

The package `witharrows` for plain-TeX and LaTeX*

F. Pantigny
fpantigny@wanadoo.fr

March 9, 2025

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.

The package `witharrows` is entirely contained in the file `witharrows.sty`. This file may be put in the current directory or in a `texmf` tree. However, the best is to install `witharrows` with a TeX distribution such as MiKTeX, TeX Live or MacTeX.

In fact, `witharrows` may also be used with plain-TeX and, in that case, the only required file is `witharrows.tex`: see p. 23. In what follows, we describe the LaTeX package.

This package can be used with `xelatex`, `lualatex`, `pdflatex` but also by the classical workflow `latex-dvips-ps2pdf` (or Adobe Distiller). However, the file `witharrows.dtx` of the present documentation should be compiled with *LuaLaTeX*. This package loads the packages `varwidth`, `tikz` and the Tikz libraries `arrows.meta` and `bending`. The final user only has to load the package with the classical instruction: `\usepackage{witharrows}`.

The arrows are drawn with Tikz and that's why **several compilations may be necessary**.¹

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

```
$\begin{WithArrows}
A & = (a+1)^2 \quad \text{\Arrow{we expand}} \quad \backslash\backslash
& = a^2 + 2a + 1 \quad \% <----- don't put \backslash\backslash here
\end{WithArrows}$
```

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

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 two environments `{DispWithArrows}` and `{DispWithArrows*}` which are similar to the environments `{align}` and `{align*}` of the package `amsmath`: cf. p. 17.

*This document corresponds to the version 2.9a of `witharrows`, at the date of 2024/10/19.

¹If you use Overleaf, Overleaf will do automatically a number compilations sufficient (by using `latexmk`).

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 number² of rows the arrow must jump (the default value is, of course, 1).

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

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

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

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

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

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

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

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

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.

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

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

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

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

```

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

```

$$\begin{array}{l}
 A = (a+1)^2 \\
 = a^2 + 2a + 1
 \end{array} \curvearrowright \textit{we factorize}$$

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

```

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

```

$$\begin{array}{l}
 A = (a+1)^2 \\
 = a^2 + 2a + 1
 \end{array} \bigg) \textit{very classical}$$

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}

```

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

In fact, it's possible to change more drastically the shape or the arrows with the option `tikz-code` (presented p. 24).

It's possible to use the Tikz option “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}

```

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

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. 20.

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}

```

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

It's possible to put commands `\` in the text to force new lines³. 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 provides 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.

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

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

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

The options can be given directly between square brackets to the environment `{WithArrows}`. There must be no space between the `\begin{WithArrows}` and the opening bracket (`[`) of the options of the environment. Such options apply to all the arrows of the environment.⁴

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

$$A = ((a + b) + 1)^2 \\ = (a + b)^2 + 2(a + b) + 1 \quad \downarrow \text{first expansion.} \\ = a^2 + 2ab + b^2 + 2a + 2b + 1 \quad \downarrow \text{second expansion.}$$

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`:

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

$$\int_0^1 (x + 1)^2 dx = \int_0^1 (x^2 + 2x + 1) dx \\ = \int_0^1 x^2 dx + 2 \int_0^1 x dx + \int_0^1 dx \quad \downarrow \text{linearity of integration} \\ = \frac{1}{3} + 2\frac{1}{2} + 1 \\ = \frac{7}{3}$$

³By 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.

⁴They also apply to the nested environments `{WithArrows}` (with the logical exceptions of `interline`, `code-before` and `code-after`).

The same example with the option `displaystyle`:

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

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}`.⁵

```

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

```

$$\begin{aligned}
 \sum_{i=1}^n (x_i + 1)^2 &= \sum_{i=1}^n (x_i^2 + 2x_i + 1) \\
 &= \sum_{i=1}^n x_i^2 + 2 \sum_{i=1}^n x_i + n \quad \left. \vphantom{\sum_{i=1}^n} \right\} \text{by linearity}
 \end{aligned}$$

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 `command-name` for this purpose. The new name of the command must be given to the option *without* the leading backslash.

