

The package `witharrows`*

F. Pantigny
fpantigny@wanadoo.fr

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Abstract

The LaTeX package `witharrows` provides environments `{WithArrows}` and `{DispWithArrows}` similar to the environments `{aligned}` and `{align}` of `amsmath` but with the possibility to draw arrows on the right side of the alignment. These arrows are usually used to give explanations concerning the mathematical calculus presented.

This package can be used with `xelatex`, `lualatex`, `pdflatex` but also by the classical workflow `latex-dvips-ps2pdf` (or Adobe Distiller). Two compilations may be necessary. This package requires the packages `expl3`, `xparse` and `tikz`. The Tikz libraries `arrows.meta` and `bending` are also required.

This package provides an environment `{WithArrows}` to construct alignments of equations with arrows for the explanations on the right side:

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow{we expand} \\
& = a^2 + 2a + 1 \\
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \begin{array}{l} \searrow \\ \text{we expand} \end{array}$$

The arrow has been drawn with the command `\Arrow` on the row from which it starts. The command `\Arrow` must be used in the second column (the best way is to put it at the end of the second cell of the row as in the previous example).

The environment `{WithArrows}` bears similarities with the environment `{aligned}` of `amsmath` (and `mathtools`). The extension `witharrows` also provides an environment `{DispWithArrows}` which is similar to the environment `{align}` of `amsmath`: cf. p. 14.

1 Options for the shape of the arrows

The command `\Arrow` has several options. These options can be put between square brackets, before, or after the mandatory argument.

The option `jump` gives the number¹ of rows the arrow must jump (the default value is, of course, 1).

```
$\begin{WithArrows}
A & = \bigl((a+b)+1\bigr)^2 \Arrow[jump=2]{we expand} \\
& = (a+b)^2 + 2(a+b) + 1 \\
& = a^2 + 2ab + b^2 + 2a + 2b + 1 \\
\end{WithArrows}$
```

*This document corresponds to the version 1.10 of `witharrows`, at the date of 2018/09/13.

¹It's not possible to give a non-positive value to `jump`. See below (p. 2) the way to draw an arrow which goes backwards.

$$\begin{aligned}
 A &= ((a+b)+1)^2 \\
 &= (a+b)^2 + 2(a+b) + 1 \\
 &= a^2 + 2ab + b^2 + 2a + 2b + 1
 \end{aligned}
 \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{we expand}$$

It's possible to put several arrows which start from the same row.

```

 $\begin{WithArrows}$ 
A &= \bigl((a+b)+1\bigr)^2 \quad \textcolor{violet}{\Arrow{}}\textcolor{violet}{\Arrow{}}[jump=2] \\
&= (a+b)^2 + 2(a+b) + 1 \\
&= a^2 + 2ab + b^2 + 2a + 2b + 1
\end{WithArrows}

```

$$\begin{aligned}
 A &= ((a+b)+1)^2 \\
 &= (a+b)^2 + 2(a+b) + 1 \\
 &= a^2 + 2ab + b^2 + 2a + 2b + 1
 \end{aligned}
 \quad \left. \begin{array}{l} \\ \\ \end{array} \right\}$$

The option `xoffset` shifts the arrows to the right (we usually don't want the arrows to be stucked on the text). The default value of `xoffset` is 3 mm.

```

 $\begin{WithArrows}$ 
A &= \bigl((a+b)+1\bigr)^2 \\
\textcolor{violet}{\Arrow[xoffset=1cm]{}}\textcolor{violet}{\texttt{\texttt{xoffset=1cm}}}} \\
&= (a+b)^2 + 2(a+b) + 1
\end{WithArrows}

```

$$\begin{aligned}
 A &= ((a+b)+1)^2 \\
 &= (a+b)^2 + 2(a+b) + 1
 \end{aligned}
 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{with } \textcolor{violet}{xoffset=1cm}$$

The arrows are drawn with Tikz. That's why the command `\Arrow` has an option `tikz` which can be used to give to the arrow (in fact, the command `\path` of Tikz) the options proposed by Tikz for such an arrow. The following example gives an thick arrow.

```

 $\begin{WithArrows}$ 
A &= (a+1)^2 \quad \textcolor{violet}{\Arrow[tikz=thick]{}}\textcolor{violet}{\texttt{we expand}} \\
&= a^2 + 2a + 1
\end{WithArrows}

```

$$\begin{aligned}
 A &= (a+1)^2 \\
 &= a^2 + 2a + 1
 \end{aligned}
 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{we expand}$$

It's also possible to change the arrowheads. For example, we can draw an arrow which goes backwards with the Tikz option `<-`.

```

 $\begin{WithArrows}$ 
A &= (a+1)^2 \quad \textcolor{violet}{\Arrow[tikz=<-]{}}\textcolor{violet}{\texttt{we factorize}} \\
&= a^2 + 2a + 1
\end{WithArrows}

```

$$\begin{aligned}
 A &= (a+1)^2 \\
 &= a^2 + 2a + 1
 \end{aligned}
 \quad \left. \begin{array}{l} \\ \end{array} \right\} \text{we factorize}$$

It's also possible to suppress both tips of the arrow with the Tikz option `-`.

```

 $\begin{WithArrows}$ 
A &= (a+1)^2 \quad \textcolor{violet}{\Arrow[tikz=-]{}}\textcolor{violet}{\texttt{very classical}} \\
&= a^2 + 2a + 1
\end{WithArrows}

```

$$A = (a + 1)^2 \\ = a^2 + 2a + 1 \quad \Bigg) \textit{ very classical}$$

In order to have straight arrows instead of curved ones, we must use the Tikz option “`bend left = 0`”.

```
$\begin{WithArrows}
A &= (a+1)^2 \Arrow[tikz={bend left=0}]{we expand} \\
&= a^2 + 2a + 1 \\
\end{WithArrows}$
```

$$A = (a + 1)^2 \\ = a^2 + 2a + 1 \quad \downarrow \textit{we expand}$$

In fact, it’s possible to change more drastically the shape or the arrows with the option `TikzCode` presented p. 16.

One of the most useful options is “`text width`” to control the width of the text associated to the arrow.

```
$\begin{WithArrows}
A &= \bigl((a+b)+1\bigr)^2 \\
\Arrow[jump=2,tikz={text width=5.3cm}]{We have done...} \\
&= (a+b)^2 + 2(a+b) + 1 \\
&= a^2 + 2ab + b^2 + 2a + 2b + 1 \\
\end{WithArrows}$
```

$$A = ((a + b) + 1)^2 \\ = (a + b)^2 + 2(a + b) + 1 \\ = a^2 + 2ab + b^2 + 2a + 2b + 1 \quad \Bigg) \begin{array}{l} \textit{We have done a two-stages expansion} \\ \textit{but it would have been clever to ex-} \\ \textit{pand with the multinomial theorem.} \end{array}$$

In the environments `{DispWithArrows}` and `{DispWithArrows*}`, there is an option `wrap-lines`. With this option, the lines of the labels are automatically wrapped on the right: see p. 15.

If we want to change the font of the text associated to the arrow, we can, of course, put a command like `\bfseries`, `\large` or `\sffamily` at the beginning of the text. But, by default, the texts are composed with a combination of `\small` and `\itshape`. When adding `\bfseries` at the beginning of the text, we won’t suppress the `\small` and the `\itshape` and we will consequently have a text in a bold, italic and small font.

```
$\begin{WithArrows}
A &= (a+1)^2 \Arrow{\bfseries we expand} \\
&= a^2 + 2a + 1 \\
\end{WithArrows}$
```

$$A = (a + 1)^2 \\ = a^2 + 2a + 1 \quad \Bigg) \textit{we expand}$$

It’s possible to put commands `\\` in the text to force new lines². However, if we put a `\\`, a command of font placed in the beginning of the text will have effect only until the first command `\\` (like in an environment `{tabular}`). That’s why Tikz gives an option `font` to modify the font of the whole text. Nevertheless, if we use the option `tikz={font={\bfseries}}`, the default specification of `\small` and `\itshape` will be overwritten.

²By default, this is not possible in a Tikz node. However, in `witharrows`, the nodes are created with the option `align=left`, and, thus, it becomes possible.

```

 $\begin{WithArrows}$ 
A & = (a+1)^2 \Arrow[tikz={font={\bfseries}}]{we expand} \\
& = a^2 + 2a + 1 \\
\end{WithArrows}

```

$$\begin{aligned}
 A &= (a+1)^2 \\
 &= a^2 + 2a + 1 \quad \searrow \text{we expand}
 \end{aligned}$$

If we want exactly the same result as previously, we have to give to the option `font` the value `{\itshape\small\bfseries}`.

Almost all the options can be given directly to the environment `{WithArrows}` (between square brackets). In this case, they apply to all the arrows of the environment.³

```

 $\begin{WithArrows}[tikz=blue]$ 
A & = \bigl((a+b)+1\bigr)^2 \Arrow{First expansion.} \\
& = (a+b)^2 + 2(a+b) + 1 \Arrow{Second expansion.} \\
& = a^2 + 2ab + b^2 + 2a + 2b + 1 \\
\end{WithArrows}

```

$$\begin{aligned}
 A &= ((a+b)+1)^2 \\
 &= (a+b)^2 + 2(a+b) + 1 \quad \searrow \text{First expansion.} \\
 &= a^2 + 2ab + b^2 + 2a + 2b + 1 \quad \searrow \text{Second expansion.}
 \end{aligned}$$

The environment `{WithArrows}` has an option `displaystyle`. With this option, all the elements are composed in `\displaystyle` (like in an environment `{aligned}` of `amsmath`).

Without the option `displaystyle`:

```

 $\begin{WithArrows}$ 
\int_0^1 (x+1)^2 dx
& = \int_0^1 (x^2+2x+1) dx \\
\Arrow{linearity of integration} \\
& = \int_0^1 x^2 dx + 2 \int_0^1 x dx + \int_0^1 dx \\
& = \frac{1}{3} + 2\frac{1}{2} + 1 \\
& = \frac{7}{3} \\
\end{WithArrows}

```

$$\begin{aligned}
 \int_0^1 (x+1)^2 dx &= \int_0^1 (x^2 + 2x + 1) dx \\
 &= \int_0^1 x^2 dx + 2 \int_0^1 x dx + \int_0^1 dx \quad \searrow \text{linearity of integration} \\
 &= \frac{1}{3} + 2\frac{1}{2} + 1 \\
 &= \frac{7}{3}
 \end{aligned}$$

The same example with the option `displaystyle`:

$$\begin{aligned}
 \int_0^1 (x+1)^2 dx &= \int_0^1 (x^2 + 2x + 1) dx \\
 &= \int_0^1 x^2 dx + 2 \int_0^1 x dx + \int_0^1 dx \quad \searrow \text{linearity of integration} \\
 &= \frac{1}{3} + 2\frac{1}{2} + 1 \\
 &= \frac{7}{3}
 \end{aligned}$$

There are also two options for a fine tuning of the arrows:

³They also apply to the nested environments `{WithArrows}` (with the logical exceptions of `interline`, `CodeBefore` and `CodeAfter`).

- the option `ystart` sets the vertical distance between the base line of the text and the start of the arrow (default value: 0.4 ex);
- the option `ygap` sets the vertical distance between two consecutive arrows (default value: 0.4 ex).

$$\begin{aligned}
 (\cos x + \sin x)^2 &= \cos^2 x + 2 \cos x \sin x + \sin^2 x \xrightarrow{\text{ystart}} \\
 &= \cos^2 x + \sin^2 x + 2 \sin x \cos x \xrightarrow{\text{ygap}} \\
 &= 1 + \sin(2x)
 \end{aligned}$$

Remark: It's also possible to use the options “`shorten <`” and “`shorten >`” of Tikz (via the option `tikz` of `witharrows`).

Almost all the options can also be set at the document level with the command `\WithArrowsOptions`. In this case, the scope of the declarations is the current TeX group (these declarations are “semi-global”). For example, if we want all the environments `{WithArrows}` composed in `\displaystyle` with blue arrows, we can write `\WithArrowsOptions{displaystyle,tikz=blue}`.⁴

```

\WithArrowsOptions{displaystyle,tikz=blue}
$\begin{WithArrows}
\sum_{i=1}^n (x_i+1)^2
&= \sum_{i=1}^n (x_i^2+2x_i+1) \ \Arrow{by linearity}\\
&= \sum_{i=1}^n x_i^2 + 2\sum_{i=1}^n x_i + n
\end{WithArrows}$

```

$$\begin{aligned}
 \sum_{i=1}^n (x_i + 1)^2 &= \sum_{i=1}^n (x_i^2 + 2x_i + 1) \\
 &= \sum_{i=1}^n x_i^2 + 2 \sum_{i=1}^n x_i + n
 \end{aligned}
 \quad \begin{array}{l} \text{by linearity} \end{array}$$

The command `\Arrow` is recognized only in the environments `{WithArrows}`. If we have a command `\Arrow` previously defined, it's possible to go on using it outside the environments `{WithArrows}`. However, a previously defined command `\Arrow` may still be useful in an environment `{WithArrows}`. If we want to use it in such an environment, it's possible to change the name of the command `\Arrow` of the package `witharrows`: there is an option `CommandName` for this purpose. The new name of the command must be given to the option *without* the leading backslash.

```

\NewDocumentCommand {\Arrow} {} {\longmapsto}
$\begin{WithArrows}[CommandName=Explanation]
f &= \bigl(x \ \Arrow (x+1)^2\bigr)
\Explanation{we work directly on fonctions}\\
&= \bigl(x \ \Arrow x^2+2x+1\bigr)
\end{WithArrows}$

```

$$\begin{aligned}
 f &= (x \mapsto (x+1)^2) \\
 &= (x \mapsto x^2 + 2x + 1)
 \end{aligned}
 \quad \begin{array}{l} \text{we work directly on fonctions} \end{array}$$

The environment `{WithArrows}` gives also two options `CodeBefore` and `CodeAfter` for LaTeX code that will be executed at the beginning and at the end of the environment. These options are not designed to be hooks (they are available only at the environment level and they are not applied to the nested environments).

⁴It's also possible to configure `witharrows` by modifying the Tikz style `WithArrows/arrow` which is the style used by `witharrows` when drawing an arrow. For example, to have the labels in blue with roman (upright) types, one can use the following instruction: `\tikzset{WithArrows/arrow/.append style = {blue, font = {}}}`.

```

 $\begin{WithArrows}[CodeBefore = \color{blue}]
A \& = (a+b)^2 \Arrow{we expand} \\
& = a^2 + 2ab + b^2 \\
\end{WithArrows}$ 

```

$$\begin{array}{l}
A = (a+b)^2 \\
= a^2 + 2ab + b^2 \quad \downarrow \text{we expand}
\end{array}$$

Special commands are available in **CodeAfter**: a command **\NbLines** which gives the number of lines (=rows) of the current environment (this is a command and not a counter), a special form of the command **\Arrow** and the command **\MultiArrow**: these commands are described in the section concerning the nested environments, p. 10.

2 Precise positioning of the arrows

The environment **{WithArrows}** defines, during the composition of the array, two series of nodes materialized in red in the following example.⁵

$$\begin{array}{l}
I = \int_{\frac{\pi}{4}}^0 \ln\left(1 + \tan\left(\frac{\pi}{4} - u\right)\right)(-du) \quad , \\
= \int_0^{\frac{\pi}{4}} \ln\left(1 + \tan\left(\frac{\pi}{4} - u\right)\right)du \quad , \\
= \int_0^{\frac{\pi}{4}} \ln\left(1 + \frac{1 - \tan u}{1 + \tan u}\right) du \quad , \\
= \int_0^{\frac{\pi}{4}} \ln\left(\frac{1 + \tan u + 1 - \tan u}{1 + \tan u}\right) du \quad , \\
= \int_0^{\frac{\pi}{4}} \ln\left(\frac{2}{1 + \tan u}\right) du \quad , \\
= \int_0^{\frac{\pi}{4}} (\ln 2 - \ln(1 + \tan u)) du \quad , \\
= \frac{\pi}{4} \ln 2 - \int_0^{\frac{\pi}{4}} \ln(1 + \tan u) du \quad , \\
= \frac{\pi}{4} \ln 2 - I \quad ,
\end{array}$$

The nodes of the left are at the end of each line of text. These nodes will be called *left nodes*. The nodes of the right side are aligned vertically on the right side of the array. These nodes will be called *right nodes*.

By default, the arrows use the right nodes. We will say that they are in **rr** mode (*r* for *right*). These arrows are **vertical** (we will say that an arrow is *vertical* when its two ends have the same abscissa).

However, it's possible to use the left nodes, or a combination of left and right nodes, with one of the options **lr**, **rl** and **ll** (*l* for *left*). Those arrows are, usually, not vertical.

⁵The option **shownodes** can be used to materialize the nodes. The nodes are in fact Tikz nodes of shape “rectangle”, but with zero width. An arrow between two nodes starts at the *south* anchor of the first node and arrives at the *north* anchor of the second node.

Therefore $I = \int_{\frac{\pi}{4}}^0 \ln\left(1 + \tan\left(\frac{\pi}{4} - u\right)\right)(-du)$ *This arrow uses the `lr` option.*

$$\begin{aligned}
&= \int_0^{\frac{\pi}{4}} \ln\left(1 + \tan\left(\frac{\pi}{4} - u\right)\right) du \\
&= \int_0^{\frac{\pi}{4}} \ln\left(1 + \frac{1 - \tan u}{1 + \tan u}\right) du \\
&= \int_0^{\frac{\pi}{4}} \ln\left(\frac{1 + \tan u + 1 - \tan u}{1 + \tan u}\right) du \\
&= \int_0^{\frac{\pi}{4}} \ln\left(\frac{2}{1 + \tan u}\right) du \\
&= \int_0^{\frac{\pi}{4}} (\ln 2 - \ln(1 + \tan u)) du \quad \leftarrow \text{This arrow uses a `ll` option and a `jump` equal to 2} \\
&= \frac{\pi}{4} \ln 2 - \int_0^{\frac{\pi}{4}} \ln(1 + \tan u) du \\
&= \frac{\pi}{4} \ln 2 - I
\end{aligned}$$

There is also an option called `i` (*i* for *intermediate*). With this option, the arrow is vertical and at the leftmost position.

```

\begin{WithArrows}
(a+b)(a+ib)(a-b)(a-ib)
&= (a+b)(a-b)\cdot(a+ib)(a-ib) \\\
&= (a^2-b^2)(a^2+b^2) \ \Arrow[i]{because \$(x-y)(x+y)=x^2-y^2\$}\\
&= a^4-b^4
\end{WithArrows}

```

$$\begin{aligned}
(a+b)(a+ib)(a-b)(a-ib) &= (a+b)(a-b) \cdot (a+ib)(a-ib) \\
&= (a^2-b^2)(a^2+b^2) \\
&= a^4-b^4 \quad \downarrow \text{because } (x-y)(x+y) = x^2-y^2
\end{aligned}$$

The environment `{WithArrows}` gives also a `group` option. With this option, *all* the arrows of the environment are grouped on a same vertical line and at a leftmost position.

```

\begin{WithArrows}[displaystyle,group]
2xy'-3y=\sqrt{x}
&\Longleftarrow 2x(K'y_0+Ky_0')-3Ky_0 = \sqrt{x} \\\
&\Longleftarrow 2xK'y_0 + K(2xy_0'-3y_0) = \sqrt{x} \\\
&\Longleftarrow 2xK'y_0 = \sqrt{x} \ \Arrow{...} \\\
...
\end{WithArrows}

```

$$\begin{aligned}
2xy' - 3y &= \sqrt{x} \iff 2x(K'y_0 + Ky_0') - 3Ky_0 = \sqrt{x} \\
&\iff 2xK'y_0 + K(2xy_0' - 3y_0) = \sqrt{x} \\
&\iff 2xK'y_0 = \sqrt{x} \\
&\iff 2xK'x^{\frac{3}{2}} = x^{\frac{1}{2}} \quad \downarrow \text{We replace } y_0 \text{ by its value.} \\
&\iff K' = \frac{1}{2x^2} \quad \downarrow \text{simplification of the } x \\
&\iff K = -\frac{1}{2x} \quad \downarrow \text{antiderivation}
\end{aligned}$$

The environment `{WithArrows}` gives also a `groups` option (with a *s* in the name). With this option, the arrows are divided into several “groups”. Each group is a set of connected⁶ arrows. All the arrows of a given group are grouped on a same vertical line and at a leftmost position.

