

# CeTZ

ein Typst  
Zeichenpaket

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## 1 Introduction

This package provides a way to draw onto a canvas using a similar API 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!

The name CeTZ is a recursive acronym for “CeTZ, ein Typst Zeichenpaket” (german for “CeTZ, a Typst drawing package”).

## 2 Usage

This is the minimal starting point:

```
#import "@preview/cetz:0.2.0"
#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 function's such as `line`.

### 2.1 CeTZ Unique Argument 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** Any coordinate system. See [coordinate-systems](#).

**number** Any of `float`, `integer` or `length`.

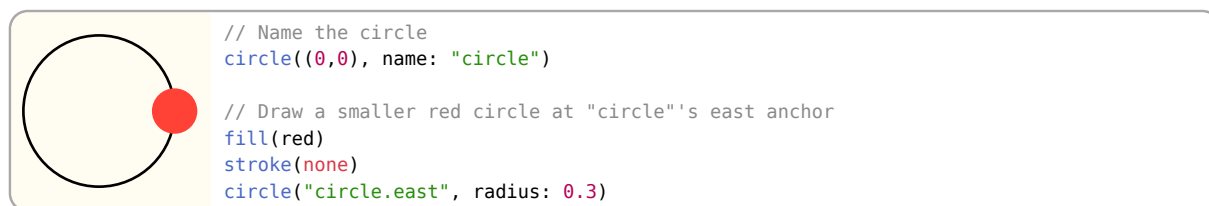
**style** Named arguments (or a dictionary if used for a single argument) of style key-values.

**context** A CeTZ context object that holds internal state.

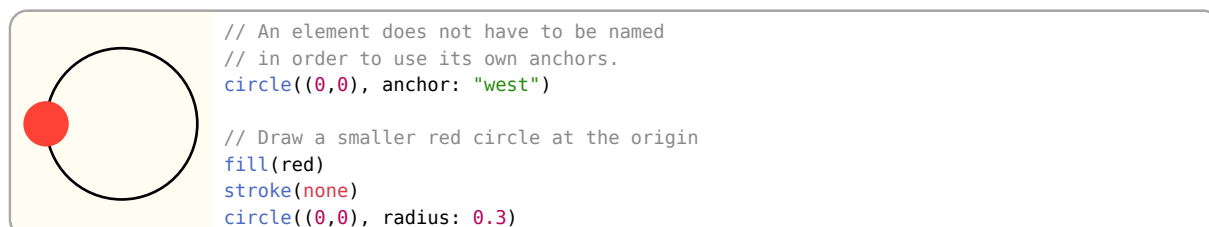
**vector** A three element array of `float`s

### 2.2 Anchors

Anchors are positions relative to named elements. To use an anchor of an element, you must give the element a name using the `name` argument. All elements with the `name` argument allow anchors.

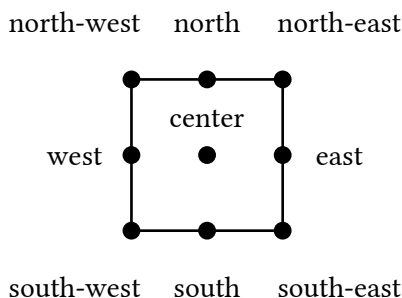


Elements can be placed relative to their own anchors if they have an argument called `anchor`:



#### 2.2.1 Compass Anchors

Compass anchors are positioned on the border of elements in the direction of a compass.



## 3 Draw Function Reference

### 3.1 Canvas

#### 3.1.1 canvas

Sets up a canvas for drawing on.

##### Parameters

```
canvas(
  length: length ratio,
  debug: bool,
  background: none color,
  body: none array element
) -> content
```

**length:** length or ratio

Default: 1cm

Used to specify what 1 coordinate unit is. If given a ratio, that ratio is relative to the containing elements width!

**debug:** bool

Default: false

Shows the bounding boxes of each element when true.

**background:** none or color

Default: none

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

**body:** none or array or element

A code block in which functions from `draw.typ` have been called.

### 3.2 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.

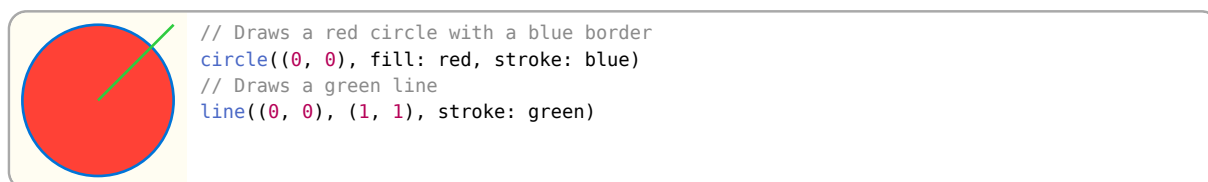
**fill:** color or none

Default: none

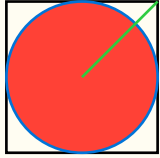
How to fill the drawn element.

**stroke:** none or auto or length or color or dictionary or stroke Default: 1pt + luma(0%)

How to stroke the border or the path of the draw element. See Typst's line documentation for more details: <https://typst.app/docs/reference/visualize/line/#parameters-stroke>



Instead of having to specify the same styling for each time you want to draw an element, you can use the `set-style()` function to change the style for all elements after it. You can still pass styling to a draw function to override what has been set with `set-style()`. You can also use the `fill()` and `stroke()` functions as a shorthand to set the fill and stroke respectively.



```
// Draws an empty square with a black border
rect((-1, -1), (1, 1))

// Sets the global style to have a fill of red and a stroke of blue
set-style(stroke: blue, fill: red)
circle((0,0))

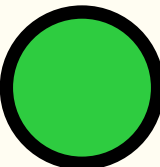
// Draws a green line despite the global stroke is blue
line((0, (1,1), stroke: green)
```

When using a dictionary for a style, it is important to note that they update each other instead of overriding the entire option like a non-dictionary value would do. For example, if the stroke is set to (paint: red, thickness: 5pt) and you pass (paint: blue), the stroke would become (paint: blue, thickness: 5pt).



```
// Sets the stroke to red with a thickness of 5pt
set-style(stroke: (paint: red, thickness: 5pt))
// Draws a line with the global stroke
line((0,0), (1,0))
// Draws a blue line with a thickness of 5pt because dictionaries update the style
line((0,0), (1,1), stroke: (paint: blue))
// Draws a yellow line with a thickness of 1pt because other values override the style
line((0,0), (0,1), stroke: yellow)
```

You can also specify styling for each type of element. Note that dictionary values will still update with its global value, the full hierarchy is function > element type > global. When the value of a style is auto, it will become exactly its parent style.



```
set-style(
  // Global fill and stroke
  fill: green,
  stroke: (thickness: 5pt),
  // Stroke and fill for only rectangles
  rect: (stroke: (dash: "dashed"), fill: blue),
)
rect((0,0), (1,1))
circle((0.5, -1.5))
rect((0,-3), (1, -4), stroke: (thickness: 1pt))
```

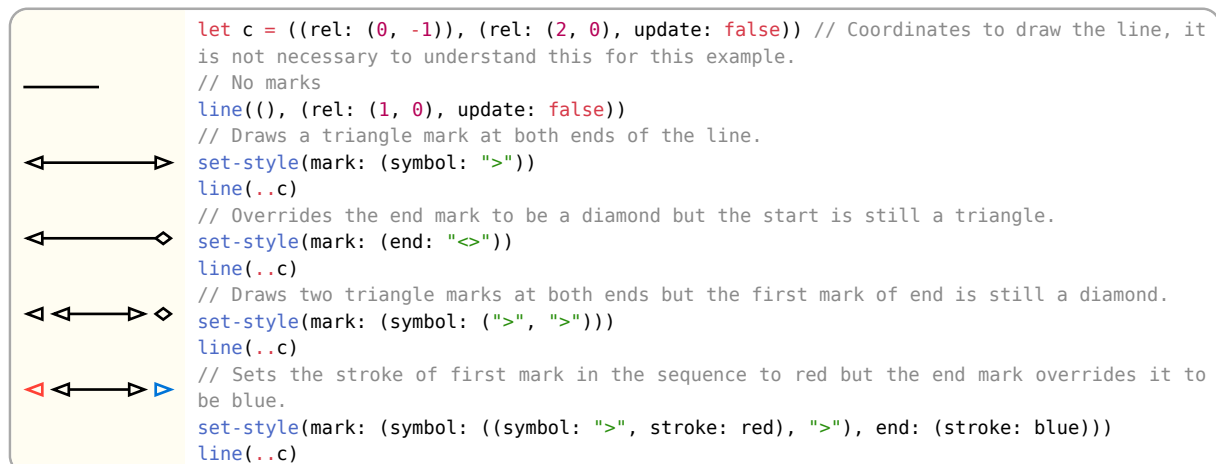


```
// Its a nice drawing okay
set-style(
  rect: (
    fill: red,
    stroke: none
  ),
  line: (
    fill: blue,
    stroke: (dash: "dashed")
  ),
)
rect((0,0), (1,1))
line((0, -1.5), (0.5, -0.5), (1, -1.5), close: true)
circle((0.5, -2.5), radius: 0.5, fill: green)
```

### 3.2.1 Marks

Marks are arrow tips that can be added to the end of path based elements that support the `mark style` key, or can be directly drawn by using the `mark draw` function. Marks are specified by giving there names as strings and have several options to customise them. You can give an array of names to have multiple marks in a row, dictionaries can also be used in the array for per mark styling.

Name	Shorthand	Shape
triangle	>	—▶
triangle (reversed)	<	—◀
diamond	<>	—◊
rect	[]	—◻
bracket	]	—⌋
bracket (reversed)	[	—⌈
bar		—
circle	o	—○
plus	+	—+
x	x	—x
star	*	—*



**symbol:** `none` or `string` or `array` or `dictionary`

Default: `none`

This option sets the mark to draw when using the `mark draw` function, or applies styling to both mark ends of path based elements. The mark's name or shorthand can be given, multiple marks can be drawn by passing an array of names or shorthands. When `none` no marks will be drawn. A style dictionary can be given instead of a string to override styling for that particular mark, just make sure to still give the mark name using the `symbol` key otherwise nothing will be drawn!.

**start:** `none` or `string` or `array` or `dictionary`

Default: `none`

This option sets the mark to draw at the start of a path based element. It will override all options of the `symbol` key and will not effect marks drawn using the `mark draw` function.

**end:** `none` or `string` or `array` or `dictionary`

Default: `none`

This option sets the mark to draw at the end of a path based element. It will override all options of the `symbol` key and will not effect marks drawn using the `mark draw` function.

**length:** `number`

Default: `5.67pt`

The size of the mark in the direction it is pointing.

**width:** number

Default: 4.25pt

The size of the mark along the normal of its direction.

**inset:** number

Default: 1.42pt

It specifies a distance by which something inside the arrow tip is set inwards; for the Stealth arrow tip it is the distance by which the back angle is moved inwards.

**scale:** float

Default: 1

A factor that is applied to the mark's length, width and inset.

**sep:** number

Default: 2.83pt

The distance between multiple marks along their path.

**flex:** boolean

Default: true

Only applicable when marks are used on curves such as bezier and hobby. If true, the mark will point along the secant of the curve. If false, the tangent at the marks tip is used.

**position-samples:** integer

Default: 30

Only applicable when marks are used on curves such as bezier and hobby. The maximum number of samples to use for calculating curve positions. A higher number gives better results but may slow down compilation.

**pos:** number or ratio

Default: none

Overrides the mark's position along a path. A number will move it an absolute distance, while a ratio will be a distance relative to the length of the path. Note that this may be removed in the future in preference of a different method.

**offset:** number or ratio

Default: none

Like pos but it moves the position of the mark instead of overriding it.

**slant:** ratio

Default: 0%

How much to slant the mark relative to the axis of the arrow. 0% means no slant 100% slants at 45 degrees

**harpoon:** boolean

Default: false

When true only the top half of the mark is drawn.

**flip:** boolean

Default: false

When true the mark is flipped along its axis.

**reverse:** boolean

Default: false

Reverses the direction of the mark.

**xy-up:** vector

Default: (0, 0, 1)

The direction which is "up" for use when drawing 2D marks.

**z-up:** vector

Default: (0, 1, 0)

The direction which is "up" for use when drawing 3D marks.

**shorten-to:** integer or auto or none

Default: none

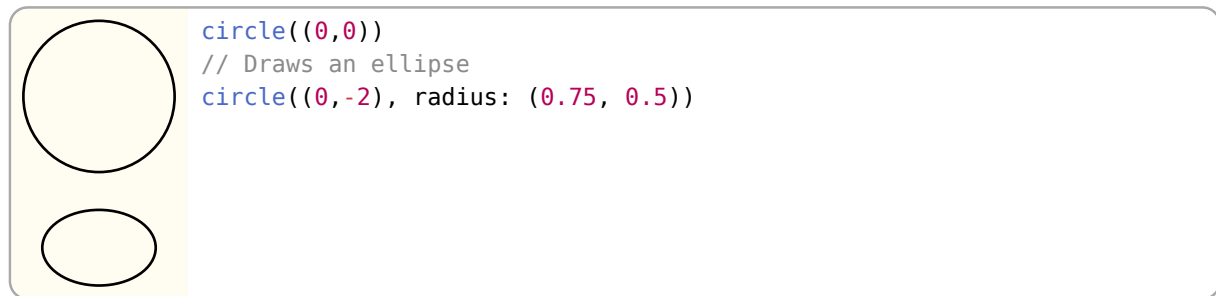


Which mark to shorten the path to when multiple marks are given. `auto` will shorten to the last mark, `none` will shorten to the first mark (effectively disabling path shortening). An integer can be given to select the mark's index.

## 3.3 Shapes

### 3.3.1 circle

Draws a circle or ellipse.



#### Parameters

```

circle(
  position: coordinate,
  name: none string,
  anchor: none string,
  ..style: style
)

```

**position:** coordinate

The position to place the circle on.

#### Styling

**Root:** circle

#### Keys

**radius:** number or array

Default: 1

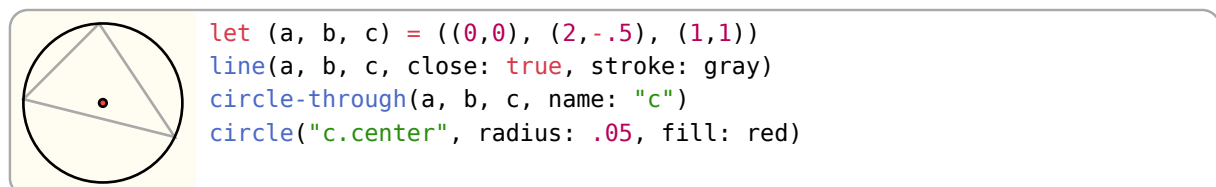
A number that defines the size of the circle's radius. Can also be set to a tuple of two numbers to define the radii of an ellipse, the first number is the x radius and the second is the y radius.

#### Anchors

Supports compass, distance and angle anchors. The “center” anchor is the default.

### 3.3.2 circle-through

Draws a circle through three coordinates.



## Parameters

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

**a:** coordinate

Coordinate a.

**b:** coordinate

Coordinate b.

**c:** coordinate

Coordinate c.

## 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.

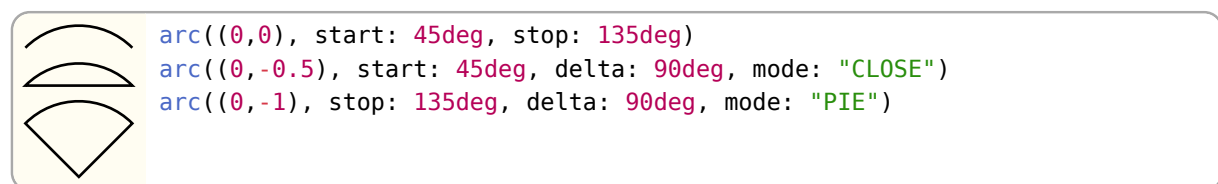
## Anchors

Supports the same anchors as `circle` as well as:

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

### 3.3.3 arc

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).

## Parameters

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

**position:** coordinate

Position to place the arc at.

**start:** auto or angle

Default: auto

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

**stop:** auto or angle

Default: auto

The angle at which the arc should stop.

**delta:** auto or angle

Default: auto

The change in angle away start or stop.

## Styling

**Root:** arc

## Keys

**radius:** number or array

Default: 1

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:** string

Default: "OPEN"

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

Default: true

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.

## Anchors

Supports compass, distance anchors and angle anchors if mode is "PIE"

**center** The center of the arc, this is the default anchor.

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

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

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

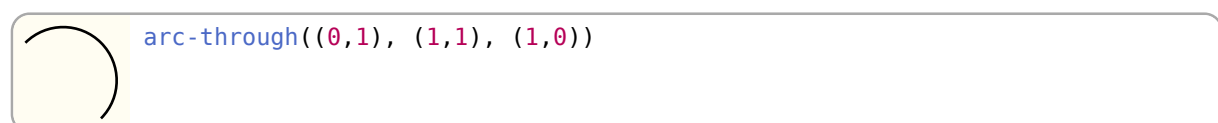
**arc-start** The position at which the arc's curve starts.

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

### 3.3.4 arc-through

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.



```
arc-through((0,1), (1,1), (1,0))
```

## Parameters

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

**a:** coordinate

Start position of the arc

**b:** coordinate

Position the arc passes through

**c:** coordinate

End position of the arc

## Styling

**Root:** arc


Uses the same styling as `arc()`

## Anchors

For anchors see `arc()`.

### 3.3.5 mark

Draws a single mark pointing towards a target coordinate.