```

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

```

$$\begin{aligned}
 f &= (x \longmapsto (x+1)^2) \\
 &= (x \longmapsto x^2 + 2x + 1) \quad \left. \vphantom{f} \right\} \text{we work directly on fonctions}
 \end{aligned}$$

The environment `{WithArrows}` provides also two options `code-before` and `code-after` 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 do not apply to the nested environments).

```

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

```

⁵It’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 = {}}}`.

$$\begin{array}{lcl}
 A = (a + b)^2 & & \\
 = a^2 + 2ab + b^2 & \searrow & \text{we expand}
 \end{array}$$

Special commands are available in `code-after`: a command `\WithArrowsNbLines` 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`: the latter two commands are described in the section concerning the nested environments, p. 14.

2 Numbers of columns

So far, we have used the environment `{WithArrows}` with two columns. However, it's possible to use the environment with an arbitrary number of columns with the option `format`. The value given to this option is like the preamble of an environment `{array}`, that is to say a sequence of letters `r`, `c` and `l`, but also `R`, `C` and `L`.

The letters `R`, `C` and `L` add empty groups `{}` which provide correct spaces when these columns contain symbols with the type `\mathrel` (such as `=`, `≤`, etc.) or `\mathbin` (such as `+`, `×`, etc.). This system is inspired by the environment `{IEEEeqnarray}` of the package `IEEEtrantools`.

The initial value of the parameter `format` is, in fact, `rL`.

For example, if we want only one column left-aligned, we use the option `format=l`.

```

 $\begin{WithArrows}[format = l]
f(x) \geq g(x) \Arrow{by squaring both sides} \\
f(x)^2 \geq g(x)^2 \Arrow{by moving to left side} \\
f(x)^2 - g(x)^2 \geq 0
\end{WithArrows}$ 

```

$$\begin{array}{lcl}
 f(x) \geq g(x) & & \\
 f(x)^2 \geq g(x)^2 & \searrow & \text{by squaring both sides} \\
 f(x)^2 - g(x)^2 \geq 0 & \searrow & \text{by moving to left side}
 \end{array}$$

In the following example, we use five columns all centered (the environment `{DispWithArrows*}` is presented p. 17).

```

 $\begin{DispWithArrows*}[format = cCcCc,
wrap-lines,
interline=1mm]
k & \leq & t & \leq & k+1 \\
\frac{1}{k+1} & \leq & \frac{1}{t} & \leq & \frac{1}{k} \\
\int_k^{k+1} \frac{dt}{k+1} & \leq & \int_k^{k+1} \frac{dt}{t} & \leq & \int_k^{k+1} \frac{dt}{k} \\
& & & & \\
& & & & \\
& & & & \\
\frac{1}{k+1} & \leq & \ln(k+1) - \ln(k) & \leq & \frac{1}{k}
\end{DispWithArrows*}$ 

```

$$\begin{array}{ccccc}
 k & \leq & t & \leq & k+1 \\
 \frac{1}{k+1} & \leq & \frac{1}{t} & \leq & \frac{1}{k} \\
 \int_k^{k+1} \frac{dt}{k+1} & \leq & \int_k^{k+1} \frac{dt}{t} & \leq & \int_k^{k+1} \frac{dt}{k} \\
 & & & & \\
 & & & & \\
 & & & & \\
 \frac{1}{k+1} & \leq & \ln(k+1) - \ln(k) & \leq & \frac{1}{k}
 \end{array}
 \left. \begin{array}{c} \\ \\ \\ \\ \end{array} \right\} \text{we can integrate the}$$

inequalities since $k \leq k+1$

3 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.⁶

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

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.

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.

⁶The option `show-nodes` 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.

```

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

```

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

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.

