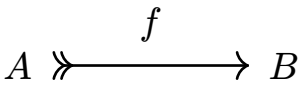

fletcher

(noun) a maker of arrows

A Typst package for diagrams with lots of arrows, built on top of CeTZ.

Commutative diagrams, flow charts, state machines, block diagrams...

`github.com/Jollywatt/typst-fletcher`

Version 0.4.3

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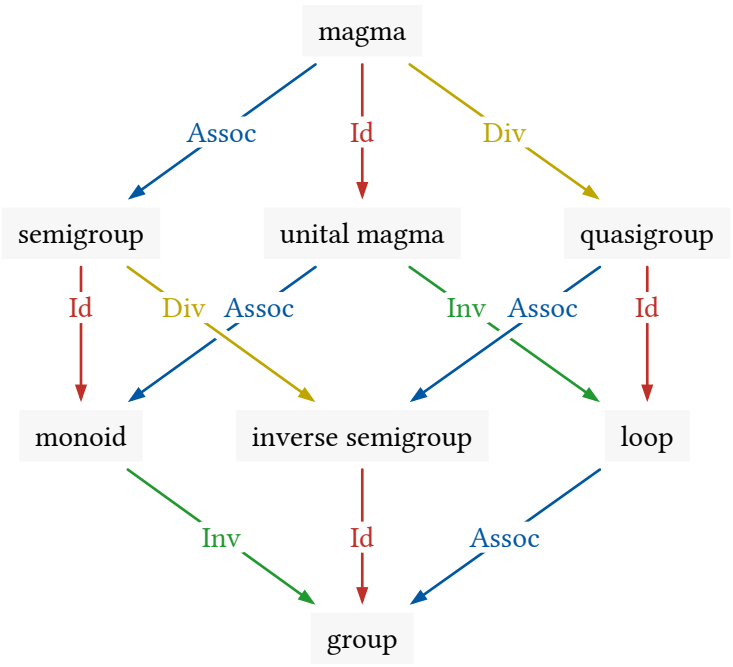
magma
Assoc
Id
Div
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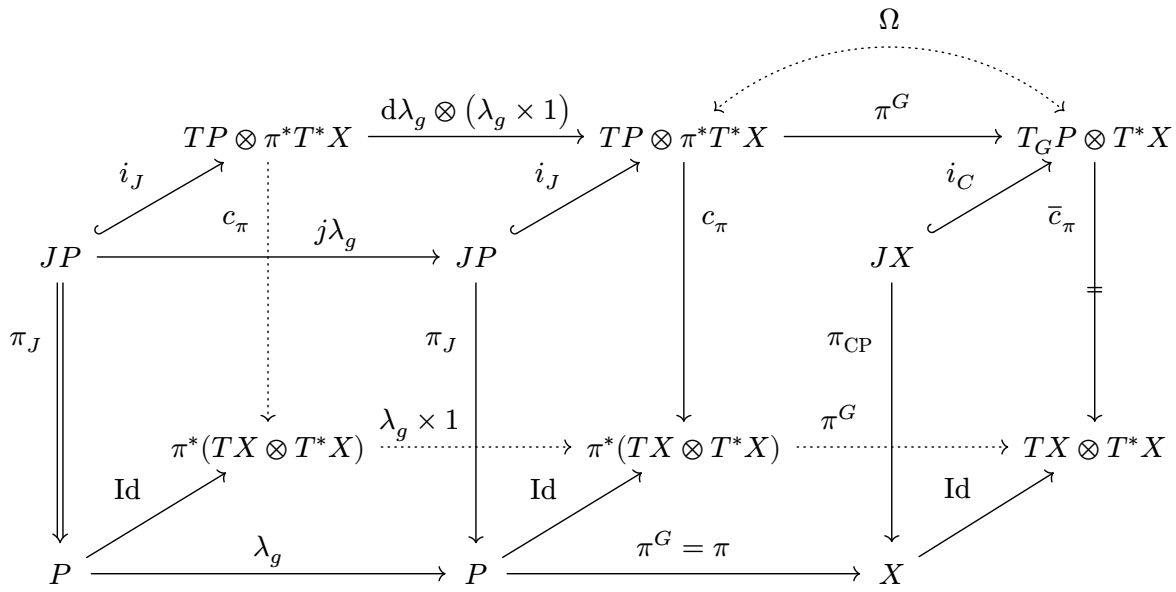
Ω
$TP \otimes \pi^*T^*X$
$\mathrm{d}\lambda_g \otimes (\lambda_g \times 1)$
$TP \otimes \pi^*T^*X$
π^G
$T_GP \otimes T^*X$
i_J
c_π
$j\lambda_g$
i_J
c_π
i_C
$\bar{c}_\pi$
JP
JP
JX
π_J
π_J
π_{CP}
$\lambda_g \times 1$
π^G
$\pi^*(TX \otimes T^*X)$
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Id
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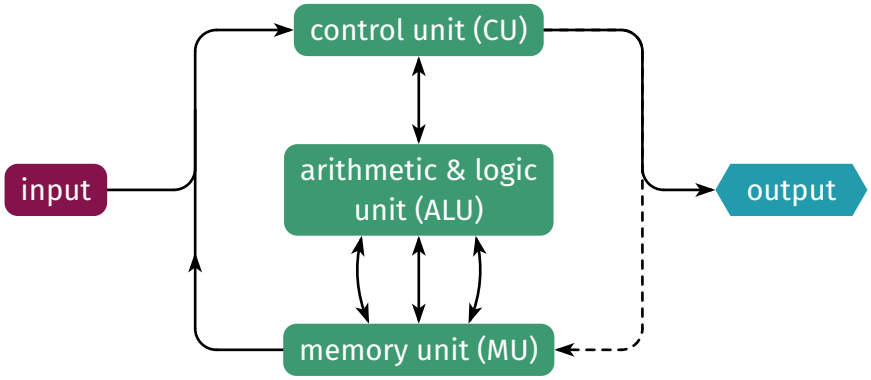
λ_g
$\pi^G = \pi$
P
P
X

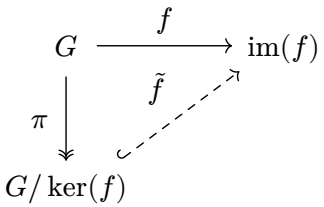

control unit (CU)
input
arithmetic & logic unit (ALU)
output
memory unit (MU)

Usage examples

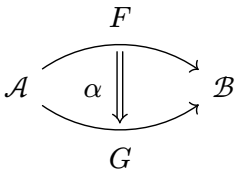
Avoid importing everything with * as many internal functions are also exported.

```
#import "@preview/fletcher:0.4.3" as fletcher: node, edge
```

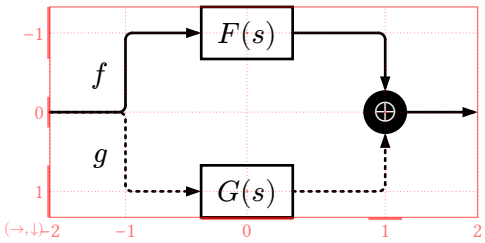
```
// You can specify nodes in math-mode, separated by `&`:
#fletcher.diagram($
G edge(f, ->) edge("d", pi, ->>) & im(f) \
G slash ker(f) edge("ur", tilde(f), "hook-->")
$)
```




```
// Or you can use code-mode, with variables, loops, etc:
#fletcher.diagram(spacing: 2cm, {
let (A, B) = ((0,0), (1,0))
node(A, $cal(A)$)
node(B, $cal(B)$)
edge(A, B, $F$, "->", bend: +35deg)
edge(A, B, $G$, "->", bend: -35deg)
let h = 0.2
edge((.5,-h), (.5,+h), $alpha$, "=>")
})
```



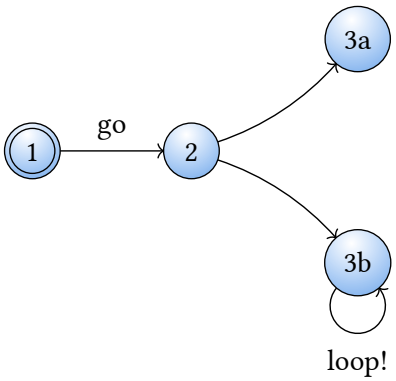

```
#fletcher.diagram(
debug: true,           // show a coordinate grid
spacing: (10mm, 5mm), // wide columns, narrow rows
node-stroke: 1pt,      // outline node shapes
edge-stroke: 1pt,      // make lines thicker
mark-scale: 60%,       // make arrowheads smaller
edge((-2,0), "r,u,r", "-|>", $f$, label-side: left),
edge((-2,0), "r,d,r", "..|>", $g$),
node((0,-1), $F(s)$),
node((0,+1), $G(s)$),
edge((0,+1), (1,0), "..|>", corner: left),
edge((0,-1), (1,0), "-|>", corner: right),
node((1,0), text(white, $ plus.circle $), inset: 2pt, fill: black),
edge("-|>"),
)
```




```
An equation $f: A -> B$ and \
an inline diagram #fletcher.diagram(
node-inset: 2pt,
label-sep: 0pt,
$A edge(->, text(#0.8em, f)) & B$
).
```

