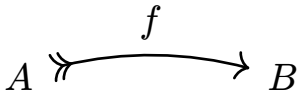



# fletcher

*(noun) a maker of arrows*

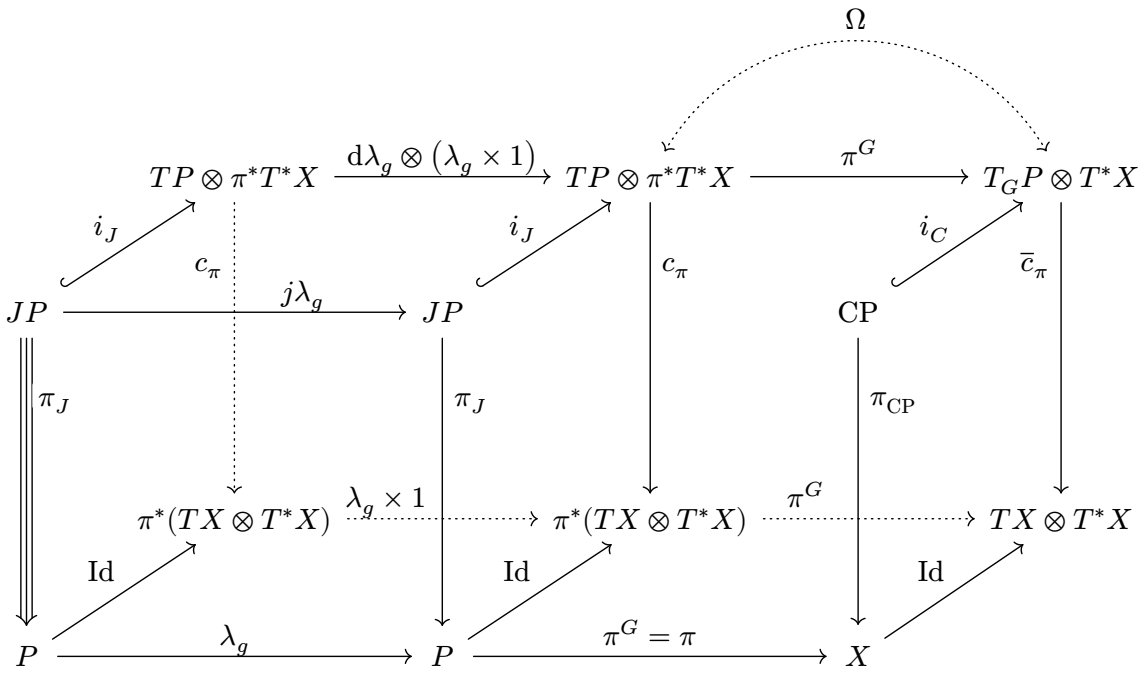
A Typst package for diagrams with lots of arrows, built on top of CeTZ.