```

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

```

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

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 connected⁷ arrows. All the arrows of a given group are grouped on a same vertical line and at a leftmost position.

$$\begin{aligned}
 A &= B \\
 &= C + D \quad \bigg\rangle \text{one} \\
 &= D' \quad \bigg\rangle \text{two} \\
 &= E + F + G + H + I \\
 &= K + L + M \quad \bigg\rangle \text{three} \\
 &= N \quad \bigg\rangle \text{four} \\
 &= O
 \end{aligned}$$

In an environment which uses the option `group` or the option `groups`, it’s still possible to give an option of position (`ll`, `lr`, `rl`, `rr` or `i`) to an individual arrow⁸. Such arrow will be drawn irrespective of the groups. It’s also possible to start a new group by applying the option `new-group` to an given arrow.

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]`

⁷More precisely: for each arrow *a*, we note *i(a)* the number of its initial row and *f(a)* the number of its final row; for two arrows *a* and *b*, we say that *a* ~ *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 ~.

⁸Such arrow will be called *independent* in the technical documentation

In the following example, we have used the option **groups** for the environment and the option **new-group** for the last arrow (that's why the last arrow is not aligned with the others).

$$\begin{aligned}
\sum_{k=0}^n \frac{\cos kx}{\cos^k x} &= \sum_{k=0}^n \frac{\Re(e^{ikx})}{(\cos x)^k} \\
&= \sum_{k=0}^n \Re\left(\frac{e^{ikx}}{(\cos x)^k}\right) \\
&= \Re\left(\sum_{k=0}^n \left(\frac{e^{ix}}{\cos x}\right)^k\right) \\
&= \Re\left(\frac{1 - \left(\frac{e^{ix}}{\cos x}\right)^{n+1}}{1 - \frac{e^{ix}}{\cos x}}\right) \\
&= \Re\left(\frac{1 - \frac{e^{i(n+1)x}}{\cos^{n+1} x}}{1 - \frac{e^{ix}}{\cos x}}\right) \\
&= \Re\left(\frac{\frac{\cos^{n+1} x - e^{i(n+1)x}}{\cos^{n+1} x}}{\frac{\cos x - e^{ix}}{\cos x}}\right) \\
&= \frac{1}{\cos^n x} \Re\left(\frac{\cos^{n+1} x - e^{i(n+1)x}}{\cos x - e^{ix}}\right) \\
&= \frac{1}{\cos^n x} \Re\left(\frac{\cos^{n+1} x - (\cos(n+1)x + i \sin(n+1)x)}{\cos x - (\cos x + i \sin x)}\right) \\
&= \frac{1}{\cos^n x} \Re\left(\frac{(\cos^{n+1} x - \cos(n+1)x) - i \sin(n+1)x}{-i \sin x}\right) \\
&= \frac{1}{\cos^n x} \cdot \frac{\sin(n+1)x}{\sin x}
\end{aligned}$$

$(\cos x)^k$ is real
 $\Re(z + z') = \Re(z) + \Re(z')$
sum of terms of a geometric progression
algebraic calculation
reduction to common denominator
 $\Re(kz) = k \cdot \Re(z)$ if k is real
algebraic form of the complexes

4 The option “o” for individual arrows

Let's consider, in a given environment, two arrows called a and b . We will note i_a and i_b the numbers of the initial lines of a et b dans f_a and f_b the numbers of the final lines. Of course, we have $i_a \leq f_a$ and $i_b \leq f_b$.

We will say that the arrow a covers the arrow b when $i_a \leq i_b \leq f_b \leq f_a$. We will also say that the arrow a is over the arrow b .

In the exemple on the right, the red arrow covers the blue one.

$$\begin{aligned}
A &= B \\
&= C \\
&= D \\
&= E
\end{aligned}$$

On the local level, there exists a key **o**. This key is available only when the option **group** or the option **groups** is in force (cf. p. 8).

An arrow of type **o** is drawn with an horizontal shift (such as those set by **xoffset**) automatically computed by taking into account the arrows covered by our arrow.⁹

```
$\begin{WithArrows}[groups]
```

```

A &= B      \Arrow{one}\Arrow[o,jump=3]{direct} \\
&= C + C   \Arrow{two} \\
&= D + D + D \Arrow{three} \\
&= E + E \\
&= F + F
\end{WithArrows}$
```

$$\begin{aligned}
A &= B \\
&= C + C \\
&= D + D + D \\
&= E + E \\
&= F + F
\end{aligned}$$

⁹ Among the covered arrows, the independent ones (that is to say with an explicit key **rr**, **ll**, **lr**, **rl**, **i**, **up** or **down**) are not taken into account in the computation of the value of **xoffset**.

Arrows of type `o` may themselves be covered by other arrows of type `o`.