An equation $f : A \to B$ and an inline diagram $A \xrightarrow{f} B$.

```
#fletcher.diagram(
node-stroke: black + 0.5pt,
node-fill: gradient.radial(white, blue, center: (40%, 20%),
                           radius: 150%),
spacing: (15mm, 8mm),
node((0,0), [1], extrude: (0, -4)), // double stroke effect
node((1,0), [2]),
node((2,-1), [3a]),
node((2,+1), [3b]),
edge((0,0), (1,0), [go], "->"),
edge((1,0), (2,-1), "->", bend: -15deg),
edge((1,0), (2,+1), "->", bend: +15deg),
edge((2,+1), (2,+1), "->", bend: -130deg, label: [loop!]),
)
```



Diagrams

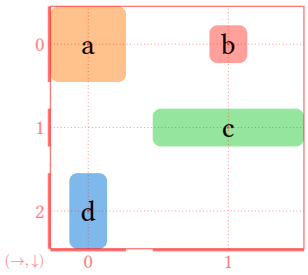
Diagrams are a collection of nodes and edges rendered on a CeTZ canvas.

Elastic coordinates

Diagrams are laid out on a flexible coordinate grid, visible when the `debug` option is turned on. When a node is placed, the rows and columns grow to accommodate the node's size, like a table.

By default, coordinates (x, y) have x going $\rightarrow$ and y going $\downarrow$. This can be changed with the `axes` option of `diagram()`. The `cell-size` option is the minimum row and column width, and `spacing` is the gutter between rows and columns.

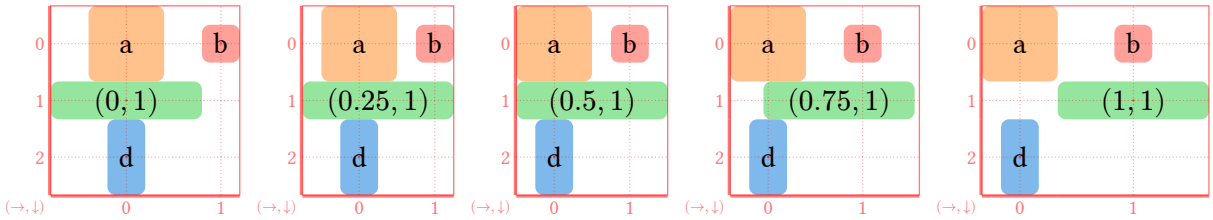
```
#let c = (orange, red, green, blue).map(x => x.lighten(50%))
#fletcher.diagram(
debug: true,
spacing: 10pt,
node-corner-radius: 3pt,
node((0,0), [a], fill: c.at(0), width: 10mm, height: 10mm),
node((1,0), [b], fill: c.at(1), width:  5mm, height:  5mm),
node((1,1), [c], fill: c.at(2), width: 20mm, height:  5mm),
node((0,2), [d], fill: c.at(3), width:  5mm, height: 10mm),
)
```



Fractional coordinates

So far, this is just like a table — however, coordinates can be fractional. These are dealt with by linearly interpolating the diagram between what it would be if the coordinates were rounded up or down.

For example, see how the column sizes change as the green box moves from $(0, 0)$ to $(1, 0)$:

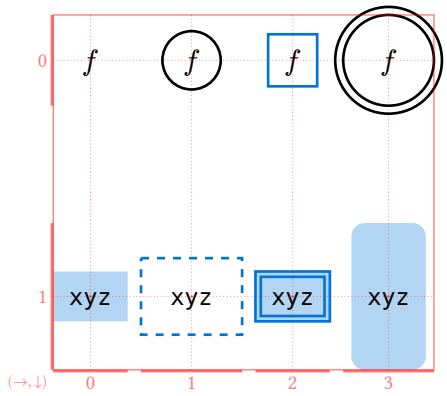


Nodes

`node((x, y), label, ..options)`

Nodes are content centered at a particular coordinate. They can be circular, rectangular, or of any custom shape. Nodes automatically fit the size of their label (with an `inset`), but can also be given an exact `width`, `height`, or `radius`, as well as a `stroke` and `fill`. For example:

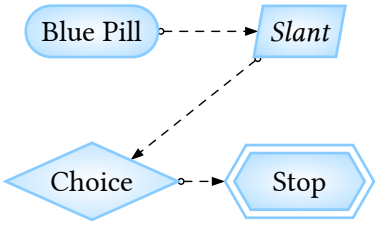
```
#fletcher.diagram(
debug: true, // show a coordinate grid
spacing: (5pt, 4em), // small column gaps, large row spacing
node((0,0), $f$),
node((1,0), $f$, stroke: 1pt),
node((2,0), $f$, stroke: blue, shape: rect),
node((3,0), $f$, stroke: 1pt, radius: 6mm, extrude: (0, 3)),
{
let b = blue.lighten(70%)
node((0,1), `xyz`, fill: b, )
let dash = (paint: blue, dash: "dashed")
node((1,1), `xyz`, stroke: dash, inset: 1em)
node((2,1), `xyz`, fill: b, stroke: blue, extrude: (0, -2))
node((3,1), `xyz`, fill: b, height: 5em, corner-radius: 5pt)
}
)
```



Node shapes

By default, nodes are circular or rectangular depending on the aspect ratio of their label. The `shape` option accepts `rect`, `circle`, various shapes provided in the `fletcher.shapes` submodule, or a function.

```
#import fletcher.shapes: pill, parallelogram, diamond, hexagon
#let theme = rgb("8cf")
#fletcher.diagram(
node-fill: gradient.radial(white, theme, radius: 100%),
node-stroke: theme,
(
node((0,0), [Blue Pill], shape: pill),
node((1,0), [_Slant_], shape: parallelogram.with(angle: 20deg)),
node((0,1), [Choice], shape: diamond),
node((1,1), [Stop], shape: hexagon, extrude: (-3, 0), inset: 10pt),
).intersperse(edge("o--|>")).join()
)
```



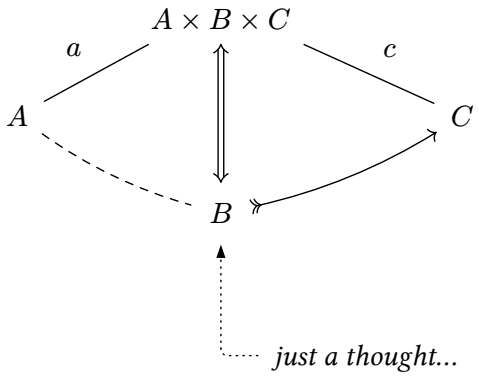
Custom CeTZ shapes are possible by passing a callback to `shape`, but it is up to the user implement outline extrusion; see the `shape` option of `node()` for details.

Edges

`edge(from, to, label, marks, ..options)`

Edges connect two coordinates. If there is a node at an endpoint, the edge attaches to the nodes' bounding shape (after applying the node's `outset`). Edges can have `labels`, can `bend` into arcs, and can have various arrow `marks`.

```
#fletcher.diagram(spacing: (12mm, 6mm), {
let (a, b, c, abc) = ((-1,0), (0,1), (1,0), (0,-1))
node(abc, $A times B times C$)
node(a, $A$)
node(b, $B$)
node(c, $C$)

edge(a, b, bend: -10deg, "dashed")
edge(c, b, bend: +10deg, "<-<<")
edge(a, abc, $a$)
edge(b, abc, "<=>")
edge(c, abc, $c$)

node((.6,3), [_just a thought..._])
edge(b, "..|>", corner: right)
})
```

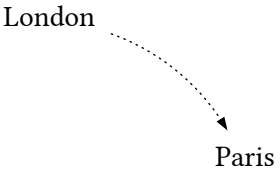


Specifying edge vertices

Implicit coordinates

To specify the start and end points of an edge, you may provide both explicitly (like `edge(from, to)`); leave `from` implicit (like `edge(to)`); or leave both implicit. When `from` is implicit, it becomes the coordinate of the last `node`, and if `to` is implicit, the next `node`.

```
#fletcher.diagram(
node((0,0), [London]),
edge("..|>", bend: 20deg),
node((1,1), [Paris]),
)
```

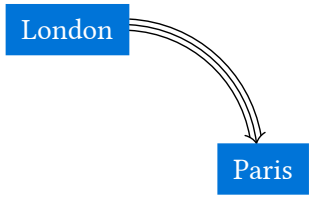


Implicit coordinates can be handy for diagrams in math-mode:

```
#fletcher.diagram($ L edge("->", bend: #30deg) & P $)
```

However, don't forget you can also use variables in code-mode, which is a more explicit and flexible way to reduce repetition of coordinates.