*Commutative diagrams, finite state machines, block diagrams...*

`github.com/Jollywatt/typst-fletcher`

Version 0.4.0

## Contents


$\Omega$
$TP \otimes \pi^* T^* X$
$\mathrm{d}\lambda_g \otimes (\lambda_g \times 1)$
$TP \otimes \pi^* T^* X$
$\pi^G$
$T_G P \otimes T^* X$
$i_J$
$c_\pi$
$j\lambda_g$
$i_J$
$c_\pi$
$i_C$
$\bar{c}_\pi$
$JP$
$JP$
CP
$\pi_J$
$\pi_J$
$\pi_{\mathrm{CP}}$
$\pi^*(TX \otimes T^* X)$
$\lambda_g \times 1$
$\pi^*(TX \otimes T^* X)$
$\pi^G$
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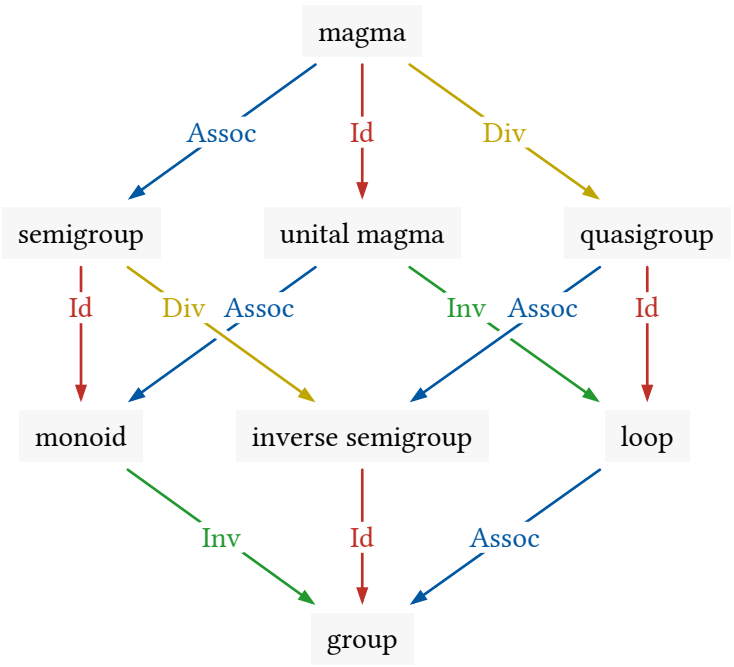
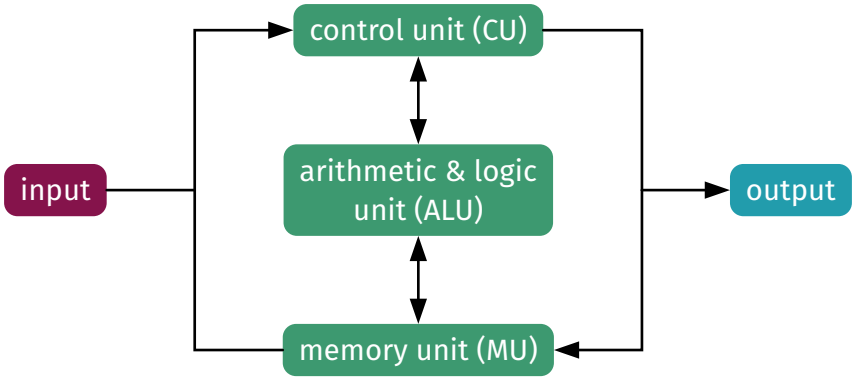
$P$
$\pi^G = \pi$
$X$


magma
Assoc
Id
Div
semigroup
unital magma
quasigroup
Id
Div
Assoc
Inv
Assoc
Id
monoid
inverse semigroup
loop
Inv
Id
Assoc
group

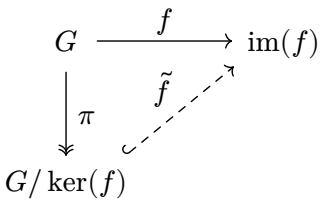

control unit (CU)
input
arithmetic & logic unit (ALU)
output
memory unit (MU)

# Getting started

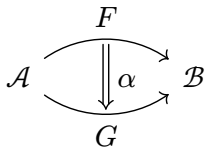
```
#import "@preview/fletcher:0.4.0" as fletcher: node, edge
```

Avoid importing everything * as many internal functions are exported.

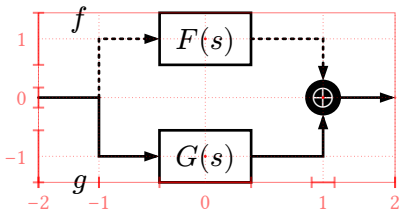
```
// You can specify nodes in math-mode, separated by `&`:
#fletcher.diagram($
  G edge(f, ->) edge("d", pi, ->>) & im(f) \
  G slash ker(f) edge("ur", tilde(f), "hook-->")
$)
```




```
// 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), $alpha$, "=>")
})
```