```

 $\begin{WithArrows}[groups]
A \& = B \Arrow{one}\Arrow[o,jump=2]{two}\Arrow[o,jump=3]{three}\\
& = C \\
& = D \\
& = E + E + E + E + E + E + E
\end{WithArrows}$ 

```

$$\begin{array}{l}
 A = B \\
 = C \\
 = D \\
 = E + E + E + E + E + E + E
 \end{array}
 \begin{array}{l}
 \searrow \textit{one} \\
 \searrow \textit{two} \\
 \searrow \textit{three}
 \end{array}$$

The horizontal space between an arrow of type `o` and the arrows immediately covered is fixed by the dimension `xoffset-for-o-arrows` which can be set with the command `\WithArrowsOptions` (initial value: 2 mm).

5 The options “up” and “down” for individual arrows

At the local level, there are also two options for individual arrows, called `up` and `down`. The following example illustrates these types of arrows:

```

 $\begin{WithArrows}
A \& = B
\Arrow{up}{an arrow of type \texttt{up}} \\
& = C + C + C + C + C + C + C + C \\
& = C + C + C + C + C + C + C + C
\Arrow{down}{an arrow of type \texttt{down}} \\
& = E + E
\end{WithArrows}$ 

```

$$\begin{array}{l}
 A = B \xrightarrow{\textit{an arrow of type up}} \\
 = C + C + C + C + C + C + C + C \searrow \\
 = C + C + C + C + C + C + C + C \\
 = E + E \xleftarrow{\textit{an arrow of type down}}
 \end{array}$$

The options `up` and `down` require the Tikz library `calc`. If it has not been previously loaded by the user, an error will be raised.

In fact, the options `up` and `down` may be used with a value which is a list of couples key-value.

- The key `radius` is the radius of the rounded corner of the arrow.¹⁰
- The key `width` is the width of the (horizontal part of) the arrow:

¹⁰The initial value of this parameter is 4 pt, which is the default value of the “rounded corners” of Tikz.

$$\begin{aligned}
 A &= (a+1)^2 \\
 &= a^2 + 2a + 1
 \end{aligned}
 \left. \vphantom{\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned}} \right) \textit{we expand}$$

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 a given environment.¹²

```

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

```

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

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

```

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

```

$$\begin{aligned}
 \varphi(x,y) = 0 &\Leftrightarrow (x+y)^2 + (x+2y)^2 = 0 \\
 &\Leftrightarrow \left\{ \begin{array}{l} x+y=0 \\ x+2y=0 \end{array} \right.
 \end{aligned}
 \left. \vphantom{\begin{aligned} \varphi(x,y) = 0 &\Leftrightarrow (x+y)^2 + (x+2y)^2 = 0 \\ &\Leftrightarrow \left\{ \begin{array}{l} x+y=0 \\ x+2y=0 \end{array} \right. \end{aligned}} \right) \textit{x and y are real}$$

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.

```

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

```

¹²It's also possible to change `\jot` with the environment `{spreadlines}` of `mathtools`.

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

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

Like the environment `{aligned}`, `{WithArrows}` has an option of placement which can assume the values `t`, `c` or `b`. However, the initial 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.

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

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

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

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

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

$$\text{Let's set } \left\{ \begin{array}{l} f(x) = 3x^3 + 2x^2 - x + 4 \\ g(x) = 5x^2 - 5x + 6 \end{array} \right\} \text{both are polynoms}$$

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.

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

7 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`, `code-before` and `code-after`). The command `\Arrow` can be used as usual in each environment `{WithArrows}`.