⁶More precisely: for each arrow a , we note $i(a)$ the number of its initial row and $f(a)$ the number of its final line; for two arrows a and b , we say that $a \sim b$ when $\llbracket i(a), f(a) \rrbracket \cap \llbracket i(b), f(b) \rrbracket \neq \emptyset$; the groups are the equivalence classes of the transitive closure of \sim .

$$\begin{aligned}
A &= B \\
&= C + D && \left. \begin{array}{l} \downarrow \text{one} \\ \downarrow \text{two} \end{array} \right\} \\
&= D' \\
&= E + F + G + H + I \\
&= K + L + M && \left. \begin{array}{l} \downarrow \text{three} \\ \downarrow \text{four} \end{array} \right\} \\
&= N \\
&= O
\end{aligned}$$

If desired, the option `group` or the option `groups` can be given to the command `\WithArrowsOptions` so that it will become the default value. In this case, it's still possible to come back to the default behaviour for a given environment `{WithArrows}` with the option `rr`: `\begin{WithArrows}[rr]`

3 Comparison with the environment `{aligned}`

`{WithArrows}` bears similarities with the environment `{aligned}` of the extension `amsmath`. These are only similarities because `{WithArrows}` has not been written upon the environment `{aligned}`.⁷

As in the environments of `amsmath`, it's possible to change the spacing between two given rows with the option of the command `\` of end of line (it's also possible to use `*` but it has exactly the same effect as `\` since an environment `{WithArrows}` is always unbreakable).

```

$\begin{WithArrows}
A &= (a+1)^2 \Arrow{we expand} \\\[2ex]
&= a^2 + 2a + 1
\end{WithArrows}$

```

$$\begin{aligned}
A &= (a+1)^2 \\
&= a^2 + 2a + 1 && \left. \begin{array}{l} \downarrow \text{we expand} \end{array} \right\}
\end{aligned}$$

In the environments of `amsmath` (or `mathtools`), the spacing between rows is fixed by a parameter called `\jot` (it's a dimension and not a skip). That's also the case for the environment `{WithArrows}`. An option `jot` has been given to the environment `{WithArrows}` in order to change the value of this parameter `\jot` for an given environment.⁸

```

$\begin{WithArrows}[displaystyle,jot=2ex]
F &= \frac{1}{2}G \Arrow{we expand} \\\
&= H + \frac{1}{2}K \Arrow{we go on} \\\
&= K
\end{WithArrows}$

```

$$\begin{aligned}
F &= \frac{1}{2}G \\
&= H + \frac{1}{2}K && \left. \begin{array}{l} \downarrow \text{we expand} \\ \downarrow \text{we go on} \end{array} \right\} \\
&= K
\end{aligned}$$

However, this new value of `\jot` will also be used in other alignments included in the environment `{WithArrows}`:

⁷In fact, it's possible to use the package `witharrows` without the package `amsmath`.

⁸It's also possible to change `\jot` with the environment `{spreadlines}` of `mathtools`.


```

 $\begin{WithArrows}[jot=2ex]
\varphi(x,y) = 0 \quad \& \quad \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0
\Arrow{$x$ and $y$ are real}\\
& \Leftrightarrow \left\{ \begin{array}{l} x+y = 0 \\ x+2y = 0 \end{array} \right.
\begin{aligned}
x+y &= 0 \\
x+2y &= 0
\end{aligned}
\right.
\end{WithArrows}$ 

```

$$\varphi(x,y) = 0 \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0 \quad \left. \vphantom{\varphi(x,y) = 0} \right\} x \text{ and } y \text{ are real}$$

$$\Leftrightarrow \begin{cases} x+y = 0 \\ x+2y = 0 \end{cases}$$

Maybe this doesn't correspond to the desired outcome. That's why an option `interline` is proposed. It's possible to use a skip (`=glue`) for this option.

```

 $\begin{WithArrows}[interline=2ex]
\varphi(x,y) = 0 \quad \& \quad \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0
\Arrow{$x$ and $y$ are real}\\
& \Leftrightarrow \left\{ \begin{array}{l} x+y = 0 \\ x+2y = 0 \end{array} \right.
\begin{aligned}
x+y &= 0 \\
x+2y &= 0
\end{aligned}
\right.
\end{WithArrows}$ 

```

$$\varphi(x,y) = 0 \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0 \quad \left. \vphantom{\varphi(x,y) = 0} \right\} x \text{ and } y \text{ are real}$$

$$\Leftrightarrow \begin{cases} x+y = 0 \\ x+2y = 0 \end{cases}$$

Like the environment `{aligned}`, `{WithArrows}` has an option of placement which can assume the values `t`, `c` or `b`. However, the default value is not `c` but `t`. If desired, it's possible to have the `c` value as the default with the command `\WithArrowsOptions{c}` at the beginning of the document.

```

 $\enskip
\begin{WithArrows}
A \&= (a+1)^2 \quad \Arrow{we \text{ expand}} \\
&= a^2 + 2a + 1
\end{WithArrows}$ 

```

$$\text{So } A = (a+1)^2 \quad \left. \vphantom{A = (a+1)^2} \right\} \text{we expand}$$

$$= a^2 + 2a + 1$$

The value `c` may be useful, for example, if we want to add curly braces:

```

 $\enskip
\begin{WithArrows}[c]
f(x) \&= 3x^3+2x^2-x+4
\Arrow[tikz=-]{both \text{ are polynoms}} \\
g(x) \&= 5x^2-5x+6
\end{WithArrows}
\right.$$ 
```

On pose $\left\{ \begin{array}{l} f(x) = 3x^3 + 2x^2 - x + 4 \\ g(x) = 5x^2 - 5x + 6 \end{array} \right\}$ both are *polynoms*

Unlike `{aligned}`, the environment `{WithArrows}` uses `\textstyle` by default. Once again, it's possible to change this behaviour with `\WithArrowsOptions`:
`\WithArrowsOptions{displaystyle}`.

The following example is composed with `{aligned}`:

$$\left\{ \begin{array}{l} \sum_{i=1}^n (x_i + 1)^2 = \sum_{i=1}^n (x_i^2 + 2x_i + 1) \\ \qquad \qquad \qquad = \sum_{i=1}^n x_i^2 + 2 \sum_{i=1}^n x_i + n \end{array} \right.$$

The following is composed with `{WithArrows}[c,displaystyle]`. The results are strictly identical.⁹

$$\left\{ \begin{array}{l} \sum_{i=1}^n (x_i + 1)^2 = \sum_{i=1}^n (x_i^2 + 2x_i + 1) \\ \qquad \qquad \qquad = \sum_{i=1}^n x_i^2 + 2 \sum_{i=1}^n x_i + n \end{array} \right.$$

4 Arrows in nested environments

The environments `{WithArrows}` can be nested. In this case, the options given to the encompassing environment applies also to the inner ones (with logical exceptions for `interline`, `CodeBefore` and `CodeAfter`). The command `Arrow` can be used as usual in each environment `{WithArrows}`.

```
$\begin{WithArrows}
\varphi(x,y)=0
& \Leftrightarrow (x+2y)^2 + (2x+4y)^2 = 0 \ \text{the numbers are real} \\
& \Leftrightarrow \begin{aligned}
& \left\{ \begin{array}{l} x+2y = 0 \\ 2x+4y = 0 \end{array} \right. \\
& \end{aligned} \\
& \Leftrightarrow \begin{aligned}
& \left\{ \begin{array}{l} x+2y = 0 \\ x+2y = 0 \end{array} \right. \ \text{the same equation} \\
& \end{aligned} \\
& \Leftrightarrow x+2y = 0
\end{WithArrows}$
```

$$\begin{aligned} \varphi(x,y) = 0 &\Leftrightarrow (x+2y)^2 + (2x+4y)^2 = 0 \\ &\Leftrightarrow \left\{ \begin{array}{l} x+2y = 0 \\ 2x+4y = 0 \end{array} \right. \quad \text{the numbers are real} \\ &\Leftrightarrow \left\{ \begin{array}{l} x+2y = 0 \\ x+2y = 0 \end{array} \right. \quad \text{the same equation} \\ &\Leftrightarrow x+2y = 0 \end{aligned}$$

However, one may want to draw an arrow between rows that are not in the same environment. For example, one may want to draw the following arrow :

⁹In versions of `amsmath` older than the 5 nov. 2016, an thin space was added on the left of an environment `{aligned}`. The new versions do not add this space and neither do `{WithArrows}`.

$$\begin{aligned}
\varphi(x, y) = 0 &\Leftrightarrow (x + 2y)^2 + (2x + 4y)^2 = 0 \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ 2x + 4y = 0 \end{cases} \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ x + 2y = 0 \end{cases} \quad \left. \begin{array}{l} \\ \end{array} \right) \text{Division by 2} \\
&\Leftrightarrow x + 2y = 0
\end{aligned}$$

Such a construction is possible by using `\Arrow` in the `CodeAfter` option. Indeed, in `CodeAfter`, a special version of `\Arrow` is available (we will call it “`\Arrow` in `CodeAfter`”).

A command `\Arrow` in `CodeAfter` takes three arguments :

- a specification of the start row of the arrow ;
- a specification of the end row of the arrow ;
- the label of the arrow.

As usual, it's also possible to give options within square brackets before or after the three arguments. However, these options are limited (see below).

The specification of the row is constructed with the position of the concerned environment in the nesting tree, followed (after an hyphen) by the number of the row.

In the previous example, there are two environments `{WithArrows}` nested in the main environment `{WithArrows}`.

$$\begin{aligned}
\varphi(x, y) = 0 &\Leftrightarrow (x + 2y)^2 + (2x + 4y)^2 = 0 \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ 2x + 4y = 0 \end{cases} \quad \text{environment number 1} \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ x + 2y = 0 \end{cases} \quad \text{environment number 2} \\
&\Leftrightarrow x + 2y = 0
\end{aligned}$$

The arrow we want to draw starts in the row 2 of the sub-environment number 1 (and therefore, the specification is 1-2) and ends in the row 2 of the sub-environment number 2 (and therefore, the specification is 2-2). We can draw the arrow with the following command `\Arrow` in `CodeAfter` :

```

$\begin{WithArrows}[CodeAfter = {\Arrow{1-2}{2-2}{Division by $2$}}]
\varphi(x,y)=0
& \Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0 \\\
.....
\end{WithArrows}$

```

$$\begin{aligned}
\varphi(x, y) = 0 &\Leftrightarrow (x + 2y)^2 + (2x + 4y)^2 = 0 \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ 2x + 4y = 0 \end{cases} \\
&\Leftrightarrow \begin{cases} x + 2y = 0 \\ x + 2y = 0 \end{cases} \quad \left. \begin{array}{l} \\ \end{array} \right) \text{Division by 2} \\
&\Leftrightarrow x + 2y = 0
\end{aligned}$$

The options allowed for a command `\Arrow` in `CodeAfter` are : `ll`, `lr`, `rl`, `rr`, `v`, `xoffset`, `tikz` and `TikzCode`. Except `v`, which is specific to `\Arrow` in `CodeAfter`, all these options have their usual meaning.

With the option `v`, the arrow drawn is vertical to an abscissa computed with the start row and the end row only : the intermediate lines are not taken into account unlike with the option `i`. Currently, the option `i` is not available for the command `\Arrow` in `CodeAfter`. However, it's always possible to translate an arrow with `xoffset` (or `xshift` of `Tikz`).

```

 $\begin{WithArrows}[CodeAfter = {\Arrow[v]{1-2}{2-2}{Division by $2$}}]
\varphi(x,y)=0
& \Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0 \\\
.....
\end{WithArrows}$ 

```

$$\begin{aligned}
\varphi(x,y) = 0 &\Leftrightarrow (x+2y)^2 + (2x+4y)^2 = 0 \\
&\Leftrightarrow \begin{cases} x+2y = 0 \\ 2x+4y = 0 \end{cases} \\
&\Leftrightarrow \begin{cases} x+2y = 0 \\ x+2y = 0 \end{cases} \quad \left. \begin{array}{l} \\ \end{array} \right) \text{Division by 2} \\
&\Leftrightarrow x+2y = 0
\end{aligned}$$

The package `witharrows` gives also another command available only in `CodeAfter`: the command `\MultiArrow`. This command draws a “rak”. The list of the rows of the environment concerned by this rak are given in the first argument of the command `\MultiArrow`. This list is given with the syntax of the list in a `\foreach` command of `pgfkeys`.

```

 $\begin{WithArrows}[tikz = rounded corners,
CodeAfter = {\MultiArrow{1,...,4}{text}}]
A & = B \\\
& = C \\\
& = D \\\
& = E \\\
& = F
\end{WithArrows}$ 

```

$$\begin{aligned}
A &= B && \leftarrow \\
&= C && \leftarrow \\
&= D && \leftarrow \\
&= E && \leftarrow \\
&= F && \leftarrow
\end{aligned}
\quad \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \text{text}$$

As of now, there is no option available for the command `\MultiArrow` (maybe in a future release).

5 Arrows from outside environments `{WithArrows}`

If someone wants to draw arrows from outside the environments `{WithArrows}`, he can use the Tikz nodes created in the environments.

The Tikz name of a node created by `witharrows` is prefixed by `wa-`. Then, we have a list of numbers which give the position in the nesting tree and the row number in the environment. At the end, we have the suffixe `l` for a “left node” and `r` for a “right node”.

For illustrative purposes, we give an example of nested environments `{WithArrows}`, and, for each “right node”, the name of that node.¹⁰

¹⁰There is an option `shownodenames` to show the names of these nodes.

$$\begin{aligned}
& A \triangleleft B + B + B + B + B + B + B + B + B + B + B + B + B + B \text{wa-37-1} \\
& \triangleleft \begin{cases} C \triangleleft D \text{wa-37-1-1} \\ E \triangleleft F \text{wa-37-1-2} \end{cases} \text{wa-37-2} \\
& \triangleleft \begin{cases} G \triangleleft H + H + H + H + H + H + H \text{wa-37-2-1} \\ I \triangleleft \begin{cases} J \triangleleft K \text{wa-37-2-1-1} \\ L \triangleleft M \text{wa-37-2-1-2} \end{cases} \end{cases} \text{wa-37-3} \\
& \triangleleft \begin{cases} N \triangleleft O \text{wa-37-3-1} \\ P \triangleleft Q \text{wa-37-3-2} \end{cases} \text{wa-37-4}
\end{aligned}$$

The package `witharrows` provides some tools facilitating the use of these nodes:

- the command `\WithArrowsLastEnv` gives the number of the last environment of level 0;
- a name can be given to a given environment with the option `name` and, in this case, the nodes created in the environment will have aliases constructed with this name;
- the Tikz style `WithArrows/arrow` is the style used by `witharrows` when drawing an arrow¹¹;
- the Tikz style `WithArrows/arrow/tips` is the style for the tip of the arrow (loaded by `WithArrows/arrow`).

For example, we can draw an arrow from `wa-37-2-1-2-r.south` to `wa-37-3-2-r.north` with the following Tikz command.

```

\begin{tikzpicture}[remember picture,overlay]
\draw [WithArrows/arrow]
  ([xshift=3mm]wa-\WithArrowsLastEnv-2-1-2-r.south)
  to ([xshift=3mm]wa-\WithArrowsLastEnv-3-2-r.north) ;
\end{tikzpicture}

```

$$\begin{aligned}
& A \triangleleft B + B + B + B + B + B + B + B + B + B + B + B + B + B \\
& \triangleleft \begin{cases} C \triangleleft D \\ E \triangleleft F \end{cases} \\
& \triangleleft \begin{cases} G \triangleleft H + H + H + H + H + H + H \\ I \triangleleft \begin{cases} J \triangleleft K \\ L \triangleleft M \end{cases} \end{cases} \\
& \triangleleft \begin{cases} N \triangleleft O \\ P \triangleleft Q \end{cases} \quad \curvearrowleft
\end{aligned}$$

In this case, it would be easier to use a command `\Arrow` in `CodeAfter` but this is an example to explain how the Tikz nodes created by `witharrows` can be used.

In the following example, we create two environments `{WithArrows}` named “`first`” and “`second`” and we draw a line between a node of the first and a node of the second.

```

$\begin{WithArrows}[name=first]
A & = B \\\
& = C
\end{WithArrows}$

```

```

\bigskip

```

¹¹More precisely, this style is given to the Tikz option “`every path`” before drawing the arrow with the code of the option `TikzCode`. This style is modified (in TeX scopes) by the option `tikz` of `witharrows`.

```

 $\begin{WithArrows}[name=second]$ 
 $A' \& = B' \setminus$ 
 $\& = C'$ 
 $\end{WithArrows}$ 

 $\begin{tikzpicture}[remember picture,overlay]$ 
 $\draw [WithArrows/arrow]$ 
 $([xshift=3mm]first-1-r.south)$ 
 $\text{to } ([xshift=3mm]second-1-r.north) ;$ 
 $\end{tikzpicture}$ 

```

$$\begin{array}{l}
 A = B \\
 = C \\
 A' = B' \\
 = C'
 \end{array}
 \begin{array}{l}
 \curvearrowright \\
 \downarrow
 \end{array}$$

6 The environment `{DispWithArrows}`

As previously said, the environment `{WithArrows}` bears similarities with the environment `{aligned}` of `amsmath` (and `mathtools`). This extension also provides an environment `{DispWithArrows}` which is similar to the environments `{align}` and `{flalign}` of `amsmath`.

The environment `{DispWithArrows}` must be used *outside* math mode. Like `{align}`, it should be used in horizontal mode.

```

 $\begin{DispWithArrows}$ 
 $A \& = (a+1)^2 \setminus\text{Arrow}\{we\ expand\} \setminus$ 
 $\& = a^2 + 2a + 1$ 
 $\end{DispWithArrows}$ 

```

$$\begin{array}{l}
 A = (a+1)^2 \\
 = a^2 + 2a + 1
 \end{array}
 \begin{array}{l}
 \downarrow we\ expand \\
 \downarrow we\ expand
 \end{array}
 \begin{array}{l}
 (1) \\
 (2)
 \end{array}$$

It's possible to use the command `\notag` (or `\nonumber`) to suppress a tag.

It's possible to use the command `\tag` to put a special tag (e.g. \star).¹²

It's also possible to put a label to the line of an equation with the command `\label`.

These commands must be in the second column of the environment.

```

 $\begin{DispWithArrows}$ 
 $A \& = (a+1)^2 \setminus\text{Arrow}\{we\ expand\} \setminus\text{notag} \setminus$ 
 $\& = a^2 + 2a + 1 \setminus\text{tag}\{\$ \star \$\} \setminus\text{label}\{my-equation\}$ 
 $\end{DispWithArrows}$ 

```

$$\begin{array}{l}
 A = (a+1)^2 \\
 = a^2 + 2a + 1
 \end{array}
 \begin{array}{l}
 \downarrow we\ expand \\
 \downarrow we\ expand
 \end{array}
 \begin{array}{l}
 (\star)
 \end{array}$$

A link to the equation (\star) . This link has been composed with `\eqref{my-equation}` (the command `\eqref` is a command of `amsmath`).

It's also possible to suppress all the autogenerated numbers with the option `notag` (or `nonumber`), at the global or environment level. There is also an environment `{DispWithArrows*}` which suppresses all these numbers.¹³

¹²If `amsmath` (or `mathtools`) is loaded, it's also possible to use `\tag*` which, as in `amsmath`, typesets the tag without the parenthesis.