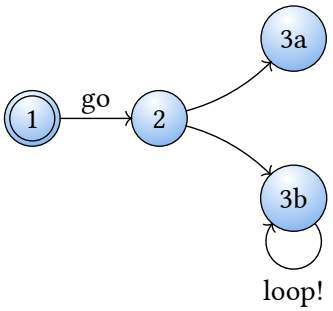

```
#fletcher.diagram(
  debug: true,          // show a coordinate grid
  axes: (ltr, btt),     // make y-axis go ↑
  spacing: (8mm, 3mm), // wide columns, narrow rows
  node-stroke: 1pt,     // outline node shapes
  edge-stroke: 1pt,     // make lines thicker
  mark-scale: 60%,      // make arrowheads smaller
  edge((-2,0), (-1,0)),
  edge((-1,0), (0,+1), $f$, "..|>", corner: right),
  edge((-1,0), (0,-1), $g$, "-|>", corner: left),
  node((0,+1), $F(s)$),
  node((0,-1), $G(s)$),
  edge((0,+1), (1,0), "..|>", corner: right),
  edge((0,-1), (1,0), "-|>", corner: left),
  node((1,0), text(white, $ plus.circle $), inset: 1pt, fill: black),
  edge((1,0), (2,0), "-|>"),
)
```




```
An equation $f: A -> B$ and \
an inline diagram #fletcher.diagram(
  node-inset: 4pt,
  label-sep: 2pt,
  $A edge(->, text(#0.8em, f)) & B$
).
```

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!]),
)
```



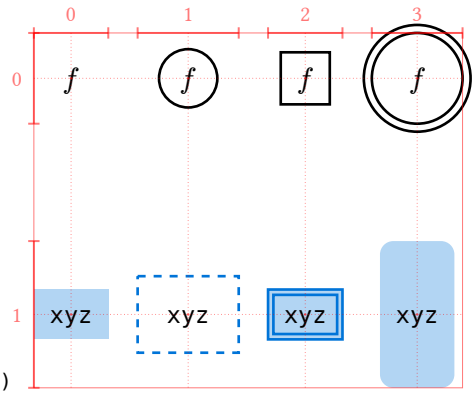
# Nodes

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

Nodes are content centered at a particular coordinate. They automatically fit to the size of their label (with an `inset` and `outset`), can be circular or rectangular (`shape`), and can be given a `stroke` and `fill`.

By default, the coorinates $(x, y)$ are $x$ going $\rightarrow$ and $y$ going $\uparrow$. This can be changed with the `axis` option of `diagram()`.

```
#fletcher.diagram(
  debug: 1,
  spacing: (1em, 4em), // (x, y)
  node((0,0), $f$),
  node((1,0), $f$, stroke: 1pt),
  node((2,0), $f$, stroke: 1pt, 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: 2em)
    node((2,1), `xyz`, fill: b, stroke: blue, extrude: (0, -2))
    node((3,1), `xyz`, fill: b, height: 5em, corner-radius: 5pt)
  }
)
```

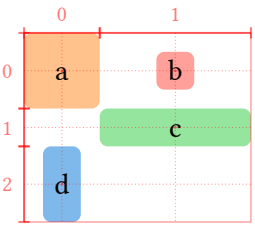



## Elastic coordinates

Diagrams are laid out on a flexible coordinate grid. When a node is placed, the rows and columns grow to accommodate the node's size, like a table. See the `diagram()` parameters for more control: `cell-size` is the minimum row and column width, and `spacing` is the gutter between rows and columns.

Elastic coordinates can be demonstrated more clearly with a debug grid and no `spacing` between cells:

```
#let c = (orange, red, green, blue).map(x => x.lighten(50%))
#fletcher.diagram(
  debug: 1,
  spacing: 0pt,
  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),
)
```

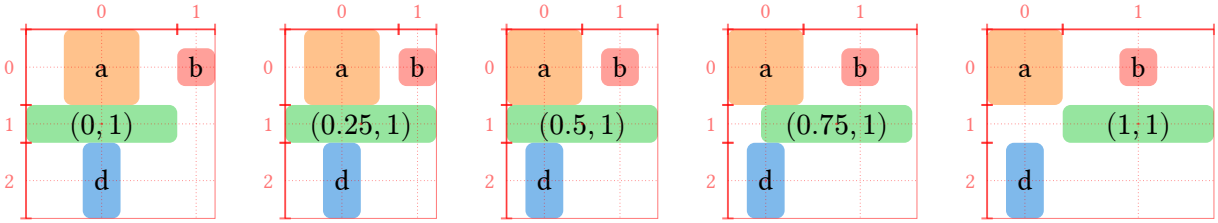



So far, this is just like a table. However, coordinates can also be fractional.

## Fractional coordinates

Rows and columns are at integer coordinates, but nodes may have fractional coordinates. These are dealt with by linearly interpolating the diagram between what it would be if the coordinates were rounded up or down. Both the node's position and its influence on row/column sizes are interpolated.

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

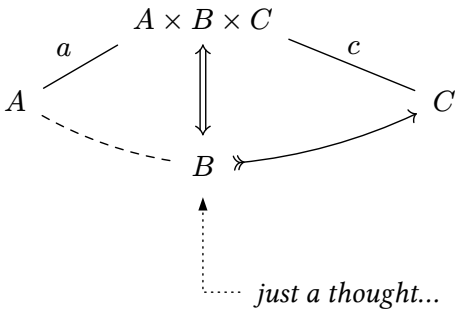


# Edges

`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. 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((0.6, 3), [_just a thought..._])
  edge((0.6, 3), b, "..|>", corner: right)
})
```