```

 $\begin{WithArrows}$ 
 $\varphi(x,y)=0$ 
 $\Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0$   $\Arrow{the\ numbers\ are\ real}$ 
 $\Leftrightarrow$ 
 $\left\{ \begin{array}{l} x+2y = 0 \\ 2x+4y = 0 \end{array} \right.$ 
 $\end{WithArrows}$ 
 $\right.$ 
 $\Leftrightarrow$ 
 $\left\{ \begin{array}{l} x+2y = 0 \\ x+2y = 0 \end{array} \right.$   $\Arrow[tikz=-]{the\ same\ equation}$ 
 $\end{WithArrows}$ 
 $\right.$ 
 $\Leftrightarrow x+2y=0$ 
 $\end{WithArrows}$ 

```

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

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 :

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

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

A command `\Arrow` in `code-after` 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 that 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 `code-after` :

```

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

```

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

The options allowed for a command `\Arrow` in `code-after` are: `ll`, `lr`, `rl`, `rr`, `v`, `xoffset`, `tikz` and `tikz-code`. Except `v`, which is specific to `\Arrow` in `code-after`, 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 `code-after`. However, it's always possible to translate an arrow with `xoffset` (or `xshift` of Tikz).

```

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

```

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

The package `witharrows` provides also another command available only in `code-after`: 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 `pgffor`.

```

 $\begin{WithArrows}[tikz = rounded corners,$ 
 $\text{code-after} = \{\MultiArrow\{1,\dots,4\}\{text\}\} ]$ 
 $A \& = B \setminus$ 
 $\& = C \setminus$ 

```

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

8 Arrows from outside environments `{WithArrows}`

For illustrative purposes, we give an example of nested environments `{WithArrows}`, and, for each “right node”, the name of that node.¹³

$$\begin{aligned}
A &\triangleleft B + B + B + B + B + B + B + B + B + B + B + B + B + B + B_{\text{wa-45-1-r}} \\
&\triangleleft \begin{cases} C \triangleleft D_{\text{wa-45-1-1-r}} \\ E \triangleleft F_{\text{wa-45-1-2-r}} \end{cases} \quad \text{wa-45-2-r} \\
&\triangleleft \begin{cases} G \triangleleft H + H + H + H + H + H + H_{\text{wa-45-2-1-r}} \\ I \triangleleft \begin{cases} J \triangleleft K_{\text{wa-45-2-1-1-r}} \\ L \triangleleft M_{\text{wa-45-2-1-2-r}} \end{cases} \end{cases} \quad \begin{matrix} \text{wa-45-3-r} \\ \text{wa-45-2-2-r} \end{matrix} \\
&\triangleleft \begin{cases} N \triangleleft O_{\text{wa-45-3-1-r}} \\ P \triangleleft Q_{\text{wa-45-3-2-r}} \end{cases} \quad \text{wa-45-4-r}
\end{aligned}$$

- the command `\WithArrowsLastEnv` gives the number of the last environment of level 0 (i.e. which is not included in another environment of the package `witharrows`);
- 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 arrow¹⁴;
- the Tikz style `WithArrows/arrow/tips` is the style for the tip of the arrow (loaded by `WithArrows/arrow`).

¹⁴More precisely, this style is given to the Tikz option “**every path**” before drawing the arrow with the code of the option `tikz-code`. This style is modified (in TeX scopes) by the option `tikz` of `witharrows`.


```

\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}

```

$$\begin{array}{l}
 A \triangleleft B + B + B + B + B + B + B + B + B + B + B + B + B \\
 \triangleleft \left\{ \begin{array}{l} C \triangleleft D \\ E \triangleleft F \end{array} \right. \\
 \triangleleft \left\{ \begin{array}{l} G \triangleleft H + H + H + H + H + H + H \\ I \triangleleft \left\{ \begin{array}{l} J \triangleleft K \\ L \triangleleft M \end{array} \right. \end{array} \right. \\
 \triangleleft \left\{ \begin{array}{l} N \triangleleft O \\ P \triangleleft Q \end{array} \right. \leftarrow
 \end{array}$$

In this case, it would be easier to use a command `\Arrow` in `code-after` 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.