¹³Even in this case, it's possible to put a "manual tag" with the command `\tag`.

```
\begin{DispWithArrows*}
A &= (a+1)^2 \Arrow{we expand} \\
&= a^2 + 2a + 1
\end{DispWithArrows*}
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \Downarrow \text{we expand}$$

With the option `fleqn`, the environment is composed flush left (in a way similar to the option `fleqn` of the standard classes of LaTeX). In this case, the left margin can be controlled with the option `mathindent` (with a name inspired by the parameter `\mathindent` of standard LaTeX). The default value of this parameter is 25 pt.

```
\begin{DispWithArrows}[fleqn,mathindent = 1cm]
A &= (a+1)^2 \Arrow{we expand} \\
&= a^2 + 2a + 1
\end{DispWithArrows}
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \Downarrow \text{we expand} \tag{3}$$

(4)

Remark : By design, the option `fleqn` of `witharrows` is independant of the option `fleqn` of LaTeX. Indeed, since the environments of `witharrows` are meant to be used with arrows on the right side, the user may want to use `witharrows` with the option `fleqn` (in order to have more space on the right of the equations for the arrows) while still centering the classical equations.

If the package `amsmath` is loaded, it's possible to use the environment `{subequations}` and the command `\intertext` in the environments `{DispWithArrows}` and `{DispWithArrows*}` (and even the `\intertext` of `nccmath` if this package is loaded).

If the option `leqno` is used as a class option, the labels will be composed on the left also for the environments `{DispWithArrows}` et `{DispWithArrows*}`.

The environment `{DispWithArrows}` is similar to the environment `{align}` of `amsmath`. However, `{DispWithArrows}` is not constructed upon `{align}` (in fact, it's possible to use `witharrows` without `amsmath`).

There are differences between `{DispWithArrows}` and `{align}`.

- The environment `{DispWithArrows}` allows only two columns.
- With `{DispWithArrows}`, an error is raised if there is a collision between an equation and its tag but the tag is not composed on the following line.
- An environment `{DispWithArrows}` is always unbreakable (even with `\allowdisplaybreaks` of `amsmath`).
- The commands `\label`, `\tag`, `\notag` and `\nonumber` are allowed only in the second column.
- **Last but not least, by default, the elements of a `{DispWithArrows}` are composed in `textstyle` and not in `displaystyle` (it's possible to change this point with the option `displaystyle`).**

Concerning the references, the package `witharrows` is compatible with the extensions `autonum`, `cleveref`, `fancyref`, `hyperref`, `prettyref`, `refstyle`, `typedref` and `varioref`, and with the options `showonlyrefs` and `showmanualtags` of `mathtools`.¹⁴

It is not compatible with `showkeys` (not all the labels are shown).

The environments `{DispWithArrows}` and `{DispWithArrows*}` provide an option `wrap-lines`. With this option, the lines of the label are automatically wrapped on the right.

¹⁴We recall that `varioref`, `hyperref`, `cleveref` and `autonum` must be loaded in this order. The package `witharrows` can be loaded anywhere.

```

\begin{DispWithArrows*}[displaystyle,wrap-lines]
S_n
& = \frac{1}{n} \operatorname{Re} \left( \sum_{k=0}^{n-1} \operatorname{bigl}(e^{i\frac{\pi}{2n}}\bigr)^k \right)
\Arrow{sum of terms of a geometric progression of ratio $e^{i\frac{2\pi}{n}}$}
& = \frac{1}{n} \operatorname{Re} \left( \frac{1 - \operatorname{bigl}(e^{i\frac{\pi}{2n}}\bigr)^n}{1 - e^{i\frac{\pi}{2n}}} \right)
\Arrow{This line has been wrapped automatically.}
& = \frac{1}{n} \operatorname{Re} \left( \frac{1 - i}{1 - e^{i\frac{\pi}{2n}}} \right)
\end{DispWithArrows*}

```

$$\begin{aligned}
S_n &= \frac{1}{n} \Re \left(\sum_{k=0}^{n-1} \left(e^{i\frac{\pi}{2n}} \right)^k \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - \left(e^{i\frac{\pi}{2n}} \right)^n}{1 - e^{i\frac{\pi}{2n}}} \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - i}{1 - e^{i\frac{\pi}{2n}}} \right)
\end{aligned}$$

sum of terms of a geometric progression of ratio $e^{i\frac{2\pi}{n}}$
This line has been wrapped automatically.

The option `wrap-lines` doesn't apply to the environments `{WithArrows}` nested in an environment `{DispWithArrows}` or `{DispWithArrows*}`. However, it applies to the instructions `\Arrow` and `\MultiArrow` of the `CodeAfter` of the environments `{DispWithArrows}` or `{DispWithArrows*}`.

7 Advanced features

7.1 The option `TikzCode` : how to change the shape of the arrows

The option `TikzCode` allows the user to change the shape of the arrows.¹⁵

The value of this option must be a valid Tikz drawing instruction (with the final semi-colon) with three markers `#1`, `#2` and `#3` for the start point, the end point and the label of the arrow.

By default, the value is the following:

```
\draw (#1) to node {#3} (#2) ;
```

In the following example, we replace this default path by a path with three segments (and the node overwriting the second segment).

```

\begin{WithArrows}[ygap=5pt,interline=4mm,
  TikzCode = {\draw[rounded corners]
    (#1) -- ($(#1) + (5mm,0)$)
    -- node[circle,
      draw,
      auto = false,
      fill = gray!50,
      inner sep = 1pt] {\tiny #3}
    ($(#2) + (5mm,0)$)
    -- (#2) ;}]
E & \Longleftarrow 3 (2x+4) = 6 & \Arrow{\$ \div 3\$} \\
& \Longleftarrow 2x+4 = 2 & \Arrow{\$ -4\$} \\
& \Longleftarrow 2x = -2 & \Arrow{\$ \div 2\$} \\
& \Longleftarrow x = -1
\end{WithArrows}

```

¹⁵If the option `wrap-lines` is used in an environment `{DispWithArrows}` or `{DispWithArrows*}`, the option `TikzCode` will have no effect for the arrows of this environment but only for the arrows in the nested environments `{WithArrows}`.

$$\begin{array}{lcl}
 E \iff 3(2x + 4) = 6 & \xrightarrow{\div 3} & \\
 \iff 2x + 4 = 2 & \xrightarrow{-4} & \\
 \iff 2x = -2 & \xrightarrow{\div 2} & \\
 \iff 2x = -1 & &
 \end{array}$$

7.2 Footnotes in the environments of witharrows

If you want to put footnotes in an environment `{WithArrows}` or `{DispWithArrows}`, you can use a pair `\footnotemark`–`\footnotetext`.

It's also possible to extract the footnotes with the help of the package `footnote` or the package `footnotehyper`.

If `witharrows` is loaded with the option `footnote` (with `\usepackage[footnote]{witharrows}` or with `\PassOptionsToPackage`), the package `footnote` is loaded (if it is not yet loaded) and it is used to extract the footnotes.

If `witharrows` is loaded with the option `footnotehyper`, the package `footnotehyper` is loaded (if it is not yet loaded) and it is used to extract footnotes.

Caution: The packages `footnote` and `footnotehyper` are incompatible. The package `footnotehyper` is the successor of the package `footnote` and should be used preferently. The package `footnote` has some drawbacks, in particular: it must be loaded after the package `xcolor` and it is not perfectly compatible with `hyperref`.

In this document, the package `witharrows` has been loaded with the option `footnotehyper` and we give an example with a footnote in the label of an arrow:

$$\begin{array}{l}
 A = (a + b)^2 \\
 = a^2 + b^2 + 2ab \quad \xrightarrow{\text{We expand}\supset 16}
 \end{array}$$

8 Examples

8.1 With only one column

It's possible to use the environment `{WithArrows}` with making use of the left column only, or the right column only.

```

 $\begin{WithArrows}$ 
&f(x) \ge g(x) \Arrow{by squaring both sides} \\\
&f(x)^2 \ge g(x)^2 \Arrow{by moving to left side} \\\
&f(x)^2 - g(x)^2 \ge 0 \\
\end{WithArrows}

```

$$\begin{array}{l}
 f(x) \ge g(x) \\
 f(x)^2 \ge g(x)^2 \\
 f(x)^2 - g(x)^2 \ge 0
 \end{array}
 \begin{array}{l}
 \xrightarrow{\text{by squaring both sides}} \\
 \xrightarrow{\text{by moving to left side}}
 \end{array}$$

¹⁶A footnote.

8.2 MoveEqLeft

It's possible to use `\MoveEqLeft` of `mathtools` (if we don't want ampersand on the first line):


```
\begin{WithArrows}[interline=0.5ex]
\MoveEqLeft \arccos(x) = \arcsin \frac{4}{5} + \arcsin \frac{5}{13}
\Arrow{because both are in $[-\frac{\pi}{2}, \frac{\pi}{2}]$} \\\
& \Leftrightarrow x = \sin \left( \arcsin \frac{4}{5} + \arcsin \frac{5}{13} \right) \\\
& \Leftrightarrow x = \frac{4}{5} \cos \arcsin \frac{5}{13} + \frac{5}{13} \cos \arcsin \frac{4}{5} \\\
\Arrow{$\forall x \in [-1, 1], \cos(\arcsin x) = \sqrt{1-x^2}$} \\\
& \Leftrightarrow x = \frac{4}{5} \sqrt{1 - \left(\frac{5}{13}\right)^2} + \frac{5}{13} \sqrt{1 - \left(\frac{4}{5}\right)^2} \\\
& + \frac{5}{13} \sqrt{1 - \left(\frac{4}{5}\right)^2} \\\
\end{WithArrows}
```

$$\begin{aligned} \arccos(x) &= \arcsin \frac{4}{5} + \arcsin \frac{5}{13} \\ \Leftrightarrow x &= \sin \left(\arcsin \frac{4}{5} + \arcsin \frac{5}{13} \right) && \left. \begin{array}{l} \\ \end{array} \right\} \text{because both are in } \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] \\ \Leftrightarrow x &= \frac{4}{5} \cos \arcsin \frac{5}{13} + \frac{5}{13} \cos \arcsin \frac{4}{5} \\ \Leftrightarrow x &= \frac{4}{5} \sqrt{1 - \left(\frac{5}{13}\right)^2} + \frac{5}{13} \sqrt{1 - \left(\frac{4}{5}\right)^2} && \left. \begin{array}{l} \\ \end{array} \right\} \forall x \in [-1, 1], \cos(\arcsin x) = \sqrt{1 - x^2} \end{aligned}$$

8.3 Modifying the shape of the nodes

It's possible to change the shape of the labels, which are Tikz nodes, by modifying the key “every node” of Tikz.

```
\begin{WithArrows}[%
interline = 4mm,
tikz = {every node/.style = {circle,
draw,
auto = false,
fill = gray!50,
inner sep = 1pt,
font = \tiny}}]
E & \Longleftarrow 3(2x+4) = 6
\Arrow{$\div 3$} \\\
& \Longleftarrow 2x+4 = 2
\Arrow{$-4$} \\\
& \Longleftarrow 2x = -2
\Arrow{$\div 2$} \\\
& \Longleftarrow 2x = -1
\end{WithArrows}
```

$$\begin{aligned} E &\Longleftarrow 3(2x+4) = 6 \\ &\Longleftarrow 2x+4 = 2 \\ &\Longleftarrow 2x = -2 \\ &\Longleftarrow 2x = -1 \end{aligned}$$


8.4 Examples with the option TikzCode

We recall that the option `TikzCode` is the Tikz code used by `witharrows` to draw the arrows.¹⁷

The value by default of `TikzCode` is `\draw (#1) to node {#3} (#2)` ; where the three markers #1, #2 and #3 represent the start row, the end row and the label of the arrow.

¹⁷If an environment `{DispWithArrows}` or `{DispWithArrows*}` is used with the option `wrap-lines`, the value of the option `TikzCode` is not used for this environment (but is used for the environments nested inside).

8.4.1 Example 1

In the following example, we define the value of `TikzCode` with two instructions `\path` : the first instruction draws the arrow itself and the second puts the label in a Tikz node in the rectangle delimited by the arrow.

```
\begin{WithArrows}[
  displaystyle,
  ygap = 2mm,
  ystart = 0mm,
  TikzCode = {\draw (#1) -- ++(4.5cm,0) |- (#2) ;
              \path (#1) -- (#2)
              node[text width = 4.2cm, right, midway] {#3} ;}]

S_n
& = \frac{1}{n} \sum_{k=0}^{n-1} \cos(\frac{\pi}{2} \cdot \frac{k}{n})
.....
```

$$\begin{aligned}
S_n &= \frac{1}{n} \sum_{k=0}^{n-1} \cos\left(\frac{\pi}{2} \cdot \frac{k}{n}\right) \\
&= \frac{1}{n} \sum_{k=0}^{n-1} \Re\left(e^{i \frac{k\pi}{2n}}\right) \\
&= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} e^{i \frac{k\pi}{2n}}\right) \\
&= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} \left(e^{i \frac{\pi}{2n}}\right)^k\right) \\
&= \frac{1}{n} \Re\left(\frac{1 - \left(e^{i \frac{\pi}{2n}}\right)^n}{1 - e^{i \frac{\pi}{2n}}}\right) \\
&= \frac{1}{n} \Re\left(\frac{1 - i}{1 - e^{i \frac{\pi}{2n}}}\right)
\end{aligned}$$

$\cos x = \Re(e^{ix})$

$\Re(z + z') = \Re(z) + \Re(z')$

exp is a morphism for \times et +

sum of terms of a geometric progression of ratio $e^{i \frac{2\pi}{n}}$

8.4.2 Example 2

In the following example, we change the shape of the arrow depending on whether the start row is longer than the end row or not. This example requires the Tikz library `calc`.

```
\begin{WithArrows}[ll,interline=5mm,xoffset=5mm,
  TikzCode = {\draw[rounded corners,
                  every node/.style = {circle,
                  draw,
                  auto = false,
                  inner sep = 1pt,
                  fill = gray!50,
                  font = \tiny }]

  let \p1 = (#1),
      \p2 = (#2)
  in \ifdim \x1 > \x2
      (\p1) -- node {#3} (\x1,\y2) -- (\p2)
    \else
      (\p1) -- (\x2,\y1) -- node {#3} (\p2)
    \fi ;}]

E & \Longleftarrow \frac{(x+4)^3}{5} + \frac{5x+3}{5} = 7
\Arrow{$\times 15$}\\
& \Longleftarrow 5(x+4) + 3(5x+3) = 105 \\
& \Longleftarrow 5x+20 + 15x+9 = 105 \\
```

```

& \Longleftarrow 20x+29 = 105
\Arrow{$-29$}\
& \Longleftarrow 20x = 76
\Arrow{$\div 20$}\
& \Longleftarrow x = \frac{38}{10}
\end{WithArrows}

```

$$\begin{aligned}
E &\iff \frac{(x+4)}{3} + \frac{5x+3}{5} = 7 && \xrightarrow{\times 15} \\
&\iff 5(x+4) + 3(5x+3) = 105 \\
&\iff 5x + 20 + 15x + 9 = 105 \\
&\iff 20x + 29 = 105 && \xrightarrow{-29} \\
&\iff 20x = 76 && \xrightarrow{\div 20} \\
&\iff x = \frac{38}{10}
\end{aligned}$$

8.5 Automatic numbered loop

Assume we want to draw a loop of numbered arrows. In this purpose, it's possible to write a dedicated command `\NumberedLoop` which will do the job when used in `CodeAfter`. In the following example, we write this command with `\NewDocumentCommand` of `xparse` and `\foreach` of `pgffor` (both packages are loaded when `witharrows` is loaded).

```

\NewDocumentCommand \NumberedLoop {}
{
  \foreach \j in {2,...,\NbLines}
  {
    \pgfmathtruncatemacro{\i}{\j-1}
    \Arrow[rr]{\i}{\j}{\i}
  }
  \Arrow[rr,xoffset=1cm,tikz=<-]{1}{\NbLines}{\NbLines}
}

```

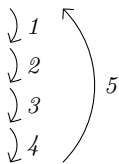
The command `\NbLines` is a command available in `CodeAfter` which gives the total number of lines (=rows) of the current environment (it's a command and not a counter).

```

$\begin{WithArrows}[CodeAfter = \NumberedLoop]
a.\;& f \text{ est continuous on } E \\\
b.\;& f \text{ est continuous in } 0 \\\
c.\;& f \text{ is bounded on the unit sphere} \\\
d.\;& \exists K > 0 \quad \forall x \in E \quad \|f(x)\| \leq K \|x\| \\\
e.\;& f \text{ is lipschitzian}
\end{WithArrows}$

```

$a.$ f est continuous on E
 $b.$ f est continuous in 0
 $c.$ f is bounded on the unit sphere
 $d.$ $\exists K > 0 \quad \forall x \in E \quad \|f(x)\| \leq K \|x\|$
 $e.$ f is lipschitzian

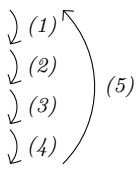


As usual, it's possible to change the characteristic of both arrows and nodes with the option `tikz`. However, if we want to change the style to have, for example, numbers in parenthesis, the best way is to change the value of `TikzCode`:

```

TikzCode = {\draw (#1) to node {\footnotesize (#3)} (#2) ;}

```

- a. f est continuous on E
 - b. f est continuous in 0
 - c. f is bounded on the unit sphere
 - d. $\exists K > 0 \quad \forall x \in E \quad \|f(x)\| \leq K\|x\|$
 - e. f is lipschitzian
- 

9 Implementation

9.1 Declaration of the package and extensions loaded

First, `tikz` and some Tikz libraries are loaded before the `\ProvidesExplPackage`. They are loaded this way because `\usetikzlibrary` in `expl3` code fails.¹⁸

```
1 \RequirePackage{tikz}
2 \usetikzlibrary{arrows.meta,bending}
```

Then, we can give the traditional declaration of a package written with `expl3`:

```
3 \RequirePackage{l3keys2e}
4 \ProvidesExplPackage
5   {witharrows}
6   {\myfiledate}
7   {\myfileversion}
8   {Draws arrows for explanations on the right}
```

The package `xparse` will be used to define the environments `{WithArrows}`, `{DispWithArrows}`, `{DispWithArrows*}` and the document-level commands `\Arrow` and `\WithArrowsOptions`.

```
9 \RequirePackage{xparse}
```

9.2 The packages `footnote` and `footnotehyper`

A few options can be given to the package `witharrows` when it is loaded (with `\usepackage`, `\RequirePackage` or `\PassOptionsToPackage`). Currently (version 1.10), there are two such options: `footnote` and `footnotehyper`. With the option `footnote`, `witharrows` loads `footnote` and uses it to extract the footnotes from the environments `{WithArrows}`. Idem for the option `footnotehyper`.