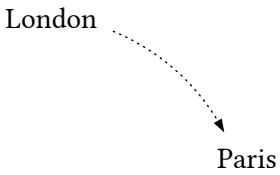



)

## Implicit coordinates

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

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

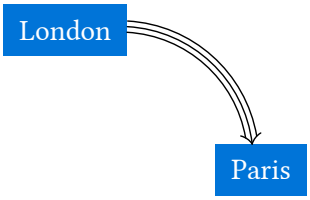



Implicit coordinates can be handy for diagrams in math-mode:

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


However, don't forget you can also use variables in code-mode to avoid repeating coordinates:

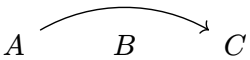
```
#fletcher.diagram(node-fill: blue, {
  let (dep, arv) = ((0,0), (1,1))
  node(dep, text(white)[London])
  node(arv, text(white)[Paris])
  edge(dep, arv, "==>", bend: 40deg)
})
```




## Relative coordinates

It can also be handy to specify the direction of an edge, instead of its end coordinate. This can be done with `edge((x, y), (rel: (Δx, Δy)))`. For convenience, you can also specify a relative coordinate with string of *directions*, 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 do to things like:

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



### The `defocus` adjustment

For aesthetic reasons, lines connecting to a node need not focus to the node's exact center, especially if the node is short and wide or tall and narrow. Notice the difference the figures below. "Defocusing" the connecting lines can make the diagram look more comfortable.

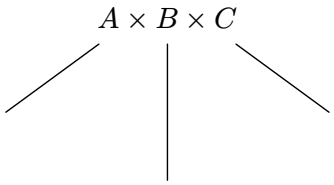



Figure 1: With defocus

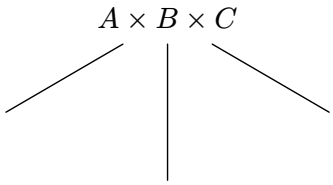
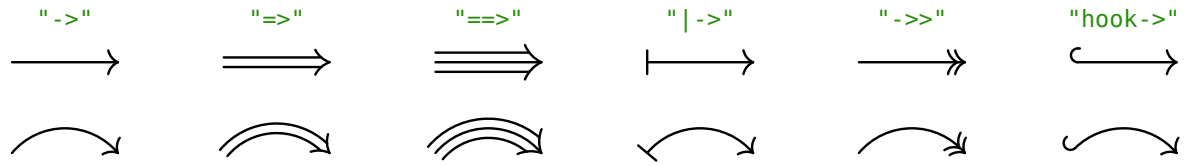



Figure 2: Without defocus

See the `node-defocus` argument of `diagram()` for details.

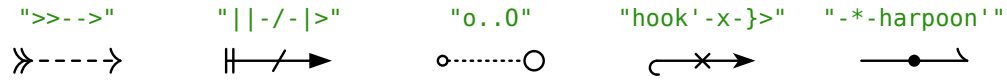
## Marks and arrows

A few mathematical arrow heads are supported, designed to match $\to$, $\Rightarrow$, $\Rrightarrow$, $\mapsto$, $\twoheadrightarrow$, $\hookrightarrow$, etc.




]

Some 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`

Edge styles can be specified with a shorthand like `edge(a, b, "-->")`. See the `marks` argument of `edge()` for details.