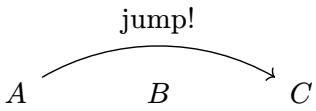
```
#fletcher.diagram(node-fill: blue, {
let (dep, arv) = ((0,0), (1,1))
node(dep, text(white)[London])
node(arv, text(white)[Paris])
edge(dep, arv, "==>", bend: 40deg)
})
```



Relative coordinates

You may specify an edge's direction instead of its end coordinate. This can be done with `edge((x, y), (rel: (Δx, Δy)))`, or with string of *directions* for short, e.g., `"u"` for up or `"br"` for bottom right. Any combination of **t**op/**u**p/**n**orth, **b**ottomp/**d**own/**s**outh, **l**eft/**w**est, and **r**ight/**e**ast are allowed. Together with implicit coordinates, this allows you to do things like:

```
#fletcher.diagram($ A edge("rr", ->, #[jump!], bend: #30deg) & B & C $)
```



Labelled coordinates

Another way coordinates can be expressed is through node names. Nodes can be given a `name`, which is a label (not a string) identifying that node. A label as an edge vertex is interpreted as the position of the node with that label.

```
#fletcher.diagram(
node((0,0), $frak(A)$, name: <A>),
node((1,0), $frak(B)$, name: <B>),
edge(<A>, <B>, "-->")
)
```

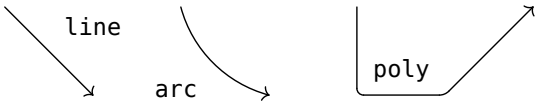
$\mathfrak{A}$ ----> $\mathfrak{B}$

Node names are labels instead of strings (like in CeTZ) so that positional arguments to `edge()` are easier to disambiguate by their type.

Edge types

There are three `kinds` of edges: `"line"`, `"arc"`, and `"poly"`. All edges have at least two `vertices`, but `"poly"` edges can have more. In unspecified, `kind` is chosen based on `bend` and the number of `vertices`.

```
#fletcher.diagram(
edge((0,0), (1,1), "->", `line`),
edge((2,0), (3,1), "->", bend: -30deg, `arc`),
edge((4,0), (4,1), (5,1), (6,0), "->", `poly`),
)
```



Instead of as positional arguments, an array of coordinates may be also be passed the the edge option `vertices`. All vertices except the first can be relative (see above), so that the `"poly"` edge above could also be written in these ways:

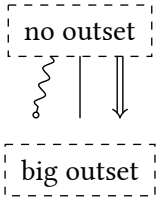
```
edge((4,0), (rel: (0,1)), (rel: (1,0)), (rel: (1,-1)), "->", `poly`)
edge((4,0), "d", "r", "ur", "->", `poly`) // using relative coordinate names
edge((4,0), "d,r,ur", "->", `poly`) // shorthand
```

Only the first and last `vertices` of an edge snap to node outlines.

Tweaking where edges connect

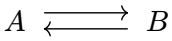
A node's `outset` controls how close edges connect to the node's boundary. To adjust where along the boundary the edge connects, you can adjust the edge's end coordinates by a fractional amount.

```
#fletcher.diagram(
node-stroke: (thickness: .5pt, dash: "dashed"),
node((0,0), [no outset], outset: 0pt),
node((0,1), [big outset], outset: 10pt),
edge((0,0), (0,1)),
edge((-0.1,0), (-0.4,1), "-o", "wave"), // shifted with fractional coordinates
edge((0,0), (0,1), "=>", shift: 15pt),  // shifted by a length
)
```



The `shift` option of `edge()` lets you shift edges sideways by an absolute length:

```
#fletcher.diagram($A edge(->, shift: #3pt) edge(<-, shift: #(-3pt)) & B$)
```



By default, edges which are incident at an angle are automatically adjusted slightly, especially if the node is wide or tall. Aesthetically, things can look more comfortable if edges don't all connect to the node's exact center, but instead spread out a bit. Notice the (subtle) difference the figures below.

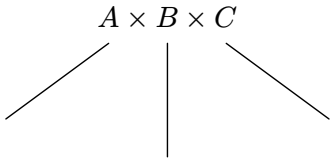


Figure 1: With focus (default)

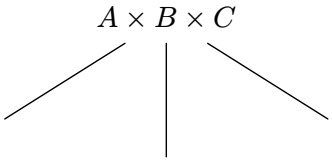
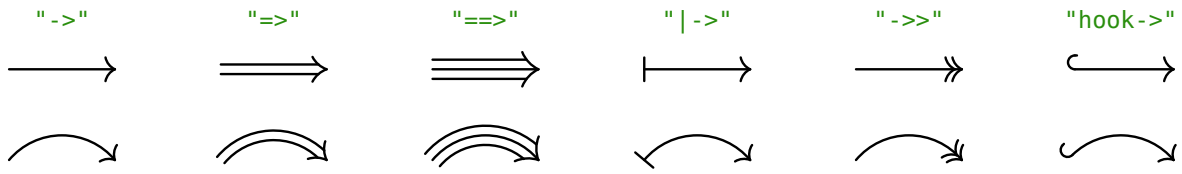


Figure 2: Without defocus

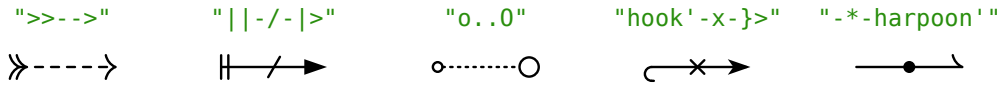
The strength of this adjustment is controlled by the `defocus` option of `node()` (or the `node-defocus` option of `diagram()`).

Marks and arrows

Edges can be arrows. Marks can be specified by shorthands like `edge(a, b, "-->")` or with the `marks` option of `edge()`. Some mathematical arrow heads are supported, matching →, ⇒, ⇛, ↦, ↠, and ↪.



A few other marks are supported, and can be placed anywhere along the edge.



All the mark shorthands are defined in `fletcher.MARK_ALIASES` and `fletcher.MARK_DEFAULTS`:

`>`, `<`, `|`, `/`, `\`, `x`, `X`, `o`, `O`, `*`, `@`, `>>`, `<<`, `|>`, `<|`, `||`, `}>`, `<{`, `>>>`, `<<<`, `|||`, `bar`, `head`, `hook`, `hook'`, `hooks`, `solid`, `cross`, `circle`, `harpoon`, `harpoon'`, `doublehead`, `triplehead`

Adjusting marks

While shorthands exist for specifying marks and stroke styles, finer control is possible.

```
#fletcher.diagram(
edge-stroke: 1.5pt,
spacing: 3cm,
edge((0,0), (-0.1,-1), bend: -10deg, marks: (
(kind: ">>", size: 6, delta: 70deg, sharpness: 45deg),
(kind: "bar", size: 1, pos: 0.5),
(kind: "head", rev: true),
(kind: "solid", rev: true, stealth: 0.1, paint: red.mix(purple)),
), stroke: green.darken(50%))
)
```

Shorthands like `"<->"` expand into specific `edge()` options. For example, `edge(a, b, "|=>")` is equivalent to `edge(a, b, marks: ("bar", "doublehead"), extrude: (-2, 2))`. Mark names such as `"bar"` or `"doublehead"` are themselves shorthands for dictionaries defining the marks' parameters. These can be retrieved from the mark name as follows:

```
#fletcher.interpret-mark("doublehead")
// In this particular example:
// - `kind` selects the type of arrow head
// - `size` controls the radius of the arc
// - `sharpness` is (half) the angle of the tip
// - `delta` is the angle spanned by the arcs
// - `tail` is approximately the distance from the cap's tip to
//    the end of its arms. This is used to calculate a "tail hang"
//    correction to the arrowhead's bearing for tightly curved edges.
// Distances are multiples of the stroke thickness.
```

```
(
  size: 10.56,
  sharpness: 19.4deg,
  delta: 43.5deg,
  outer-len: 5.5,
  kind: "head",
)
```