```
mark((0,0), (1,0), symbol: ">", fill: black)
mark((0,0), (1,1), symbol: "stealth", scale: 3, fill: black)
```

## Parameters

```
mark(
  from: coordinate,
  to: coordinate,
  ..style: style
)
```

**from:** coordinate

The position to place the mark.

**to:** coordinate

The position the mark should point towards.

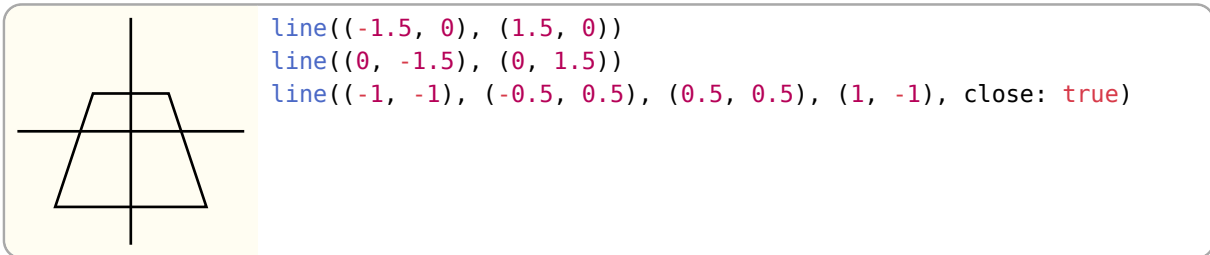
## Styling

**Root:** mark

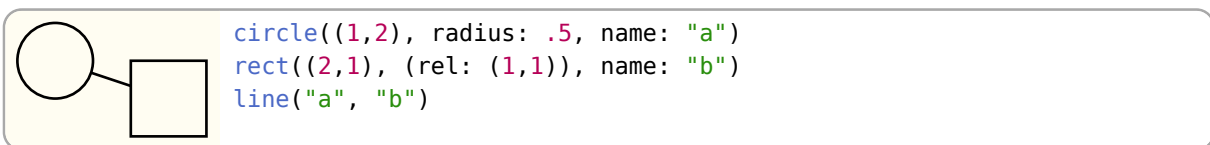
You can directly use the styling from Section 3.2.1.

### 3.3.6 line

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



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.



#### Parameters

```
line(
  ..pts-style: coordinates style,
  close: bool,
  name: none string
)
```

**..pts-style:** coordinates or style

Positional two or more coordinates to draw lines between. Accepts style key-value pairs.

**close:** bool

Default: false

If true, the line-strip gets closed to form a polygon

#### Styling

**Root:** line

Supports mark styling.

#### Anchors

Supports distance anchors.

**start** The line's start position

**mid** The line's mid position

**end** The line's end position

### 3.3.7 grid

Draws a grid between two coordinates



## Parameters

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

**from:** coordinate

The top left of the grid

**to:** coordinate

The bottom right of the grid

## Styling

**Root:** grid

## Keys

**step:** number or tuple or dictionary

Default: 1

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.

**help-lines:** bool

Default: 1

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

## Anchors

Supports compass anchors.

### 3.3.8 content

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

Hello World! `content((0,0), [Hello World!])`

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:

Text on a line

```
line((0, 0), (3, 1), name: "line")
content(
  ("line.start", 0.5, "line.end"),
  angle: "line.end",
  padding: .1,
  anchor: "south",
  [Text on a line]
)
```

This is  
a long  
text.

```
// 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))
```

## Parameters

```
content(
  ..args-style: coordinate content style,
  angle: angle coordinate,
  anchor: none string,
  name: none string
)
```

**..args-style:** coordinate or content or 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 or coordinate

Default: 0deg

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.

## Styling

**Root:** content

## Keys

**padding:** number or dictionary

Default: 0

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:** string or none

Default: none

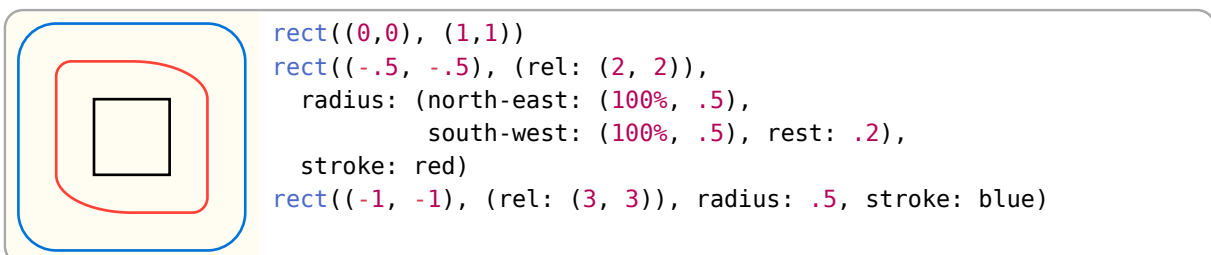
Sets the frame style. Can be none, "rect" or "circle" and inherits the stroke and fill style.

## Anchors

Supports compass anchors.

### 3.3.9 rect

Draws a rectangle between two coordinates.





## Parameters

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

**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)`).

## Styling

**Root** rect

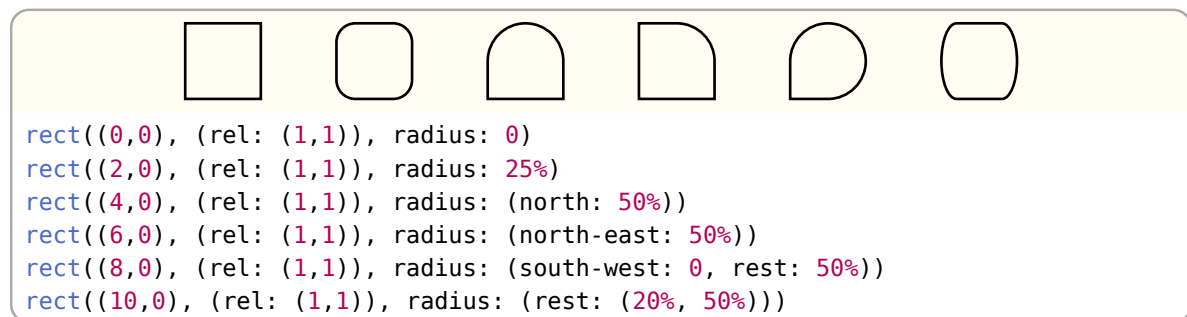
## Keys

**radius:** number or ratio or dictionary

Default: 0

The rectangles 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, 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.

Ratio values are relative to the rects width/height.

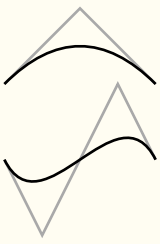


## Anchors

Supports compass, distance and angle anchors.

### 3.3.10 bezier

Draws a quadratic or cubic bezier curve



```
let (a, b, c) = ((0, 0), (2, 0), (1, 1))
line(a, c, b, stroke: gray)
bezier(a, b, c)

let (a, b, c, d) = ((0, -1), (2, -1), (.5, -2), (1.5, 0))
line(a, c, d, b, stroke: gray)
bezier(a, b, c, d)
```

## Parameters

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

**start:** coordinate

Start position

**end:** coordinate

End position (last coordinate)

**..ctrl-style:** coordinate or 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.

## Styling

**Root** bezier

Supports marks.

## Anchors

Supports distance anchors.

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

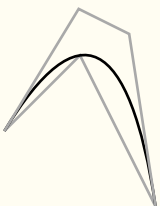
**start** The start position of the curve.

**mid** The mid position of the curve

**end** The end position of the curve.

### 3.3.11 bezier-through

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))
line(a, b, c, stroke: gray)
bezier-through(a, b, c, name: "b")

// Show calculated control points
line(a, "b.ctrl-0", "b.ctrl-1", c, stroke: gray)
```

## Parameters

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

**start:** coordinate

The position to start the curve.

**pass-through:** coordinate

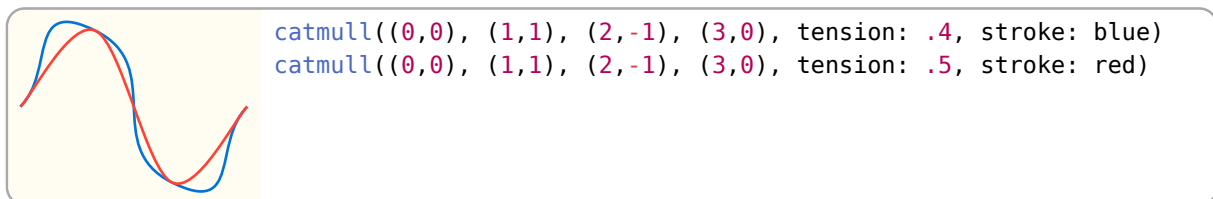
The position to pass the curve through.

**end:** coordinate

The position to end the curve.

### 3.3.12 catmull

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



## Parameters

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

**..pts-style:** coordinate or style

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

**close:** bool

Default: **false**

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

## Styling

**Root** catmull

Supports marks.

## Keys

**tension:** float

Default: **0.5**

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

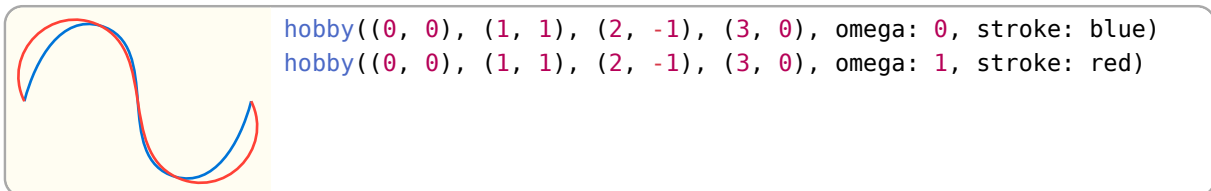
## Anchors

Supports distance anchors.

**start** The position of the start of the curve.  
**mid** The mid position of the curve  
**end** The position of the end of the curve.  
**pt-n** The nth given position (0 indexed so “pt-0” is equal to “start”)

### 3.3.13 hobby

Draws a Hobby curve through a set of points.



#### Parameters

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

**..pts-style:** coordinate or style

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

**ta:** auto or array Default: auto

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.

**tb:** auto or array Default: auto

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.

**close:** bool Default: false

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

#### Styling

**Root** hobby

Supports marks.

#### Keys

**omega:** tuple of float Default: (1, 1)

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.

#### Anchors

Supports distance anchors.

**start** The position of the start of the curve.

- mid** The mid position of the curve
- end** The position of the end of the curve.
- pt-n** The nth given position (0 indexed, so “pt-0” is equal to “start”)

### 3.3.14 merge-path

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.



```
merge-path(fill: white, {
  line((0, 0), (1, 0))
  bezier((0, 0), (1,1), (0,1))
})
```

Elements hidden via `hide()` are ignored.

#### Parameters

```
merge-path(
  body: elements,
  close: bool,
  name: none string,
  ..style: style
)
```

**body:** `elements`

Elements with paths to be merged together.

**close:** `bool`

Default: `false`

Close the path with a straight line from the start of the path to its end.

#### Anchors

Supports distance anchors.

**start** The start of the merged path.

**mid** The mid position of the merged path.

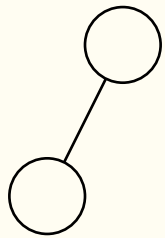
**end** The end of the merged path.

## 3.4 Grouping

### 3.4.1 hide

Hides an element.

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



```
set-style(radius: .5)
intersections("i", {
  circle((0,0), name: "a")
  circle((1,2), name: "b")
  // Use a hidden line to find the border intersections
  hide(line("a.center", "b.center"))
})
line("i.0", "i.1")
```

#### Parameters

`hide(body: element)`

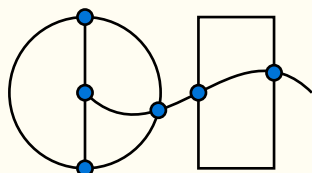
**body:** element

One or more elements to hide

### 3.4.2 intersections

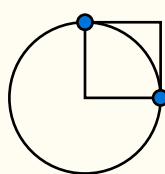
Calculates the intersections between multiple paths and creates one anchor per intersection point.

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.



```
intersections("i", {
  circle((0, 0))
  bezier((0,0), (3,0), (1,-1), (2,1))
  line((0,-1), (0,1))
  rect((1.5,-1),(2.5,1))
})
for-each-anchor("i", (name) => {
  circle("i." + name, radius: .1, fill: blue)
})
```

You can also use named elements:



```
circle((0,0), name: "a")
rect((0,0), (1,1), name: "b")
intersections("i", "a", "b")
for-each-anchor("i", (name) => {
  circle("i." + name, radius: .1, fill: blue)
})
```

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

## Parameters

```
intersections(
  name: string,
  ..elements: elements string,
  samples: int
)
```

**name:** string

Name to prepend to the generated anchors.

**..elements:** elements or string

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

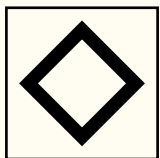
**samples:** int

Default: 10

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

### 3.4.3 group

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.



```
// Create group
group({
  stroke(5pt)
  scale(.5); rotate(45deg)
  rect((-1,-1),(1,1))
})
rect((-1,-1),(1,1))
```

## Parameters

```
group(
  body: elements function,
  name: none string,
  anchor: none string,
  ..style: style
)
```

**body:** elements or function

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

**anchor:** none or string

Default: none

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

## Styling

### Root group

## Keys

**padding:** none or number or array or dictionary

Default: none

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)`.

## Anchors

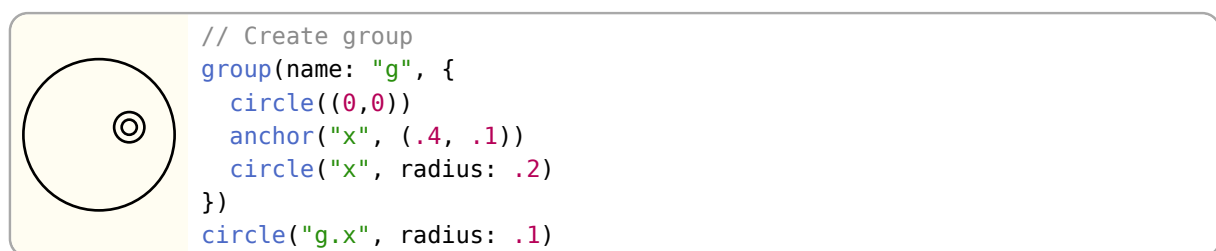
Supports compass, distance and angle anchors. These are created based on the axis aligned bounding box of all the child elements of the group.

You can add custom anchors to the group by using the `anchor` element while in the scope of said group, see `anchor` for more details. You can also copy over anchors from named child element by using the `copy-anchors` element as they are not accessible from outside the group.

The default anchor is “center” but this can be overridden by using `anchor` to place a new anchor called “default”.

### 3.4.4 anchor

Creates a new anchor for the current group. This element can only be used inside a group otherwise it will panic. The new anchor will be accessible from inside the group by using just the anchor's name as a coordinate.



## Parameters

```
anchor(
  name: string,
  position: coordinate
)
```

**name:** `string`

The name of the anchor

**position:** `coordinate`

The position of the anchor

### 3.4.5 copy-anchors

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

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



**element:** `string`

The name of the element to copy anchors from.

**filter:** `auto` or `array`

Default: `auto`

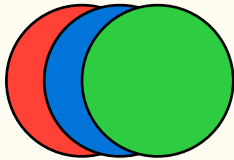
When set to `auto` all anchors will be copied to the group. An array of anchor names can instead be given so only the anchors that are in the element and the list will be copied over.

### 3.4.6 set-ctx

An advanced element that allows you to modify the current canvas context.

A context object holds the canvas' state, such as the element dictionary, the current transformation matrix, group and canvas unit length. The following fields are considered stable:

- `length (length)`: Length of one canvas unit as typst length
- `transform (cetz.matrix)`: Current 4x4 transformation matrix
- `debug (bool)`: True if the canvas' debug flag is set



```
// 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)
```

#### Parameters

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

**callback:** `function`

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

### 3.4.7 get-ctx

An advanced element that allows you to read the current canvas context through a callback and return elements based on it.

```
(
  (1, 0, 0.5, 0),
  (0, -1, -0.5, 0),
  (0, 0, 1, 0),
  (0, 0, 0, 1),
)

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

#### Parameters

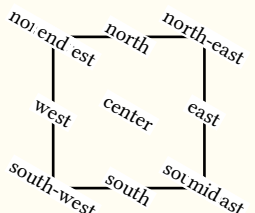
`get-ctx`(callback: `function`)

**callback:** function

A function that accepts the context dictionary and can return elements.

**3.4.8 for-each-anchor**

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



```
// Label nodes anchors
rect((0, 0), (2,2), name: "my-rect")
for-each-anchor("my-rect", (name) => {
  content((), box(inset: 1pt, fill: white, text(8pt, [#name])),
  angle: -30deg)
})
```

**Parameters**

```
for-each-anchor(
  name: string,
  callback: function
)
```

**name:** string

The name of the element with the anchors to loop through.

**callback:** function


A function that takes the anchor name and can return elements.

**3.4.9 on-layer**

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.



```
// Draw something behind text
set-style(stroke: none)
content((0, 0), [This is an example.], name: "text")
on-layer(-1, {
  circle("text.north-east", radius: .3, fill: red)
  circle("text.south", radius: .4, fill: green)
  circle("text.north-west", radius: .2, fill: blue)
})
```

**Parameters**

```
on-layer(
  layer: float integer,
  body: elements
)
```

**layer:** float or integer

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

**body:** elements

Elements to draw on the layer specified.

### 3.5 Transformations

All transformation functions push a transformation matrix onto the current transform stack. To apply transformations scoped use a `group(...)` object.

Transformation matrices get multiplied in the following order:

$$M_{\text{world}} = M_{\text{world}} \cdot M_{\text{local}}$$

#### 3.5.1 set-transform

Sets the transformation matrix.

##### Parameters

`set-transform(mat: none matrix)`

**mat:** `none` or `matrix`

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

#### 3.5.2 rotate

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



```

// Rotate on z-axis
rotate(z: 45deg)
rect((-1, -1), (1, 1))
// Rotate on y-axis
rotate(y: 80deg)
circle((0, 0))

```

##### Parameters

```

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

```

**..angles:** `angle`

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

**origin:** `none` or `coordinate`

Default: `none`

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

#### 3.5.3 translate

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))

```

## Parameters

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

**..args:** vector or float or length

A single vector or any combination of the named arguments x, y and z to translate by. A translation matrix with the given offsets gets multiplied with the current transformation depending on the value of pre.

**pre:** bool

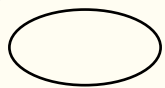
Default: **false**

Specify matrix multiplication order

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

### 3.5.4 scale

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



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

## Parameters

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

**..args:** float or ratio

A single value to scale the transformation matrix by or per axis 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.

