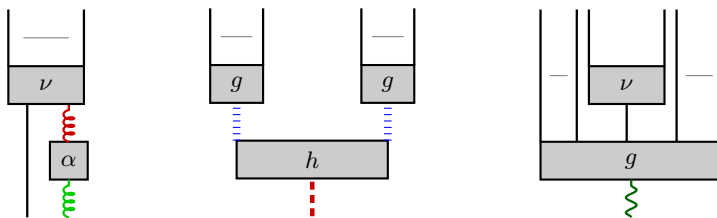


BOX DIAGRAMS IN TIKZ

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1. INTRODUCTION

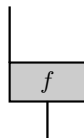
Box diagrams are a rudimentary form of string diagram used to represent a function or morphism in a category. We implement them as a type of object in tikz, analogous to a node. Some examples created with this package include:



2. BASICS

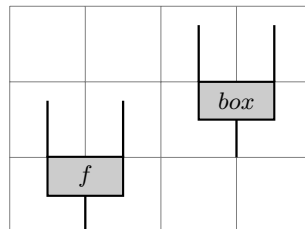
2.1. Box diagrams are created and drawn using `\boxdiagram` and `\drawBd`, e.g.,

```
\begin{tikzpicture}
  \boxdiagram{f}; \drawBd{f};
\end{tikzpicture}
```

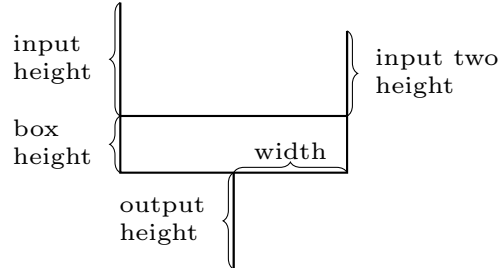


2.2. Just as one can set the coordinate, label, etc. of a node, each box has many attributes. There are default values that can be changed when creating or drawing the box, by passing an optional list of key-value pairs. Two of the most basic attributes are `coord`, the coordinate of the bottom end of the output, with default value `(0,0)`, and `label`, the label printed inside the box (with default value the name of the diagram).

```
\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \boxdiagram[coord = {(2,1)},
    label = box]{g};
  \drawBd{g};
\end{tikzpicture}
```

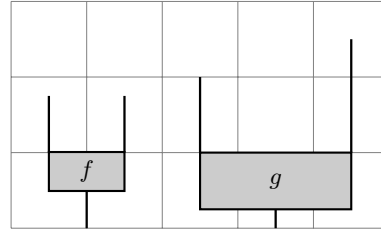


2.3. There are five size attributes: `width`, `box height`, `input height`, `input two height`, `output height`:¹



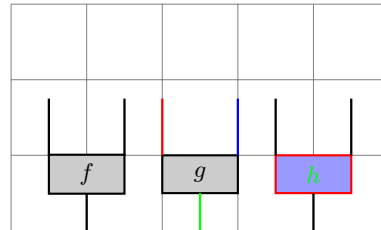
The default values are: `width = .5cm`, `box height = .5cm`, `input height = .75cm`, `input two height = .75cm`, `output height = .5cm`. For example:

```
\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \boxdiagram[coord = {(2.5,0)}]{g};
  \drawBd[width = 1cm,
    box height = .75cm,
    input height = 1cm,
    input two height = 1.5cm,
    output height = .25cm]{g};
\end{tikzpicture}
```



2.4. Colors can be changed with the attributes `input color`, `input two color`, `output color`, `box line color`, `box fill color`, `label color`, whose default values are all black, except for `box fill color`, which is black!20. For example:

```
\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \boxdiagram[coord = {(1.5,0)}]{g};
  \drawBd[input color = red,
    input two color = blue,
    output color = green]{g};
  \boxdiagram[coord = {(3,0)}]{h};
  \drawBd[box line color = red,
    box fill color = blue!40,
    label color = green]{h};
\end{tikzpicture}
```

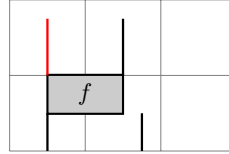


2.5. Instead of drawing the whole diagram, one can draw pieces with the functions `drawBox`, `drawInput`, `drawInputTwo`, `drawOutput`; the last three take as a second argument the relative horizontal position of the line to be drawn, with -1 the left side of the box and 1 the right side of the box. The relative position does not

¹An explanation for the variable names is that box diagrams can be used to represent functions, with the top lines representing input values and the bottom line the value on the function on these inputs; more generally, the diagram can be used in the same way to represent a morphism from a tensor product of a module to another module.

have to be between $[-1,1]$. For example:

```
\begin{tikzpicture}
  \boxdiagram[input color = red]{f};
  \drawBox{f};
  \drawInput{f}{-1};
  \drawInputTwo{f}{1};
  \drawOutput{f}{-1};
  \drawOutput{f}{1.5};
\end{tikzpicture}
```



You can draw straight lines using the following:

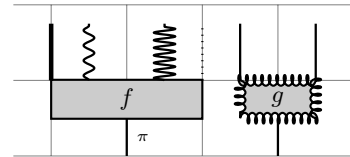
```
\begin{tikzpicture}
  \boxdiagram[box height = 0pt,
    output height = 0pt]{f};
  \drawInput{f}{-1};
  \drawInput{f}{0};
  \drawInput{f}{1};
\end{tikzpicture}
```



You can draw lines the usual way in TikZ, but using a box diagram can help with spacing in a more complicated display.