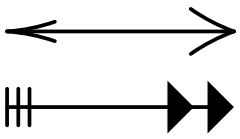
Finally, the fully expanded version of a mark shorthand can be obtained with `interpret-marks-arg()`:

```
#fletcher.interpret-marks-arg("|=>")

// `edge(..args, marks: "|=>")` is equivalent to
// `edge(..args, ..fletcher.interpret-marks-arg("|=>"))`
```

```
(
  marks: (
    (
      size: 4.9,
      angle: 0deg,
      pos: 0.0,
      rev: true,
      kind: "bar",
    ),
    (
      size: 10.56,
      sharpness: 19.4deg,
      delta: 43.5deg,
      outer-len: 5.5,
      pos: 1.0,
      rev: false,
      kind: "head",
    ),
  ),
  extrude: (-2, 2),
)
```

You can customise the basic marks somewhat by adjusting these parameters. For example:

```
#let my-head = (kind: "head", sharpness: 4deg, size: 50, delta: 15deg)
#let my-bar = (kind: "bar", extrude: (0, -3, -6))
#let my-solid = (kind: "solid", sharpness: 45deg)
#fletcher.diagram(
edge-stroke: 1.4pt,
spacing: (3cm, 1cm),
edge((0,0), (1,0), marks: (my-head, my-head + (sharpness: 20deg))),
edge((0,1), (1,1), marks: (my-bar, my-solid + (pos: 0.8), my-solid)),
)
```

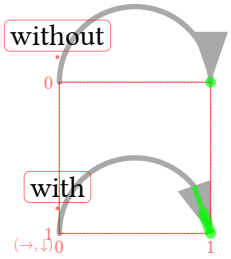


The particular marks and parameters are hard-wired and will likely change as this package is updated (so they are not documented). However, you are encouraged to use the functions `interpret-marks-arg()` and `interpret-mark()` to discover the parameters for finer control.

Hanging tail correction

All marks accept an `outer-len` parameter, the effect of which can be seen below:

```
#fletcher.diagram(
edge-stroke: 2pt,
spacing: 2cm,
debug: 4,

edge((0,0), (1,0), stroke: gray, bend: 90deg, label-pos: 0.1, label: [without],
marks: (none, (kind: "solid", outer-len: 0))),
edge((0,1), (1,1), stroke: gray, bend: 90deg, label-pos: 0.1, label: [with],
marks: (none, (kind: "solid"))), // use default hang
)
```



The tail length (specified in multiples of the stroke thickness) is the distance that the arrow head visually extends backwards over the stroke. This is visualised by the green line shown above. The mark is rotated so that the ends of the line both lie on the arc.

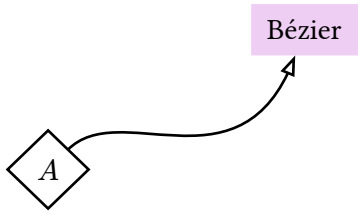
CeTZ integration

Fletcher's drawing cababilities are deliberately restricted to a few simple building blocks. However, an escape hatch is provided with the `render` option of `diagram()` so you can intercept diagram data and draw things using CeTZ directly.

Bézier edges

Here is an example of how you might hack together a Bézier edge using the same functions that `fletcher` uses internally to anchor edges to nodes:

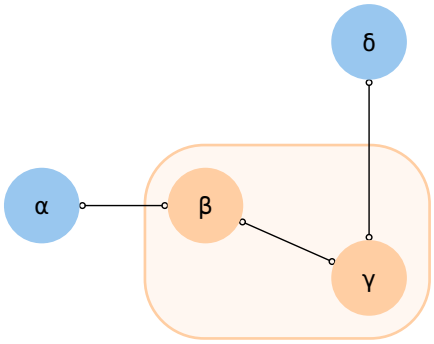
```
#fletcher.diagram(
node((0,1), $A$, stroke: 1pt, shape: fletcher.shapes.diamond),
node((2,0), [Bézier], fill: purple.lighten(80%)),

render: (grid, nodes, edges, options) => {
// cetz is also exported as fletcher.cetz
cetz.canvas({
// this is the default code to render the diagram
fletcher.draw-diagram(grid, nodes, edges, debug: options.debug)

// retrieve node data by coordinates
let n1 = fletcher.find-node-at(nodes, (0,1))
let n2 = fletcher.find-node-at(nodes, (2,0))

let out-angle = 45deg
let in-angle = -110deg

fletcher.get-node-anchor(n1, out-angle, p1 => {
fletcher.get-node-anchor(n2, in-angle, p2 => {
// make some control points
let c1 = (to: p1, rel: (out-angle, 10mm))
let c2 = (to: p2, rel: (in-angle, 20mm))
cetz.draw.bezier(
p1, p2, c1, c2,
mark: (end: ">") // cetz-style mark
)
})
})

})
}
)
```



Node groups

Here is another example of how you could automatically draw “node groups” around selected nodes. First, we find all nodes of a certain fill, obtain their final coordinates, and then draw a rectangle around their bounding box.

```
#let in-group = orange.lighten(60%)
#let out-group = blue.lighten(60%)

// draw a blob around nodes
#let enclose-nodes(nodes, clearance: 8mm) = {
let points = nodes.map(node => node.final-pos)
let (center, size) = fletcher.bounding-rect(points)

cetz.draw.content(
center,
rect(
width: size.at(0) + 2*clearance,
height: size.at(1) + 2*clearance,
radius: clearance,
stroke: in-group,
fill: in-group.lighten(85%),
)
)
}

#fletcher.diagram(
  node((-1,0), `α`, fill: out-group, radius: 5mm),
  edge("o-o"),
  node((0, 0), `β`, fill: in-group, radius: 5mm),
  edge("o-o"),
  node((1,.5), `γ`, fill: in-group, radius: 5mm),
  edge("o-o"),
  node((1,-1), `δ`, fill: out-group, radius: 5mm),

  render: (grid, nodes, edges, options) => {
    // find nodes by color
    let group = nodes.filter(node => node.fill == in-group)
    cetz.canvas({
      enclose-nodes(group) // draw a node group in the background
      fletcher.draw-diagram(grid, nodes, edges, debug: options.debug)
    })
  }
)
```



Touying integration

You can create incrementally-revealed diagrams in Touying presentation slides by defining the following `touying-reducer`:

```
#import "@preview/touying:0.2.1": *
#let diagram = touying-reducer.with(reduce: fletcher.diagram, cover: fletcher.hide)
#let (init, slide) = utils.methods(s)
#show: init

#slide[
Slide with animated figure:
#diagram(
node-stroke: .1em,
node-fill: gradient.radial(blue.lighten(80%), blue,
center: (30%, 20%), radius: 80%),
spacing: 4em,
edge((-1,0), "r", "-|>", `open(path)`, label-pos: 0, label-side: center),
node((0,0), `reading`, radius: 2em),
pause,
edge((0,0), (0,0), `read()`, "--|>", bend: 130deg),
edge(`read()`, "-|>"),
node((1,0), `eof`, radius: 2em),
pause,
edge(`close()`, "-|>"),
node((2,0), `closed`, radius: 2em, extrude: (-2.5, 0)),
edge((0,0), (2,0), `close()`, "-|>", bend: -40deg),
)
]
```

Main functions

diagram()

Draw a diagram containing node()s and edge()s.

```
diagram(
  ..args: array,
  debug: bool 1 2 3,
  axes: pair of directions,
  spacing: length pair of lengths,
  cell-size: length pair of lengths,
  edge-stroke: stroke,
  node-stroke: stroke none,
  edge-corner-radius: length none,
  node-corner-radius: length none,
  node-inset: length pair of lengths,
  node-outset: length pair of lengths,
  node-fill: paint,
  node-defocus: number,
  label-sep: length,
  mark-scale: length,
  crossing-fill: paint,
  crossing-thickness: number,
  render: function,
)
```

..args array

Content to draw in the diagram, including nodes and edges.