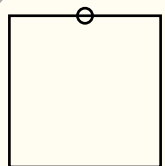
**origin:** none or coordinate

Default: **none**

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

### 3.5.5 set-origin

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



```
// Outer rect
rect((0,0), (2,2), name: "r")
// Move origin to top edge
set-origin("r.north")
circle((0, 0), radius: .1)
```

## Parameters

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

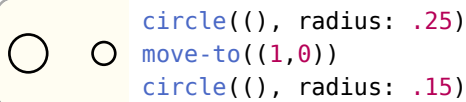
**origin:** coordinate

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

### 3.5.6 move-to

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.



```
circle(), radius: .25
move-to((1,0))
circle(), radius: .15
```

#### Parameters

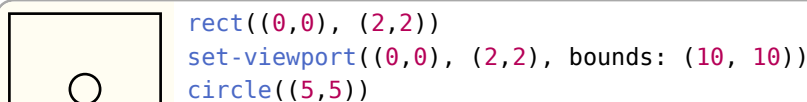
`move-to`(pt: coordinate)

**pt:** coordinate

The coordinate to move to.

### 3.5.7 set-viewport

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



```
rect((0,0), (2,2))
set-viewport((0,0), (2,2), bounds: (10, 10))
circle((5,5))
```

#### Parameters

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

**from:** coordinate

Bottom-Left corner coordinate

**to:** coordinate

Top right corner coordinate

**bounds:** vector

Default: (1, 1, 1)

Viewport bounds vector that describes the inner width, height and depth of the viewport

## 4 Coordinate Systems

A *coordinate* is a position on the canvas on which the picture is drawn. They take the form of dictionaries and the following sub-sections define the key value pairs for each system. Some systems have a more implicit form as an array of values and CeTZ attempts to infer the system based on the element types.

## 4.1 XYZ

Defines a point x units right, y units upward, and z units away.

**x:** `number` Default: `0`

The number of units in the x direction.

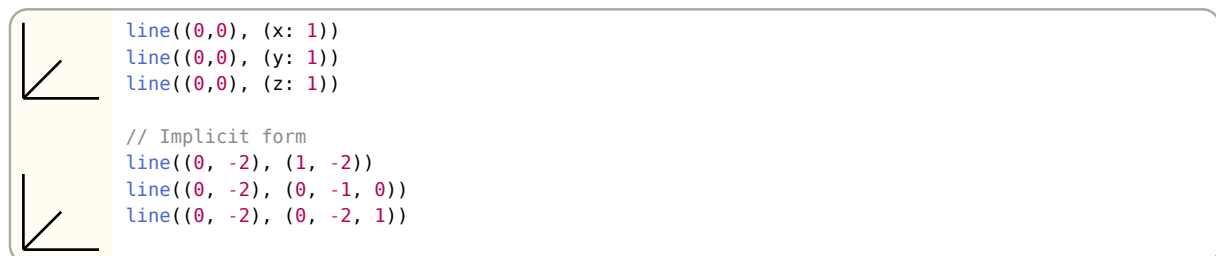
**y:** `number` Default: `0`

The number of units in the y direction.

**z:** `number` Default: `0`

The number of units in the z direction.

The implicit form can be given as an array of two or three `number`s, as in  $(x, y)$  and  $(x, y, z)$ .



## 4.2 Previous

Use this to reference the position of the previous coordinate passed to a draw function. This will never reference the position of a coordinate used in to define another coordinate. It takes the form of an empty array `()`. The previous position initially will be  $(0, 0, 0)$ .



## 4.3 Relative

Places the given coordinate relative to the previous coordinate. Or in other words, for the given coordinate, the previous coordinate will be used as the origin. Another coordinate can be given to act as the previous coordinate instead.

**rel:** `coordinate`

The coordinate to be place relative to the previous coordinate.

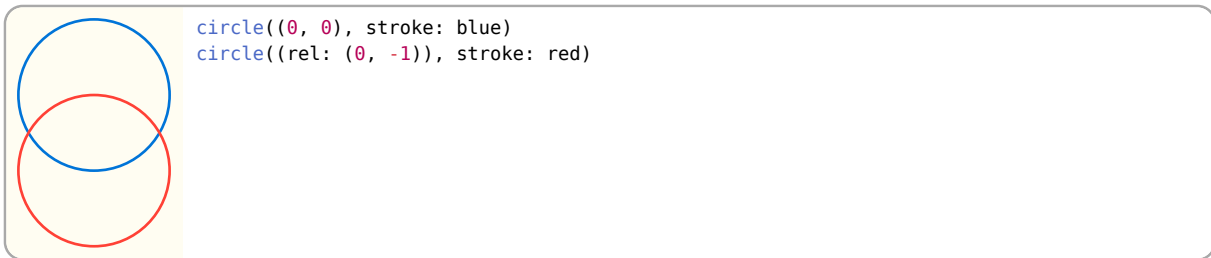
**update:** `boolean` Default: `true`

When false the previous position will not be updated.

**to:** `coordinate` Default: `()`

The coordinate to treat as the previous coordinate.

In the example below, the red circle is placed one unit below the blue circle. If the blue circle was to be moved to a different position, the red circle will move with the blue circle to stay one unit below.



## 4.4 Polar

Defines a point that is radius distance away from the origin at the given angle.

**angle:** `angle`

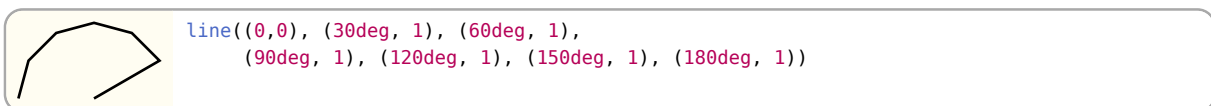
The angle of the coordinate. An angle of `0deg` is to the right, a degree of `90deg` is upward. See <https://typst.app/docs/reference/layout/angle/> for details.

**radius:** `number` or `tuple<number>`

The distance from the origin. An array can be given, in the form `(x, y)` to define the x and y radii of an ellipse instead of a circle.



The implicit form is an array of the angle then the radius `(angle, radius)` or `(angle, (x, y))`.



## 4.5 Barycentric

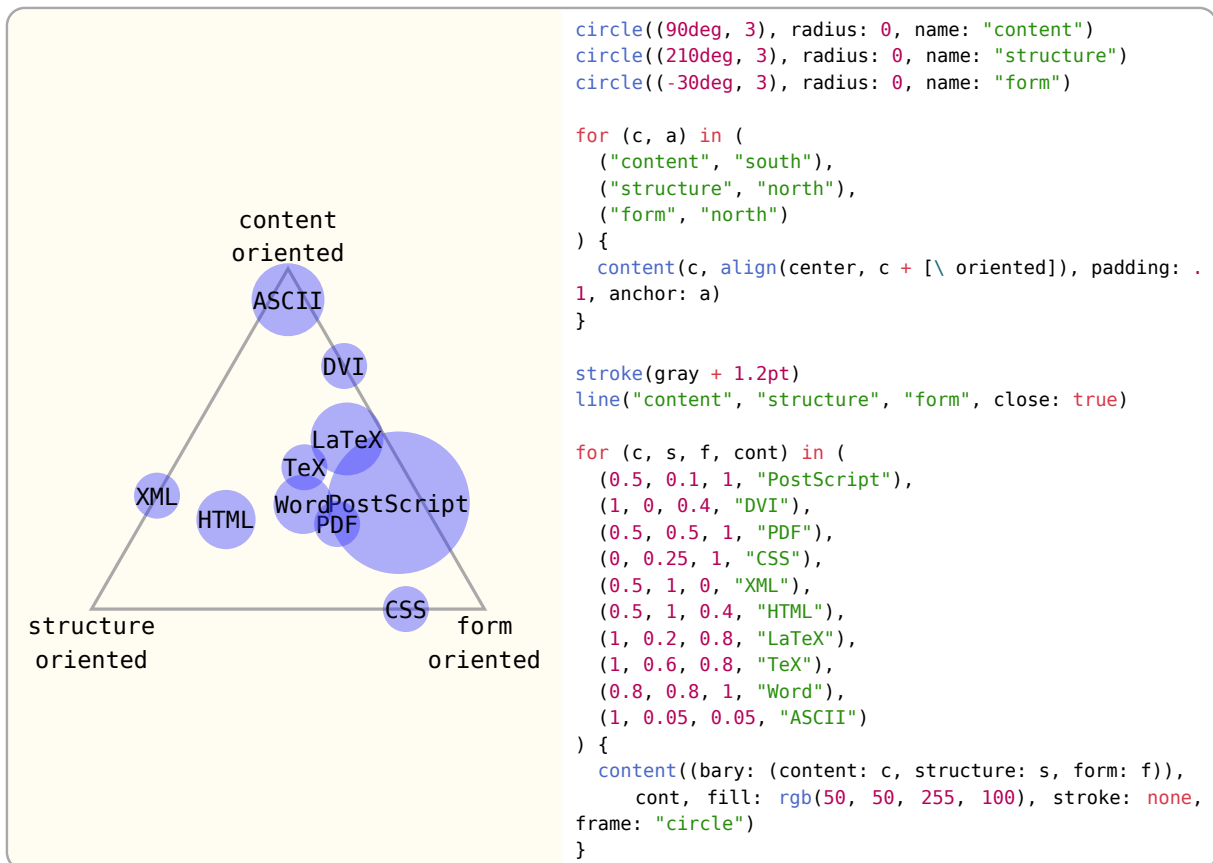
In the barycentric coordinate system a point is expressed as the linear combination of multiple vectors. The idea is that you specify vectors  $v_1, v_2, \dots, v_n$  and numbers  $\alpha_1, \alpha_2, \dots, \alpha_n$ . Then the barycentric coordinate specified by these vectors and numbers is

$$\frac{\alpha_1 v_1 + \alpha_2 v_2 + \dots + \alpha_n v_n}{\alpha_1 + \alpha_2 + \dots + \alpha_n}$$

**bary:** `dictionary`

A dictionary where the key is a named element and the value is a `float`. The center anchor of the named element is used as  $v$  and the value is used as  $a$ .





## 4.6 Anchor

Defines a point relative to a named element using anchors, see Section 2.2.

**name:** string

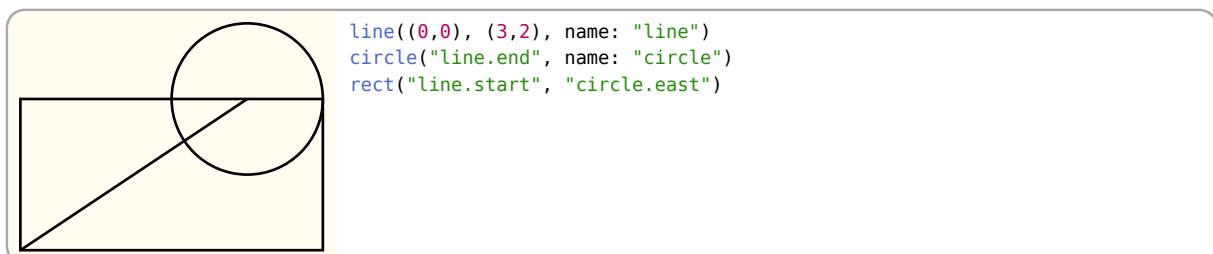
The name of the element that you wish to use to specify a coordinate.

**anchor:** number or angle or string

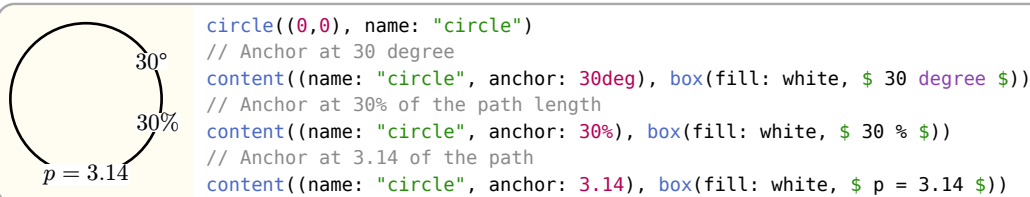
Default: none

An anchor of the element. If one is not given a default anchor will be used. On most elements this is center but it can be different.

You can also use implicit syntax of a dot separated string in the form "name.anchor" for named anchors.



Using the dictionary anchor syntax, you can not only use named anchors, but also query the element for distance or angle anchors on it's path:



Note, that not all elements provide angle or distance based anchors!

## 4.7 Tangent

This system allows you to compute the point that lies tangent to a shape. In detail, consider an element and a point. Now draw a straight line from the point so that it “touches” the element (more formally, so that it is *tangent* to this element). The point where the line touches the shape is the point referred to by this coordinate system.

**element:** string

The name of the element on whose border the tangent should lie.

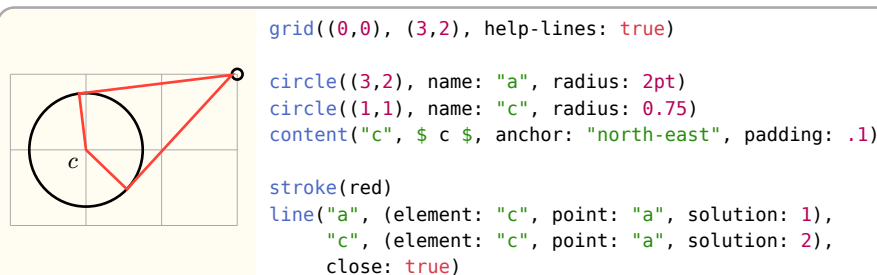
**point:** coordinate

The point through which the tangent should go.

**solution:** integer

Which solution should be used if there are more than one.

A special algorithm is needed in order to compute the tangent for a given shape. Currently it does this by assuming the distance between the center and top anchor (See Section 2.2) is the radius of a circle.



## 4.8 Perpendicular

Can be used to find the intersection of a vertical line going through a point  $p$  and a horizontal line going through some other point  $q$ .

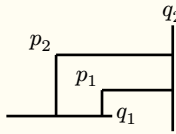
**horizontal:** coordinate

The coordinate through which the horizontal line passes.

**vertical:** coordinate

The coordinate through which the vertical line passes.

You can use the implicit syntax of (horizontal, "-|", vertical) or (vertical, "|-", horizontal)



```

set-style(content: (padding: .05))
content((30deg, 1), $ p_1 $, name: "p1")
content((75deg, 1), $ p_2 $, name: "p2")

line((-0.2, 0), (1.2, 0), name: "xline")
content("xline.end", $ q_1 $, anchor: "west")
line((2, -0.2), (2, 1.2), name: "yline")
content("yline.end", $ q_2 $, anchor: "south")

line("p1.south-east", (horizontal: (), vertical: "xline.end"))
line("p2.south-east", ((), "|-", "xline.end")) // Short form
line("p1.south-east", (vertical: (), horizontal: "yline.end"))
line("p2.south-east", ((), "-|", "yline.end")) // Short form

```

## 4.9 Interpolation

Use this to linearly interpolate between two coordinates **a** and **b** with a given distance number. If number is a **number** the position will be at the absolute distance away from **a** towards **b**, a **ratio** can be given instead to be the relative distance between **a** and **b**. An angle can also be given for the general meaning: "First consider the line from **a** to **b**. Then rotate this line by **angle** around point **a**. Then the two endpoints of this line will be **a** and some point **c**. Use this point **c** for the subsequent computation."

**a:** coordinate

The coordinate to interpolate from.

**b:** coordinate

The coordinate to interpolate to.

**number:** ratio or number

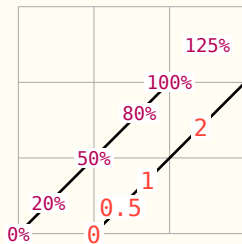
The distance between **a** and **b**. A ratio will be the relative distance between the two points, a number will be the absolute distance between the two points.

**angle:** angle

Default: 0deg

Angle between  $\overline{AB}$  and  $\overline{AP}$ , where **P** is the resulting coordinate. This can be used to get the *normal* for a tangent between two points.

Can be used implicitly as an array in the form (**a**, **number**, **b**) or (**a**, **number**, **angle**, **b**).