The boolean `\g_@@_footnotehyper_bool` will indicate if the option `footnotehyper` is used.

```
10 \bool_new:N \g_@@_footnotehyper_bool
```

The boolean `\g_@@_footnote_bool` will indicate if the option `footnote` is used, but quickly, it will also be set to true if the option `footnotehyper` is used.

```
11 \bool_new:N \g_@@_footnote_bool
```

We define a set of keys `WithArrows/package` for these options. However, first, we define a “level of options” `\l_@@_level_int` even if, in the version 1.10 of `witharrows`, this integer is not used by the options of the set `WithArrows/package`.

```
12 \int_new:N \l_@@_level_int
13 \keys_define:nn {WithArrows/package}
14   {footnote      .bool_gset:N = \g_@@_footnote_bool,
15    footnotehyper .bool_gset:N = \g_@@_footnotehyper_bool,
16    unknown       .code:n      = \msg_fatal:nn {witharrows}
17                                   {Option-unknown-for-package}}
18 \msg_new:nnn {witharrows}
19   {Option-unknown-for-package}
20   {You-can't-use-the-option-"\tl_use:N\l_keys_key_tl"-when-loading-the-
21    package-witharrows.}
```

¹⁸cf. tex.stackexchange.com/questions/57424/using-of-usetikzlibrary-in-an-expl3-package-fails

We process the options when the package is loaded (with `\usepackage`).

```

22 \ProcessKeysOptions {WithArrows/package}

23 \msg_new:nnn {witharrows}
24     {Option~incompatible~with~Beamer}
25     {The~option~"\tl_use:N \l_keys_key_tl"~is~incompatible~
26       with~Beamer~because~Beamer~has~its~own~system~to~extract~footnotes.}

27 \msg_new:nnn {witharrows}
28     {footnote~with~footnotehyper~package}
29     {You~can't~use~the~option~footnote~because~the~package~
30       footnotehyper~has~already~been~loaded.~
31       If~you~want,~you~can~use~the~option~"footnotehyper"~and~the~footnotes~
32       within~the~environments~{WithArrows}~will~be~extracted~with~the~tools~
33       of~the~package~footnotehyper.}

34 \msg_new:nnn {witharrows}
35     {footnotehyper~with~footnote~package}
36     {You~can't~use~the~option~"footnotehyper"~because~the~package~
37       footnote~has~already~been~loaded.~
38       If~you~want,~you~can~use~the~option~"footnote"~and~the~footnotes~
39       within~the~environments~{WithArrows}~will~be~extracted~with~the~tools~
40       of~the~package~footnote.}

41 \bool_if:NT \g_@@_footnote_bool
42     {\@ifclassloaded {beamer}
43       {\msg_fatal:nn {witharrows}
44         {Option~incompatible~with~Beamer}}}
45     {}

46     \@ifpackageloaded{footnotehyper}
47       {\msg_fatal:nn {witharrows}
48         {footnote~with~footnotehyper~package}}
49     {}

50     \usepackage{footnote}}

51 \bool_if:NT \g_@@_footnotehyper_bool
52     {\@ifclassloaded {beamer}
53       {\msg_fatal:nn {witharrows}
54         {Option~incompatible~with~Beamer}}}
55     {}

56     \@ifpackageloaded{footnote}
57       {\msg_fatal:nn {witharrows}
58         {footnotehyper~with~footnote~package}}
59     {}

60     \usepackage{footnotehyper}
61     \bool_gset_true:N \g_@@_footnote_bool}

```

The flag `\g_@@_footnote_bool` is raised and so, we will only have to test `\g_@@_footnote_bool` in order to know if we have to insert an environment `{savenotes}` (the `\begin{savenotes}` is in `\@@_pre_environment:n` and `\end{savenotes}` in `\@@_post_environment:` which are executed at the beginning and at the end of the environments `{WithArrows}` and `{DispWithArrows}`).

9.3 The class option `leqno`

The boolean `\c_@@_leqno_bool` will indicate if the class option `leqno` is used. When this option is used in LaTeX, the command `\eqnnum` is redefined (as one can see in the file `leqno.clo`). That's enough to put the labels on the left in our environments `{DispWithArrows}` and `{DispWithArrows*}`. However, that's not enough when our option `wrap-lines` is used. That's why we have to know if this option is used as a class option. With the following programming, `leqno` *can't* be given as an option of `witharrows` (by design).

```

62 \bool_new:N \c_@@_leqno_bool
63 \DeclareOption {leqno} {\bool_set_true:N \c_@@_leqno_bool}
64 \DeclareOption* {}
65 \ProcessOptions \relax

```

9.4 Some technical definitions

```

66 \cs_new_protected:Nn \@@_msg_error:n
67     {\msg_error:nn {\witharrows} {#1}}

```

We create booleans in order to know if some packages are loaded. For example, for the package `amsmath`, the boolean is called `\c_@@_amsmath_loaded_bool`.¹⁹

```

68 \AtBeginDocument{\clist_map_inline:nn
69     {amsmath,mathtools,autonum,cleveref,hyperref,typedref}
70     {\bool_new:c {c_@@_#1_loaded_bool}
71     \ifpackageloaded {#1}
72         {\bool_set_true:c {c_@@_#1_loaded_bool}}
73     {}}}

```

We define a Tikz style `@@_node_style` for the nodes that will be created in the `\halign`. The nodes are Tikz nodes of shape “rectangle” but with zero width. An arrow between two nodes starts from the *south* anchor of the first node and arrives at the *north* anchor of the second node.

```

74 \tikzset{@@_node_style/.style= {
75     above = \l_@@_ystart_dim,
76     inner~sep = 0 pt,
77     minimum~width = 0pt,
78     minimum~height = \l_@@_ygap_dim,
79     red,
80     \bool_if:NT \l_@@_shownodes_bool {draw} }}

```

The color of the nodes is red, but in fact, the nodes will be drawn only when the option `shownodes` is used (this option is useful for debugging).

The style `@@_standard` is load in standard in the `{tikzpicture}` we need. The names of the nodes are prefixed by `wa` (by security) but also by a prefix which is the position-in-the-tree of the nested environments.

```

81 \tikzset{@@_standard/.style= { remember~picture,
82     overlay,
83     name~prefix = wa-\l_@@_prefix_str- }}

```

We also define a style for the tips of arrow. The final user of the extension `witharrows` will use this style if he wants to draw an arrow directly with a Tikz command in his document (probably using the Tikz nodes created by `{WithArrows}` in the `\halign`).

```

84 \tikzset{WithArrows/arrow/tips/.style = { > = {Straight~Barb[scale=1.2,bend]} }}

```

The style `WithArrows/arrow` will be used to draw the arrow (more precisely, it will be pass to `every~path`).

```

85 \tikzset{WithArrows/arrow/.style = { align = left,

```

We have put the option `align = left` because we want to give the user the possibility of using `\` in the labels.

```

86     auto = left,
87     font = \small\itshape,
88     WithArrows/arrow/tips,
89     bend~left = 45,
90     -> }}

```

In order to increase the interline in the environments `{WithArrows}`, we will use the command `\spread@equation` of `amsmath`. When used, this command becomes no-op (in the current TeX group). Therefore, it will be possible to use the environments of `amsmath` (e.g. `{aligned}`) in an environment `{WithArrows}`.

Nevertheless, we want the extension `witharrows` available without `amsmath`. That’s why we give a definition of `\spread@equation` if `amsmath` is not loaded (you put the code in a `\AtBeginDocument` because the flag `\c_@@_amsmath_loaded_bool` is itself set in a `\AtBeginDocument`).

```

91 \AtBeginDocument
92     {\bool_if:NF \c_@@_amsmath_loaded_bool

```

¹⁹It’s not possible to use `\ifpackageloaded` in the core of the functions because `\ifpackageloaded` is available only in the preamble.

```

93      {\cs_set_protected:Npn \spread@equation
94       {\openup\jot
95        \cs_set_protected:Npn \spread@equation {}}}}

```

Don't put `\cs_set_eq:NN \spread@equation \prog_do_nothing:` in the last line because this would raise errors with nested environments.

9.5 Variables

The boolean `\l_@@_in_witharrows_bool` will be raised if (and only if) we are in an environment `{WithArrows}` (and not in an environment `{DispWithArrows}` or `{DispWithArrows*}`).

```

96 \bool_new:N \l_@@_in_witharrows_bool

```

The following sequence is the position of the last environment `{WithArrows}` in the tree of the nested environments `{WithArrows}`.

```

97 \seq_new:N \g_@@_position_in_the_tree_seq
98 \seq_gput_right:Nn \g_@@_position_in_the_tree_seq 1

```

The following counter will give the number of the last environment `{WithArrows}` of level 0. This counter will be used only in the definition of `\WithArrowsLastEnv`.

```

99 \int_new:N \g_@@_last_env_int

```

The following skip (`=glue`) is the vertical space inserted between two lines (`=rows`) of the `\halign`.

```

100 \skip_new:N \l_@@_interline_skip

```

The following integer indicates the position of the box that will be created: 0 (`=t=\vtop`), 1 (`=c=\vcenter`) or 2 (`=b=\vbox`).

```

101 \int_new:N \l_@@_pos_env_int

```

```

102 \dim_new:N \l_@@_xoffset_dim

```

```

103 \dim_set:Nn \l_@@_xoffset_dim {3mm}

```

The integer `\l_@@_pos_arrows_int` indicates the position of the arrows with the following code (the option `v` is accessible only for the arrows in `CodeAfter` where the options `i`, `group` et `groups` are not available).

option	rr	ll	rl	lr	v	i	group	groups
<code>\l_@@_pos_arrows_int</code>	0	1	2	3	4	5	6	7

The option `v` can be used only in `\Arrow` in `CodeAfter` (see below).

```

104 \int_new:N \l_@@_pos_arrows_int

```

When we scan a list of options, we want to be able to raise an error if two options of position of the arrows are present. That's why we keep the code of the first option of position in a variable called `\l_@@_previous_pos_arrows_int`. This variable will be set to `-1` each time we start the scanning of a list of options.

```

105 \int_new:N \l_@@_previous_pos_arrows_int

```

At each possible level for the options (*global*, *environment* or *local*: see below), the new values will be appended on the right of this token list.

The dimension `\g_@@_x_dim` will be used to compute the *x*-value for some vertical arrows when one of the options `i`, `group` and `groups` (values 5, 6 and 7 of `\l_@@_pos_arrows_int`) is used.

```

106 \dim_new:N \g_@@_x_dim

```

In the `\halign` of an environment `{WithArrows}`, we will have to use three counters:

- `\g_@@_arrow_int` to count the arrows created in the environment ;

- `\g_@@_line_int` to count the lines of the `\halign` ;
- `\g_@@_line_bis_int` to count the lines of the `\halign` which have a second column.²⁰

These three counters will be incremented in a cell of the `\halign` and, therefore, the incrementation must be global. However, we want to be able to include a `{WithArrows}` in another `{WithArrows}`. To do so, we must restore the previous value of these counters at the end of an environment `{WithArrows}` and we decide to manage a stack for each of these counters.

```

107 \seq_new:N \g_@@_arrow_int_seq
108 \int_new:N \g_@@_arrow_int
109 \seq_new:N \g_@@_line_int_seq
110 \int_new:N \g_@@_line_int
111 \seq_new:N \g_@@_line_bis_int_seq
112 \int_new:N \g_@@_line_bis_int

```

The token list `\l_@@_name_tl` will contain the name of the environment (given with the option `name`). This name will be used to create aliases for the names of the nodes.

```

113 \tl_new:N \l_@@_name_tl

```

The boolean `\l_@@_notag_bool` will be used in `{DispWithArrows}`. In particular, it will be raised when the command `\notag` is used.

```

114 \bool_new:N \l_@@_notag_bool

```

The token list `\l_@@_tag_tl` will contain the argument of the command `\tag`.

```

115 \tl_new:N \l_@@_tag_tl

```

The boolean `\l_@@_tag_star_bool` will be raised if the user uses the command `\tag` with a star.

```

116 \bool_new:N \l_@@_tag_star_bool

```

The command `\@@_label:n` will be linked to `\label` in the second column of the `\halign` of the environment `{DispWithArrows}`. It's possible to put several labels for the same line (it's not possible in the environments of `amsmath`). That's why we store the different labels of a same line in a sequence `\l_@@_labels_seq`.

```

117 \seq_new:N \l_@@_labels_seq
118 \cs_set:Nn \@@_label:n {\seq_if_empty:NF \l_@@_labels_seq
119     {\@@_msg_error:n {Multiple~labels}}
120     \seq_put_right:Nn \l_@@_labels_seq {#1}
121     \bool_if:nT \c_@@_mathtools_loaded_bool
122     {\MH_if_boolean:nT {show_only_refs}
123     {\cs_if_exist:cTF {MT_r_#1}
124     {\bool_set_false:N \l_@@_notag_bool}
125     {\bool_set_true:N \l_@@_notag_bool}}}
126     \bool_if:nT \c_@@_autonum_loaded_bool
127     {\cs_if_exist:cTF {autonum@#1Referenced}
128     {\bool_set_false:N \l_@@_notag_bool}
129     {\bool_set_true:N \l_@@_notag_bool}}}

```

The boolean `\l_@@_fleqn_bool` indicates whether the environments `{DispWithArrows}` must be composed flush left or centered. It corresponds to the option `fleqn`.

```

130 \bool_new:N \l_@@_fleqn_bool

```

The dimension `\l_@@_mathindent_dim` is used only by the environments `{DispWithArrows}`: it's the left margin of the environments `{DispWithArrows}` if the environment `{DispWithArrows}` is composed flush left (option `fleqn`).

```

131 \dim_new:N \l_@@_mathindent_dim
132 \dim_set:Nn \l_@@_mathindent_dim {25pt}

```

²⁰This counter is used in order to raise an error if there is a line without the second column (such an situation could raise a PGF error for an undefined node).

The boolean `\l_@@_wrap_lines_bool` corresponds to the option `wrap-lines`.

```
133 \bool_new:N \l_@@_wrap_lines_bool
```

9.6 The definition of the options

There are four levels where options can be set:

- with `\usepackage[...]{witharrows}`: this level will be called *package* level (number 0);
- with `\WithArrowsOptions{...}`: this level will be called *global* level (number 1);
- with `\begin{WithArrows}[...]`: this level will be called *environment* level (number 2);
- with `\Arrow[...]` (included in `CodeAfter`): this level will be called *local* level (number 3).

The level is specified in the variable `\l_@@_level_int` and the code attached to the options can use this information to alter its actions.

```
134 \int_set:Nn \l_@@_level_int 1
```

We start with a submodule which will be loaded only at the global or the environment level.

The options `t`, `c` and `b` indicate if we will create a `\vtop`, a `\vcenter` or a `\vbox`. This information is stored in the variable `\l_@@_pos_env_int`. Of course, they are available only in `{WithArrows}` and not in `{DispWithArrows}` or `{DispWithArrows*}`

```
135 \keys_define:nn {WithArrows/GlobalOrEnv}
136   { t .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
137                     {\int_set:Nn \l_@@_pos_env_int 0}
138                     {\@@_msg_error:n {Option-will-be-ignored}}},
139   t .value_forbidden:n = true,
140   c .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
141                     {\int_set:Nn \l_@@_pos_env_int 1}
142                     {\@@_msg_error:n {Option-will-be-ignored}}},
143   c .value_forbidden:n = true,
144   b .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
145                     {\int_set:Nn \l_@@_pos_env_int 2}
146                     {\@@_msg_error:n {Option-will-be-ignored}}},
147   b .value_forbidden:n = true,
```

The gap between two consecutive arrows.

```
148   ygap .dim_set:N = \l_@@_ygap_dim,
149   ygap .value_required:n = true,
150   ygap .initial:n = 0.4 ex,
```

The vertical position of the start point of an arrow.

```
151   ystart .dim_set:N = \l_@@_ystart_dim,
152   ystart .value_required:n = true,
153   ystart .initial:n = 0.4 ex,
```

Usually, the number of columns in a `{WithArrows}` environment is limited to 2. Nevertheless, it's possible to have more columns with the option `MoreColumns`.

```
154   MoreColumns .code:n = { \msg_redirect_name:nnn
155                           {witharrows}
156                           {Third-column-in-an-environment-{WithArrows}}
157                           {none} },
158   MoreColumns .value_forbidden:n = true,
```

By default, an error message is raised if there is a line without ampersand (&). However, it's possible to suppress this error with the option `AllowLineWithoutAmpersand`.

```

159     AllowLineWithoutAmpersand .code:n = { \msg_redirect_name:nnn
160                                         {witharrows}
161                                         {All~lines~must~have~an~ampersand}
162                                         {none} },
163     AllowLineWithoutAmpersand .value_forbidden:n = true,

```

If the user wants to give a new name to the `\Arrow` command (and the name `\Arrow` remains free).

```

164     CommandName .tl_set:N          = \l_@@_CommandName_tl,
165     CommandName .initial:n         = Arrow ,
166     CommandName .value_required:n = true,

167     TikzCode .tl_set:N            = \l_@@_tikz_code_tl,
168     TikzCode .initial:n           = \draw~(#1)~to~node{#3}~(#{2})~; ,
169     TikzCode .value_required:n = true,

```

With the option `displaystyle`, the environments will be composed in `\displaystyle`.

```

170     displaystyle .bool_set:N      = \l_@@_displaystyle_bool,
171     displaystyle .initial:n       = false,

```

With the option `shownodes`, the nodes will be drawn in red (useful only for debugging).

```

172     shownodes .bool_set:N        = \l_@@_shownodes_bool,
173     shownodes .initial:n         = false,

```

With the option `shownodenames`, the name of the “right nodes” will be written in the document (useful only for debugging).

```

174     shownodenames .bool_set:N    = \l_@@_shownodenames_bool,
175     shownodenames .initial:n     = false,

```

With the option `group`, *all* the arrows of the environment are vertical with the same abscissa and at a leftmost position.

```

176     group .code:n = {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
177                     {\@@_msg_error:n {Two~options~are~incompatible}}
178                     \int_set:Nn \l_@@_previous_pos_arrows_int 6
179                     \int_set:Nn \l_@@_pos_arrows_int 6} ,
180     group .value_forbidden:n = true,

```

With the option `groups` (with a *s*), the arrows of the environment are divided in groups by an argument of connexity, and, in each group, the arrows are vertical with the same abscissa and at a leftmost position. When the option `group` or `groups` is used, it's not possible to another option of position like `ll`, `lr`, etc. for a individual key.

```

181     groups .code:n = {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
182                     {\@@_msg_error:n {Two~options~are~incompatible}}
183                     \int_set:Nn \l_@@_previous_pos_arrows_int 7
184                     \int_set:Nn \l_@@_pos_arrows_int 7} ,
185     groups .value_forbidden:n = true,

```

The option `CodeBefore` gives a code that is executed at the beginning of the environment `{WithArrows}` (after the eventual `\begin{savenotes}`).

```

186     CodeBefore .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
187                          {\@@_msg_error:n {Option~will~be~ignored}}
188                          {\tl_put_right:Nn \l_@@_code_before_tl {#1}}} ,
189     CodeBefore .value_required:n = true,

```

The option `CodeAfter` gives a code that is executed at the end of the environment `{WithArrows}` (after the eventual `\end{savenotes}`).

```

190     CodeAfter .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
191                          {\@@_msg_error:n {Option~will~be~ignored}}
192                          {\tl_put_right:Nn \l_@@_code_after_tl {#1}}} ,
193     CodeAfter .value_required:n = true,
```

The option `name` is a name given to the environment. If this option is used, the nodes created in the environment will have aliases constructed with this name (and it will be easier to use these nodes from outside the environment).

```

194     name .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
195                    {\@@_msg_error:n {Option~will~be~ignored}}
196                    {\tl_set:Nn \l_@@_name_tl {#1}}} ,
197     name .value_required:n = true,
```

The option `fleqn` indicates whether the environments `{DispWithArrows}` are composed centered or flush left.

```

198     fleqn .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
199                      {\@@_msg_error:n {Option~will~be~ignored}}
200                      {\tl_if_eq:nnTF {#1} {true}
201                       {\bool_set_true:N \l_@@_fleqn_bool}
202                       {\bool_set_false:N \l_@@_fleqn_bool}}},
203     fleqn .default:n = true,
```

The option `mathindent` is the left margin of the environments `{DispWithArrows}` when the option `fleqn` is used.

```

204     mathindent .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
205                          {\@@_msg_error:n {Option~will~be~ignored}}
206                          {\dim_set:Nn \l_@@_mathindent_dim {#1}}},
207     mathindent .value_required:n = true,
```

The option `notag` indicates whether the environments `{DispWithArrows}` will be without tags (like `{DispWithArrows*}`).

```

208     notag .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
209                     {\@@_msg_error:n {Option~will~be~ignored}}
210                     {\tl_if_eq:nnTF {#1} {true}
211                      {\bool_set_true:N \l_@@_notag_bool}
212                      {\bool_set_false:N \l_@@_notag_bool}}},
213     notag .default:n = true,
214     nonumber .meta:n = notag,
```

The option `AllowMultipleLabels` indicates whether multiple labels are allowed for the same line of an environment `{DispWithArrows}` or `{DispWithArrows*}`.

```

215     AllowMultipleLabels .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
216                                   {\@@_msg_error:n {Option~will~be~ignored}}
217                                   {\msg_redirect_name:nnn {witharrows}
218                                    {Multiple~labels}
219                                    {none}}},
220     AllowMultipleLabels .value_forbidden:n = true,
```

With the option `wrap-lines`, a special `TikzCode` is used in the environments `{DispWithArrows}` and `{DispWithArrows*}` and, with this `TikzCode`, the lines of the labels are automatically wrapped on the right.

```

221     wrap-lines .code:n = {\bool_if:NTF \l_@@_in_witharrows_bool
222                          {\@@_msg_error:n {Option~will~be~ignored}}
223                          {\tl_if_eq:nnTF {#1} {true}
224                           {\bool_set_true:N \l_@@_wrap_lines_bool}
225                           {\bool_set_false:N \l_@@_wrap_lines_bool}}},
226     wrap-lines .default:n = true,
```

```

227     unknown .code:n = \@@_msg_error:n {Option-unknown}
228 }

```

Then we define the main module called `WithArrows/General` which will be loaded at all the levels.