```

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

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

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

```

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

9 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 \Arrow{we expand} \\
&= a^2 + 2a + 1
\end{DispWithArrows}
```

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

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).
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 \Arrow{we expand} \notag \\
&= a^2 + 2a + 1 \tag{$\star$} \label{my-equation}
\end{DispWithArrows}
```

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

A link to the equation (\star) .¹⁵

If `amsmath` (or `mathtools`) is loaded, it's also possible to use `\tag*` which, as in `amsmath`, typesets the tag without the parentheses. For example, it's possible to use it to put the symbol `\square` of `amssymb`. This symbol is often used to mark the end of a proof.¹⁶

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

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

It's also possible to suppress all the autogenerated numbers with the boolean option `notag` (or `nonumber`), at the global or environment level. There is also an environment `{DispWithArrows*}` which suppresses all these numbers.¹⁷

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

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

¹⁵In this document, the references have been customized with `\labelformat{equation}{(#1)}` in the preamble.

¹⁶Notice that the environment `{DispWithArrows}` is compatible with the command `\qedhere` of `amsthm`.

¹⁷Even in this case, it's possible to put a “manual tag” with the command `\tag`.

In fact, there is also another option `tagged-lines` which can be used to control the lines that will be tagged. The value of this option is a list of the numbers of the lines that must to be tagged. For example, with the option `tagged-lines = {first,3,last}`, only the first, the third and the last line of the environment will be tagged. There is also the special value `all` which means that all the lines will be tagged.

```
\begin{DispWithArrows}[tagged-lines = last]
A & = A_1 \Arrow{first stage} \\
& = A_2 \Arrow{second stage} \\
& = A_3
\end{DispWithArrows}
```

$$\begin{aligned} A &= A_1 \\ &= A_2 \\ &= A_3 \end{aligned} \begin{array}{l} \downarrow \textit{first stage} \\ \downarrow \textit{second stage} \end{array} \quad (3)$$

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 initial value of this parameter is 25 pt. It's possible to use as value for that key a *skip* (*=glue*).

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

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \begin{array}{l} \downarrow \textit{we expand} \end{array} \quad \begin{array}{l} (4) \\ (5) \end{array}$$

Remark: By design, the option `fleqn` of `witharrows` is independent 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 option `leqno` is used as a class option, the labels will be composed on the left also for the environments `{DispWithArrows}` and `{DispWithArrows*}`.¹⁸

If the package `amsmath` is loaded, it's possible to use the command `\intertext` in the environments `{DispWithArrows}`. It's also possible to use the environment `{subequations}`. However, there is, for the environments `{DispWithArrows}`, an option `subequations` to encapsulate the environment in an environment `{subequations}`.

In the following example, the key `{subequations}` is fixed by the command `\WithArrowsOptions`. Each environment `{DispWithArrows}` will be subnumerated (in the scope of `\WithArrowsOptions`)

```
\WithArrowsOptions{subequations}
First environment.
\begin{DispWithArrows}
A & = B \\
& = C
\end{DispWithArrows}
Second environment.
```

¹⁸The package `amsmath` has an option `leqno` but `witharrows`, of course, is not aware of that option: `witharrows` only checks the option `leqno` of the document class.

```
\begin{DispWithArrows}
D & = E \\
& = F
\end{DispWithArrows}
```

First environment.

$$A = B \tag{6a}$$

$$= C \tag{6b}$$

Second environment.

$$D = E \tag{7a}$$

$$= F \tag{7b}$$

If there is not enough space to put the tag at the end of a line, there is no automatic positioning of the label on the next line (as in the environments of `amsmath`). However, in `{DispWithArrows}`, the user can use the command `\tagnextline` to manually require the composition of the tag on the following line.