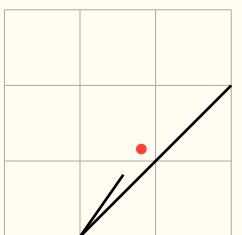
```

grid((0,0), (3,3), help-lines: true)

line((0,0), (2,2), name: "a")
for i in (0%, 20%, 50%, 80%, 100%, 125%) { /* Relative distance */
  content(("a.start", i, "a.end"),
    box(fill: white, inset: 1pt, [#i]))
}

line((1,0), (3,2), name: "b")
for i in (0, 0.5, 1, 2) { /* Absolute distance */
  content(("b.start", i, "b.end"),
    box(fill: white, inset: 1pt, text(red, [#i])))
}

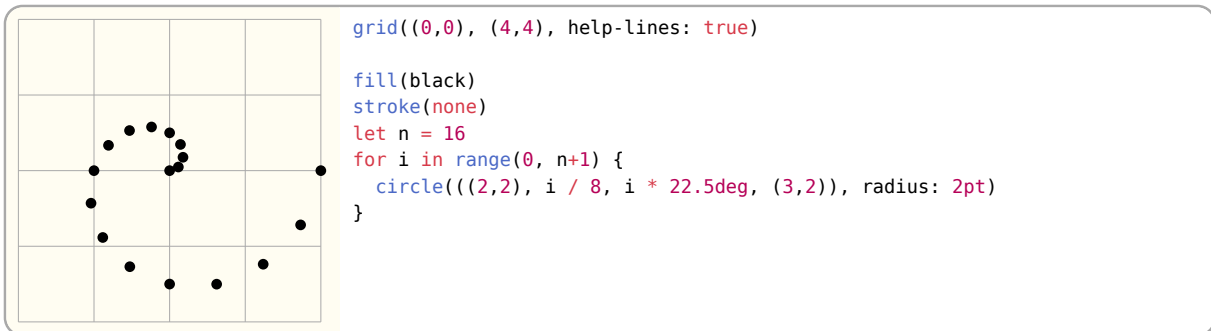
```



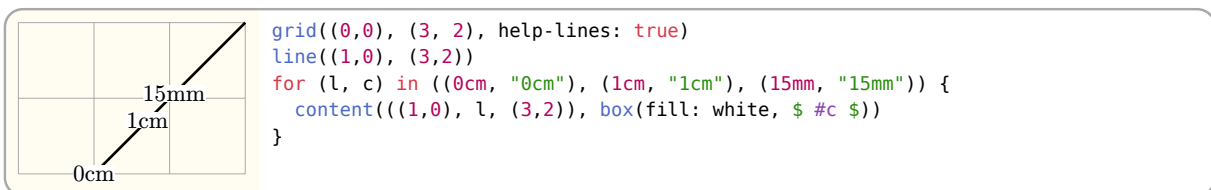
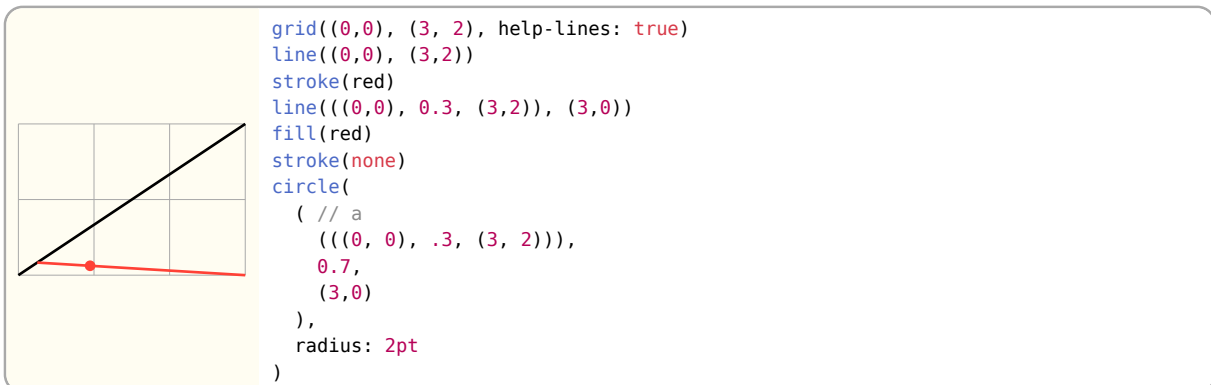
```

grid((0,0), (3,3), help-lines: true)
line((1,0), (3,2))
line((1,0), ((1, 0), 1, 10deg, (3,2)))
fill(red)
stroke(none)
circle(((1, 0), 50%, 10deg, (3, 2)), radius: 2pt)

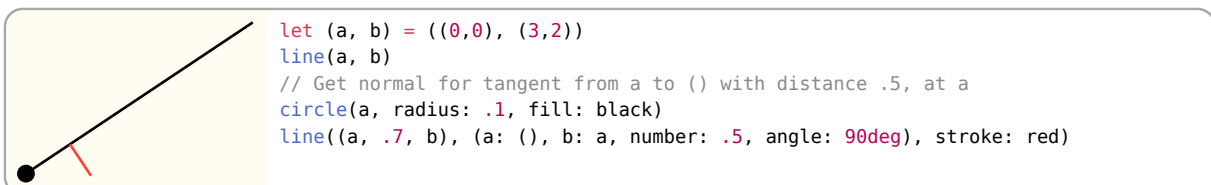
```



You can even chain them together!



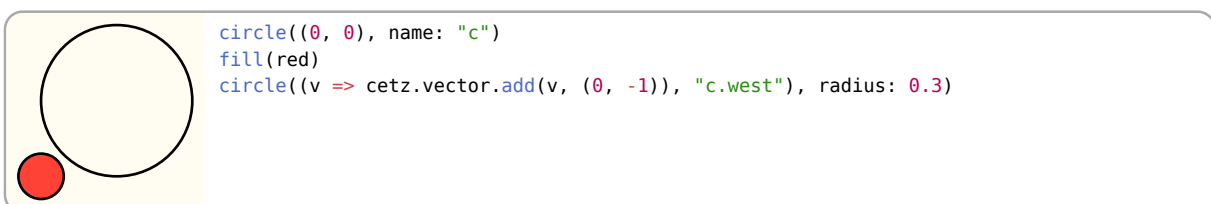
Interpolation coordinates can be used to get the *normal* on a tangent:



## 4.10 Function

An array where the first element is a function and the rest are coordinates will cause the function to be called with the resolved coordinates. The resolved coordinates have the same format as the implicit form of the 3-D XYZ coordinate system, Section 4.1.

The example below shows how to use this system to create an offset from an anchor, however this could easily be replaced with a relative coordinate with the `to` argument set, Section 4.3.



## 5 Libraries

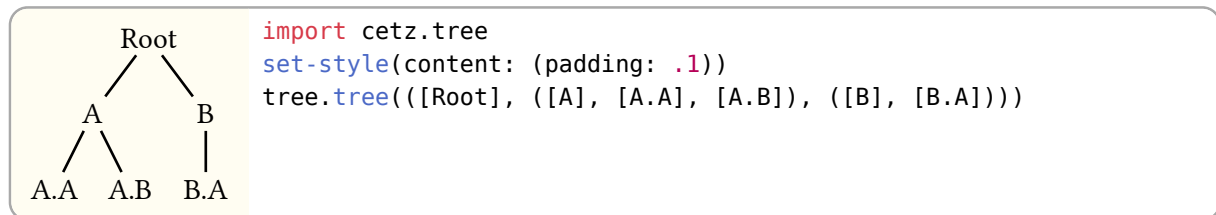
### 5.1 Tree

The tree library allows the drawing diagrams with simple tree layout algorithms

#### 5.1.1 tree

Lays out and renders tree nodes.

For each node, the tree function creates an anchor of the format "node-<depth>-<child-index>" that can be used to query a nodes position on the canvas.



#### Parameters

```
tree(
  root: array,
  draw-node: auto function,
  draw-edge: none auto function,
  direction: string,
  parent-position: string,
  grow: float,
  spread: float,
  name: none string
)
```

**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 or function

Default: auto

The function to call to draw a node. The function will be passed two positional arguments, the node to draw and the node's parent, and is expected to return elements ((node, parent-node) => elements). The node's position is accessible through the "center" anchor or by using the previous position coordinate (). If auto is given, just the node's value will be drawn as content. The following predefined styles can be used:

**draw-edge:** none or auto or function

Default: auto

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, and the end node and is expected to return elements ((source-name, target-name, target-node) => elements). If auto is given, a straight line will be drawn between nodes.

**direction:** string

Default: "down"

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

**parent-position:** string

Default: "center"

Positioning of parent nodes (begin, center, end)

**grow:** float

Default: 1

Depth grow factor

**spread:** float

Default: 1

Sibling spread factor

**name:** none or string

Default: none

The tree elements name

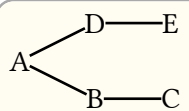
## Nodes

A tree node is an array consisting of the nodes value at index 0 followed by its child nodes. For the default draw-node function, the value (first item) of an node must be of type `content`.

### Example of a list of nodes:

A—B—C—D    `cetz.tree.tree([A], ([B], ([C], ([D],)))), direction: "right")`

### Example of a tree of nodes:

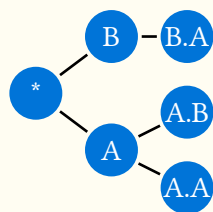
    `cetz.tree.tree([A], ([B], [C]), ([D], [E])), direction: "right")`

## Drawing and Styling Tree Nodes

The `tree()` function takes an optional `draw-node:` and `draw-edge:` callback function that can be used to customize node and edge drawing.

The `draw-node` function must take the current node and its parents node anchor as arguments and return one or more elements.

For drawing edges between nodes, the `draw-edge` function must take two node anchors and the target node as arguments and return one or more elements.



```
import cetz.tree
set-style(content: (padding: .1))
let data = ([\*, ([A], [A.A], [A.B]), ([B], [B.A]))
tree.tree(
  data,
  direction: "right",
  draw-node: (node, ..) => {
    circle(), radius: .35, fill: blue, stroke: none
    content(), text(white, [#node.content])
  },
  draw-edge: (from, to, ..) => {
    let (a, b) = (from + ".center", to + ".center")
    line((a: a, b: b, abs: true, number: .40),
        (a: b, b: a, abs: true, number: .40))
  }
)
```

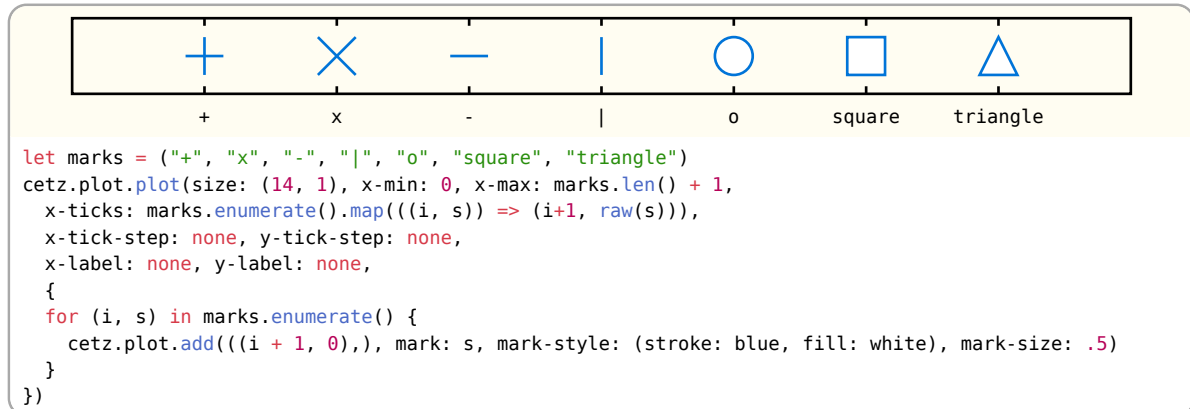
## 5.2 Plot

The library plot of CeTZ allows plotting data.

### 5.2.1 Types

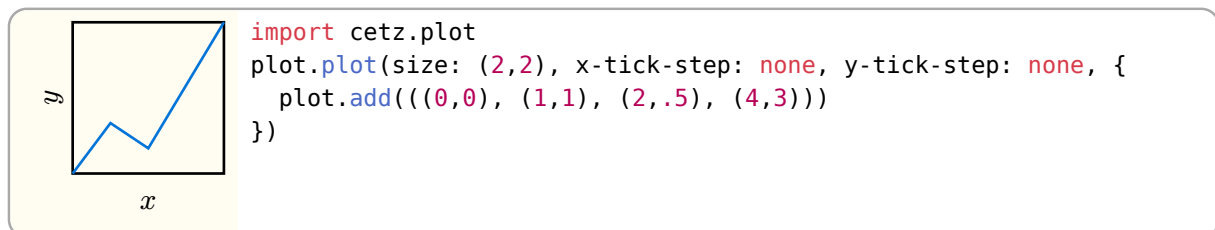
Types commonly used by function of the plot library:

- **domain**: Tuple representing a functions domain as closed interval. Example domains are:  $(0, 1)$  for  $[0, 1]$  or  $(-\text{calc.pi}, \text{calc.pi})$  for  $[-\pi, \pi]$ .
- **axes**: Tuple of axis names. Plotting functions taking an axes tuple will use those axes as their x and y axis for plotting. To rotate a plot, you can simply swap its axes, for example  $(\text{"y"}, \text{"x"})$ .
- **mark**: Plots feature their own set of marks. The following mark symbols are available:



### 5.2.2 plot

Create a plot environment. Data to be plotted is given by passing it to the `plot.add` or other plotting functions. The plot environment supports different axis styles to draw, see its parameter `axis-style`.



To draw elements inside a plot, using the plots coordinate system, use the `plot.annotate(...)` function.

#### Parameters

```

plot(
  body: body,
  size: array,
  axis-style: none string,
  name: string,
  plot-style: style function,
  mark-style: style function,
  fill-below: bool,
  legend: none auto coordinate,
  legend-anchor: auto string,
  legend-style: style,
  ..options: any
)

```

#### **body**: body

Calls of `plot.add` or `plot.add-*` commands. Note that normal drawing commands like `line` or `rect` are not allowed inside the plots body, instead wrap them in `plot.annotate`, which lets you select the axes used for drawing.

#### **size**: array

Default:  $(1, 1)$

Plot size tuple of (<width>, <height>) in canvas units. This is the plots inner plotting size without axes and labels.

**axis-style:** `none` or `string`

Default: `"scientific"`

How the axes should be styled:

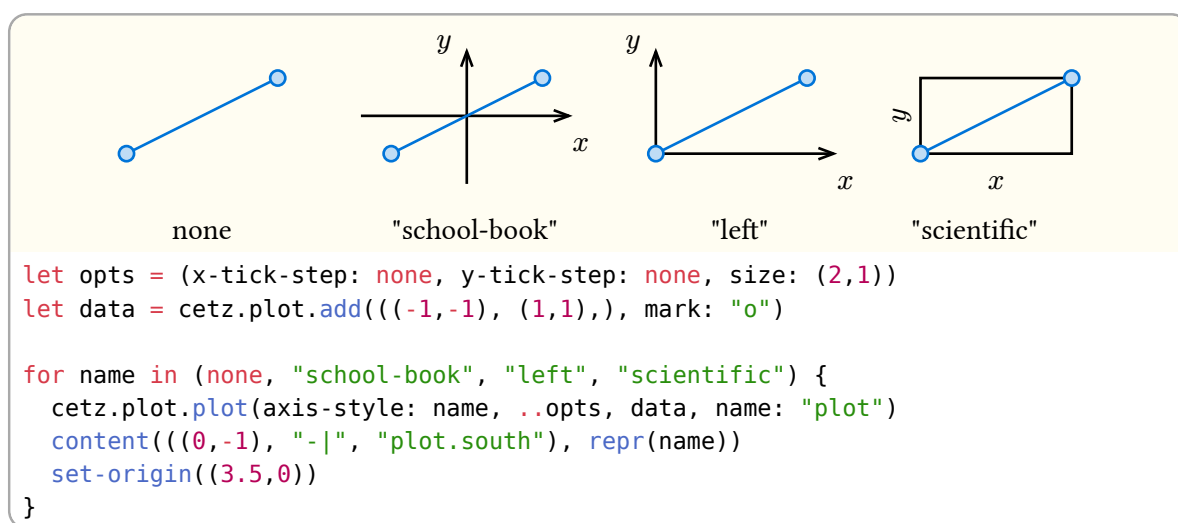
**scientific** Frames plot area using a rectangle and draw axes  $x$  (bottom),  $y$  (left),  $x_2$  (top), and  $y_2$  (right) around it. If  $x_2$  or  $y_2$  are unset, they mirror their opposing axis.

**scientific-auto** Draw set (used) axes  $x$  (bottom),  $y$  (left),  $x_2$  (top) and  $y_2$  (right) around the plotting area, forming a rect if all axes are in use or a L-shape if only  $x$  and  $y$  are in use.

**school-book** Draw axes  $x$  (horizontal) and  $y$  (vertical) as arrows pointing to the right/top with both crossing at  $(0, 0)$

**left** Draw axes  $x$  and  $y$  as arrows, while the  $y$  axis stays on the left (at  $x.min$ ) and the  $x$  axis at the bottom (at  $y.min$ )

**none** Draw no axes (and no ticks).



**name:** `string`

Default: `none`

The plots element name to be used when referring to anchors

**plot-style:** `style` or `function`

Default: `default-plot-style`

Styling to use for drawing plot graphs. This style gets inherited by all plots and supports palette functions. The following style keys are supported:

**stroke:** `none` or `stroke`

Default: `1pt`

Stroke style to use for stroking the graph.

**fill:** `none` or `paint`

Default: `none`

Paint to use for filled graphs. Note that not all graphs may support filling and that you may have to enable filling per graph, see `plot.add(fill: ..)`.

**mark-style:** `style` or `function`

Default: `default-mark-style`

Styling to use for drawing plot marks. This style gets inherited by all plots and supports palette functions. The following style keys are supported:

**stroke:** `none` or `stroke`

Default: `1pt`

Stroke style to use for stroking the mark.

**fill:** `none` or `paint`

Default: `none`



Paint to use for filling marks.

**fill-below:** `bool`

Default: `true`

If true, the filled shape of plots is drawn *below* axes.

**legend:** `none` or `auto` or `coordinate`

Default: `auto`

The position the legend will be drawn at. See Section 5.2.4 for information about legends. If set to `auto`, the legend's "default-placement" styling will be used. If set to a `coordinate`, it will be taken as relative to the plot's origin.

**legend-anchor:** `auto` or `string`

Default: `auto`

Anchor of the legend group to use as its origin. If set to `auto` and `legend` is one of the predefined legend anchors, the opposite anchor to `legend` gets used.

**legend-style:** `style`

Default: `(:)`

Style key-value overwrites for the legend style with style root `legend`.

**..options:** `any`

Axis options, see *options* below.

## Options

You can use the following options to customize each axis of the plot. You must pass them as named arguments prefixed by the axis name followed by a dash (-) they should target. Example: `x-min: 0`, `y-ticks: (...)` or `x2-label: [...]`.

**label:** `none` or `content`

Default: `"none"`

The axis' label. If and where the label is drawn depends on the `axis-style`.

**min:** `auto` or `float`

Default: `"auto"`

Axis lower domain value. If this is set greater than `max`, the axis' direction is swapped

**max:** `auto` or `float`

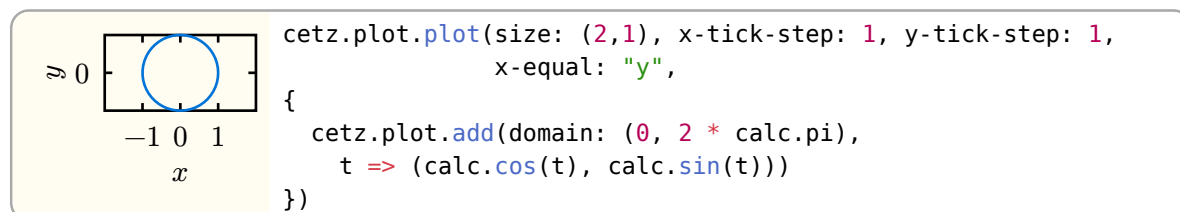
Default: `"auto"`

Axis upper domain value. If this is set to a lower value than `min`, the axis' direction is swapped

**equal:** `string`

Default: `"none"`

Set the axis domain to keep a fixed aspect ratio by multiplying the other axis domain by the plots aspect ratio, depending on the other axis orientation (see `horizontal`). This can be useful to force one axis to grow or shrink with another one. You can only "lock" two axes of different orientations.