The option `tikz` gives Tikz parameters that will be given to the arrow when it is drawn (more precisely, the parameters will be given to the command `\path` of Tikz).

```

229 \keys_define:nn {WithArrows/General}
230 {tikz .code:n = \tikzset {WithArrows/arrow/.append-style = {#1}},
231 tikz .initial:n = {},
232 tikz .value_required:n = true,

```

The other options are for the position of the arrows. The treatment is the same for the options `ll`, `rr`, `lr`, `rl` and `i` and that's why a dedicated function `\@@_analyze_option_position:n` has been written (see below).

```

233 rr .value_forbidden:n = true,
234 rr .code:n = \@@_analyze_option_position:n 0 ,
235 ll .value_forbidden:n = true,
236 ll .code:n = \@@_analyze_option_position:n 1 ,
237 rl .value_forbidden:n = true,
238 rl .code:n = \@@_analyze_option_position:n 2 ,
239 lr .value_forbidden:n = true,
240 lr .code:n = \@@_analyze_option_position:n 3 ,
241 i .value_forbidden:n = true,
242 i .code:n = \@@_analyze_option_position:n 5 ,

```

The option `xoffset` change the x -offset of the arrows (towards the right). It's a dimension and not a skip. It's not possible to change the value of this parameter for a individual arrow if the option `group` or the option `groups` is used. When we will treat an individual arrow, we will give it the option `tikz={xshift=\l_@@_xoffset_dim}` (we can't to it at the global or the environment level because the Tikz options `xshift` are cumulative).

```

243 xoffset .code:n = {\bool_if:nTF {\int_compare_p:nNn \l_@@_level_int = 3 &&
244 \int_compare_p:nNn \l_@@_pos_arrows_int > 5}
245 {\@@_msg_error:n {Option-incompatible-with-"group(s)"} }
246 {\dim_set:Nn \l_@@_xoffset_dim {#1}}} ,
247 xoffset .value_required:n = true,

```

The option `jot` exists for compatibility. It changes directly the value of the parameter `\jot`, which is a LaTeX parameter and not a parameter specific to `witharrows`. It's allowed only at the level of the environment (maybe we should suppress completely this option in the future).

```

248 jot .code:n = {\int_compare:nNnTF \l_@@_level_int = 2
249 {\dim_set:Nn \jot {#1}}
250 {\@@_msg_error:n {Option-will-be-ignored}}} ,
251 jot .value_required:n = true,

```

The option `interline` gives the vertical skip (=glue) inserted between two lines (independently of `\jot`). It's accepted only at the level of the environment (this last point is a kind of security). Futhermore, this option has a particular behaviour: it applies only to the current environment and doesn't apply to the nested environments.

```

252 interline .code:n = {\int_compare:nNnTF \l_@@_level_int = 2
253 {\skip_set:Nn \l_@@_interline_skip {#1}}
254 {\@@_msg_error:n {Option-will-be-ignored}}} ,
255 interline .value_required:n = true,

```

Eventually, a key `jump` (see below) and a key for unknown keys.

```

256 jump .code:n = \@@_msg_error:n {Option-will-be-ignored} ,
257 unknown .code:n = \@@_msg_error:n {Option-unknown}
258 }

```

The key `jump` indicates the number of lines jumped by the arrow (1 by default). This key will be extracted when the command `\Arrow` will be executed. That's why there is a special module for this key. The key `jump` is extracted in the command `\Arrow` because we want to compute right away the final line of the arrow (this will be useful for the options `group` and `groups`).

```

259 \keys_define:nn {WithArrows/jump}
260   {jump .code:n = {\int_set:Nn \l_@@_jump_int {#1}
261                   \int_compare:nNnF \l_@@_jump_int > 0
262                   {\@@_msg_error:n {The~option~"jump"~must~be~non~negative}}}} ,
263   jump .value_required:n = true}

```

The following command is for technical reasons. It's used for the following options of position: `ll`, `lr`, `rl`, `rr` and `i`. The argument is the corresponding code for the position of the arrows.

```

264 \cs_new_protected:Nn \@@_analyze_option_position:n
265   {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
266   {\@@_msg_error:n {Two~options~are~incompatible}}
267   \int_set:Nn \l_@@_previous_pos_arrows_int {#1}}

```

It's not possible to use one of the considered options at the level of an arrow (level 2) when the option `group` or the option `groups` is used. However, if we are at the level of an environment, it's possible to override a previous option `group` or `groups` (this previous option `group` or `groups` would necessarily have been set at a global level by `\WithArrowsOptions`).

```

268   \bool_if:nTF { \int_compare_p:nNn \l_@@_level_int = 3 &&
269               \int_compare_p:nNn \l_@@_pos_arrows_int > 5}
270   {\@@_msg_error:n {Option~incompatible~with~"group(s)"}
271   {\int_set:Nn \l_@@_pos_arrows_int {#1}}}

```

`\WithArrowsOptions` is the command of the `witharrows` package to fix options at the document level.

```

272 \NewDocumentCommand \WithArrowsOptions {m}
273   {\int_set:Nn \l_@@_previous_pos_arrows_int {-1}
274   \keys_set_known:nnN {WithArrows/General} {#1} \l_tmpa_tl
275   \keys_set:nV {WithArrows/GlobalOrEnv} \l_tmpa_tl}

```

9.7 The command `Arrow`

In fact, the internal command is not named `\Arrow` but `\@@_Arrow`. Usually, at the beginning of an environment `{WithArrows}`, `\Arrow` is set to be equivalent to `\@@_Arrow`. However, the user can change the name with the option `CommandName` and the user command for `\@@_Arrow` will be different. This mechanism can be useful when the user has already a command named `\Arrow` he wants to still be able to use in the environment `{WithArrows}`.

```

276 \NewDocumentCommand \@@_Arrow {0{} m 0{}}
277   {

```

The counter `\g_@@_arrow_int` counts the arrows in the environment. The incrementation must be global (`gincr`) because the command `\Arrow` will be used in the cell of a `\halign`. It's recalled that we manage a stack for this counter.

```

278   \int_gincr:N \g_@@_arrow_int

```

We decide to extract immediatly the key `jump` in order to compute the end line. That's the reason why there is a module `WithArrows/jump` with this sole key. The remained key-value pairs are stored in `\l_tmpa_tl` and will be stored further in the properly list of the arrow.

```

279   \int_zero_new:N \l_@@_jump_int
280   \int_set:Nn \l_@@_jump_int 1
281   \keys_set_known:nnN {WithArrows/jump} {#1,#3} \l_tmpa_tl

```

We will construct a global property list to store the informations of the considered arrow. The four fields of this property list are “initial”, “final”, “options” and “label”.

1. First, the line from which the arrow starts:

```

282   \prop_put:NnV \l_tmpa_prop {initial} \g_@@_line_int

```

2. The line where the arrow ends (that's why it was necessary to extract the key `jump`):

```
283 \int_set:Nn \l_tmpa_int {\g_@@_line_int + \l_@@_jump_int}
284 \prop_put:NnV \l_tmpa_prop {final} \l_tmpa_int
```

3. All the options of the arrow (it's a token list):

```
285 \prop_put:NnV \l_tmpa_prop {options} \l_tmpa_tl
```

4. The label of the arrow (it's also a token list):

```
286 \prop_put:Nnn \l_tmpa_prop {label} {#2}
```

The property list has been created in a local variable for convenience. Now, it will be stored in a global variable indicating both the position-in-the-tree and the number of the arrow.

```
287 \prop_gclear_new:c
288 {g_@@_arrow_\l_@@_prefix_str_\int_use:N\g_@@_arrow_int_\prop}
289 \prop_gset_eq:cN
290 {g_@@_arrow_\l_@@_prefix_str_\int_use:N\g_@@_arrow_int_\prop}
291 \l_tmpa_prop
292 }
```

```
293 \cs_new_protected:Nn \@@_Arrow_first_column:
```

All messages of LaTeX3 must be *fully expandable* and that's why we do the affectation (necessary for a comparison) before the `\msg_error:nn`.

```
294 {\tl_set:Nn \l_tmpa_tl {Arrow}
295 \@@_msg_error:n {Arrow~in~first~column}
296 \@@_Arrow}
```

9.8 The environment `{WithArrows}`

The command `\@@_pre_environment:` is a code common to the environments `{WithArrows}` and `{DispWithArrows}`. The argument is the options given to the environment.

```
297 \cs_new_protected:Nn \@@_pre_environment:n
```

First the initialisation of the three counters `\g_@@_arrow_int`, `\g_@@_line_int` and `\g_@@_line_bis_int`. However, we have to save their previous values with the three stacks created for this end.

```
298 { \seq_gput_right:NV \g_@@_arrow_int_seq \g_@@_arrow_int
299 \int_gzero:N \g_@@_arrow_int
300 \seq_gput_right:NV \g_@@_line_int_seq \g_@@_line_int
301 \int_gzero:N \g_@@_line_int
302 \seq_gput_right:NV \g_@@_line_bis_int_seq \g_@@_line_bis_int
303 \int_gzero:N \g_@@_line_bis_int
```

We also have to update the position on the nesting tree.

```
304 \seq_gput_right:Nn \g_@@_position_in_the_tree_seq 1
```

The nesting tree is used to create a prefix which will be used in the names of the Tikz nodes and in the names of the arrows (each arrow is a property list of four fields). If we are in the second environment `{WithArrows}` nested in the third environment `{WithArrows}` of the document, the prefix will be 3-2 (although the position in the tree is [3, 2, 1] since such a position always ends with a 1). First, we do a copy of the position-in-the-tree and then we pop the last element of this copy (in order to drop the last 1).

```
305 \seq_set_eq:NN \l_tmpa_seq \g_@@_position_in_the_tree_seq
306 \seq_pop_right:NN \l_tmpa_seq \l_tmpa_tl
307 \str_clear_new:N \l_@@_prefix_str
308 \str_set:Nx \l_@@_prefix_str {\seq_use:Nnnn \l_tmpa_seq {-} {-} {-}}
```

We define the command `\` to be the command `\@@_cr`: (defined below).

```
309 \cs_set_eq:NN \ \ \@@_cr:
310 \dim_zero:N \mathsurround
```

These counters will be used later as variables.

```
311 \int_zero_new:N \l_@@_initial_int
312 \int_zero_new:N \l_@@_final_int
313 \int_zero_new:N \l_@@_arrow_int
```

The value corresponding to the key `interline` is put to zero before the treatment of the options of the environment.²¹

```
314 \skip_zero:N \l_@@_interline_skip
```

The value corresponding to the key `CodeBefore` is put to nil before the treatment of the options of the environment, because, of course, we don't want the code executed at the beginning of all the nested environments `{WithArrows}`. Idem for `CodeAfter`.

```
315 \tl_clear_new:N \l_@@_code_before_tl
316 \tl_clear_new:N \l_@@_code_after_tl
```

We process the options given to the `{WithArrows}` environment. The level of options is set to 1.

```
317 \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
318 \int_set:Nn \l_@@_level_int 2
319 \keys_set_known:nnN {WithArrows/General} {#1} \l_tmpa_tl
320 \keys_set:nV {WithArrows/GlobalOrEnv} \l_tmpa_tl
```

If the option `footnote` or the option `footnotehyper` is used, then we extract the footnotes with an environment `{savenotes}` (of the package `footnote` or the package `footnotehyper`).

```
321 \bool_if:NT \g_@@_footnote_bool {\begin{savenotes}}
```

We execute the code `\l_@@_code_before_tl` of the option `CodeBefore` of the environment after the eventual `\begin{savenotes}` and, symetrically, we will execute the `\l_@@_code_after_tl` before the eventual `\end{savenotes}` (we have a good reason for the last point : we want to extract the footnotes of the arrows executed in the `CodeAfter`).

```
322 \l_@@_code_before_tl
```

If the user has given a value for the option `CommandName` (at the global or at the *environment* level), a command with this name is defined locally in the environment with meaning `\@@_Arrow`. The default value of the option `CommandName` is “Arrow” and thus, by default, the name of the command will be `\Arrow`.

```
323 \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow}
```

This is the end of `\@@_pre_environment:n`.

Now, we begin the environment `{WithArrows}`.

```
324 \NewDocumentEnvironment {WithArrows} {0{}}
325 { \bool_set_true:N \l_@@_in_witharrows_bool
326 \reverse_if:N \if_mode_math:
327 \@@_msg_error:n {{WithArrows}-used-outside-math-mode}
328 \fi:
329 \cs_set:Npn \notag {\msg_error:nnn {witharrows}
330 {Command-not-allowed-in~{WithArrows}}
331 {\notag}}
332 \cs_set:Npn \nonumber {\msg_error:nnn {witharrows}
333 {Command-not-allowed-in~{WithArrows}}
334 {\nonumber}}
335 \cs_set:Npn \tag ##1 {\msg_error:nnn {witharrows}}
```

²¹It's recalled that, by design, the option `interline` of an environment doesn't apply in the nested environments.


```

336                                     {Command-not-allowed-in-{WithArrows}}
337                                     {\tag}}
338 \cs_set:Npn \label ##1 {\msg_error:nnn {witharrows}
339                                     {Command-not-allowed-in-{WithArrows}}
340                                     {\label}}
341 \@@_pre_environment:n {#1}

```

The environment begins with a `\vtop`, a `\vcenter` or a `\vbox`²² depending of the value of `\l_@@_pos_env_int` (fixed by the options `t`, `c` or `b`). The environment `{WithArrows}` must be used in math mode²³ and therefore, we can use `\vcenter`.

```

342 \int_case:nn \l_@@_pos_env_int
343     {0 {\vtop}
344      1 {\vcenter}
345      2 {\vbox}}
346 \bgroup

```

The command `\spread@equation` is the command used by `amsmath` in the beginning of an alignment to fix the interline. When used, it becomes no-op. However, it's possible to use `witharrows` without `amsmath` since we have redefined `\spread@equation` (if it is not defined yet).

```

347 \spread@equation

```

We begin the `\halign` and the preamble.

```

348 \ialign\bgroup

```

We increment the counter `\g_@@_line_int` which will be used in the names of the Tikz nodes created in the array. This incrementation must be global (`gincr`) because we are in the cell of a `\halign`. It's recalled that we manage a stack for this counter.

```

349 \int_gincr:N \g_@@_line_int
350 \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
351 \strut\hfil
352 $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
353 &

```

In the second column, we increment the counter `\g_@@_line_bis_int` because we want to count the lines with a second column and raise an error if there is lines without a second column. Once again, the incrementation must be global and it's recalled that we manage a stack for this counter too.

```

354 \int_gincr:N \g_@@_line_bis_int
355 $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{##}}$

```

We create the “left node” of the line (when using macros in Tikz node names, the macros have to be fully expandable: here, `\tl_use:N` and `\int_use:N` are fully expandable).

```

356 \tikz [remember~picture,overlay]
357     \node [@@_node_style,
358           name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-l,
359           alias = {\tl_if_empty:NF \l_@@_name_tl
360                   {\l_@@_name_tl-\int_use:N\g_@@_line_int-l}} ] {} ;
361 \hfil

```

Now, after the `\hfil`, we create the “right node” and, if the option `shownodenames` is raised, the name of the node is written in the document (useful for debugging).

```

362 \tikz [remember~picture,overlay]
363     \node [@@_node_style,
364           name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
365           alias = {\tl_if_empty:NF \l_@@_name_tl
366                   {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
367 \bool_if:NT \l_@@_shownodenames_bool
368     {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
369                             -\int_use:N\g_@@_line_int}}

```

²²Notice that the use of `\vtop` seems color-safe here...

²³An error is raised if the environment is used outside math mode.

Usually, the `\halign` of an environment `{WithArrows}` will have exactly two columns. Nevertheless, if the user wants to use more columns (without arrows) it's possible with the option `MoreColumns`.

```

370      && \@@_msg_error:n {Third~column~in~an~environment~{WithArrows}}
371      $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
372      \cr
373    }

```

We begin the second part of the environment `{WithArrows}`. We have two `\egroup`: one for the `\halign` and one for the `\vtop` (or `\vcenter` or `\vbox`).

```

374    {\crrcr
375      \egroup
376      \egroup
377      \@@_post_environment:

```

If the option `footnote` or the option `footnotehyper` is used, then we extract the footnotes with an environment `{footnote}` (of the package `footnote` or the package `footnotehyper`).

```

378      \bool_if:NT \g_@@_footnote_bool {\end{savenotes}}
379    }

```

This is the end of the environment `{WithArrows}`.

The command `\@@_post_environment:` is a code common to the second part of the environment `{WithArrows}` and the environment `{DispWithArrows}`.

```

380 \cs_new_protected:Nn \@@_post_environment:

```

If there is a line without the second column, we raise an error (a line without the second column could generate an PGF error for an unknown node since the nodes are created in the second column).

```

381      {\int_compare:nNnT \g_@@_line_bis_int < \g_@@_line_int
382        {\@@_msg_error:n {All~lines~must~have~an~ampersand}}

```

If there is really arrows in the environment, we draw the arrows:

- if neither option `group` or `groups` is used, we can draw directly ;
- if option `group` or option `groups` is used (`\l_@@_pos_arrows_int > 5`), we have to draw the arrows group by group ; the macro `\@@_draw_arrows:` does the work.

```

383      \int_compare:nNnT \g_@@_arrow_int > 0
384        {\int_compare:nNnTF \l_@@_pos_arrows_int > 5
385          \@@_draw_arrows:
386          {\@@_draw_arrows:nn 1 \g_@@_arrow_int}}

```

We will execute the code specified in the option `CodeAfter`, after some settings.

```

387      \group_begin:
388      \tikzset{every~picture/.style = @@_standard}

```

The command `\NbLines` is not used by `witharrows`. It's only a convenience given to the user.

```

389      \cs_set:Npn \NbLines {\int_use:N \g_@@_line_int}

```

The command `\MultiArrow` is available in `CodeAfter`, and we have a special version of `\Arrow`, called “`\Arrow` in `CodeAfter`” in the documentation.²⁴

```

390      \cs_set_eq:NN \MultiArrow \@@_MultiArrow:nn
391      \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_code_after
392      \l_@@_code_after_tl
393      \group_end:

```

We update the position-in-the-tree. First, we drop the last component and then we increment the last element.

```

394      \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
395      \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
396      \seq_gput_right:Nx \g_@@_position_in_the_tree_seq {\int_eval:n {\l_tmpa_tl+1}}

```

²⁴As for now, `\MultiArrow` has no option, and that's why its internal name is a name of `expl3` with the signature `:nn` whereas `\Arrow` in `CodeAfter` provides options and has the name of a function defined with `\NewDocumentCommand`.