The results of node() and edge() can be *joined*, meaning you can specify them as separate arguments, or in a block:

```
#fletcher.diagram(
// one object per argument
node((0, 0), $A$),
node((1, 0), $B$),
{
// multiple objects in a block
// can use scripting, loops, etc
node((2, 0), $C$)
node((3, 0), $D$)
},
for x in range(4) { node((x, 1) [#x]) },
)
```

Nodes and edges can also be specified in math-mode.

```
#fletcher.diagram($
A & B \          // two nodes at (0,0) and (1,0)
C edge(->) & D \ // an edge from (0,1) to (1,1)
node(sqrt(pi), stroke: #1pt) // a node with options
$)
```

debug `bool` or `1` or `2` or `3`

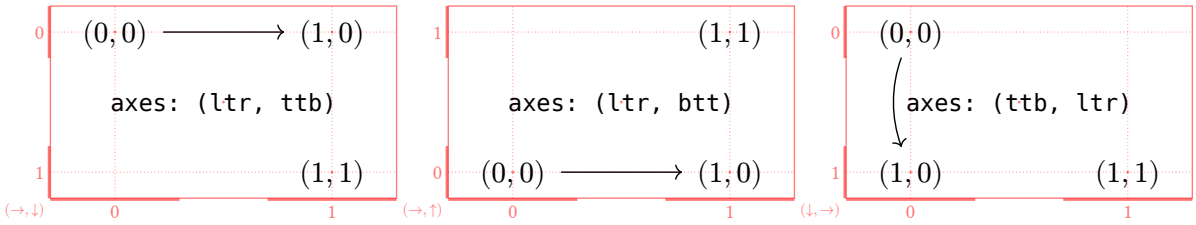
Level of detail for drawing debug information. Level `1` or `true` shows a coordinate grid; higher levels show bounding boxes and anchors, etc.

Default: `false`

axes `pair of directions`

The orientation of the diagram's axes.

This defines the elastic coordinate system used by nodes and edges. To make the y coordinate increase up the page, use `(ltr, btt)`. For the matrix convention `(row, column)`, use `(ttb, ltr)`.



Default: `(ltr, ttb)`

spacing `length` or `pair of lengths`

Gaps between rows and columns. Ensures that nodes at adjacent grid points are at least this far apart (measured as the space between their bounding boxes).

Separate horizontal/vertical gutters can be specified with `(x, y)`. A single length `d` is short for `(d, d)`.

Default: `3em`

cell-size `length` or `pair of lengths`

Minimum size of all rows and columns. A single length `d` is short for `(d, d)`.

Default: `0pt`

edge-stroke `stroke`

Default value of the `stroke` option of `edge()`. By default, this is chosen to match the thickness of mathematical arrows such as $A \to B$ in the current font size.

The default stroke is folded with the stroke specified for the edge. For example, if `edge-stroke` is `1pt` and the `stroke` option of `edge()` is `red`, then the resulting stroke is `1pt + red`.

Default: `0.048em`

node-stroke `stroke` or `none`

Default value of the `stroke` option of `node()`.

The default stroke is folded with the stroke specified for the node. For example, if `node-stroke` is `1pt` and the `stroke` option of `node()` is `red`, then the resulting stroke is `1pt + red`.

Default: `none`

edge-corner-radius `length` or `none`

Default value of the `corner-radius` option of `edge()`.

Default: `2.5pt`

node-corner-radius `length` or `none`

Default value of the `corner-radius` option of `node()`.

Default: `none`

node-inset `length` or `pair of lengths`

Default value of the `inset` option of `node()`.

Default: `6pt`

node-outset `length` or `pair of lengths`

Default value of the `outset` option of `node()`.

Default: `0pt`

node-fill `paint`

Default value of the `fill` option of `node()`.

Default: `none`

node-defocus `number`

Default value of the `defocus` option of `node()`.

Default: `0.2`

label-sep `length`

Default value of the `label-sep` option of `edge()`.

Default: `0.2em`

`mark-scale` `length`

Default value of the `mark-scale` option of `edge()`.

Default: `100%`

`crossing-fill` `paint`

Color to use behind connectors or labels to give the illusion of crossing over other objects. See the `crossing-fill` option of `edge()`.

Default: `white`

`crossing-thickness` `number`

Default thickness of the occlusion made by crossing connectors. See `crossing-thickness`.

Default: `5`

`render` `function`

After the node sizes and grid layout have been determined, the `render` function is called with the following arguments:

- `grid`: a dictionary of the row and column widths and positions;
- `nodes`: an array of nodes (dictionaries) with computed attributes (including size and physical coordinates);
- `edges`: an array of connectors (dictionaries) in the diagram; and
- `options`: other diagram attributes.

This callback is exposed so you can access the above data and draw things directly with CeTZ.

Default:
```
(grid, nodes, edges, options) => {
cetz.canvas(draw-diagram(grid, nodes, edges, debug: options.debug))
}
```

node()

Draw a labelled node in a diagram which can connect to edges.

```
node(
  ..args,
  pos: coordinate,
  name: label none,
  label: content,
  inset: length auto,
  outset: length auto,
  stroke: stroke,
  fill: paint,
  width,
  height,
  radius,
  corner-radius: length,
  shape: rect circle function auto,
  extrude: array,
  defocus: number,
  post: function,
)
```

pos `coordinate`

Dimensionless "elastic coordinates" `(x, y)` of the node.

See the options of `diagram()` to control the physical scale of elastic coordinates.

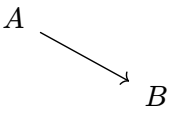
Default: `auto`

name `label` or `none`

An optional name to give the node.

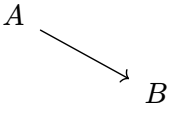
Names can sometimes be used in place of coordinates. For example:

```
fletcher.diagram(
node((0,0), $A$, name: <A>),
node((1,0.6), $B$, name: <B>),
edge(<A>, <B>, "->"),
)
```



Note that you can also just use variables to refer to coordinates:

```
fletcher.diagram({
let A = (0,0)
let B = (1,0.6)
node(A, $A$)
node(B, $B$)
edge(A, B, "->")
})
```



Default: `none`

label `content`

Content to display inside the node.

Default: `auto`

inset `length` or `auto`

Padding between the node's content and its bounding box or bounding circle.

Default: `auto`

outset `length` or `auto`

Margin between the node's bounds to the anchor points for connecting edges.

This does not affect node layout, only how closely edges connect to the node.

Default: `auto`

stroke `stroke`

Stroke style for the node outline.

Defaults to the `node-stroke` option of `diagram()`.

Default: `auto`

fill `paint`

Fill style of the node. The fill is drawn within the node outline as defined by the first `extrude` value.

Defaults to the `node-fill` option of `diagram()`.

Default: `auto`

corner-radius `length`

Radius of rounded corners, if supported by the node `shape`.

Defaults to the `node-corner-radius` option of `diagram()`.

Default: `auto`

shape `rect` or `circle` or `function` or `auto`

Shape to draw for the node. If `auto`, one of `rect` or `circle` is chosen depending on the aspect ratio of the node's label.

Some other shape functions are provided in the `fletcher.shapes` submodule, including `diamond`, `pill`, `parallelogram`, `hexagon`, and `house`.

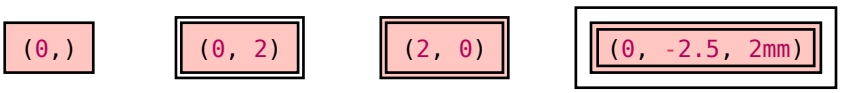
Custom shapes should be specified as a function `(node, extrude) => (..)` returning `cetz` objects.
- The `node` argument is a dictionary containing the node's attributes, including its dimensions (`node.size`), and other options (such as `node.corner-radius`).
- The `extrude` argument is a length which the shape outline should be extruded outwards by. This serves two functions: to support automatic edge anchoring with a non-zero node `outset`, and to create multi-stroke effects using the `extrude` node option.

Default: `auto`

`extrude` `array`

Draw strokes around the node at the given offsets to obtain a multi-stroke effect. Offsets may be numbers (specifying multiples of the stroke's thickness) or lengths.

The node's fill is drawn within the boundary defined by the first offset in the array.



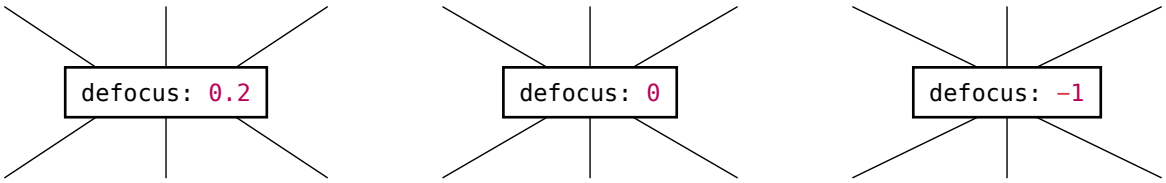
See also the `extrude` option of `edge()`.

Default: `(0,)`

`defocus` `number`

Strength of the "defocus" adjustment for connectors incident with this node.