### 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 parameters 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: 19deg,
  delta: 43.7deg,
  outer-len: 5.5,
  kind: "head",
)
```

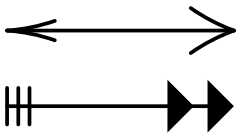
Finally, the fully expanded version of a `marks` shorthand can be inspected by invoking `interpret-marks-arg()`:

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

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

```
(
  marks: (
    (
      size: 4.9,
      angle: 0deg,
      pos: 0,
      rev: true,
      kind: "bar",
    ),
    (
      size: 10.56,
      sharpness: 19deg,
      delta: 43.7deg,
      outer-len: 5.5,
      pos: 1,
      rev: false,
      kind: "head",
    ),
  ),
  extrude: (-2, 2),
)
```

You can customise these basic marks 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)),
)
```

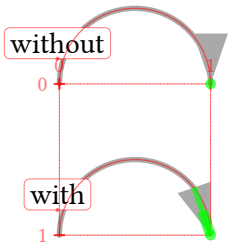


The particular marks and parameters are hard-wired and will likely change as this package is updated (so they are not documented). However, you are encouraged to use the functions `interpret-marks-arg()` and `interpret-mark()` to discover the parameters for finer control.

### 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
)
```



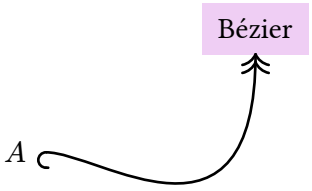

The tail length (specified in multiples of the stroke thickness) is the distance that the arrow head visually extends backwards over the stroke. This is visualised by the green line shown above. The mark is rotated so that the ends of the line both lie on the arc.

## CeTZ integration

Currently, only straight, arc and right-angled connectors are supported. However, an escape hatch is provided with the `render` argument of `diagram()` so you can intercept diagram data and draw things using CeTZ directly.

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

```
#fletcher.diagram(
  node((0,1), $A$),
  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, options)

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

      // get anchor points for the connector
      let p1 = fletcher.get-node-anchor(n1, 0deg)
      let p2 = fletcher.get-node-anchor(n2, -90deg)

      // make some control points
      let c1 = cetz.vector.add(p1, (20pt, 0pt))
      let c2 = cetz.vector.add(p2, (0pt, -80pt))

      cetz.draw.bezier(p1, p2, c1, c2)

      // place an arrow head at a given point and angle
      fletcher.draw-arrow-cap(p2,  90deg, 1pt + black, ">>")
      fletcher.draw-arrow-cap(p1, 180deg, 1pt + black,
        (kind: "hook'", outer-len: 0))
    })
  }
)
```



# Function reference

---

## `diagram()`

Draw an arrow diagram.

**Parameters**

```
diagram(
  ..objects: array,
  debug: bool 1 2 3,
  axes: pair of directions,
  spacing: length pair of lengths,
  cell-size: length pair of lengths,
  node-inset: length pair of lengths,
  node-outset: length pair of lengths,
  node-stroke: stroke,
  node-fill: paint,
  node-corner-radius,
  node-defocus: number,
  label-sep: length,
  edge-stroke,
  mark-scale: length,
  crossing-fill: paint,
  crossing-thickness: number,
  render: function
)
```

### ..objects `array`

An array of dictionaries specifying the diagram's nodes and connections.

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), $D$)
  },
)
```

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

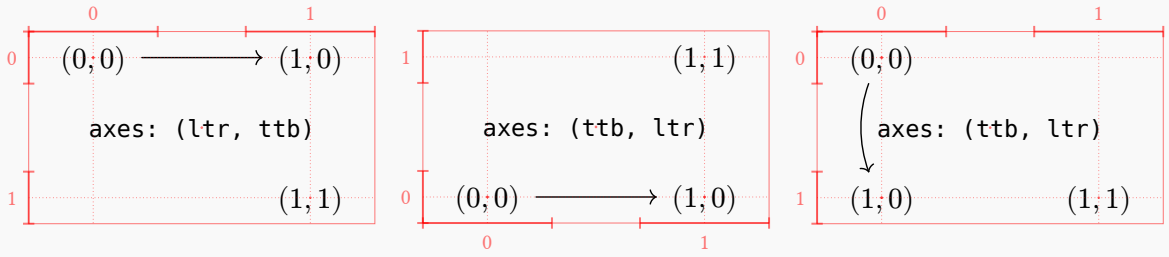
Level of detail for drawing debug information. Level `1` shows a coordinate grid; higher levels show bounding boxes and anchors, etc.