2.6. Each of the four line types: input, input two, output, and box line, have six different style attributes: `dash pattern`, `line width`, `label`, `dec`, `dec amp`, `dec seg length`, where `dec` stands for decoration, and uses the decoration library of TikZ (also there is no label allowed on the box line). The default values are `dash pattern = {}`, `line width = .3mm`, `label = {}`, `dec = {}`, `dec amp = 2`, `dec seg length = .2cm`. For example:

```
\begin{tikzpicture}
  \boxdiagram[width = 1cm,
    input two dash pattern = dotted,
    output label = \pi]{f};
  \drawBd[input line width = .6mm]{f};
  \drawInput[input dec = snake]{f}{-.5};
  \drawInput[input dec = snake,
    input dec amp = 4,
    input dec seg length = .1cm]{f}{.5};
  \boxdiagram[coord = {(2,0)},
    box line dec = coil,
    box line dec seg length = .1cm]{g};
  \drawBd{g};
\end{tikzpicture}
```

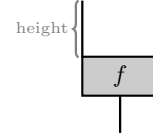


Another common type of example is:

```

\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \drawInput[input dec = brace,
             input color = gray,
             input label = \text{height},
             input label position = left]{f}{-1.1};
\end{tikzpicture}

```

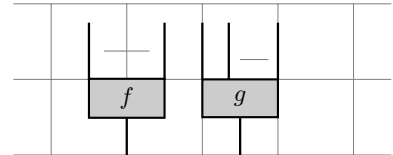


2.7. To draw a horizontal line in the diagram one can use `drawHLine`. Horizontal lines can be used to imply that there are many inputs. The position attributes of an hline are `hline left`, `hline right` and `hline vert`. The left and right attributes give the relative starting and ending position of the horizontal line: -1 is the left end of the box and 1 is the right end of the box (parameters outside of $[-1,1]$ are allowed). The default values are $-.6$ and $.6$; `hline vert` is the relative vertical position above the diagram: 0 is the top of the box and 1 is the top of the input line. The default value is $.5$. For example:

```

\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \drawHLine{f};
  \boxdiagram[coord = {(1.5,0)}]{g};
  \drawBd{g};
  \drawInput{g}{-.3};
  \drawHLine[hline left = 0,
             hline right = .75,
             hline vert = .25]{g};
\end{tikzpicture}

```

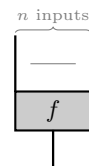


The color of an hline is `hline color`, with default gray, and there is `hline dash pattern` with default value empty. Labels can be assigned and positioned on hlines with `hline label`, `hline label position`, with default value empty and above, respectively. Finally, we can decorate hlines analogously to other lines using `hline dec`, `hline dec amp`, `hline dec seg length`. For example:

```

\begin{tikzpicture}
  \boxdiagram{f};
  \drawBd{f};
  \drawHLine{f};
  \drawHLine[hline left = -1,
             hline right = 1,
             hline vert = 1.05,
             hline dec = brace,
             hline label = n \text{ inputs}]{f};
\end{tikzpicture}

```



2.8. We can use `pgfkeys` to set commonly used sets of key-values. For instance, the brace above the diagram in the above example is often used, so we set

```

\pgfkeys{braceDec/.style = {hline left = -1, hline right = 1,

```

```
hline vert = 1.05, hline dec = brace}}.
```

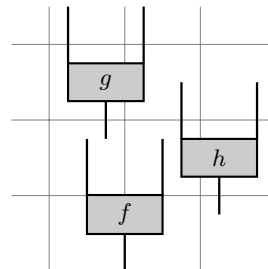
We can then do the following:

```
\begin{tikzpicture}
\boxdiagram{f};
\drawBd{f};
\drawHLine{f};
\drawHLine[/braceDec,
           hline label = \text{n inputs}]{f};
\end{tikzpicture}
```



2.9. Coordinates make it easier to work with several diagrams. The coordinate functions are `coordTopInput`, `coordTopBox`, `coordBottomBox`, `coordBottomOutput`. They each take three inputs: the first is a box diagram, the second is the name of the coordinate to be returned, and the third is a relative horizontal position, with -1 the left end of the box and 1 the right end. We stress that you do not need to create a coordinate node, just pass a name. For example:

```
\begin{tikzpicture}
\boxdiagram{f};
\drawBd{f};
\coordTopInput{f}{coor}{-.5};
\boxdiagram[coord = (coor)]{g};
\drawBd{g};
\coordTopBox{f}{coor1}{2.5};
\coordBottomBox{f}{coor2}{2.5};
\boxdiagram[coord = ($(coor1)!.5!(coor2)$)]{h};
\drawBd{h};
\end{tikzpicture}
```



3. BUGS

- (1) The following won't compile:

```
\boxdiagram[label = \mu]{mu}
```

but, e.g., the following does:

```
\boxdiagram[label = \mu]{m}.
```

The following does not,

```
\boxdiagram[label = \alpha]{a},
```

but the following does

```
\boxdiagram[label = \alpha]{ab}.
```