We update the value of the counter `\g_@@_last_env_int`. This counter is used only by the user function `\WithArrowsLastEnv`.

```
397         \int_compare:nNtT {\seq_count:N \g_@@_position_in_the_tree_seq} = 1
398             {\int_gincr:N \g_@@_last_env_int}
```

Finally, we restore the previous values of the three counters `\g_@@_arrow_int`, `\g_@@_line_int` and `\g_@@_line_bis_int`. It is recalled that we manage three stacks in order to be able to do such a restoration.

```
399         \seq_gpop_right:NN \g_@@_arrow_int_seq {\l_tmpa_tl}
400         \int_gset:Nn \g_@@_arrow_int {\l_tmpa_tl}
401         \seq_gpop_right:NN \g_@@_line_int_seq \l_tmpa_tl
402         \int_gset:Nn \g_@@_line_int {\l_tmpa_tl}
403         \seq_gpop_right:NN \g_@@_line_bis_int_seq \l_tmpa_tl
404         \int_gset:Nn \g_@@_line_bis_int {\l_tmpa_tl}
405     }
```

That's the end of the command `\@@_post_environment:`.

We give now the definition of `\@@_cr:` which is the definition of `\` in an environment `{WithArrows}`. The two `expl3` commands `\group_align_safe_begin:` and `\group_align_safe_end:` are specifically designed for this purpose: test the token that follows in a `\halign` structure.

First, we remove an eventual token `*` since the commands `\` and `*` are equivalent in an environment `{WithArrows}` (an environment `{WithArrows}`, like an environment `{aligned}` of `amsmath`, is always unbreakable).

```
406 \cs_new_protected:Nn \@@_cr:
407     {\scan_stop:
408     \group_align_safe_begin:
409     \peek_meaning_remove:NTF * \@@_cr_i: \@@_cr_i:}
```

Then, we peek the next token to see if it's a `[`. In this case, the command `\` has an optional argument which is the vertical skip (`=glue`) to put.

```
410 \cs_new_protected:Nn \@@_cr_i:
411     {\peek_meaning:NTF [ {\@@_cr_ii:} {\@@_cr_ii:[c_zero_dim]} }
412 \cs_new_protected:Npn \@@_cr_ii: [#1]
413     {\group_align_safe_end:
```

For the environment `{DispWithArrows}`, the behaviour of `\` is different because we add the third column which is the column for the tag (number of the equation).

```
414     \bool_if:NF \l_@@_in_witharrows_bool
415     {\bool_if:NTF \l_@@_notag_bool
```

If there is no tag to put, we use as well the third column because you want to raise an error if the user uses more than two columns.

```
416         & \tikz [@@_standard] \coordinate (\int_use:N\g_@@_line_int-v) ; }
417     {
```

Here, we can't use `\refstepcounter{equation}` because if the user has issued a `\tag` command, we have to use `\l_@@_tag_tl` and not `\theequation`. That's why we have to do the job done by `\refstepcounter` manually.

First, the incrementation of the counter (potentially).

```
418         \tl_if_empty:NT \l_@@_tag_tl
419         {\int_gincr:N \c@equation}
```

We store in `\g_tmpa_tl` the tag we will have to compose at the end of the line. We use a global variable because we will use it in the *next* cell (after the `&`).

```
420     \cs_gset:Npx \g_tmpa_tl
421     {\tl_if_empty:NTF \l_@@_tag_tl
422     \theequation
423     \l_@@_tag_tl}
```

It's possible to put several labels for the same line (it's not possible in the environments of `amsmath`). That's why the different labels of a same line are stored in a sequence `\l_@@_labels_seq`.

```
424     \seq_if_empty:NF \l_@@_labels_seq
425     {
```

Now, we do the job done by `\refstepcounter` and by the redefinitions of `\refstepcounter` done by some packages (the incrementation of the counter has been done yet).

First an action which is in the definition of `\refstepcounter` in `source2e`.

```
426 \cs_set:Npx \@currentlabel {\p@equation \g_tmpa_tl}
```

Then, an action done by `hyperref` in its redefinition of `\refstepcounter`.

```
427 \bool_if:NT \c_@@_hyperref_loaded_bool
428 {\cs_set:Npn \This@name {equation}
429 \hyper@refstepcounter{equation}}
```

Then, an action done by `cleveref` in its redefinition of `\refstepcounter`. The package `cleveref` creates in the `aux` file a command `\cref@currentlabel` similar to `\@currentlabel` but with more informations.

```
430 \bool_if:NT \c_@@_cleveref_loaded_bool
431 {\cref@constructprefix{equation}{\cref@result}
432 \ifundefined{cref@equation@alias}
433 {\def\@tempa{equation}}
434 {\def\@tempa{\csname cref@equation@alias\endcsname}}
435 \protected@edef\cref@currentlabel
436 {[\@tempa][\arabic{equation}][\cref@result]
437 \p@equation \g_tmpa_tl}}
```

Then, an action done by `typedref` in its redefinition of `\refstepcounter`. The command `\sr@name` is a prefix added to the name of the label by the redefinition of `\label` done by `typedref`.

```
438 \bool_if:NT \c_@@_typedref_loaded_bool
439 {\cs_set:Npn \sr@name {equation}}
```

Now, we can issue the command `\label` (some package may have redefined `\label`, for example `typedref`) for each item in the sequence of the labels (it's possible to put several labels to the same line and that's why the labels are in the sequence `\l_@@_labels_seq`).

```
440 \seq_map_function:NN \l_@@_labels_seq \@_old_label}
```

We store the boolean `\l_@@_tag_star_bool` in the global variable `\g_tmpa_bool` because we will use it in the *next* cell (after the `&`).

```
441 \bool_gset_eq:NN \g_tmpa_bool \l_@@_tag_star_bool
442 & \cs_set_eq:NN \theequation \g_tmpa_tl
443 \bool_if:NT \g_tmpa_bool {\cs_set:Npn \tagform@ {}}
```

We use `\@eqnnum` (we recall that there are two definitions of `\@eqnnum`, a standard definition and another, loaded if the class option `leqno` is used). However, of course, the position of the v-node is not the same whether the option `leqno` is used or not. That's here that we use the flag `\c_@@_leqno_bool`.

```
444 \hbox_overlap_left:n
445 {\bool_if:NF \c_@@_leqno_bool
446 {\tikz [@@_standard] \coordinate (\int_use:N \g_@@_line_int-v) ;}
447 \quad
448 \@eqnnum }
449 \bool_if:NT \c_@@_leqno_bool
450 {\tikz [@@_standard] \coordinate (\int_use:N \g_@@_line_int-v) ;}
451 }}
452 \cr\noalign{\skip_vertical:n {#1 + \l_@@_interline_skip}
453 \scan_stop:}}
```

According to the documentation of `expl3`, the previous addition in “`#1 + \l_@@_interline_skip`” is really an addition of skips (=glues).

9.9 The environment `{DispWithArrows}`

For the environment `{DispWithArrows}`, the construction is a construction of the type:

```
\[ \vcenter{\halign to \displaywidth {...}}\]
```

The purpose of the `\vcenter` is to have an environment unbreakable.

```
454 \NewDocumentEnvironment {DispWithArrows} {0{}}
455 {
```

If `mathtools` has been loaded with the option `showonlyrefs`, we disable the code of `mathtools` for the option `showonlyrefs` with the command `\MT_showonlyrefs_false`: (it will be reactivated at the end of the environment).

```

456     \bool_if:nT \c_@@_mathtools_loaded_bool
457         {\MH_if_boolean:nT {show_only_refs}
458         {\MT_showonlyrefs_false:

```

However, we have to re-raise the flag `{show_only_refs}` of `mhsetup` because it has been switched off by `\MT_showonlyrefs_false`: and we will use it in the code of the new version of `\label`.

```

459         \MH_set_boolean:T:n {show_only_refs}
460         \bool_set_true:N \l_@@_notag_bool}}

```

The command `\intertext@` is a command of `amsmath` which loads the definition of `\intertext`.

```

461     \bool_if:NT \c_@@_amsmath_loaded_bool \intertext@
462     \if_mode_math:
463         \@@_msg_error:n {{DispWithArrows}~used-in-math-mode}
464     \fi:
465     \bool_set_false:N \l_@@_in_witharrows_bool
466     \@@_pre_environment:n {#1}

```

We don't use `\[` of LaTeX because some extensions, like `autonum`, do a redefinition of `\[`. However, we put the following lines which are in the definition of `\[` even though they are in case of misuse.

```

467     \if_mode_vertical:
468         \nointerlineskip
469         \makebox[.6\linewidth]{}
470     \fi:
471     $$

```

We use a `\vcenter` in order to prevent page breaks in the environment.

```

472     \vcenter \bgroup
473     \spread@equation
474     \bool_if:NTF \l_@@_fleqn_bool
475         {\tabskip = \c_zero_skip}
476         {\tabskip = 0 pt plus 1000 pt minus 1000 pt}

```

If `amsmath` is loaded, the LaTeX version of `\label` is stored in `\ltx@label`. If not, it's, of course, stored in `\label`. We store this definition of `\label` because we will redefine `\label` in the environment.

```

477     \bool_if:NTF \c_@@_amsmath_loaded_bool
478         {\cs_set_eq:NN \_@@_old_label \ltx@label}
479         {\cs_set_eq:NN \_@@_old_label \label}
480     \cs_set:Npn \notag {\msg_error:nnn {witharrows}
481         {Command-not-allowed-in~{DispWithArrows}}
482         {\notag}}
483     \cs_set:Npn \nonumber {\msg_error:nnn {witharrows}
484         {Command-not-allowed-in~{DispWithArrows}}
485         {\nonumber}}
486     \cs_set:Npn \tag ##1 {\msg_error:nnn {witharrows}
487         {Command-not-allowed-in~{DispWithArrows}}
488         {\tag}}
489     \cs_set:Npn \label ##1 {\msg_error:nnn {witharrows}
490         {Command-not-allowed-in~{DispWithArrows}}
491         {\label}}
492     \halign to \displaywidth \bgroup
493         \int_gincr:N \g_@@_line_int
494         \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
495         \strut
496         \bool_if:NT \l_@@_fleqn_bool
497             {\skip_horizontal:n \l_@@_mathindent_dim}
498         \hfil
499         $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
500         \tabskip = \c_zero_skip
501     &
502     \cs_set:Npn \notag {\bool_set_true:N \l_@@_notag_bool}
503     \cs_set_eq:NN \nonumber \notag

```

```

504 \cs_set_eq:NN \tag \@@_tag
505 \cs_set_eq:NN \label \@@_label:n
506 $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{}}##$
507 \tabskip = 0 pt plus 1000 pt minus 1000 pt
508 \int_gincr:N \g_@@_line_bis_int
509 \tikz [remember~picture,overlay]
510 \node [_@@_node_style,
511         name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-1,
512         alias = {\tl_if_empty:NF \l_@@_name_tl
513                 {\l_@@_name_tl-\int_use:N\g_@@_line_int-1}} ] {} ;
514 \hfil
515 \tikz [remember~picture,overlay]
516 \node [_@@_node_style,
517         name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
518         alias = {\tl_if_empty:NF \l_@@_name_tl
519                 {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
520 \bool_if:NT \l_@@_shownodenames_bool
521 {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
522                         -\int_use:N\g_@@_line_int}}
523 & ##
524 \tabskip = \c_zero_skip
525 && \@@_msg_error:n {Third-column-in-an-environment~{DispWithArrows}}
526 \iffalse ## \fi
527 \cr}
528 {\}

```

The following `\egroup` is for the `\halign`.

```

529 \egroup

```

The following `\egroup` is for the `\vcenter` (aimed to prevent page breaks).

```

530 \egroup

```

If the option `wrap-lines` is used (only in `{DispWithArrows}` and `{DispWithArrows*}`), we compute `\g_@@_x_right_dim`. As a first approximation, `\g_@@_x_right_dim` is the x -value of the right side of the current composition box. In fact, we must take into account the potential labels of the equations. That's why we compute `\g_@@_x_right_dim` with the v -nodes of each row specifically built in this goal. `\g_@@_x_right_dim` is the minimal value of the x -value of these nodes.

```

531 \bool_if:NT \l_@@_wrap_lines_bool
532 {\dim_gzero_new:N \g_@@_x_right_dim
533 \dim_gset:Nn \g_@@_x_right_dim \c_max_dim
534 \begin{tikzpicture} [@@_standard]
535 \int_step_variable:nnnNn 1 1 \g_@@_line_int \l_tmpa_int
536 {\tikz@parse@node\pgfutil@firstofone (\l_tmpa_int-v)
537 \dim_set:Nn \l_tmpa_dim \pgf@x
538 \dim_compare:nNnT \l_tmpa_dim < \g_@@_x_right_dim
539 {\dim_gset:Nn \g_@@_x_right_dim \l_tmpa_dim} }
540 \end{tikzpicture}}

```

We test whether there is a collision between a line and a label of equation. If there is no problem, we should probably merge this code with the previous one.

```

541 {\begin{tikzpicture} [@@_standard]
542 \int_step_variable:nnnNn 1 1 \g_@@_line_int \l_tmpa_int
543 {\tikz@parse@node\pgfutil@firstofone (\l_tmpa_int-v)
544 \dim_set:Nn \l_tmpa_dim \pgf@x
545 \tikz@parse@node\pgfutil@firstofone (\l_tmpa_int-l)
546 \dim_set:Nn \l_tmpb_dim \pgf@x
547 \dim_compare:nNnT \l_tmpb_dim > \l_tmpa_dim
548 {\@@_msg_error:n {Collision}}}
549 \end{tikzpicture}}

```

The code in `\@@_post_environment:` is common to `{WithArrows}` and `{DispWithArrows}`.

```

550 \@@_post_environment:

```

If `mathtools` has been loaded with the option `showonlyrefs`, we reactivate the code of `mathtools` for the option `showonlyrefs` with the command `\MT_showonlyrefs_true`: (it has been deactivated in the beginning of the environment).

```

551         \bool_if:nT \c_@@_mathtools_loaded_bool
552             {\MH_if_boolean:nT {show_only_refs}
553              \MT_showonlyrefs_true:}
554     $$

```

If the option `footnote` or the option `footnotehyper` is used, then we extract the footnotes with an environment `{footnote}` (of the package `footnote` or the package `footnotehyper`).

```

555         \bool_if:nT \g_@@_footnote_bool {\end{savenotes}}
556         \ignorespacesafterend
557     }

```

The command `\@@_tag` will be linked to `\tag` in the environment `{DispWithArrows}`.

```

558 \NewDocumentCommand \@@_tag {sm}
559   {\tl_if_empty:NF \l_@@_tag_tl
560    {\msg_error:nnn {witharrows} {Multiple-tags} {#2}}
561    \bool_set_false:N \l_@@_notag_bool
562    \bool_if:nT \c_@@_mathtools_loaded_bool
563        {\MH_if_boolean:nT {show_only_refs}
564         {\MH_if_boolean:nF {show_manual_tags}
565          {\bool_set_true:N \l_@@_notag_bool}}}
566    \tl_set:Nn \l_@@_tag_tl {#2}
567    \bool_set:Nn \l_@@_tag_star_bool {#1}

```

The starred version `\tag*` can't be use if `amsmath` has not been loaded because this version does the job by deactivating the command `\tagform@` inserted by `amsmath` in the (two versions of the) command `\eqnnum`.²⁵

```

568     \bool_if:nT {#1 && ! \bool_if_p:N \c_@@_amsmath_loaded_bool}
569     { \@@_msg_error:n {tag*~without~amsmath} }
570 }

```

With the environment `{DispWithArrows*}`, the equations are not numbered. We don't put `\begin{DispWithArrows}` and `\end{DispWithArrows}` because there is a `\@currenvir` in an error message.

```

571 \NewDocumentEnvironment {DispWithArrows*} {}
572   {\WithArrowsOptions{notag}
573    \DispWithArrows}
574   {\endDispWithArrows}

```

9.10 We draw the arrows

`\@@_draw_arrows`: draws the arrows when the option `group` or the option `groups` is used. In both cases, we have to compute the x -value of a group of arrows before actually drawing the arrows of that group. The arrows will actually be drawn by the macro `\@@_draw_arrows:nn`.

```

575 \cs_new_protected:Nn \@@_draw_arrows:
576   { \group_begin:

```

`\l_@@_first_arrow_of_group_int` will be the first arrow of the current group.

`\l_@@_first_line_of_group_int` will be the first line involved in the group of arrows (equal to the initial line of the first arrow of the group because the option `jump` is always positive).

`\l_@@_last_line_of_group_int` will be the last line involved in the group (impossible to guess in advance).

```

577     \int_zero_new:N \l_@@_first_arrow_of_group_int
578     \int_zero_new:N \l_@@_first_line_of_group_int
579     \int_zero_new:N \l_@@_last_line_of_group_int
580     \bool_set_true:N \l_@@_new_group_bool

```

²⁵There are two versions of `\eqnnum`, a standard version and a version for the option `leqno`.

We begin a loop over all the arrows of the environment. Inside this loop, if a group is finished, we will draw the lines of that group.

```

581 \int_set:Nn \l_@@_arrow_int 1
582 \int_until_do:nNnn \l_@@_arrow_int > \g_@@_arrow_int
583 {

```

We extract from the property list of the current arrow the fields “initial” and “final” and we store these values in `\l_@@_initial_int` and `\l_@@_final_int`. However, we have to do a conversion because the components of a property list are token lists.

```

584 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
585 {initial} \l_tmpa_tl
586 \int_set:Nn \l_@@_initial_int {\l_tmpa_tl}
587 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
588 {final} \l_tmpa_tl
589 \int_set:Nn \l_@@_final_int {\l_tmpa_tl}

```

We test if the previous arrow was in fact the last arrow of a group. In this case, we have to draw all the arrows of that group (with the x -value computed in `\g_@@_x_dim`).

```

590 \bool_if:nT { \int_compare_p:nNn \l_@@_pos_arrows_int = 7
591             && \int_compare_p:nNn \l_@@_arrow_int > 1
592             && \int_compare_p:nNn
593               \l_@@_initial_int > \l_@@_last_line_of_group_int}
594 {\@@_draw_arrows:nn \l_@@_first_arrow_of_group_int {\l_@@_arrow_int - 1}
595 \bool_set_true:N \l_@@_new_group_bool}

```

The flag `\l_@@_new_group_bool` indicates if we have to begin a new group of arrows. In fact, we have to begin a new group in two circumstances: if we are at the first arrow of the environment (that’s why the flag is raised before the beginning of the loop) and if we have just finished a group (that’s why the flag is raised in the previous conditionnal). At the beginning of a group, we have to initialize four variables: `\l_@@_first_arrow_int`, `\l_@@_first_line_of_group_int`, `\l_@@_last_line_of_group` and `\g_@@_x_dim` (global for technical reasons). The last two will evolve during the construction of the group.

```

596 \bool_if:nTF \l_@@_new_group_bool
597 {\bool_set_false:N \l_@@_new_group_bool
598 \int_set:Nn \l_@@_first_arrow_of_group_int \l_@@_arrow_int
599 \int_set:Nn \l_@@_first_line_of_group_int \l_@@_initial_int
600 \int_set:Nn \l_@@_last_line_of_group_int \l_@@_final_int
601 \begin{tikzpicture} [@@_standard]
602 \tikz@parse@node\pgfutil@firstofone (\int_use:N\l_@@_initial_int-1)
603 \dim_gset:Nn \g_@@_x_dim \pgf@x
604 \end{tikzpicture}
605 }

```

If we are not at the beginning of a new group, we actualize `\l_@@_last_line_of_group_int`.

```

606 {\int_set:Nn \l_@@_last_line_of_group_int
607 {\int_max:nn \l_@@_last_line_of_group_int \l_@@_final_int}}

```

We update the current x -value (in `\g_@@_x_dim`) even if we are at the beginning of a group. Indeed, the previous initialisation of `\g_@@_x_dim` only considers the initial line of the arrows and now we consider all the lines between the initial and the final line. This is done with `\@@_update_x_value:nn`. We have written a command for this because it is also used with the option `i` (`\l_@@_pos_arrows_int = 5`).

```

608 \@@_update_x_value:nn \l_@@_initial_int \l_@@_final_int

```

Incrementation of the index of the loop (and end of the loop).

```

609 \int_incr:N \l_@@_arrow_int
610 }