Default: `false`

**axes** `pair of directions`

The directions of the diagram's axes.

This defines the orientation of the 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.

Default: `0pt`

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

Default padding between a node's content and its bounding box.

Default: `12pt`

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

Default padding between a node's boundary and where edges terminate.

Default: `0pt`

**node-stroke** `stroke`

Default stroke for all nodes in diagram. Overridden by individual node options.

Default: `none`

### node-fill `paint`

Default fill for all nodes in diagram. Overridden by individual node options.

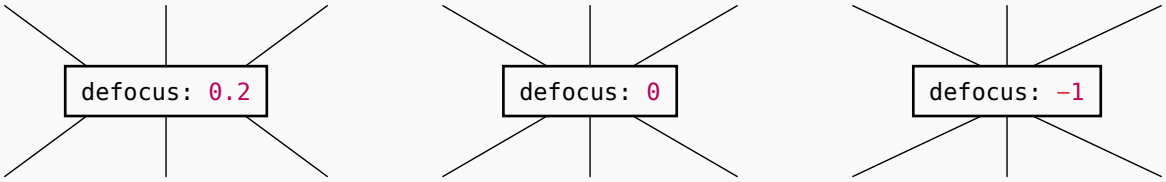
Default: `none`

### node-corner-radius

Default: `0pt`

### node-defocus `number`

Default strength of the "defocus" adjustment for nodes. 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.




Default: `0.2`

### label-sep `length`

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

Default: `0.2em`

### edge-stroke

Default: `0.048em`

### mark-scale `length`

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

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, options)
    )
  }
```

---

## `edge()`

Draw a connecting line or arc in an arrow diagram.

### Parameters

```
edge(
  ..args: any,
  from: elastic coord,
  to: elastic coord,
  label: content,
  label-side: left right center,
  label-pos: number,
  label-sep: number,
  label-anchor: anchor,
  stroke: stroke,
  dash: dash type,
  kind,
  bend: angle,
  corner,
  marks: pair of strings,
  mark-scale: percent,
  extrude: array,
  crossing: bool,
  crossing-thickness: number,
  crossing-fill: paint
)
```

#### ..args `any`

The connector's `label` and `marks` named arguments can also be specified as positional arguments. For example, the following are equivalent:

```
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: "->")
```

#### from `elastic coord`

Start coordinate `(x, y)` of connector. If there is a node at that point, the connector is adjusted to begin at the node's bounding rectangle/circle.

Default: `auto`

#### to `elastic coord`

End coordinate `(x, y)` of connector. If there is a node at that point, the connector is adjusted to end at the node's bounding rectangle/circle.

Default: `auto`

#### label `content`

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

Default: `none`

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

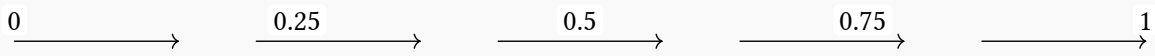
Which side of the connector to place the label on, viewed as you walk along it. If `center`, then the label is place over the connector. When `auto`, a value of `left` or `right` is chosen to automatically so that the label is

- 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 `number`

Separation between the connector and the label anchor.

With the default anchor (`"bottom"`):


With `label-anchor: "center"`:


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`

### stroke `stroke`

Stroke style of the edge. Arrows scale with the stroke thickness.

Default: `auto`

### dash `dash type`

Dash style for the connector stroke.

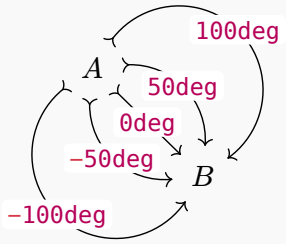
Default: `none`

### kind

Default: `auto`

### bend `angle`

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




Default: `0deg`

### corner

Default: `none`

### marks `pair of strings`

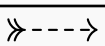
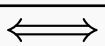
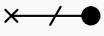
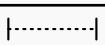
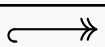
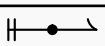
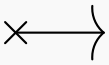
The marks (arrowheads) to draw along an edge's stroke. This may be:

- 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("=>"))`.

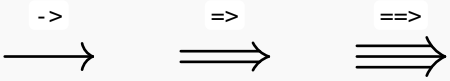
| Arrow | marks |
|---|---|
|  | `"->"` |
|  | `">>--->"` |
|  | `"<=>"` |
|  | `"==>"` |
|  | `"->>-"` |
|  | `"x-/-@"` |
|  | `"\|..\|"` |
|  | `"hook->>"` |
|  | `"hook'->>"` |
|  | `"\|\|-*-harpoon'"` |
|  | `("X", (kind: "head", size: 15, sharpness: 40deg))` |
|  | `((kind: "circle", pos: 0.5, fill: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

Default: `(none, none)`

### mark-scale `percent`

Scale factor for marks or arrowheads.


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

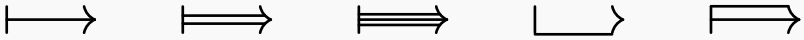



Default: `100%`

### 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.

`(0,)` `(-1.5, 1.5)` `(-2, 0, 2)` `(-0.5em,)` `(0, 5pt)`



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()`.

Default: `(0,)`

### 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, if `crossing: 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 the `crossing-fill` option of `diagram()`.


Default: `auto`

---

## `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 types.

Generally, the following combinations are allowed:

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

**Parameters**