This affects how connectors attach to non-square nodes. If `0`, the adjustment is disabled and connectors are always directed at the node's exact center.



Defaults to the `node-defocus` option of `diagram()`.

Default: `auto`

`post` `function`

Callback function to intercept `cetz` objects before they are drawn to the canvas.

This can be used to hide elements without affecting layout (for use with Touying, for example). The `hide()` function also helps for this purpose.

Default: `x => x`

edge()

Draw a connecting line or arc in an arrow diagram.

```
edge(
  ..args: any,
  vertices: array,
  extrude: array,
  shift: length number pair,
  label: content,
  label-side: left right center,
  label-pos: number,
  label-sep: length,
  label-anchor: anchor,
  label-fill: bool paint,
  stroke: stroke,
  dash: string,
  decorations: none string function,
  kind: string,
  bend: angle,
  corner: none left right,
  corner-radius: length none,
  marks: array,
  mark-scale: percent,
  crossing: bool,
  crossing-thickness: number,
  crossing-fill: paint,
  snap-to: pair,
  post: function,
)
```

..args any

An edge's positional arguments may specify:

- the edge's vertices
- the label content
- marks and other style options

Vertex coordinates must come first, and are optional:

```
edge(from, to, ..) // explicit start and end nodes
edge(to, ..) // start node chosen automatically based on last node specified
edge(..) // both nodes chosen automatically depending on adjacent nodes
edge(from, v1, v2, ..vs, to, ..) // a multi-segmented edge
```

All coordinates except the start point can be relative (a dictionary of the form `(rel: (Δx, Δy))` or a string containing the characters {`l`, `r`, `u`, `d`, `t`, `b`, `n`, `e`, `s`, `w`}).

An edge's marks and label can be also be specified as positional arguments. They are disambiguated by guessing based on the types. For example, the following are equivalent:

```
edge((0,0), (1,0), $f$, "->")
edge((0,0), (1,0), "->", $f$)
edge((0,0), (1,0), $f$, marks: "->")
edge((0,0), (1,0), "->", label: $f$)
edge((0,0), (1,0), label: $f$, marks: "->")
```

Additionally, some common options are given flags that may be given as string positional arguments. These are `"dashed"`, `"dotted"`, `"double"`, `"triple"`, `"crossing"`, `"wave"`, `"zigzag"`, and `"coil"`. For example, the following are equivalent:

```
edge((0,0), (1,0), $f$, "wave", "crossing")
edge((0,0), (1,0), $f$, decorations: "wave", crossing: true)
```

`vertices` `array`

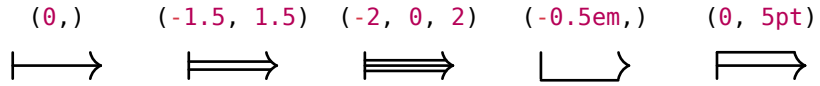
Array of (at least two) coordinates for the edge.

Vertices can also be specified as leading positional arguments, but if so, the `vertices` option must be empty. If the number of vertices is greater than two, `kind` defaults to `"poly"`.

Default: `()`

`extrude` `array`

Draw a separate stroke for each extrusion offset to obtain a multi-stroke effect. Offsets may be numbers (specifying multiples of the stroke's thickness) or lengths.



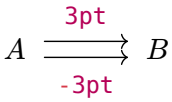
Notice how the ends of the line need to shift a little depending on the mark. For basic arrow heads, this offset is computed with `round-arrow-cap-offset()`.

See also the `extrude` option of `node()` .

Default: `(0,)`

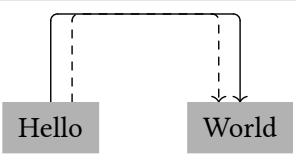
`shift` `length` or `number` or `pair`

Amount to shift the edge sideways by, perpendicular to its direction. A pair `(from, to)` controls the shifts at each end of the edge independently, and a single shift `s` is short for `(s, s)`. Shifts can absolute lengths (e.g., `5pt`) or coordinate differences (e.g., `0.1`).



If an edge has many vertices, the shifts only affect the first and last segments of the edge.

```
diagram(
node-fill: luma(70%),
node((0,0), [Hello]),
edge("u,r,d", "->"),
edge("u,r,d", "-->", shift: 8pt),
node((1,0), [World]),
)
```



Default: `0pt`

`label` `content`

Content for the edge label. See the `label-pos` and `label-side` options to control the position (and `label-sep` and `label-anchor` for finer control).

Default: `none`

`label-side` `left` or `right` or `center`

Which side of the edge to place the label on, viewed as you walk along it from base to tip.

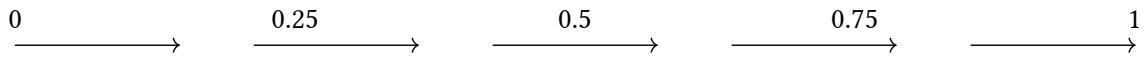
If `center`, then the label is placed directly on the edge and `label-fill` defaults to `true`. When `auto`, a value of `left` or `right` is automatically chosen so that the label is:

- roughly above the connector, in the case of straight lines; or
- on the outside of the curve, in the case of arcs.

Default: `auto`

`label-pos` `number`

Position of the label along the connector, from the start to end (from `0` to `1`).

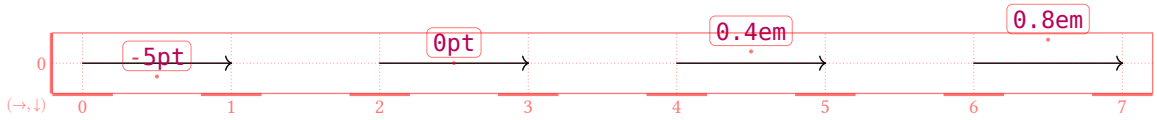


Default: `0.5`

`label-sep` `length`

Separation between the connector and the label anchor.

With the default anchor (automatically set to `"bottom"` in this case):



With `label-anchor` set to `"center"`:

Set `debug` to `2` or higher to see label anchors and outlines as seen here.

Default: `auto`

label-anchor `anchor`

The anchor point to place the label at, such as `"top-right"`, `"center"`, `"bottom"`, etc. If `auto`, the anchor is automatically chosen based on `label-side` and the angle of the connector.

Default: `auto`

label-fill `bool` or `paint`

The background fill for the label. If `true`, defaults to the value of `crossing-fill`. If `false` or `none`, no fill is used. If `auto`, then defaults to `true` if the label is covering the edge (`label-side: center`).

Default: `auto`

stroke `stroke`

Stroke style of the edge. Arrows/marks scale with the stroke thickness (and with `mark-scale`).

Default: `auto`

dash `string`

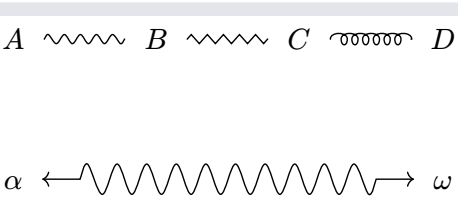
The stroke's dash style. This is also set by some mark styles. For example, setting `marks: "<..>"` applies `dash: "dotted"`.

Default: `none`

decorations `none` or `string` or `function`

Apply a CeTZ path decoration to the stroke. Preset options are `"wave"`, `"zigzag"`, and `"coil"` (which may also be passed as convenience positional arguments), but a decoration function may also be specified.

```
diagram(
$
A edge("wave") &
B edge("zigzag") &
C edge("coil") & D \
alpha &&& omega
$,
edge((0,1), (3,1), "<->", decorations:
cetz.decorations.wave
.with(amplitude: .4)
)
)
```



Default: `none`

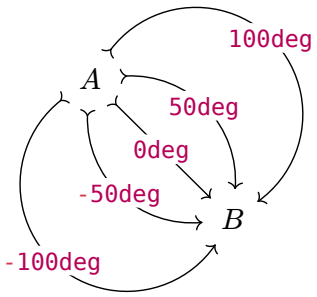
kind `string`

The kind of the edge, one of `"line"`, `"arc"`, or `"poly"`. This is chosen automatically based on the presence of other options (`bend` implies `"arc"`, `corner` or additional vertices implies `"poly"`).

Default: `auto`

bend `angle`

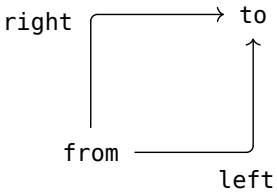
Edge curvature. If `0deg`, the connector is a straight line; positive angles bend clockwise.