```


After the last arrow of the environment, we have to draw the last group of arrows.

```

611 \@@_draw_arrows:nn \l_@@_first_arrow_of_group_int \g_@@_arrow_int
612 \group_end:
613 }

```

The following code is necessary because we will have to expand an argument exactly 3 times.

```

614 \cs_generate_variant:Nn \keys_set:nn {no}
615 \cs_new_protected:Nn \@@_keys_set: {\keys_set:no {WithArrows/General}}

```

The macro `\@@_draw_arrows:nn` draws all the arrows whose numbers are between `#1` and `#2`. `#1` and `#2` must be expressions that expands to an integer (they are expanded in the beginning of the macro).

```

616 \cs_new_protected:Nn \@@_draw_arrows:nn
617 {\group_begin:
618 \int_zero_new:N \l_@@_first_arrow_int
619 \int_set:Nn \l_@@_first_arrow_int {#1}
620 \int_zero_new:N \l_@@_last_arrow_int
621 \int_set:Nn \l_@@_last_arrow_int {#2}

```

We begin a loop over the arrows we have to draw. The variable `\l_@@_arrow_int` (local in the environment `{WithArrows}`) will be used as index for the loop.

```

622 \int_set:Nn \l_@@_arrow_int \l_@@_first_arrow_int
623 \int_until_do:nNnn \l_@@_arrow_int > \l_@@_last_arrow_int
624 {

```

We extract from the property list of the current arrow the fields “initial” and “final” and we store these values in `\l_@@_initial_int` and `\l_@@_final_int`. However, we have to do a conversion because the components of a property list are token lists.

```

625 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
626 {initial} \l_tmpa_tl
627 \int_set:Nn \l_@@_initial_int {\l_tmpa_tl}
628 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
629 {final} \l_tmpa_tl
630 \int_set:Nn \l_@@_final_int {\l_tmpa_tl}

```

If the arrow ends after the last line of the environment, we raise an error (we recall that, after the construction of the `\halign`, `\g_@@_line_int` is the total number of lines of the environment). If the initial node or the final node doesn’t exist, we also raise an error.²⁶

```

631 \int_compare:nNnTF \l_@@_final_int > \g_@@_line_int
632 {\@@_msg_error:n {Too~few~lines~for~an~arrow}}
633 {\cs_if_free:cTF{pgf@sh@ns@wa-\l_@@_prefix_str-\int_use:N\l_@@_initial_int-1}
634 { \@@_msg_error:n {A-PGF-node-doesn't-exist} }
635 {\cs_if_free:cTF{pgf@sh@ns@wa-\l_@@_prefix_str-\int_use:N\l_@@_final_int-1}
636 { \@@_msg_error:n {A-PGF-node-doesn't-exist} }
637 {\@@_draw_arrows_i:}}
638 \int_incr:N \l_@@_arrow_int
639 }
640 \group_end:
641 }

```

The macro `\@@_draw_arrows_i:` is only for the lisibility of the code. This macro will draw the current arrow if the arrow is not impossible (that is to say if the Tikz nodes exist). The first `\group_begin:` is for the options of the arrow.

```

642 \cs_new:Nn \@@_draw_arrows_i:
643 {\group_begin:
644 \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
645 \int_set:Nn \l_@@_level_int 3

```

²⁶This case occurs if the considered line has no ampersand. In fact, we raise an error if there is such a line in the `\halign`, but, nonetheless, we consider the case where the user goes on and we try to avoid other errors.

We process the options of the current arrow. The second argument of `\keys_set:nn` must be expanded exactly three times. An x-expansion is not possible because there can be tokens like `\bfseries` in the option `font` of the option `tikz`. This expansion is a bit tricky.

```

646 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str
647             _\int_use:N\l_@@_arrow_int _prop} {options} \l_tmpa_tl
648 \exp_args:NNo \exp_args:No
649 \@@_keys_set: {\l_tmpa_tl,tikz={xshift = \l_@@_xoffset_dim}}
```

We create two booleans to indicate the position of the initial node and final node of the arrow in cases of options `rr`, `rl`, `lr` or `ll`:

```

650 \bool_set_false:N \l_@@_initial_r_bool
651 \bool_set_false:N \l_@@_final_r_bool
652 \int_case:nn \l_@@_pos_arrows_int
653     {0 {\bool_set_true:N \l_@@_initial_r_bool
654         \bool_set_true:N \l_@@_final_r_bool}
655      2 {\bool_set_true:N \l_@@_initial_r_bool}
656      3 {\bool_set_true:N \l_@@_final_r_bool}}
```

option	rr	ll	rl	lr	v	i	group	groups
<code>\l_@@_pos_arrows_int</code>	0	1	2	3	4	5	6	7

The option `v` can be used only in `\Arrow` in `CodeAfter` (see below).

In case of option `i` (`\l_@@_pos_arrows_int = 5`), we have to compute the x -value of the arrow (which is vertical). The computed x -value is stored in `\g_@@_x_dim` (the same variable used when the option `group` or the option `groups` is used). This variable is global for technical reasons: we have to do assignments in a Tikz node.

```

657 \int_compare:nNnT \l_@@_pos_arrows_int = 5
658 {
```

First, we calculate the initial value for `\g_@@_x_dim`. We use a Tikz command, but, in fact, nothing is drawn. We use this Tikz command only to read the abscissa of a Tikz node.

```

659 \begin{tikzpicture} [@@_standard]
660 \tikz@parse@node\pgfutil@firstofone (\int_use:N\l_@@_initial_int-1)
661 \dim_gset:Nn \g_@@_x_dim \pgf@x
662 \end{tikzpicture}
```

A global assignment is necessary because of Tikz.

Then, we will loop to determine the maximal length of the lines between the lines `\l_@@_initial_int` and `\l_@@_final_int`... but we have written a command dedicated to this work because it will also be used in `\@@_draw_arrows:.`

```

663 \@@_update_x_value:nn \l_@@_initial_int \l_@@_final_int
664 }
```

`\l_@@_initial_tl` contains the name of the Tikz node from which the arrow starts (in normal cases... because with the option `i`, `group` and `groups`, the point will perhaps have another x -value — but always the same y -value). Idem for `\l_@@_final_tl`.

```

665 \tl_set:Nx \l_@@_initial_tl
666     {\int_use:N\l_@@_initial_int-\bool_if:NTF\l_@@_initial_r_bool rl .south}
667 \tl_set:Nx \l_@@_final_tl
668     {\int_use:N\l_@@_final_int-\bool_if:NTF\l_@@_final_r_bool rl .north}
```

We use “`.south`” and “`.north`” because we want a small gap between two consecutive arrows (and the Tikz nodes created have the shape of small vertical segments: use option `shownodes` to visualize the nodes).

The label of the arrow will be stored in `\l_tmpa_tl`.

```

669 \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
670             {label}
671             \l_tmpa_tl
```

We have to compute the coordinates of the extremities of the arrow. We retrieve the coordinates in `\g_tmpa_tl` and `\g_tmpb_tl`. This extraction of the coordinates is necessary because we must give coordinates and not nodes (even anchored) to `\@@_draw_arrow:nnn` to have the `xshift` correct.

```

672 \int_compare:nNnTF \l_@@_pos_arrows_int < 5
673   {\begin{tikzpicture} [@@_standard]
674     \tikz@scan@one@point\pgfutil@firstofone(\l_@@_initial_tl)
675     \tl_gset:Nx \g_tmpa_tl {\dim_use:N\pgf@x,\dim_use:N\pgf@y}
676     \tikz@scan@one@point\pgfutil@firstofone(\l_@@_final_tl)
677     \tl_gset:Nx \g_tmpb_tl {\dim_use:N\pgf@x,\dim_use:N\pgf@y}
678   \end{tikzpicture}}
679 }

```

If we use option `i` or `group` or `groups`, we use the abscissa specially computed in `\g_@@_x_dim`.

```

680   {\begin{tikzpicture} [@@_standard]
681     \tikz@scan@one@point\pgfutil@firstofone (\l_@@_initial_tl)
682     \tl_gset:Nx \g_tmpa_tl {\dim_use:N \g_@@_x_dim , \dim_use:N \pgf@y}
683     \tikz@scan@one@point\pgfutil@firstofone (\l_@@_final_tl)
684     \tl_gset:Nx \g_tmpb_tl {\dim_use:N \g_@@_x_dim , \dim_use:N \pgf@y}
685   \end{tikzpicture}}

```

Eventually, we can draw the arrow with the code in `\l_@@_tikz_code_tl`. We recall that the value by default for this token list is : “`\draw (#1) to node {#3} (#2) ;`”. This value can be modified with the option `TikzCode`. We use the variant `\@@_draw_arrow:nno` of the macro `\@@_draw_arrow:nnn` because of the characters *underscore* in the name `\l_tmpa_tl` : if the user uses the Tikz library `babel`, the third argument of the command `\@@_draw_arrow:nno` will be rescanned because this third argument will be in the argument of a command `node` of an instruction `\draw` of Tikz... and we will have an error because of the characters *underscore*.²⁷

```

686 \@@_draw_arrow:nno {\g_tmpa_tl} {\g_tmpb_tl} {\l_tmpa_tl}

```

We close the TeX group opened for the options given to `\Arrow[...]` (local level of the options).

```

687 \group_end: }

```

The function `@@_tmpa:nnn` will draw the arrow. It’s merely an environment `{tikzpicture}`. However, the Tikz instruction in this environment must be inserted from `\l_@@_tikz_code_tl` with the markers `#1`, `#2` and `#3`. That’s why we create a function `\@@_def_function_tmpa:n` which will create the function `\@@_tmpa:nnn`.

```

688 \cs_new_protected:Nn \@@_def_function_tmpa:n
689   {\cs_set:Nn \@@_tmpa:nnn
690     {\begin{tikzpicture}[@@_standard,every~path/.style = {WithArrows/arrow}]
691       #1
692     \end{tikzpicture}}}

```

When we draw the arrow (with `\@@_draw_arrow:nnn`), we first create the function `\@@_tmpa:nnn` and, then, we use the function `\@@_tmpa:nnn` :

```

693 \cs_new_protected:Nn \@@_draw_arrow:nnn
694   {

```

If the option `wrap-lines` is used, we have to use a special version of `\l_@@_tikz_code_tl` (which corresponds to the option `TikzCode`).

```

695   \bool_if:nT {\l_@@_wrap_lines_bool && ! \l_@@_in_witharrows_bool}
696   { \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_wrap_lines_tl }

```

Now, the main lines of this function `\@@_draw_arrow:nnn`.

```

697   \exp_args:No \@@_def_function_tmpa:n \l_@@_tikz_code_tl
698   \@@_tmpa:nnn {#1} {#2} {#3} }
699 \cs_generate_variant:Nn \@@_draw_arrow:nnn {nno}

```

²⁷There were other solutions : use another name without *underscore* (like `\ltmpat1`) or use the package `underscore` (with this package, the characters *underscore* will be rescanned without errors, even in text mode).

If the option `wrap-lines` is used, we have to use a special version of `\l_@@_tikz_code_tl` (which corresponds to the option `TikzCode`).

```
700 \tl_set:Nn \c_@@_tikz_code_wrap_lines_tl
701 {
```

First, we draw the arrow without the label.

```
702 \draw (#1) to node (@@_label) {} (#2) ;
```

We retrieve in `\pgf@x` the abscissa of the left-side of the label we will put.

```
703 \tikz@parse@node \pgfutil@firstofone (@@_label.west)
```

We compute in `\l_tmpa_dim` the maximal width possible for the label. `0.3333 em` is the default value of `inner sep` in the nodes of Tikz. Maybe we should put the exact Tikz parameter. Here is the use of `\g_@@_x_right_dim` which has been computed previously with the `v-nodes`.

```
704 \dim_set:Nn \l_tmpa_dim {\g_@@_x_right_dim - \pgf@x - 0.3333 em}
```

We retrieve in `\g_tmpa_tl` the current value of the Tikz parameter “`text width`”.²⁸

```
705 \path \pgfextra {\tl_gset:Nx \g_tmpa_tl \tikz@text@width} ;
```

Maybe the current value of the parameter “`text width`” is shorter than `\l_tmpa_dim`. In this case, we must use “`text width`” (we update `\l_tmpa_dim`).

```
706 \tl_if_empty:NF \g_tmpa_tl
707 {\dim_set:Nn \l_tmpb_dim \g_tmpa_tl
708 \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
709 {\dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim}}
```

Now, we can put the label with the right value for “`text width`”.

```
710 \dim_compare:nNnT \l_tmpa_dim > \c_zero_dim
711 {\path (@@_label.west)
712 node [anchor = west, text-width = \dim_use:N \l_tmpa_dim]
713 {#3} ; } }
```

The command `\@@_update_x_value:nn` will analyze the lines²⁹ between `#1` and `#2` in order to modify `\g_@@_x_dim` in consequence. More precisely, `\g_@@_x_dim` is increased if a line longer than the current value of `\g_@@_x_dim` is found. `\@@_update_x_value:nn` is used in `\@@_draw_arrows:` (for options `group` and `groups`) and in `\@@_draw_arrows:nn` (for option `i`).

```
714 \cs_new_protected:Nn \@@_update_x_value:nn
715 {\int_step_inline:nnnn {#1} 1 {#2}
716 {\cs_if_exist:cT {pgf@sh@ns@wa-\l_@@_prefix_str-##1-l}
717 {\begin{tikzpicture} [@@_standard]
718 \tikz@scan@one@point\pgfutil@firstofone (##1-l)
719 \dim_gset:Nn \g_@@_x_dim {\dim_max:nn \g_@@_x_dim \pgf@x}
720 \end{tikzpicture} } } }
```

The command `\WithArrowsLastEnv` is not used by the package `witharrows`. It’s only a facility given to the final user. It gives the number of the last environment `{WithArrows}` at level 0 (to the sens of the nested environments). This macro is fully expandable and, thus, can be used directly in the name of a Tikz node.

```
721 \cs_new:Npn \WithArrowsLastEnv {\int_use:N \g_@@_last_env_int}
```

²⁸In fact, it’s not the current value of “`text width`”: it’s the value of “`text width`” set in the option `tikz` provided by `witharrows`. These options are given to Tikz in a “`every path`”. That’s why we have to retrieve it in a path.

²⁹If a line has no ampersand, this line is ignored. In fact, we raise an error if there is a line without ampersand but, nonetheless, we consider the case where the user goes on and we try to avoid other errors.

9.11 The command Arrow in CodeAfter

The option `CodeAfter` is an option of the environment `{WithArrows}` (this option is only available at the environment level). In the option `CodeAfter`, one can use the command `Arrow` but it's a special version of the command `Arrow`. For this special version (internally called `\@@_Arrow_code_after`), we define a special set of keys called `WithArrows/CodeAfter`.

```

722 \keys_define:nn {WithArrows/CodeAfter}
723   {tikz      .code:n          = \tikzset {WithArrows/arrow/.append-style = {#1}} ,
724   tikz      .value_required:n = true,
725   rr        .value_forbidden:n = true,
726   rr        .code:n          = \@@_analyze_option_position:n 0 ,
727   ll        .value_forbidden:n = true,
728   ll        .code:n          = \@@_analyze_option_position:n 1 ,
729   rl        .value_forbidden:n = true,
730   rl        .code:n          = \@@_analyze_option_position:n 2 ,
731   lr        .value_forbidden:n = true,
732   lr        .code:n          = \@@_analyze_option_position:n 3 ,
733   v         .value_forbidden:n = true,
734   v         .code:n          = \@@_analyze_option_position:n 4 ,
735   TikzCode .tl_set:N         = \l_@@_tikz_code_tl,
736   TikzCode .value_required:n = true,
737   xoffset   .dim_set:N       = \l_@@_xoffset_dim,
738   xoffset   .value_required:n = true}

739 \NewDocumentCommand \@@_Arrow_code_after {0{ } mmm 0{ }}
740   {\int_set:Nn \l_@@_pos_arrows_int 1
741    \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
742    \group_begin:

```

Even if `\Arrow` in `CodeAfter` has its own set of options (`WithArrows/CodeAfter`), we set the level of the options to 3 (as with the classical command `\Arrow`) because of the error messages.

```

743   \int_set:Nn \l_@@_level_int 3
744   \keys_set:nn {WithArrows/CodeAfter}
745     {#1,#5,tikz={xshift = \l_@@_xoffset_dim}}
746   \bool_set_false:N \l_@@_initial_r_bool
747   \bool_set_false:N \l_@@_final_r_bool
748   \int_case:nn \l_@@_pos_arrows_int
749     {0 {\bool_set_true:N \l_@@_initial_r_bool
750        \bool_set_true:N \l_@@_final_r_bool}
751      2 {\bool_set_true:N \l_@@_initial_r_bool}
752      3 {\bool_set_true:N \l_@@_final_r_bool}}

```

We test whether the two Tikz nodes (#2-1) and (#3-1) really exist. If not, the arrow won't be drawn.

```

753   \cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-#2-1}
754     {\msg_error:nxx {witharrows} {Wrong-line-specification-in-Arrow} {#2}}
755   \cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-#3-1}
756     {\msg_error:nxx {witharrows} {Wrong-line-specification-in-Arrow} {#3}}
757   \int_compare:nNnTF \l_@@_pos_arrows_int = 4
758     {\begin{tikzpicture} [@@_standard]
759       \tikz@scan@one@point\pgfutil@firstofone(#2-1.south)
760       \dim_set_eq:NN \l_tmpa_dim \pgf@x
761       \dim_set_eq:NN \l_tmpb_dim \pgf@y
762       \tikz@scan@one@point\pgfutil@firstofone(#3-1.north)
763       \dim_set:Nn \l_tmpa_dim {\dim_max:nn \l_tmpa_dim \pgf@x}
764       \tl_gset:Nx \g_tmpa_tl
765         {\dim_use:N \l_tmpa_dim , \dim_use:N \l_tmpb_dim}
766       \tl_gset:Nx \g_tmpb_tl
767         {\dim_use:N \l_tmpa_dim , \dim_use:N \pgf@y}
768     \end{tikzpicture} }
769   {\begin{tikzpicture} [@@_standard]
770     \tikz@scan@one@point\pgfutil@firstofone
771       (#2-\bool_if:NnTF\l_@@_initial_r_bool rl .south)
772     \tl_gset:Nx \g_tmpa_tl {\dim_use:N \pgf@x , \dim_use:N \pgf@y}

```

```

773 \tikz@scan@one@point\pgfutil@firstofone
774 (#3-\bool_if:NTF\l_@@_final_r_bool rl .north)
775 \tl_gset:Nx \g_tmpb_tl {\dim_use:N \pgf@x , \dim_use:N \pgf@y}
776 \end{tikzpicture}}
777 \@@_draw_arrow:nnn {\g_tmpa_tl} {\g_tmpb_tl} {#4} }}
778 \group_end:
779 }

```

9.12 MultiArrow

The command `\@@_MultiArrow:nn` will be linked to `\MultiArrow` when the `CodeAfter` is executed.

```

780 \cs_new_protected:Nn \@@_MultiArrow:nn
781 {

```

The user of the command `\MultiArrow` (in `CodeAfter`) will be able to specify the list of lines with the same syntax as the loop `\foreach` of `pgffor`. That’s why we construct a “clist” of `expl3` from the specification of list given by the user. The construction of the “clist” must be global in order to exit the `\foreach` and that’s why we construct the list in `\g_tmpa_clist`.

```

782 \foreach \x in {#1} {\cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-\x-l}
783 \msg_error:nnx {witharrows}
784 {Wrong~line~specification~in~MultiArrow}
785 {\x}}
786 {\clist_gput_right:Nx \g_tmpa_clist {\x}}}

```

We sort the list `\g_tmpa_clist` because we want to extract the minimum and the maximum.

```

787 \int_compare:nNnTF {\clist_count:N \g_tmpa_clist} < 2
788 {\@@_msg_error:n {Too~small~specification~for~MultiArrow}}
789 {\clist_sort:Nn \g_tmpa_clist
790 {\int_compare:nNnTF {##1} > {##2}
791 {\sort_return_swapped:}
792 {\sort_return_same:}}}