**horizontal:** `bool`

Default: `"axis name dependant"`

If true, the axis is considered an axis that gets drawn horizontally, vertically otherwise. The default value depends on the axis name on axis creation. Axes which name start with `x` have this set to `true`, all others have it set to `false`. Each plot has to use one horizontal and one vertical axis for plotting, a combination of two y-axes will panic: ("`y`", "`y2`").

**tick-step:** `none` or `auto` or `float`

Default: `"auto"`

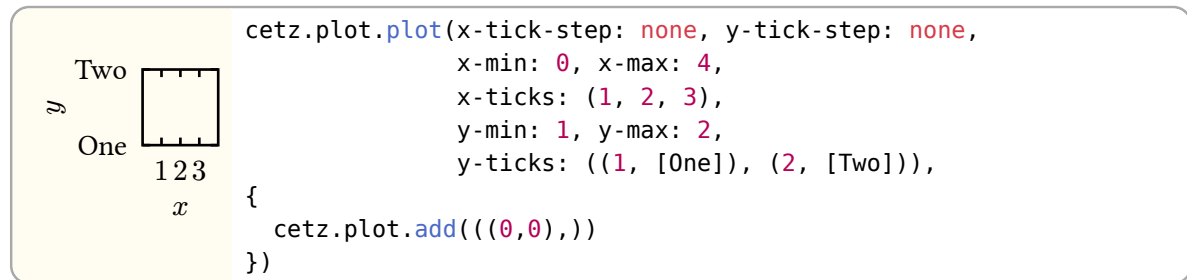
The increment between tick marks on the axis. If set to auto, an increment is determined. When set to none, incrementing tick marks are disabled.

**minor-tick-step:** `none` or `float` Default: `"none"`

Like tick-step, but for minor tick marks. In contrast to ticks, minor ticks do not have labels.

**ticks:** `none` or `array` Default: `"none"`

A List of custom tick marks to additionally draw along the axis. They can be passed as an array of `float` values or an array of (`<float>`, `<content>`) tuples for setting custom tick mark labels per mark.



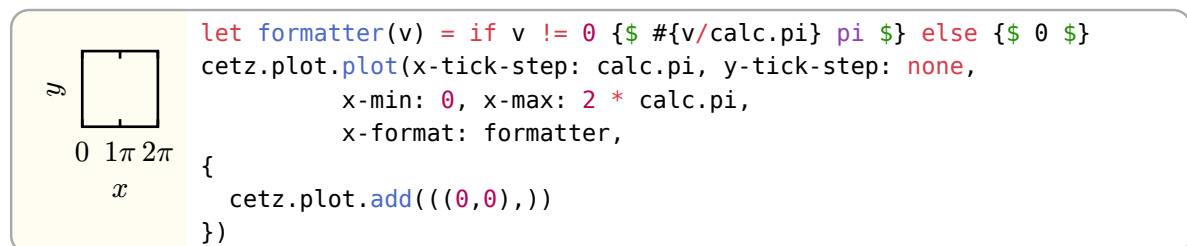
Examples: (1, 2, 3) or ((1, [One]), (2, [Two]), (3, [Three]))

**format:** `none` or `string` or `function` Default: `"float"`

How to format the tick label: You can give a function that takes a `float` and return `content` to use as the tick label. You can also give one of the predefined options:

**float** Floating point formatting rounded to two digits after the point (see decimals)

**sci** Scientific formatting with  $\times 10^n$  used as exponent syntax



**decimals:** `int` Default: `"2"`

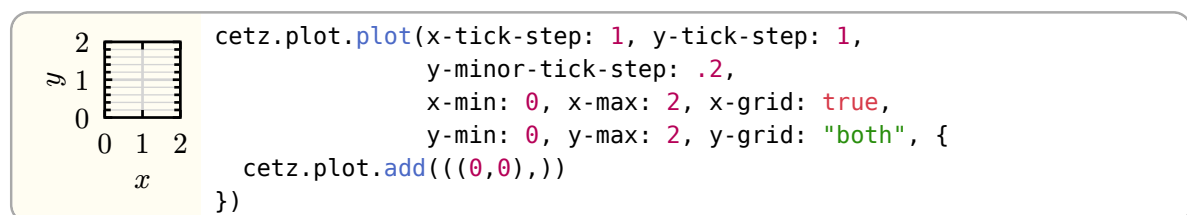
Number of decimals digits to display for tick labels, if the format is set to "float".

**unit:** `none` or `content` Default: `"none"`

Suffix to append to all tick labels.

**grid:** `bool` or `string` Default: `"false"`

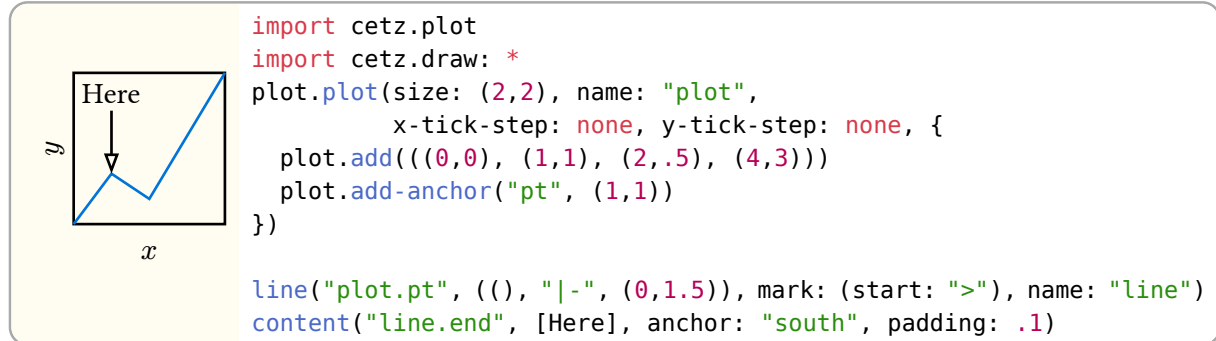
If true or "major", show grid lines for all major ticks. If set to "minor", show grid lines for minor ticks only. The value "both" enables grid lines for both, major- and minor ticks.



### 5.2.3 add-anchor

Add an anchor to a plot environment

This function is similar to `draw.anchor` but it takes an additional axis tuple to specify which axis coordinate system to use.



#### Parameters

```
add-anchor(
  name: string,
  position: tuple,
  axes: tuple
)
```

**name:** string

Anchor name

**position:** tuple

Tuple of x and y values. Both values can have the special values “min” and “max”, which resolve to the axis min/max value. Position is in axis space defined by the axes passed to axes.

**axes:** tuple Default: ("x", "y")

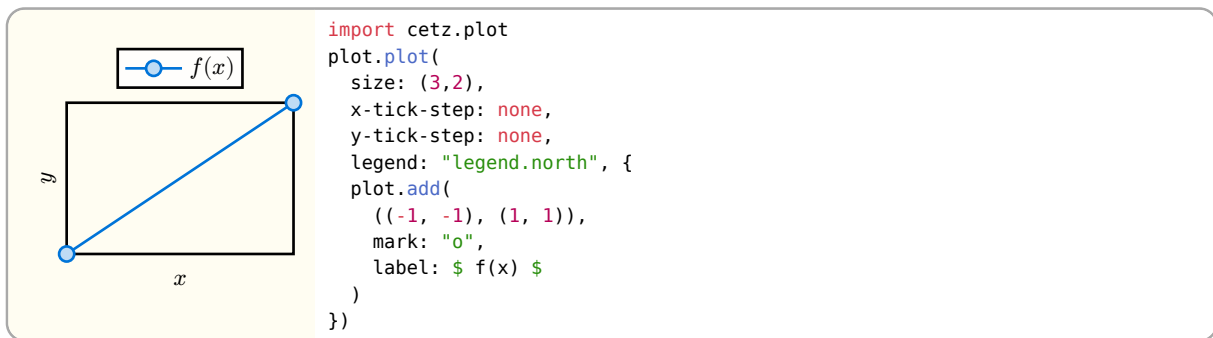
Name of the axes to use ("x", "y") as coordinate system for position. Note that both axes must be used, as add-anchors does not create them on demand.

### 5.2.4 Legends

A legend for a plot will be drawn if at least one set of data with a label that is not none is given. The following anchors are available when placing a legend on a plot:

- legend.north
- legend.south
- legend.east
- legend.west
- legend.north-east
- legend.north-west
- legend.south-east
- legend.south-west
- legend.inner-north
- legend.inner-south
- legend.inner-east
- legend.inner-west
- legend.inner-north-east
- legend.inner-north-west
- legend.inner-south-east

- `legend.inner-south-west`



## Styling

**Root:** legend

### Keys

**orientation:** direction Default: ttb

The direction the legend items get laid out to.

**default-position:** string or coordinate Default: "legend.north-east"

The default position the legend gets placed at.

**layer:** number Default: 1

The layer index the legend gets drawn at, see on-layer.

**fill:** paint Default: `rgb("#ffffffc8")`

The legends frame background color.

**stroke:** stroke Default: `luma(0%)`

The legends frame stroke style.

**padding:** float Default: 0.1

The legends frame padding, that is the distance added between its items and its frame.

**offset:** tuple Default: (0, 0)

An offset tuple (x and y coordinates) to add to the legends position.

**spacing:** number Default: 0.1

The spacing between the legend position and its frame.

**item.spacing:** number Default: 0.05

The spacing between two legend items in canvas units.

**item.preview.width:** number Default: 0.75

The width of a legend items preview picture, a small preview of the graph the legend item belongs to.

**item.preview.height:** number Default: 0.3

The height of a legend items preview picture.

**item.preview.margin:** number Default: 0.1

Margin between the preview picture and the item label.

### 5.2.5 add

Add data to a plot environment.

Note: You can use this for scatter plots by setting the stroke style to none: `add(..., style: (stroke: none))`.

Must be called from the body of a `plot(...)` command.

#### Parameters

```
add(
  domain: domain,
  hypograph: bool,
  epigraph: bool,
  fill: bool,
  fill-type: string,
  style: style,
  mark: string,
  mark-size: float,
  mark-style,
  samples: int,
  sample-at: array,
  line: string dictionary,
  axes: axes,
  label: none content,
  data: array function
)
```

**domain:** domain

Default: **auto**

Domain of data, if data is a function. Has no effect if data is not a function.

**hypograph:** bool

Default: **false**

Fill hypograph; uses the hypograph style key for drawing

**epigraph:** bool

Default: **false**

Fill epigraph; uses the epigraph style key for drawing

**fill:** bool

Default: **false**

Fill the shape of the plot

**fill-type:** string

Default: **"axis"**

Fill type:

**"axis"** Fill the shape to  $y = 0$

**"shape"** Fill the complete shape

**style:** style

Default: **(:)**

Style to use, can be used with a palette function

**mark:** string

Default: **none**

Mark symbol to place at each distinct value of the graph. Uses the mark style key of style for drawing.

**mark-size:** float

Default: **.2**

Mark size in canvas units

**mark-style:**

Default: **(:)**

**samples:** `int`Default: `50`

Number of times the data function gets called for sampling y-values. Only used if data is of type function. This parameter gets passed onto `sample-fn`.

**sample-at:** `array`Default: `()`

Array of x-values the function gets sampled at in addition to the default sampling. This parameter gets passed to `sample-fn`.

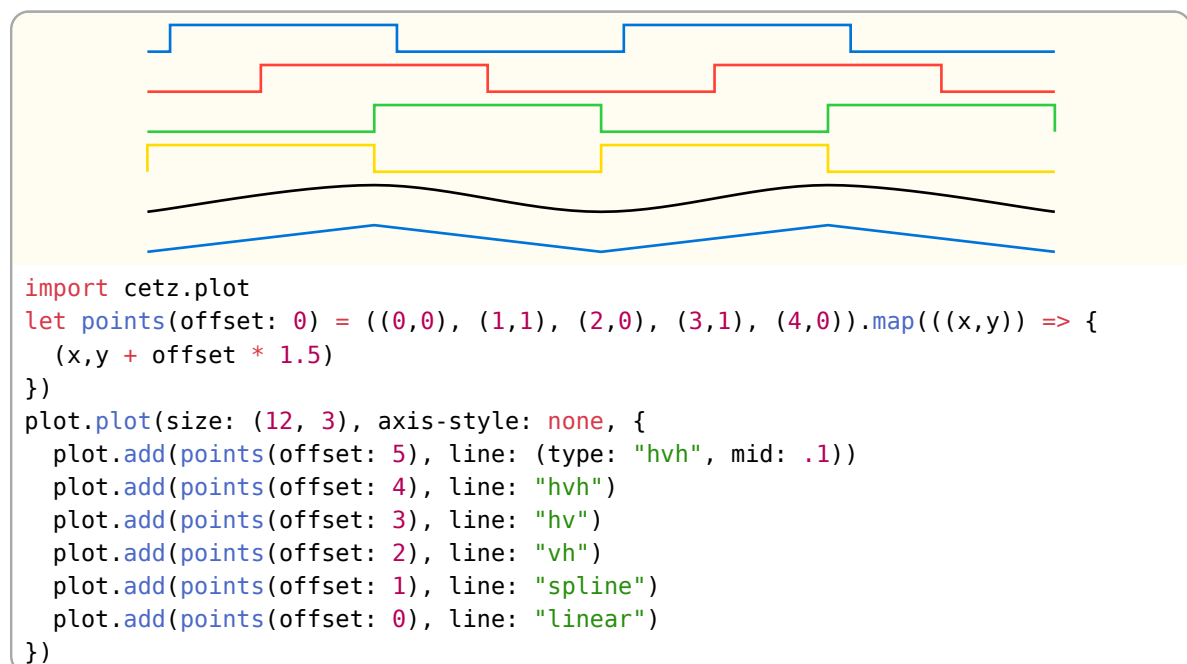
**line:** `string` or `dictionary`Default: `"linear"`

Line type to use. The following types are supported:

- `"linear"` Draw linear lines between points
- `"spline"` Calculate a Catmull-Rom through all points
- `"vh"` Move vertical and then horizontal
- `"hv"` Move horizontal and then vertical
- `"hvh"` Add a vertical step in the middle
- `"raw"` Like linear, but without linearization taking place. This is meant as a “fallback” for either bad performance or bugs.

If the value is a dictionary, the type must be supplied via the `type` key. The following extra attributes are supported:

- `"samples" <int>` Samples of splines
- `"tension" <float>` Tension of splines
- `"mid" <float>` Mid-Point of hvh lines (0 to 1)
- `"epsilon" <float>` Linearization slope epsilon for use with `"linear"`, defaults to 0.

**axes:** `axes`Default: `("x", "y")`

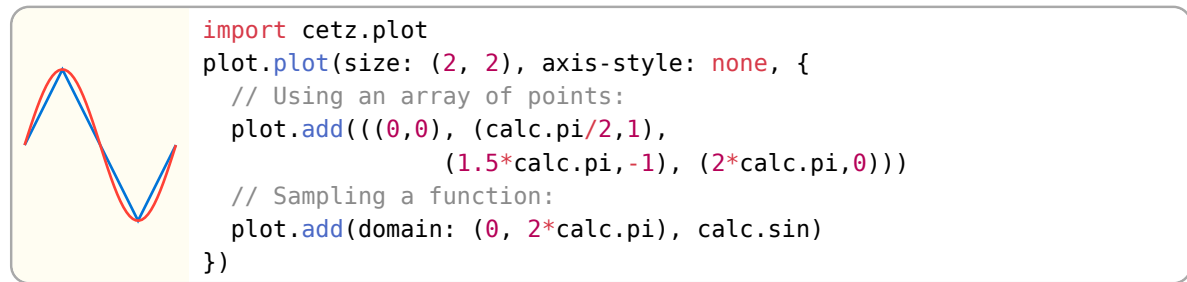
Name of the axes to use for plotting. Reversing the axes means rotating the plot by 90 degrees.

**label:** `none` or `content`Default: `none`

Legend label to show for this plot.

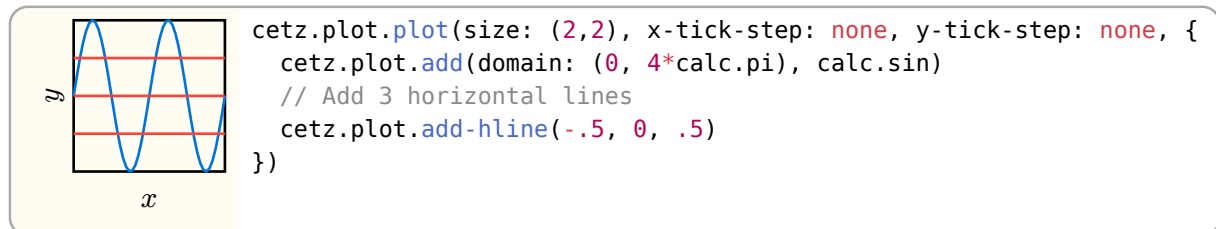
**data:** `array` or `function`

Array of 2D data points (numeric) or a function of the form  $x \Rightarrow y$ , where  $x$  is a value in domain and  $y$  must be numeric or a 2D vector (for parametric functions).



### 5.2.6 add-hline

Add horizontal lines at one or more  $y$ -values. Every lines start and end points are at their axis bounds.