Default: `0deg`

corner `none` or `left` or `right`

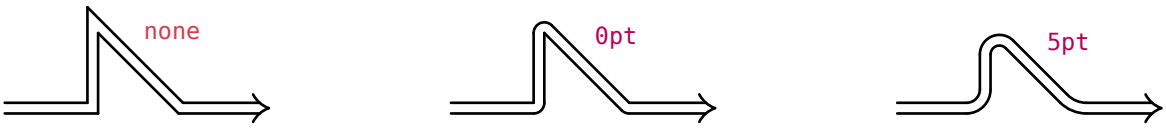
Whether to create a right-angled corner, turning `left` or `right`. (Bending right means the corner sticks out to the left, and vice versa.)



Default: `none`

corner-radius `length` or `none`

Radius of rounded corners for edges with multiple segments. Note that `none` is distinct from `0pt`.



This length specifies the corner radius for right-angled bends. The actual radius is smaller for acute angles and larger for obtuse angles to balance things visually. (Trust me, it looks naff otherwise!)

If `auto`, defaults to the `edge-corner-radius` option of `diagram()`.

Default: `auto`

marks `array`

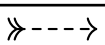
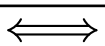
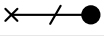
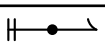
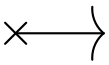
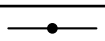
The marks (arrowheads) to draw along an edge's stroke. This may be:

- A shorthand string such as `"->"` or `"hook'-/->>"`. Specifically, shorthand strings are of the form M_1LM_2 or $M_1LM_2LM_3$, where

  $$M_i \in \{\texttt{>}, \texttt{<}, \texttt{>>}, \texttt{<<}, \texttt{>>>}, \texttt{<<<}, \texttt{|>}, \texttt{<|}, \texttt{|}, \texttt{||}, \texttt{|||}, \texttt{/}, \texttt{\}, \texttt{x}, \texttt{X}, \texttt{o}, \texttt{O}, \texttt{*}, \texttt{@}, \texttt{}>, \texttt{<}\} \cup N$$

  is a mark symbol and $L \in \{\texttt{-}, \texttt{--}, \texttt{..}, \texttt{=}, \texttt{==}\}$ is the line style. The mark symbol can also be a name, $M_i \in N = \{\texttt{hook}, \texttt{hook'}, \texttt{harpoon}, \texttt{harpoon'}, \texttt{head}, \texttt{circle}, \ldots\}$ where a trailing `'` means to reflect the mark across the stroke.
- An array of marks, where each mark is specified by name or by a dictionary of parameters.

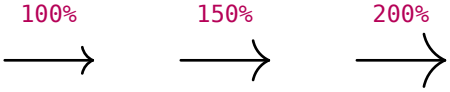
Shorthands are expanded into other arguments. For example, `edge(p1, p2, "=>")` is short for `edge(p1, p2, marks: (none, "head"), "double")`, or more precisely, `edge(p1, p2, ..fletcher.interpret-marks-arg("=>"))`.

Arrow	marks
	`"->"`
	`">>-->"`
	`"<=>"`
	`"==>"`
	`"->>-"`
	`"x-/-@"`
	`"|..|"`
	`"hook->>"`
	`"hook'->>"`
	`"||-*-harpoon'"`
	`("X", (kind: "head", size: 15, sharpness: 40deg))`
	`((kind: "circle", pos: 0.5, fill: true),)`

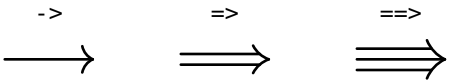
Default: `()`

mark-scale `percent`

Scale factor for marks or arrowheads, relative to the `stroke` thickness.



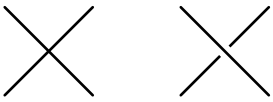
Note that the default arrowheads scale automatically with double and triple strokes:



Default: `100%`

`crossing` `bool`

If `true`, draws a backdrop of color `crossing-fill` to give the illusion of lines crossing each other.

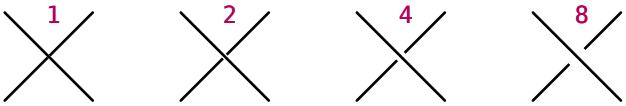


You can also pass `"crossing"` as a positional argument as a shorthand for `crossing: true`.

Default: `false`

`crossing-thickness` `number`

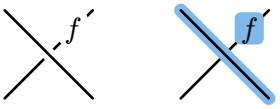
Thickness of the "crossing" background stroke (applicable if `crossing` is `true`) in multiples of the normal stroke's thickness. Defaults to the `crossing-thickness` option of `diagram()`.



Default: `auto`

`crossing-fill` `paint`

Color to use behind connectors or labels to give the illusion of crossing over other objects. Defaults to `crossing-fill`.



Default: `auto`

`snap-to` `pair`

The nodes the start and end of an edge should snap to. Each node can be a position or node `name`, or `none` to disable snapping.

By default, an edge's first and last `vertices` snap to nearby nodes. This option can be used in case automatic snapping fails (if there are many nodes close together, for example.)

Default: `(auto, auto)`

post `function`

Callback function to intercept `cetz` objects before they are drawn to the canvas.

This can be used to hide elements without affecting layout (for use with Touying, for example). The `hide()` function also helps for this purpose.

Default: `x => x`

Behind the scenes

`main.typ`

- `interpret-edge-args()`

`interpret-edge-args()`

Interpret the positional arguments given to an `edge()`

Tries to intelligently distinguish the `from`, `to`, `marks`, and `label` arguments based on the argument types.

Generally, the following combinations are allowed:

```
edge(..<coords>, ..<marklabel>, ..<options>)
<coords> = () or (to) or (from, to) or (from, ..vertices, to)
<marklabel> = (marks, label) or (label, marks) or (marks) or (label) or ()
<options> = any number of options specified as strings
```

```
interpret-edge-args(args, options)
```

`coords.typ`

- `uv-to-xy()`
- `xy-to-uv()`
- `duv-to-dxy()`
- `dxy-to-duv()`

`uv-to-xy()`

Convert from elastic to absolute coordinates, $(u, v) \mapsto (x, y)$.

Elastic coordinates are specific to the diagram and adapt to row/column sizes; *absolute* coordinates are the final, physical lengths which are passed to `cetz`.

```
uv-to-xy(grid: dictionary, uv: array)
```

grid `dictionary`

Representation of the grid layout, including:

- `origin`
- `centers`
- `spacing`
- `flip`

uv `array`

Elastic coordinate, `(float, float)`.

xy-to-uv()

Convert from absolute to elastic coordinates, $(x, y) \mapsto (u, v)$.

Inverse of `uv-to-xy()`.

```
xy-to-uv(grid, xy)
```

duv-to-dxy()

Jacobian of the coordinate map `uv-to-xy()`.

Used to convert a "nudge" in uv coordinates to a "nudge" in xy coordinates. This is needed because uv coordinates are non-linear (they're elastic). Uses a balanced finite differences approximation.

```
duv-to-dxy(
  grid: dictionary,
  uv: array,
  duv: array,
)
```

grid `dictionary`

Representation of the grid layout.

uv `array`

The point `(float, float)` in the uv-manifold where the shift tangent vector is rooted.

duv `array`

The shift tangent vector `(float, float)` in uv coordinates.

dxy-to-duv()

Jacobian of the coordinate map xy-to-uv().

```
dxy-to-duv(
  grid,
  xy,
  dxy,
)
```

layout.typ

- compute-node-sizes()
- expand-fractional-rects()
- interpret-axes()
- compute-cell-sizes()
- compute-cell-centers()
- compute-grid()

compute-node-sizes()

Resolve the sizes of nodes.

Widths and heights that are auto are determined by measuring the size of the node's label.

```
compute-node-sizes(nodes, styles)
```

expand-fractional-rects()

Convert an array of rects with fractional positions into rects with integral positions.

If a rect is centered at a factional position floor(x) < x < ceil(x), it will be replaced by two new rects centered at floor(x) and ceil(x). The total width of the original rect is split across the two new rects according two which one is closer. (E.g., if the original rect is at x = 0.25, the new rect at x = 0 has 75% the original width and the rect at x = 1 has 25%.) The same splitting procedure is done for y positions and heights.

```
expand-fractional-rects(rects: array of rects) -> array of rects
```

rects `array of rects`

An array of rectangles of the form (center: (x, y), size: (width, height)). The coordinates x and y may be floats.

interpret-axes()

Interpret the axes option of diagram() .