```

We extract the minimum in `\l_tmpa_tl` (it must be an integer but we store it in a token list of `expl3`).

```

793 \clist_pop:NN \g_tmpa_clist \l_tmpa_tl

```

We extract the maximum in `\l_tmpb_tl`. The remaining list (in `\g_tmpa_clist`) will be sorted in decreasing order but never mind...

```

794 \clist_reverse:N \g_tmpa_clist
795 \clist_pop:NN \g_tmpa_clist \l_tmpb_tl

```

We draw the teeth of the rak (except the first one and the last one) with the auxiliary function `\@@_MultiArrow_i:n`. This auxiliary function is necessary to expand the specification of the list in the `\foreach` loop. The first and the last teeth of the rak can’t be drawn the same way as the others (think, for example, to the case of the option “rounded corners” is used).

```

796 \exp_args:Nx \@@_MultiArrow_i:n {\g_tmpa_clist}

```

Now, we draw the rest of the structure.

```

797 \begin{tikzpicture}[@@_standard,every~path/.style={WithArrows/arrow}]
798 \draw [<->] ([xshift = \l_@@_xoffset_dim]\l_tmpa_tl-r.south)
799 -- ++(5mm,0)
800 -- node (@@_label) {}
801 ([xshift = \l_@@_xoffset_dim+5mm]\l_tmpb_tl-r.south)
802 -- ([xshift = \l_@@_xoffset_dim]\l_tmpb_tl-r.south) ;
803 \tikz@parse@node \pgfutil@firstofone (@@_label.west)
804 \dim_set:Nn \l_tmpa_dim {20 cm}
805 \path \pgfextra {\tl_gset:Nx \g_tmpa_tl \tikz@text@width} ;
806 \tl_if_empty:NF \g_tmpa_tl {\dim_set:Nn \l_tmpa_dim \g_tmpa_tl}
807 \bool_if:nT {\l_@@_wrap_lines_bool && ! \l_@@_in_witharrows_bool}
808 {\dim_set:Nn \l_tmpb_dim {\g_@@_x_right_dim - \pgf@x - 0.3333 em}
809 \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
810 {\dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim}}
811 \path (@@_label.west)

```

```

812         node [anchor = west, text-width = \dim_use:N \l_tmpa_dim] {#2} ;
813     \end{tikzpicture} } }
814
815 \cs_new_protected:Nn \@@_MultiArrow_i:n
816     {\begin{tikzpicture}[\@@_standard, every~path/.style={WithArrows/arrow}]
817         \foreach \k in {#1}
818             {\draw[<-] ([xshift = \l_@@_xoffset_dim]\k-r.south) -- ++(5mm,0) ;} ;
819     \end{tikzpicture}}

```

9.13 The error messages of the package

```

820 \msg_new:nnn {witharrows}
821     {Option~unknown}
822     {The~option~"\tl_use:N\l_keys_key_tl"~is~unknown~or~
823     meaningless~in~the~context.~If~you~go~on,~it~will~be~ignored.}
824 \msg_new:nnn {witharrows}
825     {Collision}
826     {You~have~a~collision~(or~almost~a~collision)~at~the~end~of~row~
827     \int_use:N\g_@@_line_int.~
828     You~can~go~on~but~maybe~you~will~have~overlapping~texts.}
829 \msg_new:nnn {witharrows}
830     {Third~column~in~an~environment~{WithArrows}}
831     {By~default,~an~environment~{WithArrows}~can~only~have~two~columns.~
832     Maybe~you~have~forgotten~a~\str_use:N \c_backslash_str
833     \str_use:N \c_backslash_str.~If~you~really~want~more~than~two~columns,~
834     you~should~use~the~option~"MoreColumns"~at~a~global~level~or~for~
835     an~environment.~However,~you~can~go~one~for~this~time.}
836 \msg_new:nnn {witharrows}
837     {Third~column~in~an~environment~{DispWithArrows}}
838     {An~environment~{DispWithArrows}~or~{DispWithArrows*}~can~only~
839     have~two~columns.~If~you~go~on,~you~may~have~an~incorrect~output.}
840 \msg_new:nnn {witharrows}
841     {The~option~"jump"~must~be~non~negative}
842     {You~can't~use~a~strictly~negative~value~for~the~option~"jump"~of~command~
843     \token_to_str:N\Arrow.~ You~can~create~an~arrow~going~backwards~with~
844     the~option~"<"~of~Tikz.}
845 \msg_new:nnn {witharrows}
846     {Too~few~lines~for~an~arrow}
847     {An~arrow~specified~in~line~\int_use:N \l_@@_initial_int~can't~be~drawn~
848     because~it~arrives~after~the~last~line~of~the~environment~(remind~that~
849     the~command~\token_to_str:N\Arrow~ must~be~in~the~*start*~line~
850     of~the~arrow).~If~you~go~on,~this~arrow~will~be~ignored.}
851 \msg_new:nnn {witharrows}
852     {{WithArrows}~used~outside~math~mode}
853     {The~environment~{WithArrows}~should~be~used~only~in~math~mode.~
854     Nevertheless,~you~can~go~on.}
855 \msg_new:nnn {witharrows}
856     {{DispWithArrows}~used~in~math~mode}
857     {The~environment~{DispWithArrows}~should~be~used~only~outside~math~mode.~
858     If~you~go~on,~you~will~have~other~errors.}
859 \msg_new:nnn {witharrows}
860     {Two~options~are~incompatible}
861     {You~try~to~use~the~option~"\tl_use:N\l_keys_key_tl"~but~
862     this~option~is~incompatible~or~redundant~with~the~option~"
863     \int_case:nn\l_@@_previous_pos_arrows_int
864         {0 {rr}
865          1 {ll}
866          2 {rl}
867          3 {lr}

```

```

868         4 {v}
869         5 {i}
870         6 {group}
871         7 {groups}}"~
872 set~in~the~same~
873 \int_case:nn\l_@@_level_int
874     {1 {command~\token_to_str:N\WithArrowsOptions}
875      2 {declaration~of~options~of~the~environment~
876        \{\@currenvir\}}
877      3 {command~\token_to_str:N\Arrow}}.~
878 If~you~go~on,~I~will~use~the~option~"\tl_use:N\l_keys_key_tl".}

879 \msg_new:nnnn {witharrows}
880     {All~lines~must~have~an~ampersand}
881     {All~lines~of~an~environment~\{WithArrows\}~should~
882     have~an~second~column~(because~the~nodes~are~created~
883     in~the~second~column).~However,~you~can~go~on~but~you~will~
884     have~an~error~if~one~of~your~arrows~needs~an~PGF~
885     node~absent~by~lack~of~ampersand.~If~you~don't~want~to~
886     see~this~message~again,~you~can~use~the~option~
887     AllowLineWithoutAmpersand.}
888     {Moreover, the~ampersand~can~be~implicit~
889     (e.g.~if~you~use~\token_to_str:N\MoveEqLeft\ of~mathtools).}

890 \msg_new:nnn {witharrows}
891     {Option~incompatible~with~"group(s)"}
892     {You~try~to~use~the~option~"\tl_use:N\l_keys_key_tl"~while~
893     you~are~using~the~option~"
894     \int_compare:nNnTF \l_@@_pos_arrows_int = 5
895     {group}
896     {groups}}".~
897     It's~incompatible.~You~can~go~on~ignoring~this~option~
898     "\tl_use:N\l_keys_key_tl"~but~you~should~correct~your~code.}

899 \msg_new:nnn {witharrows}
900     {Option~will~be~ignored}
901     {The~option~"\tl_use:N\l_keys_key_tl"~can't~be~used~here.~
902     If~you~go~on,~it~will~be~ignored.}

903 \msg_new:nnn {witharrows}
904     {Arrow~in~first~column}
905     {You~should~not~use~the~command~\token_to_str:N\Arrow\
906     \tl_if_eq:NnF \l_@@_CommandName_tl \l_tmpa_tl
907     {(renamed~in~\str_use:N \c_backslash_str
908     \tl_use:N \l_@@_CommandName_tl)~}
909     ~in~the~first~column~but~only~in~the~second~column.\\
910     However~you~can~go~on~for~this~time.}

911 \msg_new:nnn {witharrows}
912     {Wrong~line~specification~in~Arrow}
913     {The~specification~of~line~"#1"~you~use~in~\token_to_str:N\Arrow\
914     ~doesn't~exist.\\
915     If~you~go~on,~the~arrow~will~be~ignored.}

916 \msg_new:nnn {witharrows}
917     {Wrong~line~specification~in~MultiArrow}
918     {The~specification~of~line~"#1"~doesn't~exist.\\
919     If~you~go~on,~it~will~be~ignored~for~\token_to_str:N \MultiArrow.}

920 \msg_new:nnn {witharrows}
921     {Too~small~specification~for~MultiArrow}
922     {The~specification~of~lines~you~gave~to~\token_to_str:N \MultiArrow\
923     is~too~small:~we~need~at~least~two~lines.~If~you~go~on,~the~
924     command~\token_to_str:N\MultiArrow\ ~will~be~ignored.}

925 \msg_new:nnn {witharrows}
926     {A~PGF~node~doesn't~exist}
927     {A~PGF~node~necessary~to~draw~an~arrow~doesn't~exist~

```



```

928         because~you~didn't~put~an~ampersand~in~the~corresponding~line.~
929         If~you~go~on,~the~arrow~will~be~ignored.}

930 \msg_new:nnn {witharrows}
931     {tag*~without~amsmath}
932     {We~can't~use~\token_to_str:N\tag*~because~you~haven't~load~amsmath~
933     (or~mathtools).~If~you~go~on,~the~command~\token_to_str:N\tag\
934     will~be~used~instead.}

935 \msg_new:nnn {witharrows}
936     {Command~not~allowed~in~{DispWithArrows}}
937     {The~command~\token_to_str:N #1
938     is~not~allowed~in~the~first~column~of~\{DispWithArrows\}~but~
939     only~in~the~second~column~(and,~of~course,~in~the~
940     environments~of~amsmath).~If~you~go~on,~this~command~will~be~ignored.}

941 \msg_new:nnn {witharrows}
942     {Command~not~allowed~in~{WithArrows}}
943     {The~command~\token_to_str:N #1
944     is~not~allowed~in~\{WithArrows\}~but~is~allowed~in~the~second~
945     column~of~\{DispWithArrows\}~(and,~of~course,~in~the~
946     environments~of~amsmath).~If~you~go~on,~this~command~will~be~ignored.}

947 \msg_new:nnn {witharrows}
948     {Multiple~tags}
949     {You~can't~use~twice~the~command~\token_to_str:N\tag\
950     in~a~line~of~the~environment~\{\@currenvir\}.~If~you~go~on,~the~tag~
951     '#1'~will~be~used.}

952 \msg_new:nnn {witharrows}
953     {Multiple~labels}
954     {Normally,~we~can't~use~the~command~\token_to_str:N\label\
955     twice~in~a~line~of~the~environment~\{\@currenvir\}.~
956     However,~you~can~go~on.~
957     If~you~don't~want~to~see~this~message~again,~you~can~use~the~option~
958     "AllowMultipleLabels"~at~the~global~or~
959     environment~level~(this~doesn't~work~if~you~use~cleveref).}

```

9.14 Environment {CasesWithArrows}

```

960 \coffin_new:N \l_@@_halign_coffin
961 \NewDocumentEnvironment {CasesWithArrows} {m O{}}
962     {\hbox_set:Nn \l_tmpa_box {$\left\{\vcenter to 1cm {\} \right.$}
963     \dim_zero_new:N \l_@@_delim_wd_dim
964     \dim_set:Nn \l_@@_delim_wd_dim {\box_wd:N \l_tmpa_box}
965     \box_clear_new:N \l_@@_left_part_box
966     \hbox_set:Nn \l_@@_left_part_box
967         {$\bool_if:NT \l_@@_displaystyle_bool \displaystyle #1 {}$}
968     \bool_if:nT \c_@@_mathtools_loaded_bool
969         {\MH_if_boolean:nT {show_only_refs}
970         {\MT_showonlyrefs_false:
971         \MH_set_boolean:T:n {show_only_refs}
972         \bool_set_true:N \l_@@_notag_bool}}
973     \bool_if:NT \c_@@_amsmath_loaded_bool \intertext@
974     \if_mode_math:
975         \@@_msg_error:n {{DispWithArrows}~used~in~math~mode}
976     \fi:
977     \bool_set_false:N \l_@@_in_witharrows_bool
978     %
979     \@@_pre_environment:n {#2}
980     \nointerlineskip
981     \hbox_to_wd:nn {0.6\linewidth} {}
982     $$
983     \spread@equation
984     \vcoffin_set:Nnw \l_@@_halign_coffin \displaywidth
985     \bool_if:NTF \l_@@_fleqn_bool
986         {\tabskip = \c_zero_skip}

```

```

987         {\tabskip = 0 pt plus 1000 pt minus 1000 pt}
988 \bool_if:NTF \c_@@_amsmath_loaded_bool
989     {\cs_set_eq:NN \_@@_old_label \ltx@label}
990     {\cs_set_eq:NN \_@@_old_label \label}
991 \cs_set:Npn \notag {\msg_error:nnn {witharrows}
992     {Command~not~allowed~in~{DispWithArrows}}}
993     {\notag}}
994 \cs_set:Npn \nonumber {\msg_error:nnn {witharrows}
995     {Command~not~allowed~in~{DispWithArrows}}}
996     {\nonumber}}
997 \cs_set:Npn \tag ##1 {\msg_error:nnn {witharrows}
998     {Command~not~allowed~in~{DispWithArrows}}}
999     {\tag}}
1000 \cs_set:Npn \label ##1 {\msg_error:nnn {witharrows}
1001     {Command~not~allowed~in~{DispWithArrows}}}
1002     {\label}}
1003 \halign to \displaywidth \bgroup
1004     \int_gincr:N \g_@@_line_int
1005     \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
1006     \strut
1007     \bool_if:NT \l_@@_fleqn_bool
1008         {\skip_horizontal:n \l_@@_mathindent_dim}
1009     \hfil
1010     \skip_horizontal:n {\box_wd:N \l_@@_left_part_box + \l_@@_delim_wd_dim}
1011     $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
1012     \tabskip = \c_zero_skip
1013     &
1014     \cs_set:Npn \notag {\bool_set_true:N \l_@@_notag_bool}
1015     \cs_set_eq:NN \nonumber \notag
1016     \cs_set_eq:NN \tag \@@_tag
1017     \cs_set_eq:NN \label \@@_label:n
1018     $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{}}##$
1019     \tabskip = 0 pt plus 1000 pt minus 1000 pt
1020     \int_gincr:N \g_@@_line_bis_int
1021     \tikz [remember~picture,overlay]
1022         \node [@@_node_style,
1023             name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-l,
1024             alias = {\tl_if_empty:NF \l_@@_name_tl
1025                 {\l_@@_name_tl-\int_use:N\g_@@_line_int-l}} ] {} ;
1026     \hfil
1027     \tikz [remember~picture,overlay]
1028         \node [@@_node_style,
1029             name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
1030             alias = {\tl_if_empty:NF \l_@@_name_tl
1031                 {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
1032     \bool_if:NT \l_@@_shownodenames_bool
1033         {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
1034             -\int_use:N\g_@@_line_int}}
1035     & ##
1036     \tabskip = \c_zero_skip
1037     && \@@_msg_error:n {Third~column~in~an~environment~{DispWithArrows}}
1038     \if_false: ## \fi:
1039     \cr}
1040 {
1041     \egroup
1042     \unskip\unpenalty\unskip\unpenalty
1043     \box_set_to_last:N \l_tmpa_box
1044     \nointerlineskip
1045     \box_use:N \l_tmpa_box
1046     \dim_gzero_new:N \g_@@_alignment_dim
1047     \dim_gset:Nn \g_@@_alignment_dim {\box_wd:N \l_tmpa_box}
1048     \box_clear_new:N \l_@@_new_box
1049     \hbox_set:Nn \l_@@_new_box {\hbox_unpack_clear:N \l_tmpa_box}

```

```

1050         \dim_compare:nNnT {\box_wd:N \l_@@_new_box} < \g_@@_alignment_dim
1051         {\dim_gset:Nn \g_@@_alignment_dim {\box_wd:N \l_@@_new_box}}
1052     \vcoffin_set_end:
1053     \hbox_to_wd:nn \displaywidth
1054     {
1055         \bool_if:NTF \l_@@_fleqn_bool
1056         {\skip_horizontal:n \l_@@_mathindent_dim}
1057         {\hfil}
1058         \hbox_to_wd:nn \g_@@_alignment_dim
1059         { \box_use_drop:N \l_@@_left_part_box
1060           \dim_set:Nn \l_tmpa_dim { \box_ht:N \l_@@_halign_coffin
1061                                     + \box_dp:N \l_@@_halign_coffin}
1062           $\left\{ \vcenter to \l_tmpa_dim {\vfil} \right.$}
1063         \hfil}
1064     \coffin_typeset:Nnnnn
1065         \l_@@_halign_coffin {l} {vc} {-\displaywidth} \c_zero_dim
1066     $$
1067     \_@@_post_environment:
1068     \bool_if:nT \c_@@_mathtools_loaded_bool
1069         {\MH_if_boolean:nT {show_only_refs}
1070          \MT_showonlyrefs_true:}
1071     \ignorespacesafterend
1072 }

```

10 History

10.1 Changes between versions 1.0 and 1.1

Option for the command `\` and option `interline`
 Compatibility with `\usetikzlibrary{babel}`
 Possibility of nested environments `{WithArrows}`
 Better error messages
 Creation of a DTX file

10.2 Changes between versions 1.1 and 1.2

The package `witharrows` can now be loaded without having loaded previously `tikz` and the libraries `arrow.meta` and `bending` (this extension and these libraries are loaded silently by `witharrows`).
 New option groups (with a *s*)
 Better error messages

10.3 Changes between versions 1.2 and 1.3

New options `ygap` and `ystart` for fine tuning.
 Minor bugs.

10.4 Changes between versions 1.3 and 1.4

The package `footnote` is no longer loaded by default. Instead, two options `footnote` and `footnotehyper` have been added. In particular, `witharrows` becomes compatible with `beamer`.

10.5 Changes between versions 1.4 and 1.5

The Tikz code used to draw the arrows can be changed with the option `TikzCode`.
 Two new options `CodeBefore` and `CodeAfter` have been added at the environment level.
 A special version of `\Arrow` is available in `CodeAfter` in order to draw arrows in nested environments.
 A command `\MultiArrow` is available in `CodeAfter` to draw arrows of other shapes.

10.6 Changes between versions 1.5 and 1.6

The code has been improved to be faster and the Tikz library `calc` is no longer required.
 A new option `name` is available for the environments `{WithArrows}`.

10.6.1 Changes between 1.6 and 1.6.1

Correction of a bug that leads to incompatibility with `\usetikzlibrary{babel}`.

10.7 Changes between 1.6.1 and 1.7

New environments `{DispWithArrows}` and `{DispWithArrows*}`.

10.8 Changes between 1.7 and 1.8

The numbers and tags of the environment `{DispWithArrows}` are now compatible with all the major LaTeX packages concerning references (`autonum`, `cleveref`, `fancyref`, `hyperref`, `prettyref`, `refstyle`, `typedref` and `varioref`) and with the options `showonlyrefs` and `showmanualtags` of `mathtools`.

10.9 Changes between 1.8 and 1.9

New option `wrap-lines` for the environments `{DispWithArrows}` and `{DispWithArrows*}`.

10.10 Changes between 1.9 and 1.10

If the option `wrap-lines` is used, the option “`text width`” of Tikz is still active: if the value given to “`text width`” is lower than the width computed by `wrap-lines`, this value is used to wrap the lines.

The option `wrap-lines` is now fully compatible with the class option `leqno`.

Correction of a bug: `\nointerlineskip` and `\makebox[.6\linewidth]{}` should be inserted in `{DispWithArrows}` only in vertical mode.