#### Parameters

```
add-hline(
  ..y: float,
  min: auto float,
  max: auto float,
  axes: array,
  style: style,
  label: none content
)
```

**..y:** float

Y axis value(s) to add a line at

**min:** auto or float

Default: auto

X axis minimum value or auto to take the axis minimum

**max:** auto or float

Default: auto

X axis maximum value or auto to take the axis maximum

**axes:** array

Default: ("x", "y")

Name of the axes to use for plotting

**style:** style

Default: (:)

Style to use, can be used with a palette function

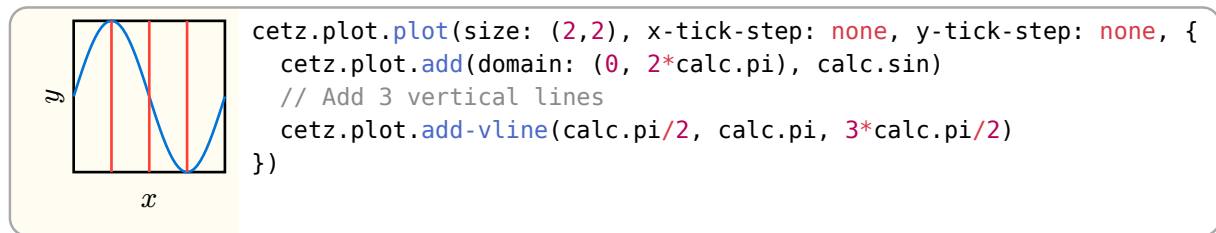
**label:** none or content

Default: none

Legend label to show for this plot.

### 5.2.7 add-vline

Add vertical lines at one or more x-values. Every lines start and end points are at their axis bounds.



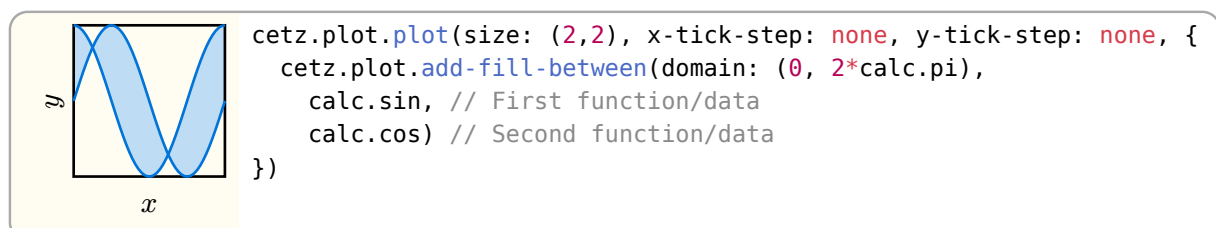
#### Parameters

<code>add-vline(</code>	
<code>..x: float,</code>	
<code>min: auto float,</code>	
<code>max: auto float,</code>	
<code>axes: array,</code>	
<code>style: style,</code>	
<code>label: none content</code>	
<code>)</code>	
<code>..x: float</code>	
X axis values to add a line at	
<b>min:</b> <code>auto</code> or <code>float</code>	Default: <code>auto</code>
Y axis minimum value or auto to take the axis minimum	
<b>max:</b> <code>auto</code> or <code>float</code>	Default: <code>auto</code>
Y axis maximum value or auto to take the axis maximum	
<b>axes:</b> <code>array</code>	Default: <code>("x", "y")</code>
Name of the axes to use for plotting, note that not all plot styles are able to display a custom axis!	
<b>style:</b> <code>style</code>	Default: <code>(:)</code>
Style to use, can be used with a palette function	
<b>label:</b> <code>none</code> or <code>content</code>	Default: <code>none</code>
Legend label to show for this plot.	

### 5.2.8 add-fill-between

Fill the area between two graphs. This behaves same as `add` but takes a pair of data instead of a single data array/function. The area between both function plots gets filled. For a more detailed explanation of the arguments, see `add()`.

This can be used to display an error-band of a function.





## Parameters

```
add-fill-between(
  data-a: array function,
  data-b: array function,
  domain: domain,
  samples: int,
  sample-at: array,
  line: string dictionary,
  axes: array,
  label: none content,
  style: style
)
```

**data-a:** array or function

Data of the first plot, see `add()`.

**data-b:** array or function

Data of the second plot, see `add()`.

**domain:** domain

Default: `auto`

Domain of both data-a and data-b. The domain is used for sampling functions only and has no effect on data arrays.

**samples:** int

Default: `50`

Number of times the data-a and data-b function gets called for sampling y-values. Only used if data-a or data-b is of type function.

**sample-at:** array

Default: `()`

Array of x-values the function(s) get sampled at in addition to the default sampling.

**line:** string or dictionary

Default: `"linear"`

Line type to use, see `add()`.

**axes:** array

Default: `("x", "y")`

Name of the axes to use for plotting.

**label:** none or content

Default: `none`

Legend label to show for this plot.

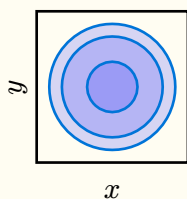
**style:** style

Default: `(:)`

Style to use, can be used with a palette function.

### 5.2.9 add-contour

Add a contour plot of a sampled function or a matrix.



```
cetz.plot.plot(size: (2,2), x-tick-step: none, y-tick-step: none, {
  cetz.plot.add-contour(x-domain: (-3, 3), y-domain: (-3, 3),
    style: (fill: rgb(50,50,250,50)),
    fill: true,
    op: "<", // Find contours where data < z
    z: (2.5, 2, 1), // Z values to find contours for
    (x, y) => calc.sqrt(x * x + y * y))
})
```

## Parameters

```
add-contour(
  data: array function,
  label: none content,
  z: float array,
  x-domain: domain,
  y-domain: domain,
  x-samples: int,
  y-samples: int,
  interpolate: bool,
  op: auto string function,
  axes: axes,
  style: style,
  fill: bool,
  limit: int
)
```

**data:** array or function

A function of the signature  $(x, y) \Rightarrow z$  or an array of arrays of floats (a matrix) where the first index is the row and the second index is the column.

**label:** none or content

Default: none

Plot legend label to show. The legend preview for contour plots is a little rectangle drawn with the contours style.

**z:** float or array

Default: (1,)

Z values to plot. Contours containing values above  $z$  ( $z \geq 0$ ) or below  $z$  ( $z < 0$ ) get plotted. If you specify multiple  $z$  values, they get plotted in the order of specification.

**x-domain:** domain

Default: (0, 1)

X axis domain used if data is a function, that is the domain inside the function gets sampled.

**y-domain:** domain

Default: (0, 1)

Y axis domain used if data is a function, see x-domain.

**x-samples:** int

Default: 25

X axis domain samples ( $2 < n$ ). Note that contour finding can be quite slow. Using a big sample count can improve accuracy but can also lead to bad compilation performance.

**y-samples:** int

Default: 25

Y axis domain samples ( $2 < n$ )

**interpolate:** bool

Default: true

Use linear interpolation between sample values which can improve the resulting plot, especially if the contours are curved.

**op:** auto or string or function

Default: auto

Z value comparison operator:

">", ">=", "<", "<=", "!=" , "==" Use the operator for comparison of  $z$  to the values from data.

**auto** Use ">=" for positive  $z$  values, "<=" for negative  $z$  values.

**function** Call comparison function of the format  $(\text{plot-}z, \text{data-}z) \Rightarrow \text{boolean}$ , where  $\text{plot-}z$  is the  $z$ -value from the plots  $z$  argument and  $\text{data-}z$  is the  $z$ -value of the data getting plotted. The function must return true if at the combinations of arguments a contour is detected.

**axes:** axes

Default: ("x", "y")

Name of the axes to use for plotting.

**style:** style

Default: ( : )

Style to use for plotting, can be used with a palette function. Note that all z-levels use the same style!

**fill:** bool

Default: false

Fill each contour

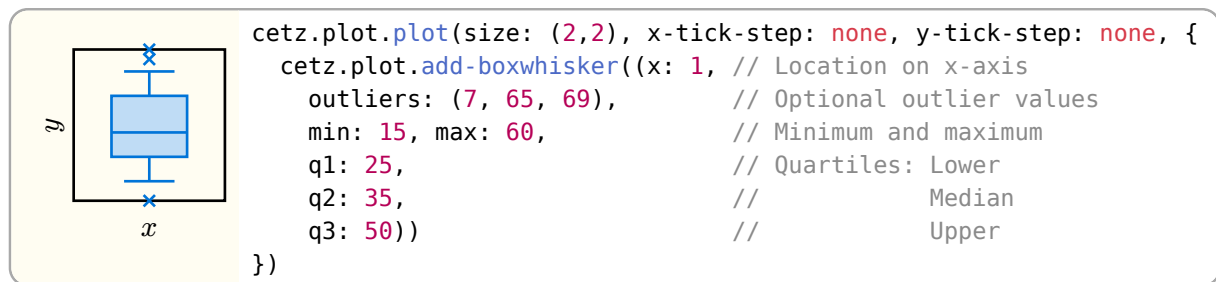
**limit:** int

Default: 50

Limit of contours to create per z value before the function panics

### 5.2.10 add-boxwhisker

Add one or more box or whisker plots



#### Parameters

```
add-boxwhisker(
    data: array dictionary,
    label: none content,
    axes: array,
    style: style,
    box-width: float,
    whisker-width: float,
    mark: string,
    mark-size: float
)
```

**data:** array or dictionary

dictionary or array of dictionaries containing the needed entries to plot box and whisker plot.

The following fields are supported:

- x (number) X-axis value
- min (number) Minimum value
- max (number) Maximum value
- q1, q2, q3 (number) Quartiles from lower to upper
- outliers (array of number) Optional outliers

**label:** none or content

Default: none

Legend label to show for this plot.

**axes:** array

Default: ("x", "y")

Name of the axes to use ("x", "y"), note that not all plot styles are able to display a custom axis!

**style:** style

Default: ( : )

Style to use, can be used with a palette function

**box-width:** float Default: 0.75

Width from edge-to-edge of the box of the box and whisker in plot units. Defaults to 0.75

**whisker-width:** float Default: 0.5

Width from edge-to-edge of the whisker of the box and whisker in plot units. Defaults to 0.5

**mark:** string Default: "\*"

Mark to use for plotting outliers. Set none to disable. Defaults to "x"

**mark-size:** float Default: 0.15

Size of marks for plotting outliers. Defaults to 0.15

### 5.2.11 add-bar

Add a bar- or column-chart to the plot

A bar- or column-chart is a chart where values are drawn as rectangular boxes.

#### Parameters

```
add-bar(
  data: array,
  mode: string,
  labels: none content array,
  bar-width: float,
  bar-position: string,
  style: dictionary,
  axes: axes
)
```

**data:** array

Array of data items. An item is an array containing a x an one or more y values. For example (0, 1) or (0, 10, 5, 30). Depending on the mode, the data items get drawn as either clustered or stacked rects.

**mode:** string Default: "basic"

The mode on how to group data items into bars:

**basic** Add one bar per data value. If the data contains multiple values, group those bars next to each other.

**clustered** Like "basic", but take into account the maximum number of values of all items and group each cluster of bars together having the width of the widest cluster.

**stacked** Stack bars of subsequent item values onto the previous bar, generating bars with the height of the sum of all an items values.

**stacked100** Like "stacked", but scale each bar to height 100, making the different bars percentages of the sum of an items values.

**labels:** none or content or array Default: none

A single legend label for "basic" bar-charts, or a list of legend labels per bar category, if the mode is one of "clustered", "stacked" or "stacked100".

**bar-width:** float Default: 1

Width of one data item on the y axis

**bar-position:** string Default: "center"

Positioning of data items relative to their x value.

- "start": The lower edge of the data item is on the x value (left aligned)

- “center”: The data item is centered on the x value
- “end”: The upper edge of the data item is on the x value (right aligned)

**style:** dictionaryDefault: `(:)`

Plot style

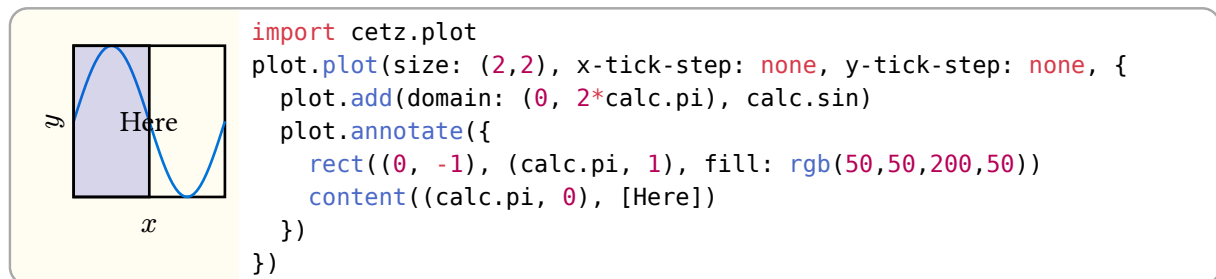
**axes:** axesDefault: `("x", "y")`

Plot axes. To draw a horizontal growing bar chart, you can swap the x and y axes.

### 5.2.12 annotate

Add an annotation to the plot

An annotation is a sub-canvas that uses the plots coordinates specified by its x and y axis.



Bounds calculation is done naively, therefore fixed size content *can* grow out of the plot. You can adjust the padding manually to adjust for that. The feature of solving the correct bounds for fixed size elements might be added in the future.

### Parameters

```
annotate(
  body: drawable,
  axes: axes,
  resize: bool,
  padding: none number dictionary,
  background: bool
)
```

**body:** drawable

Elements to draw

**axes:** axesDefault: `("x", "y")`

X and Y axis names

**resize:** boolDefault: `true`

If true, the plots axes get adjusted to contain the annotation

**padding:** none or number or dictionaryDefault: `none`

Annotation padding that is used for axis adjustment

**background:** boolDefault: `false`

If true, the annotation is drawn behind all plots, in the background. If false, the annotation is drawn above all plots.

### 5.2.13 sample-fn

Sample the given single parameter function `samples` times, with values evenly spaced within the range given by domain and return each sampled y value in an array as (x, y) tuple.

If the functions first return value is a tuple  $(x, y)$ , then all return values must be a tuple.

### Parameters

```
sample-fn(
  fn: function,
  domain: domain,
  samples: int,
  sample-at: array
) -> array: Array of (x y) tuples
```

#### fn: function

Function to sample of the form  $(x) \Rightarrow y$  or  $(t) \Rightarrow (x, y)$ , where  $x$  or  $t$  are float values within the domain specified by domain.

#### domain: domain

Domain of fn used as bounding interval for the sampling points.

#### samples: int

Number of samples in domain.

#### sample-at: array

Default: ()

List of  $x$  values the function gets sampled at in addition to the samples number of samples. Values outside the specified domain are legal.

### 5.2.14 sample-fn2

Samples the given two parameter function with  $x$ -samples and  $y$ -samples values evenly spaced within the range given by  $x$ -domain and  $y$ -domain and returns each sampled output in an array.

### Parameters

```
sample-fn2(
  fn: function,
  x-domain: domain,
  y-domain: domain,
  x-samples: int,
  y-samples: int
) -> array: Array of z scalars
```

#### fn: function

Function of the form  $(x, y) \Rightarrow z$  with all values being numbers.

#### x-domain: domain

Domain used as bounding interval for sampling point's  $x$  values.

#### y-domain: domain

Domain used as bounding interval for sampling point's  $y$  values.

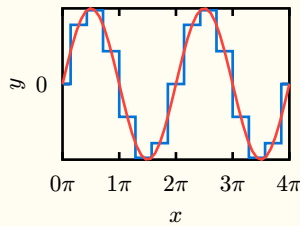
#### x-samples: int

Number of samples in the  $x$ -domain.

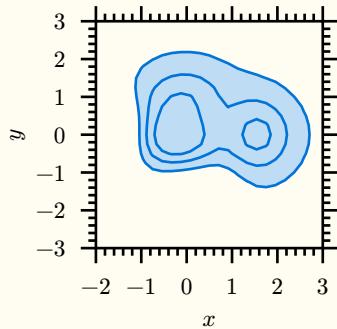
#### y-samples: int

Number of samples in the  $y$ -domain.

### 5.2.15 Examples



```
import cetz.plot
plot.plot(size: (3,2), x-tick-step: calc.pi, y-tick-step: 1,
          x-format: v => ${v/calc.pi} pi$, {
  plot.add(domain: (0, 4*calc.pi), calc.sin,
    samples: 15, line: "hvh", style: (mark: (stroke: blue)))
  plot.add(domain: (0, 4*calc.pi), calc.sin)
})
```



```
import cetz.plot
import cetz.palette

// Let ticks point outwards by giving them negative length
set-style(axes: (tick: (length: -.2, minor-length: -.1)))

// Plot something
plot.plot(size: (3,3), x-tick-step: 1, x-minor-tick-step: .2,
          y-tick-step: 1, y-minor-tick-step: .2, {
  let z(x, y) = {
    (1 - x/2 + calc.pow(x,5) + calc.pow(y,3)) * calc.exp(-(x*x) - (y*y))
  }
  plot.add-contour(x-domain: (-2, 3), y-domain: (-3, 3),
    z, z: (.1, .4, .7), fill: true)
})
```

### 5.2.16 Styling

The following style keys can be used (in addition to the standard keys) to style plot axes. Individual axes can be styled differently by using their axis name as key below the axes root.

```
set-style(axes: ( /* Style for all axes */ ))
set-style(axes: (bottom: ( /* Style axis "bottom" */ )))
```

Axis names to be used for styling:

- School-Book and Left style:
  - x: X-Axis
  - y: Y-Axis
- Scientific style:
  - left: Y-Axis
  - right: Y2-Axis
  - bottom: X-Axis
  - top: X2-Axis

### Default scientific Style

```
(
  tick-limit: 100,
  minor-tick-limit: 1000,
  auto-tick-factors: (1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10),
  auto-tick-count: 11,
  fill: none,
  stroke: luma(0%),
  label: (offset: 5.67pt, anchor: auto),
  tick: (
    fill: none,
    stroke: luma(0%),
    length: 2.83pt,
    minor-length: 80%,
    label: (offset: 5.67pt, angle: 0deg, anchor: auto),
  ),
)
```

```

    grid: (stroke: (paint: luma(83.33%), thickness: 1pt)),
    minor-grid: (stroke: (paint: luma(83.33%), thickness: 0.5pt)),
)

```

### Default school-book Style

```

(
  tick-limit: 100,
  minor-tick-limit: 1000,
  auto-tick-factors: (1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10),
  auto-tick-count: 11,
  fill: none,
  stroke: luma(0%),
  label: (offset: 5.67pt, anchor: auto),
  tick: (
    fill: none,
    stroke: luma(0%),
    length: 2.83pt,
    minor-length: 80%,
    label: (offset: 2.83pt, angle: 0deg, anchor: auto),
  ),
  grid: (stroke: (paint: luma(83.33%), thickness: 1pt)),
  minor-grid: (stroke: (paint: luma(83.33%), thickness: 0.5pt)),
  x: (stroke: auto, fill: none, mark: (end: "straight")),
  y: (stroke: auto, fill: none, mark: (end: "straight")),
  origin: (label: (offset: 1.42pt)),
  padding: 11.34pt,
)

```

## 5.3 Chart

With the chart library it is easy to draw charts.

