **transform** matrix function  
The  $4 \times 4$  transformation matrix or a function that accepts and returns a vector.
- **..vecs** vector  
Vectors to get transformed. Only the positional part of the sink is used. A dictionary of vectors can also be passed and all will be transformed.

### revert-transform

```
revert-transform(  
  transform matrix,  
  ..vecs  
) → vector
```

Reverts the transform of the given vector

#### Parameters

- **transform** matrix  
Transformation matrix
- **vec** vector  
Vector to be transformed

### line-pt

```
line-pt(  
  a vector,  
  b vector,  
  t float  
) → vector
```

Linearly interpolates between two points and returns its position

#### Parameters

- **a** vector  
Start point
- **b** vector  
End point
- **t** float  
Position on the line  $[0, 1]$

### line-normal

```
line-normal(  
  a vector,  
  b vector  
) → vector
```

Get orthogonal vector to line

#### Parameters

- **a** vector  
Start point
- **b** vector  
End point

### circle-arclen

```
circle-arclen(  
  radius float,  
  angle: angle  
) → float
```

Calculates the arc-length of a circle or arc

#### Parameters

- **radius** `float`  
Circle or arc radius
- **angle** `angle`  
The angle of the arc.

#### ellipse-point

```
ellipse-point(  
  center vector,  
  radius float array,  
  angle  
) → vector
```

Get point on an ellipse for an angle

#### Parameters

- **center** `vector`  
Center
- **radius** `float` `array`  
Radius or tuple of x/y radii
- **angled** `angle`  
Angle to get the point at

#### calculate-circle-center-3pt

```
calculate-circle-center-3pt(  
  a vector,  
  b vector,  
  c vector  
) → vector
```

Calculates the center of a circle from 3 points. The z coordinate is taken from point a.

#### Parameters

- **a** `vector`  
Point 1
- **b** `vector`  
Point 2
- **c** `vector`  
Point 3

#### resolve-number

```
resolve-number(  
  ctx context,  
  num number  
) → float
```

Converts a {{number}} to “canvas units”

### Parameters

- **ctx** context  
The current context object.
- **num** number  
The number to resolve.

### map-dict

```
map-dict(  
  d,  
  fn  
) → dictionary
```

Call function fn for each key-value pair of d and return the transformed dictionary.

- d (dictionary) Input dictionary
- fn (function) Transformation function

### resolve-radius

```
resolve-radius(  
  radius number array  
) → array
```

Ensures that a radius has an x and y component.

### Parameters

- **radius** number array

### min

```
min(  
  ..a  
) → float
```

Finds the minimum of a set of values while ignoring none values.

### Parameters

- **a** float none

### max

```
max(  
  ..a float none  
) → float
```

Finds the maximum of a set of values while ignoring none values.

### Parameters

- **..a** float none

### merge-dictionary

```
merge-dictionary(  
  a dictionary,  
  b dictionary,  
  overwrite: bool  
) → dictionary
```

Merges dictionary `b` onto dictionary `a`. If a key does not exist in `a` but does in `b`, it is inserted into `a` with `b`'s value. If a key does exist in `a` and `b`, the value in `b` is only inserted into `a` if the `overwrite` argument is `true`. If a key does exist both in `a` and `b` and both values are of type `{{dictionary}}` they will be recursively merged with this same function.

### Parameters

- `a` `dictionary`  
Dictionary `a`
- `b` `dictionary`  
Dictionary `b`
- `overwrite` `bool`  
Whether to override an entry in `a` that also exists in `b` with the value in `b`.

### measure

```
measure(  
  ctx context,  
  cnt content  
) → vector
```

Measures the size of some `{{content}}` in canvas coordinates.

### Parameters

- `ctx` `context`  
The current context object.
- `cnt` `content`  
The content to measure.

### as-padding-dict

```
as-padding-dict(  
  padding none number array dictionary  
) → dictionary
```

Get a padding/margin dictionary with keys (`top`, `left`, `bottom`, `right`) from a padding value.

Type of padding:

**none** All sides padded by 0

**number** All sides are padded by the same value

**array** CSS like padding: (`y`, `x`), (`top`, `x`, `bottom`) or (`top`, `right`, `bottom`, `left`)

**dictionary** Converts a Typst padding dictionary (`top`, `left`, `bottom`, `right`, `x`, `y`, `rest`) to a dictionary containing `top`, `left`, `bottom` and `right`.

### Parameters

- `padding` `none` `number` `array` `dictionary`  
Padding specification

### as-corner-radius-dict

```
as-corner-radius-dict(  
  ctx context,  
  radii none number dictionary,  
  size none array  
) → dictionary
```



Creates a corner-radius dictionary with keys north-east, north-west, south-east and south-west with values of a two element `{{array}}` of the radius in the x and y direction. Returns none if all radii are zero or none.

### Parameters

- **ctx** `context`  
The current canvas context object
- **radii** `none` `number` `dictionary`  
The radius specification. A `{{number}}` will cause all corners to have the same radius. An `{{array}}` with two items will cause all corners to have the same rx and ry radius. A `{{dictionary}}` can be given where the key specifies the corner and the value specifies the radius. The value can be either `{{number}}` for a circle radius or `{{array}}` for an x and y radius. The keys north, south, east and west targets both corners in that cardinal direction e.g. south sets the south west and south east corners. The keys north-east, north-west, south-east and south-west targets the corresponding corner. The key rest targets all other corners that have not been target by other keys.
- **size** `none` `array`  
Tuple of `number` used to clamp the corner radii

### sort-points-by-distance

```
sort-points-by-distance(  
  base vector,  
  pts array  
) → array
```

Sorts an array of vectors by distance to a common position.

### Parameters

- **base** `vector`  
The position to measure the distance of the other vectors from.
- **pts** `array`  
The array of vectors to sort.

### resolve-stroke

```
resolve-stroke(  
  stroke none stroke  
) → dictionary
```

Resolves a stroke into a usable dictionary with all fields that are missing or auto set to their Typst defaults.

### Parameters

- **stroke** `none` `stroke`  
The stroke to resolve.

### assert-body

```
assert-body(  
  body  
)
```

Asserts whether a “body” has the correct type.