Returns a dictionary with:
- x: Whether u is reversed
- y: Whether v is reversed
- xy: Whether the axes are swapped

```
interpret-axes(axes: array) -> dictionary
```

axes array

Pair of directions specifying the interpretation of (u, v) coordinates. For example, (ltr, ttb) means u goes $\rightarrow$ and v goes $\downarrow$.

compute-cell-sizes()

Determine the sizes of grid cells from nodes and edges.

Returns a dictionary with:
- origin: (u-min, v-min) Coordinate at the grid corner where elastic/uv coordinates are minimised.
- cell-sizes: (x-sizes, y-sizes) Lengths and widths of each row and column.

```
compute-cell-sizes(
  grid: dicitionary,
  nodes,
  edges,
)
```

grid dicitionary

Representation of the grid layout, including:
- flip

compute-cell-centers()

Determine the centers of grid cells from their sizes and spacing between them.

Returns the a dictionary with:
- centers: (x-centers, y-centers) Positions of each row and column, measured from the corner of the bounding box.
- bounding-size: (x-size, y-size) Dimensions of the bounding box.

```
compute-cell-centers(grid: dictionary) -> dictionary
```

grid dictionary

Representation of the grid layout, including:
- cell-sizes: (x-sizes, y-sizes) Lengths and widths of each row and column.
- spacing: (x-spacing, y-spacing) Gap to leave between cells.

compute-grid()

Determine the number, sizes and relative positions of rows and columns in the diagram's coordinate grid.

Rows and columns are sized to fit nodes. Coordinates are not required to start at the origin, `(0,0)`.

```
compute-grid(
  nodes,
  edges,
  options,
)
```

marks.typ

- round-arrow-cap-offset()
- interpret-mark()
- interpret-marks-arg()

round-arrow-cap-offset()

Calculate cap offset of round-style arrow cap, $r\left(\sin\theta - \sqrt{1 - \left(\cos\theta - \frac{|y|}{r}\right)^2}\right)$.

```
round-arrow-cap-offset(
  r: length,
  θ: angle,
  y: length,
)
```

r length

Radius of curvature of arrow cap.

θ angle

Angle made at the the arrow's vertex, from the central stroke line to the arrow's edge.

y length

Lateral offset from the central stroke line.

interpret-mark()

Take a string or dictionary specifying a mark and return a dictionary, adding defaults for any necessary missing parameters.

Ensures all required parameters except `rev` and `pos` are present.

```
interpret-mark(mark, defaults)
```

interpret-marks-arg()

Parse and interpret the marks argument provided to edge(). Returns a dictionary of processed edge() arguments.

interpret-marks-arg(arg: string array) -> dictiony

arg string or array

Can be a string, (e.g. "->", "<=>"), etc, or an array of marks. A mark can be a string (e.g., ">" or "head", "x" or "cross") or a dictionary containing the keys:

- kind (required) the mark name, e.g. "solid" or "bar"
- pos the position along the edge to place the mark, from 0 to 1
- rev whether to reverse the direction
- parameters specific to the kind of mark, e.g., size or sharpness

draw.typ

- draw-edge-line()
- draw-edge-arc()
- draw-edge-polyline()
- find-farthest-intersection()
- get-node-anchor()
- defocus-adjustment()
- draw-debug-axes()
- hide()

draw-edge-line()

Draw a straight edge.

draw-edge-line(edge: dictionary, debug: int)

edge dictionary

The edge object, a dictionary, containing:

- vertices: an array of two points, the line's start and end points.
- extrude: An array of extrusion lengths to apply a multi-stroke effect with.
- stroke: The stroke style.
- marks: An array of marks to draw along the edge.
- label: Content for label.
- label-side, label-pos, label-sep, and label-anchor.

debug int

Level of debug details to draw.

Default: 0

draw-edge-arc()

Draw a bent edge.

```
draw-edge-arc(edge: dictionary, debug: int)
```

edge `dictionary`

The edge object, a dictionary, containing:
- `vertices`: an array of two points, the arc's start and end points.
- `bend`: The angle of the arc.
- `extrude`: An array of extrusion lengths to apply a multi-stroke effect with.
- `stroke`: The stroke style.
- `marks`: An array of marks to draw along the edge.
- `label`: Content for label.
- `label-side`, `label-pos`, `label-sep`, and `label-anchor`.

debug `int`

Level of debug details to draw.

Default: `0`

draw-edge-polyline()

Draw a multi-segment edge

```
draw-edge-polyline(edge: dictionary, debug: int)
```

edge `dictionary`

The edge object, a dictionary, containing:
- `vertices`: an array of at least two points to draw segments between.
- `corner-radius`: Radius of curvature between segments.
- `extrude`: An array of extrusion lengths to apply a multi-stroke effect with.
- `stroke`: The stroke style.
- `marks`: An array of marks to draw along the edge.
- `label`: Content for label.
- `label-side`, `label-pos`, `label-sep`, and `label-anchor`.

debug `int`

Level of debug details to draw.

Default: `0`

find-farthest-intersection()

Of all the intersection points within a set of CeTZ objects, find the one which is farthest from a target point and pass it to a callback.

If no intersection points are found, use the target point itself.

```
find-farthest-intersection(
  objects: cetz array none,
  target: point,
  callback,
)
```

objects `cetz array` or `none`

Objects to search within for intersections. If `none`, callback is immediately called with `target`.

target `point`

Target point to sort intersections by proximity with, and to use as a fallback if no intersections are found.

get-node-anchor()

Get the anchor point around a node outline at a certain angle.

```
get-node-anchor(
  node,
  θ,
  callback,
)
```

defocus-adjustment()

Return the anchor point for an edge connecting to a node with the "defocus" adjustment.

Basically, for very long/wide nodes, don't make edges coming in from all angles go to the exact node center, but "spread them out" a bit.

See https://www.desmos.com/calculator/irt0mvixky.

```
defocus-adjustment(node, θ)
```

draw-debug-axes()

Draw diagram coordinate axes.

```
draw-debug-axes(grid: dictionary)
```

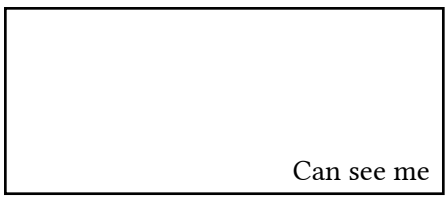
grid `dictionary`

Dictionary specifying the diagram's grid, containing:
- `origin: (u-min, v-min)`, the minimum values of elastic coordinates,
- `flip: (x, y, xy)`, the axes orientation (see `interpret-axes()`),
- `centers: (x-centers, y-centers)`, the physical offsets of each row and each column,
- `cell-sizes: (x-sizes, y-sizes)`, the physical sizes of each row and each column.

`hide()`

Make diagram contents invisible, with or without affecting layout. Works by wrapping final drawing objects in `cetz.draw.hide`.

```
rect(diagram({
fletcher.hide({
node((0,0), [Can't see me])
edge("->")
})
node((1,1), [Can see me])
}))
```



`hide(objects: content array, bounds: bool)`

objects `content` or `array`

Diagram objects to hide.

bounds `bool`

If `false`, layout is as if the objects were never there; if `true`, the layout treats the objects is present but invisible.

Default: `true`

`utils.typ`

- `interp()`
- `interp-inv()`
- `get-arc-connecting-points()`
- `is-space()`

interp()

Linearly interpolate an array with linear behaviour outside bounds

```
interp(
  values: array,
  index: int float,
  spacing: length,
)
```

values `array`

Array of lengths defining interpolation function.

index `int` or `float`

Index-coordinate to sample.

spacing `length`

Gradient for linear extrapolation beyond array bounds.

Default: `0pt`

interp-inv()

Inverse of `interp()`.

```
interp-inv(
  values: array,
  value,
  spacing: length,
)
```

values `array`

Array of lengths defining interpolation function.
- value: Value to find the interpolated index of.

spacing `length`

Gradient for linear extrapolation beyond array bounds.

Default: `0pt`

`get-arc-connecting-points()`

Determine arc between two points with a given bend angle

The bend angle is the angle between chord of the arc (line connecting the points) and the tangent to the arc and the first point.

Returns a dictionary containing:
- `center`: the center of the arc's curvature
- `radius`
- `start`: the start angle of the arc
- `stop`: the end angle of the arc

```
get-arc-connecting-points(
  from: point,
  to: point,
  angle: angle,
) -> dictionary
```

`from` `point`

2D vector of initial point.

`to` `point`

2D vector of final point.

`angle` `angle`

The bend angle between chord of the arc (line connecting the points) and the tangent to the arc and the first point.

`is-space()`

Return true if a content element is a space or sequence of spaces

```
is-space(el)
```