### 5.3.1 barchart

Draw a bar chart. A bar chart is a chart that represents data with rectangular bars that grow from left to right, proportional to the values they represent. For examples see Section 5.3.5.

#### Styling

**Root:** barchart.

**bar-width:** float

Default: 0.8

Width of a single bar (basic) or a cluster of bars (clustered) in the plot.

**y-inset:** float

Default: 1

Distance of the plot data to the plot's edges on the y-axis of the plot.

You can use any plot or axes related style keys, too.

The barchart function is a wrapper of the plot API. Arguments passed to `..plot-args` are passed to the `plot.plot` function.



## Parameters

```
barchart(
  data: array,
  label-key: int string,
  value-key: int string,
  mode: string,
  size: array,
  bar-style: style function,
  x-label: content none,
  x-unit: content auto,
  y-label: content none,
  labels: none content,
  ..plot-args: any
)
```

**data:** array

Array of data rows. A row can be of type array or dictionary, with `label-key` and `value-key` being the keys to access a rows label and value(s).

### Example

```
(([A], 1), ([B], 2), ([C], 3),)
```

**label-key:** int or string Default: 0

Key to access the label of a data row. This key is used as argument to the rows `.at( . )` function.

**value-key:** int or string Default: 1

Key(s) to access value(s) of data row. These keys are used as argument to the rows `.at( . )` function.

**mode:** string Default: "basic"

Chart mode:

**basic** Single bar per data row

**clustered** Group of bars per data row

**stacked** Stacked bars per data row

**stacked100** Stacked bars per data row relative to the sum of the row

**size:** array Default: (auto, 1)

Chart size as width and height tuple in canvas unist; width can be set to auto.

**bar-style:** style or function Default: palette.red

Style or function (`idx => style`) to use for each bar, accepts a palette function.

**x-label:** content or none Default: none

x axis label

**x-unit:** content or auto Default: auto

Tick suffix added to each tick label

**y-label:** content or none Default: none

Y axis label

**labels:** none or content Default: none

Legend labels per x value group

**..plot-args:** any

Arguments to pass to `plot.plot`

### 5.3.2 columnchart

Draw a column chart. A column chart is a chart that represents data with rectangular bars that grow from bottom to top, proportional to the values they represent. For examples see Section 5.3.6.

#### Styling

**Root:** `columnchart`.

**bar-width:** `float`

Default: `0.8`

Width of a single bar (basic) or a cluster of bars (clustered) in the plot.

**x-inset:** `float`

Default: `1`

Distance of the plot data to the plot's edges on the x-axis of the plot.

You can use any plot or axes related style keys, too.

The `columnchart` function is a wrapper of the `plot` API. Arguments passed to `..plot-args` are passed to the `plot.plot` function.

#### Parameters

```
columnchart(
  data: array,
  label-key: int string,
  value-key: int string,
  mode: string,
  size: array,
  bar-style: style function,
  x-label: content none,
  y-unit: content auto,
  y-label: content none,
  labels: none content,
  ..plot-args: any
)
```

**data:** `array`

Array of data rows. A row can be of type array or dictionary, with `label-key` and `value-key` being the keys to access a row's label and value(s).

#### Example

```
(([A], 1), ([B], 2), ([C], 3),)
```

**label-key:** `int` or `string`

Default: `0`

Key to access the label of a data row. This key is used as argument to the rows `.at(..)` function.

**value-key:** `int` or `string`

Default: `1`

Key(s) to access value(s) of data row. These keys are used as argument to the rows `.at(..)` function.

**mode:** `string`

Default: `"basic"`

Chart mode:

**basic** Single bar per data row

**clustered** Group of bars per data row

**stacked** Stacked bars per data row

**stacked100** Stacked bars per data row relative to the sum of the row

**size:** `array`

Default: `(auto, 1)`

Chart size as width and height tuple in canvas unist; width can be set to auto.

**bar-style:** `style` or `function` Default: `palette.red`

Style or function (`idx => style`) to use for each bar, accepts a palette function.

**x-label:** `content` or `none` Default: `none`

x axis label

**y-unit:** `content` or `auto` Default: `auto`

Tick suffix added to each tick label

**y-label:** `content` or `none` Default: `none`

Y axis label

**labels:** `none` or `content` Default: `none`

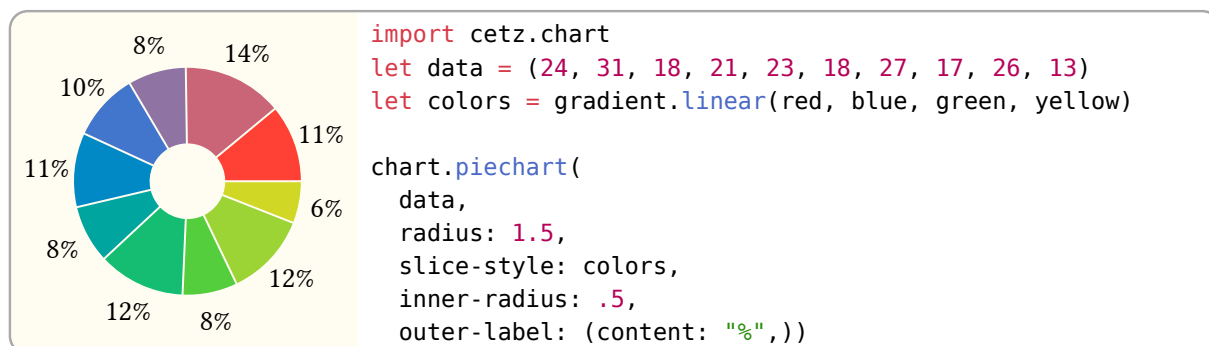
Legend labels per y value group

**..plot-args:** `any`

Arguments to pass to `plot.plot`

### 5.3.3 piechart

Draw a pie- or donut-chart



### Styling

#### Root piechart

**radius:** `number` Default: `1`

Outer radius of the chart.

**inner-radius:** `number` Default: `0`

Inner radius of the chart slices. If greater than zero, the chart becomes a “donut-chart”.

**gap:** `number` or `angle` Default: `0.5deg`

Gap between chart slices to leave empty. This does not increase the charts radius by pushing slices outwards, but instead shrinks the slice. Big values can result in slices becoming invisible if no space is left.

**outset-offset:** `number` or `ratio` Default: `10%`

Absolute, or radius relative distance to push slices marked for “outsetting” outwards from the center of the chart.

**outset-offset:** `string` Default: `"OFFSET"`

The mode of how to perform “outsetting” of slices:

- “OFFSET”: Offset slice position by `outset-offset`, increasing their gap to their siblings
- “RADIUS”: Offset slice radius by `outset-offset`, which scales the slice and leaves the gap unchanged

**start:** `angle` Default: `0deg`

The pie-charts start angle. You can use this to draw charts not forming a full circle.

**stop:** `angle` Default: `360deg`

The pie-charts stop angle.

**outer-label.content:** `none` or `string` or `function` Default: `"LABEL"`

Content to display outside the charts slices. There are the following predefined values:

**LABEL** Display the slices label (see `label-key`)

**%** Display the percentage of the items value in relation to the sum of all values, rounded to the next integer

**VALUE** Display the slices value

If passed a `function` of the format `(value, label) => content`, that function gets called with each slices value and label and must return content, that gets displayed.

**outer-label.radius:** `number` or `ratio` Default: `125%`

Absolute, or radius relative distance from the charts center to position outer labels at.

**outer-label.angle:** `angle` or `auto` Default: `0deg`

The angle of the outer label. If passed `auto`, the label gets rotated, so that the baseline is parallel to the slices secant.

**outer-label.anchor:** `string` Default: `"center"`

The anchor of the outer label to use for positioning.

**inner-label.content:** `none` or `string` or `function` Default: `none`

Content to display inside the charts slices. See `outer-label.content` for the possible values.

**inner-label.radius:** `number` or `ratio` Default: `150%`

Distance of the inner label to the charts center. If passed a `ratio`, that ratio is relative to the mid between the inner and outer radius (`inner-radius` and `radius`) of the chart

**inner-label.angle:** `angle` or `auto` Default: `0deg`

See `outer-label.angle`.

**inner-label.anchor:** `string` Default: `"center"`

See `outer-label.anchor`.

## Anchors

The chart places one anchor per item at the radius of its slice that gets named `"item-<index>"` (outer radius) and `"item-<index>-inner"` (inner radius), where `index` is the index of the slice data in `data`.

## Parameters

```
piechart(
  data: array,
  value-key: none int string,
  label-key: none int string,
  outset-key: none int string,
  outset: none int array,
  slice-style: function array gradient,
  name,
  ..style
)
```

**data:** array

Array of data items. A data item can be:

- A number: A number that is used as the fraction of the slice
- An array: An array which is read depending on value-key, label-key and outset-key
- A dictionary: A dictionary which is read depending on value-key, label-key and outset-key

**value-key:** none or int or string Default: none

Key of the “value” of a data item. If for example data items are passed as dictionaries, the value-key is the key of the dictionary to access the items chart value.

**label-key:** none or int or string Default: none

Same as the value-key but for getting an items label content.

**outset-key:** none or int or string Default: none

Same as the value-key but for getting if an item should get outset (highlighted). The outset can be a bool, float or ratio. If of type bool, the outset distance from the style gets used.

**outset:** none or int or array Default: none

A single or multiple indices of items that should get offset from the center to the outsides of the chart. Only used if outset-key is none!

**slice-style:** function or array or gradient Default: palette.red

Slice style of the following types:

- function: A function of the form `index => style` that must return a style dictionary. This can be a palette function.
- array: An array of style dictionaries or fill colors of at least one item. For each slice the style at the slices index modulo the arrays length gets used.
- gradient: A gradient that gets sampled for each data item using the the slices index divided by the number of slices as position on the gradient.

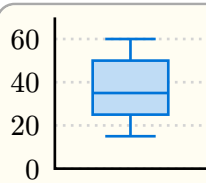
If one of stroke or fill is not in the style dictionary, it is taken from the charts style.

**name:** Default: none

**..style:**

### 5.3.4 boxwhisker

Add one or more box or whisker plots.



```
cetz.chart.boxwhisker(size: (2,2), label-key: none,
  y-min: 0, y-max: 70, y-tick-step: 20,
  (x: 1, min: 15, max: 60,
    q1: 25, q2: 35, q3: 50))
```

## Styling

### Root boxwhisker

**box-width:** float

Default: 0.75

The width of the box. Since boxes are placed 1 unit next to each other, a width of 1 would make neighbouring boxes touch.

**whisker-width:** float

Default: 0.5

The width of the whisker, that is the horizontal bar on the top and bottom of the box.

**mark-size:** float

Default: 0.15

The scaling of the mark for the boxes outlier values in canvas units.

You can use any plot or axes related style keys, too.

## Parameters

```
boxwhisker(
  data: array dictionary,
  size,
  label-key: integer string,
  mark: string,
  ..plot-args: any
)
```

**data:** array or dictionary

Dictionary or array of dictionaries containing the needed entries to plot box and whisker plot.

See plot.add-boxwhisker for more details.

## Examples:

- ```
(x: 1 // Location on x-axis
 outliers: (7, 65, 69), // Optional outliers
 min: 15, max: 60 // Minimum and maximum
 q1: 25, // Quartiles: Lower
 q2: 35, // Median
 q3: 50) // Upper
```
- size (array) : Size of chart. If the second entry is auto, it automatically scales to accommodate the number of entries plotted

**size:**

Default: (1, auto)

**label-key:** integer or string

Default: 0

Index in the array where labels of each entry is stored

**mark:** string

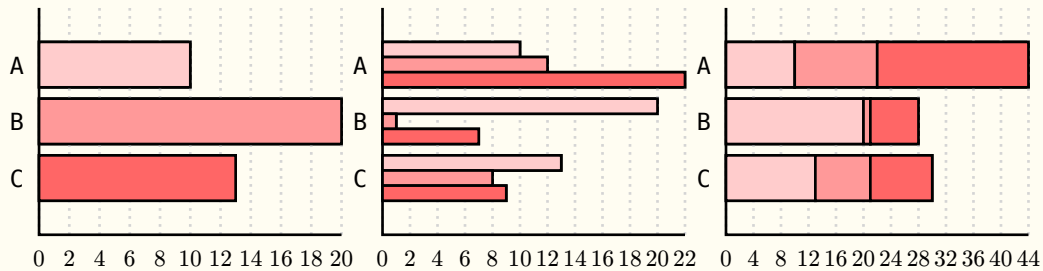
Default: "x"

Mark to use for plotting outliers. Set none to disable. Defaults to "x"

**..plot-args:** any

Additional arguments are passed to `plot.plot`

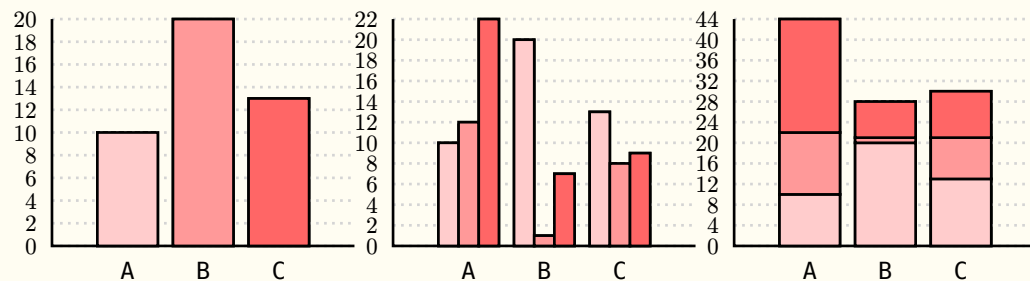
### 5.3.5 Examples – Bar Chart



```
import cetz.chart
// Left - Basic
let data = (("A", 10), ("B", 20), ("C", 13))
group(name: "a", {
  chart.barchart(size: (4, 3), data)
})
// Center - Clustered
let data = (("A", 10, 12, 22), ("B", 20, 1, 7), ("C", 13, 8, 9))
group(name: "b", anchor: "south-west", {
  anchor("center", "a.south-east")
  chart.barchart(size: (4, 3), mode: "clustered", value-key: (1,2,3), data)
})
// Right - Stacked
let data = (("A", 10, 12, 22), ("B", 20, 1, 7), ("C", 13, 8, 9))
group(name: "c", anchor: "south-west", {
  anchor("center", "b.south-east")
  chart.barchart(size: (4, 3), mode: "stacked", value-key: (1,2,3), data)
})
```

### 5.3.6 Examples – Column Chart

#### Basic, Clustered and Stacked



```
import cetz.chart
// Left - Basic
let data = (("A", 10), ("B", 20), ("C", 13))
group(name: "a", {
  chart.columnchart(size: (4, 3), data)
})
// Center - Clustered
let data = (("A", 10, 12, 22), ("B", 20, 1, 7), ("C", 13, 8, 9))
group(name: "b", anchor: "south-west", {
  anchor("center", "a.south-east")
  chart.columnchart(size: (4, 3), mode: "clustered", value-key: (1,2,3), data)
})
// Right - Stacked
let data = (("A", 10, 12, 22), ("B", 20, 1, 7), ("C", 13, 8, 9))
group(name: "c", anchor: "south-west", {
  anchor("center", "b.south-east")
  chart.columnchart(size: (4, 3), mode: "stacked", value-key: (1,2,3), data)
})
```

### 5.3.7 Styling

Charts share their axis system with plots and therefore can be styled the same way, see Section 5.2.16.

#### Default barchart Style

```
(
  axes: (
    tick: (length: 0),
    grid: (stroke: (dash: "dotted")),
  ),
  bar-width: 0.8,
  y-inset: 1,
)
```

#### Default columnchart Style

```
(
  axes: (
    tick: (length: 0),
    grid: (stroke: (dash: "dotted")),
  ),
  bar-width: 0.8,
  x-inset: 1,
)
```

#### Default boxwhisker Style

```
(
  axes: (
    tick: (length: 0),
    grid: (stroke: (dash: "dotted")),
  ),
  box-width: 0.75,
  whisker-width: 0.5,
  mark-size: 0.15,
)
```

#### Default piechart Style

```
(
  stroke: auto,
  fill: auto,
  radius: 1,
  inner-radius: 0,
  gap: 0.5deg,
  outset-offset: 10%,
  outset-mode: "OFFSET",
  start: 0deg,
  stop: 360deg,
  outer-label: (
    content: "LABEL",
    radius: 125%,
    angle: 0deg,
    anchor: "center",
  ),
  inner-label: (
    content: none,
    radius: 150%,
    angle: 0deg,
    anchor: "center",
  )
)
```



```
),
)
```

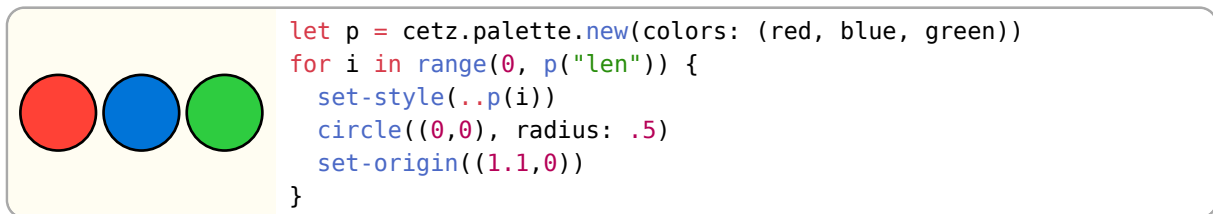
## 5.4 Palette

A palette is a function of the form `index => style` that takes an index, that can be any integer and returns a canvas style dictionary. If passed the string `"len"` it must return the length of its unique styles. An example use for palette functions is the plot library, which can use palettes to apply different styles per plot.

The palette library provides some predefined palettes.