```
interpret-edge-args(args)
```

**args**

---

## node()

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

**Parameters**

```
node(
  pos: point,
  label: content,
  inset: length auto,
  outset: length auto,
  shape: string auto,
  width,
  height,
  radius,
  stroke: stroke,
  fill: paint,
  corner-radius,
  defocus: number,
  extrude: array
)
```

**pos** `point`

Dimensionless "elastic coordinates" `(x, y)` of the node, where `x` is the column and `y` is the row (increasing upwards). The coordinates are usually integers, but can be fractional.

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

**label** `content`

Node content to display.

### inset `length` or `auto`

Padding between the node's content and its bounding box or bounding circle. If `auto`, defaults to the `node-inset` option of `diagram()`.

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 edges connect to the node.

Default: `auto`

### shape `string` or `auto`

Shape of the node, one of `"rect"` or `"circle"`. If `auto`, shape is automatically chosen depending on the aspect ratio of the node's label.

Default: `auto`

### width

Default: `auto`

### height

Default: `auto`

### radius

Default: `auto`

### stroke `stroke`

Stroke style for the node outline. Defaults to the `node-stroke` option of `diagram()`.

Default: `auto`

### fill `paint`

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

Default: `auto`

#### corner-radius

Default: `auto`

#### defocus `number`

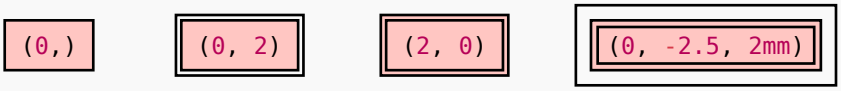
Strength of the "defocus" adjustment for connectors incident with this node. If `auto`, defaults to the `node-defocus` option of `diagram()`.

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,)`

---

## `compute-grid()`

Determine the number, sizes and positions of rows and columns.

**Parameters**

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

#### nodes

#### options

---

## `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.

**Parameters**

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

**rects** `array of rects`

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

---

## get-edge-anchors()

Get the points where a connector between two nodes should be drawn between, taking into account the nodes' sizes and relative positions.

**Parameters**

```
get-edge-anchors(
  edge: dictionary,
  nodes: pair of dictionaries
) -> pair of points
```

**edge** `dictionary`

The connector whose end points should be determined.

**nodes** `pair of dictionaries`

The start and end nodes of the connector.

---

## get-node-anchor()

Get the point at which a connector should attach to a node from a given angle, taking into account the node's size and shape.

**Parameters**

```
get-node-anchor(
  node: dictionary,
  θ: angle
) -> point
```

**node** `dictionary`

The node to connect to.

**θ** `angle`

The desired angle from the node's center to the connection point.

## 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.

**Parameters**

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

### mark

### defaults

Default: `(:)`

## interpret-marks-arg()

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

**Parameters**

`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
- `tail` the visual length of the mark's tail
- parameters specific to the kind of mark, e.g., `size` or `sharpness`

## round-arrow-cap-offset()

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

**Parameters**

```
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.

---

## `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

**Parameters**

```
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.