### 5.4.1 new

Create a new palette based on a base style



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

**fill:** bool Default: **true**

If true, the returned fill color is one of the colors from the `colors` list, otherwise the base styles fill is used.

**stroke:** bool Default: **false**

If true, the returned stroke color is one of the colors from the `colors` list, otherwise the base styles stroke color is used.

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

### Parameters

```
new(
  base: style,
  colors: none array,
  dash: none array
)-> function Palette function of the form `index => style` that returns a style for an integer index
```

**base:** style Default: **base-style**

Style dictionary to use as base style for the styles generated per color

**colors:** none or array Default: **()**







List of colors the returned palette should return styles with

**dash:** none or array Default: **()**

List of stroke dash patterns the returned palette should return styles with

### 5.4.2 List of predefined palettes

- gray
- turquoise
- red
- cyan
- orange
- blue
- light-green
- indigo
- dark-green
- purple

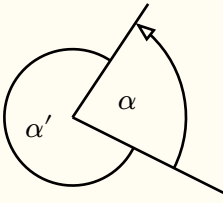
- magenta 
- pink 
- rainbow 
- tango-light 
- tango 
- tango-dark 

## 5.5 Angle

The angle function of the angle module allows drawing angles with an optional label.

### 5.5.1 angle

Draw an angle between a and b through origin origin



```

line((0,0), (1,1.5), name: "a")
line((0,0), (2,-1), name: "b")

// Draw an angle between the two lines
cetz.angle.angle("a.start", "a.end", "b.end", label: $ alpha $,
  mark: (end: ">"), radius: 1.5)
cetz.angle.angle("a.start", "b.end", "a.end", label: $ alpha' $,
  radius: 50%, inner: false)

```

**Style Root:** angle

**Style Keys:**

**radius:** number

Default: 0.5

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 or ratio

Default: 50%

The radius of the angles label origin. If of type ratio, it is relative to radius.

**Aliases**

"a" Point a

"b" Point b

"origin" Origin

"label" Label center

"start" Arc start

"end" Arc end

**Parameters**

```

angle(
  origin: coordinate,
  a: coordinate,
  b: coordinate,
  inner: bool,
  label: none content function,
  name: none string,
  ..style: style
)

```

**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.

**inner:** bool

Default: **true**

Draw the smaller (inner) angle if true, otherwise the outer angle gets drawn.

**label:** none or content or function

Default: **none**

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 or string

Default: **none**

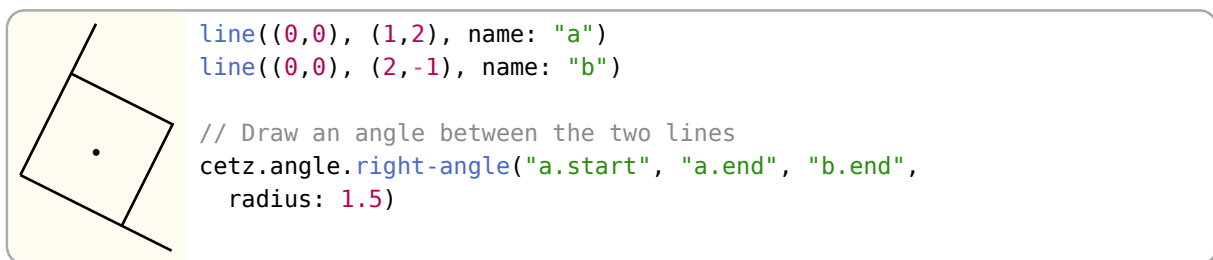
Element name, used for querying anchors.

**..style:** style

Style key-value pairs.

### 5.5.2 right-angle

Draw a right angle between a and b through origin origin



**Style Root:** angle

**Style Keys:**

**radius:** number

Default: **0.5**

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 or ratio

Default: **50%**

The radius of the angles label origin. If of type ratio, it is relative to the distance between origin and the angle corner.

**Aliases**

**"a"** Point a

**"b"** Point b

**"origin"** Origin

**"corner"** Angle corner

**"label"** Label center

## Parameters

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

**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 or content

Default: "."

Draw a label at the angles "label" anchor.

**name:** none or string

Default: none

Element name, used for querying anchors.

**..style:** style

Style key-value pairs.

## Default angle Style

```
(
  fill: none,
  stroke: auto,
  radius: 0.5,
  label-radius: 50%,
  mark: auto,
)
```




## 5.6 Decorations

Various pre-made shapes and path modifications.

### 5.6.1 Braces

#### 5.6.2 brace

Draw a curly brace between two points.

|                                                                                     |                                                                                                    |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
|  | <code>cetz.decorations.brace((0,1),(2,1))</code>                                                   |
|  | <code>cetz.decorations.brace((0,0),(2,0),<br/>pointiness: 45deg, outer-pointiness: 45deg)</code>   |
|  | <code>cetz.decorations.brace((0,-1),(2,-1),<br/>pointiness: 90deg, outer-pointiness: 90deg)</code> |

**Style Root:** brace.

**Style Keys:**

**amplitude:** number

Default: 0.5

Sets the height of the brace, from its baseline to its middle tip.

**pointiness:** `ratio` or `angle` Default: `15deg`

How pointy the spike should be. `0deg` or `0%` for maximum pointiness, `90deg` or `100%` for minimum.

**outer-pointiness:** `ratio` or `angle` Default: `15deg`

How pointy the outer edges should be. `0deg` or `0` for maximum pointiness (allowing for a smooth transition to a straight line), `90deg` or `1` for minimum. Setting this to `auto` will use the value set for pointiness.

**content-offset:** `number` or `length` Default: `0.3`

Offset of the "content" anchor from the spike of the brace.

#### 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

```
brace(
  start: coordinate,
  end: coordinate,
  flip: bool,
  debug,
  name: string or none,
  ..style: style
)
```

**start:** `coordinate`

Start point

**end:** `coordinate`

End point

**flip:** `bool`

Default: `false`

Flip the brace around

**debug:**

Default: `false`

**name:** `string` or `none`

Default: `none`

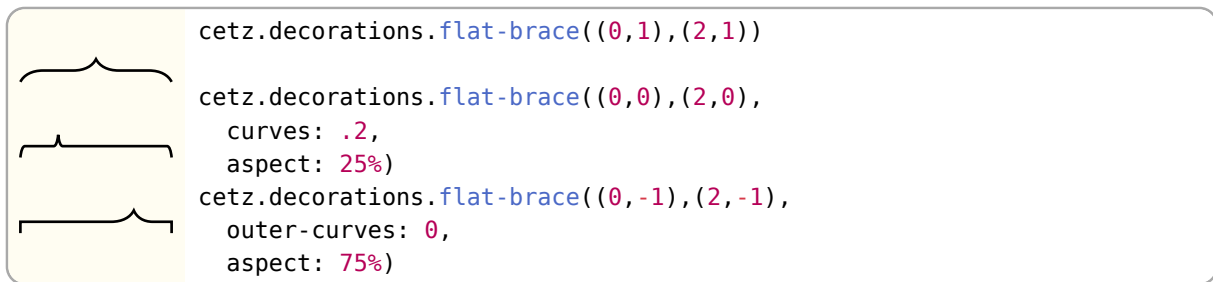
Element name used for querying anchors

**..style:** `style`

Style key-value pairs

#### 5.6.3 flat-brace

Draw a flat curly brace between two points.



This mimics the braces from TikZ's `decorations.pathreplacing` library<sup>1</sup>. In contrast to `brace()`, these braces use straight line segments, resulting in better looks for long braces with a small amplitude.

**Style Root:** `flat-brace`

**Style Keys:**

**amplitude:** `number` Default: `0.3`

Determines how much the brace rises above the base line.

**aspect:** `ratio` Default: `50%`

Determines the fraction of the total length where the spike will be placed.

**curves:** `number` Default: `auto`

Curviness factor of the brace, a factor of 0 means no curves.

**outer-curves:** `auto` or `number` Default: `auto`

Curviness factor of the outer curves of the brace. A factor of 0 means no curves.

**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**

```

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

```

**start:** `coordinate`

Start point

**end:** `coordinate`

End point

**flip:** `bool` Default: `false`

Flip the brace around

<sup>1</sup><https://github.com/pgf-tikz/pgf/blob/6e5fd71581ab04351a89553a259b57988bc28140/tex/generic/pgf/libraries/decorations/pgflibrarydecorations.pathreplacing.code.tex#L136-L185>

**debug:** Default: `false`

**name:** `string` or `none` Default: `none`

Element name for querying anchors

**..style:** `style`

Style key-value pairs

#### 5.6.4 Path Decorations

Path decorations are elements that accept a path as input and generate one or more shapes that follow that path.

All path decoration functions support the following style keys:

**start** `ratio` or `length` (default: `0%`)

Absolute or relative start of the decoration on the path.

**stop** `ratio` or `length` (default: `100%`)

Absolute or relative end of the decoration on the path.

**rest** `string` (default: `LINE`)

If set to "LINE", generate lines between the paths start/end and the decorations start/end if the path is *not closed*.

**width** `number` (default: `1`)

Width or thickness of the decoration.

**segments** `int` (default: `10`)

Number of repetitions/phases to generate. This key is ignored if `segment-length` is set `!= none`.

**segment-length** `none` or `number`

Length of one repetition/phase of the decoration.

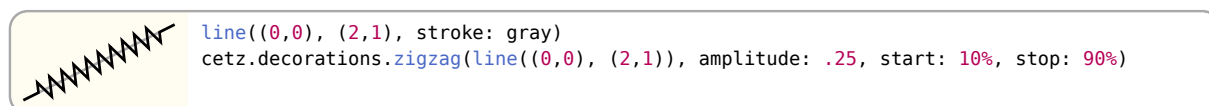
**align** `"START"`, `"MID"`, `"END"` (default: `START`)

Alignment of the decoration on the path *if segment-length is set* and the decoration does not fill up the full range between start and stop.

#### 5.6.5 zigzag

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`

#### Keys

**factor:** `ratio` Default: `100%`

Triangle mid between its start and end. Setting this to `0%` leads to a falling sawtooth shape, while `100%` results in a raising sawtooth

## Parameters

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

**target:** drawable

Target path

**name:** none or string

Default: none

Element name

**close:** auto or bool

Default: auto

Close the path

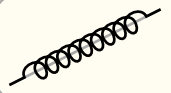
**..style:** style

Style

### 5.6.6 coil

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.



```
line((0,0), (2,1), stroke: gray)
cetz.decorations.coil(line((0,0), (2,1)), amplitude: .25, start: 10%, stop: 90%)
```

## Styling

**Root** coil

## Keys

**factor:** ratio

Default: 150%

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

## Parameters

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

**target:** drawable

Target path

**close:** auto or bool

Default: auto

Close the path

**name:** none or string

Default: none



Element name

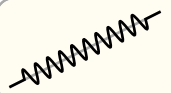
**..style:** style

Style

### 5.6.7 wave

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.



```
line((0,0), (2,1), stroke: gray)
cetz.decorations.wave(line((0,0), (2,1)), amplitude: .25, start: 10%, stop: 90%)
```

### Styling

**Root** wave

### Keys

**tension:** float

Default: 0.5

Catmull-Rom curve tension, see `catmull()`.

### Parameters

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

**target:** drawable

Target path

**close:** auto or bool

Default: auto

Close the path

**name:** none or string

Default: none

Element name

**..style:** style

Style

### Styling

### Default brace Style

```
(
  amplitude: 0.5,
  pointiness: 15deg,
  outer-pointiness: 0deg,
  content-offset: 0.3,
  debug-text-size: 6pt,
)
```

### Default flat-brace Style

```
(
  amplitude: 0.3,
  aspect: 50%,
  curves: (1, 0.5, 0.6, 0.15),
  outer-curves: auto,
  content-offset: 0.3,
  debug-text-size: 6pt,
)
```

## 6 Advanced Functions

### 6.1 Coordinate

#### 6.1.1 resolve

Resolve a list of coordinates to absolute vectors

(1, 1, 0)  
(0, 0, 0)

```
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

```
resolve(
  ctx: context,
  ..coordinates: coordinate,
  update: bool
)-> (ctx vector..) Returns a list of the new context object plus the
```

**ctx:** context

Canvas context object

**..coordinates:** coordinate

List of coordinates

**update:** bool

Default: true

Update the context's last position resolved coordinate vectors

### 6.2 Styles

#### 6.2.1 resolve

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")
)
#styles.resolve(dict, merge: (mark: (stroke: "yellow")), root: "line")
(
  stroke: "black",
  mark: (stroke: "yellow", fill: "blue"),
  fill: "red",
)

```

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: 1pt + luma(0%),
  fill: none,
  slant: none,
  harpoon: false,
  flip: false,
  reverse: false,
  flex: true,
  position-samples: 30,
  shorten-to: auto,
)

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

```

## Parameters

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

**dict:** style

Current context style (ctx.style).

**root:** none or str

Default: none

Style root element name.

**merge:** style

Default: ( : )

Style values overwriting the current style. I.e. inline styles passed with an element: `line( ..., stroke: red)`.

**base:** none or style

Default: ( : )

Style values to merge into dict without overwriting it.

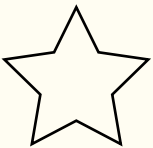
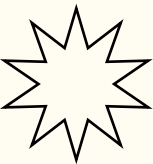
### 6.2.2 Default Style

This is a dump of the style dictionary every canvas gets initialized with. It contains all supported keys for all elements.

```
(
  fill: none,
  stroke: 1pt + luma(0%),
  radius: 1,
  shorten: "LINEAR",
  padding: none,
  mark: (
    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: auto,
    fill: auto,
    slant: none,
    harpoon: false,
    flip: false,
    reverse: false,
    flex: true,
    position-samples: 30,
    shorten-to: auto,
  ),
  circle: (radius: auto, stroke: auto, fill: auto),
  group: (padding: auto, fill: auto, stroke: auto),
  line: (mark: auto, fill: auto, stroke: auto),
  bezier: (
    stroke: auto,
    fill: auto,
    mark: auto,
    shorten: auto,
  ),
  catmull: (
    tension: 0.5,
    mark: auto,
    shorten: auto,
    stroke: auto,
    fill: auto,
  ),
  hobby: (
    omega: (1, 1),
    mark: auto,
    shorten: auto,
    stroke: auto,
    fill: auto,
  ),
  rect: (radius: 0, stroke: auto, fill: auto),
  arc: (
    mode: "OPEN",
    update-position: true,
    mark: auto,
    stroke: auto,
    fill: auto,
    radius: auto,
  ),
  content: (
    padding: auto,
    frame: none,
    fill: auto,
    stroke: auto,
  ),
)
```

## 7 Creating Custom Elements

The simplest way to create custom, reusable elements is to return them as a group. In this example we will implement a function `my-star(center)` that draws a star with `n` corners and a style specified inner and outer radius.



```
let my-star(center, name: none, ..style) = {
  group(name: name, ctx => {
    // Define a default style
    let def-style = (n: 5, inner-radius: .5, radius: 1)

    // Resolve the current style ("star")
    let style = cetz.styles.resolve(ctx.style, merge: style.named(),
      base: def-style, root: "star")

    // Compute the corner coordinates
    let corners = range(0, style.n * 2).map(i => {
      let a = 90deg + i * 360deg / (style.n * 2)
      let r = if calc.rem(i, 2) == 0 { style.radius } else { style.inner-radius }

      // Output a center relative coordinate
      (rel: (calc.cos(a) * r, calc.sin(a) * r, 0), to: center)
    })

    line(..corners, ..style, close: true)
  })
}

// Call the element
my-star((0,0))
my-star((0,3), n: 10)

set-style(star: (fill: yellow)) // set-style works, too!
my-star((0,6), inner-radius: .3)
```

## 8 Internals

### 8.1 Context

The state of the canvas is encoded in its context dictionary. Elements or other draw calls may return a modified context to the canvas to change its state, e.g. modifying the transforming matrix, adding a group or setting a style.

The context can be manually retrieved and modified using the `get-ctx` and `set-ctx` functions.

### 8.2 Elements

Each CeTZ element (`line`, `bezier`, `circle`, ...) returns an array of functions for drawing to the canvas. Such function takes the canvas' context and must return an dictionary of the following keys:

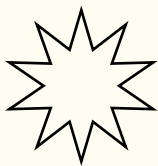
- `ctx` (required): The (modified) canvas context object
- `drawables`: List of drawables to render to the canvas
- `anchors`: A function of the form (`<anchor-identifier>`) => `<vector>`
- `name`: The elements name

An element that does only modify the context could be implemented like the following:

```
let my-element() = {
  (ctx => {
    // Do something with ctx ...
    (ctx: ctx)
  },)
}

// Call the element
my-element()
```

For drawing, elements must not use Typst native drawing functions, but output CeTZ paths. The `drawable` module provides functions for path creation (`path(...)`), the `path-util` module provides utilities for path segment creation. For demonstration, we will recreate the custom element `my-star` from Section 7:



```
import cetz.drawables: path
import cetz.vectors

let my-star(center, ..style) = {
  (ctx => {
    // Define a default style
    let def-style = (n: 5, inner-radius: .5, radius: 1, stroke: auto, fill: auto)

    // Resolve center to a vector
    let (ctx, center) = cetz.coordinate.resolve(ctx, center)

    // Resolve the current style ("star")
    let style = cetz.styles.resolve(ctx.style, merge: style.named(),
      base: def-style, root: "star")

    // Compute the corner coordinates
    let corners = range(0, style.n * 2).map(i => {
      let a = 90deg + i * 360deg / (style.n * 2)
      let r = if calc.rem(i, 2) == 0 { style.radius } else { style.inner-radius }
      vector.add(center, (calc.cos(a) * r, calc.sin(a) * r, 0))
    })

    // Build a path through all three coordinates
    let path = cetz.drawables.path((cetz.path-util.line-segment(corners)),
      stroke: style.stroke, fill: style.fill, close: true)

    (ctx: ctx,
     drawables: cetz.drawables.apply-transform(ctx.transform, path),
    ),)
  },)
}

// Call the element
my-star((0,0))
my-star((0,3), n: 10)
my-star((0,6), inner-radius: .3, fill: yellow)
```

Using custom elements instead of groups (as in Section 7) makes sense when doing advanced computations or even applying modifications to passed in elements.