```
\begin{DispWithArrows}[displaystyle]
S_{2(p+1)}
& = \sum_{k=1}^{2(p+1)} (-1)^k k^2 \\
& \smash[b]{= \sum_{k=1}^{2p} (-1)^k k^2} \\
& \quad + (-1)^{2p+1} (2p+1)^2 + (-1)^{2p+2} (2p+2)^2 \tagnextline \\
& = S_{2p} - (2p+1)^2 + (2p+2)^2 \\
& = p(2p+1) - (2p+1)^2 + (2p+2)^2 \\
& = 2p^2 + 5p + 3
\end{DispWithArrows}
```

$$S_{2(p+1)} = \sum_{k=1}^{2(p+1)} (-1)^k k^2 \tag{8}$$

$$= \sum_{k=1}^{2p} (-1)^k k^2 + (-1)^{2p+1} (2p+1)^2 + (-1)^{2p+2} (2p+2)^2 \tag{9}$$

$$= S_{2p} - (2p+1)^2 + (2p+2)^2 \tag{10}$$

$$= 2p^2 + p - 4p^2 - 4p - 1 + 4p^2 + 8p + 4 \tag{11}$$

$$= 2p^2 + 5p + 3 \tag{12}$$

The environments `{DispWithArrows}` and `{DispWithArrows*}` provide an option `wrap-lines`. With this option, the lines of the labels are automatically wrapped on the right.²

```
\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*}
```

$$\begin{aligned}
S_n &= \frac{1}{n} \Re \left(\sum_{k=0}^{n-1} \left(e^{i \frac{\pi}{2n}} \right)^k \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - \left(e^{i \frac{\pi}{2n}} \right)^n}{1 - e^{i \frac{\pi}{2n}}} \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - i}{1 - e^{i \frac{\pi}{2n}}} \right)
\end{aligned}
\begin{array}{l}
\left. \begin{array}{l} \text{sum of terms of a geometric} \\ \text{progression of ratio } e^{i \frac{2\pi}{n}} \end{array} \right\} \\
\left. \begin{array}{l} \text{This line has been wrapped} \\ \text{automatically.} \end{array} \right\}
\end{array}$$

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 code-after of the environments `{DispWithArrows}` or `{DispWithArrows*}`.

We have said that the environments `{DispWithArrows}` and `{DispWithArrows*}` should be used in horizontal mode and not in vertical mode. However, there is an exception. These environments can be used directly after a `\item` of a LaTeX list. In this case, no vertical space is added before the environment.¹⁹

Here is an example. The use of `{DispWithArrows}` gives the ability to tag an equation (and also to use `wrap-lines`).

```

\begin{enumerate}
\item
\begin{DispWithArrows}%
[displaystyle, wrap-lines, tagged-lines = last, fleqn, mathindent = 0 pt]
S_n
&= \frac{1}{n} \Re \left( \sum_{k=0}^{n-1} \left( e^{i \frac{\pi}{2n}} \right)^k \right)
\Arrow{we use the formula for a sum of terms of a geometric progression of
ratio  $e^{i \frac{2\pi}{n}}$ }
&= \frac{1}{n} \Re \left( \frac{1 - \left( e^{i \frac{\pi}{2n}} \right)^n}{1 - e^{i \frac{\pi}{2n}}} \right)
\Arrow{ $\left( e^{i \frac{\pi}{2n}} \right)^n = e^{i \frac{\pi}{2}} = i$ }
&= \frac{1}{n} \Re \left( \frac{1 - i}{1 - e^{i \frac{\pi}{2n}}} \right)
\end{DispWithArrows}
\end{enumerate}

```

$$\begin{aligned}
1. \quad S_n &= \frac{1}{n} \Re \left(\sum_{k=0}^{n-1} \left(e^{i \frac{\pi}{2n}} \right)^k \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - \left(e^{i \frac{\pi}{2n}} \right)^n}{1 - e^{i \frac{\pi}{2n}}} \right) \\
&= \frac{1}{n} \Re \left(\frac{1 - i}{1 - e^{i \frac{\pi}{2n}}} \right)
\end{aligned}
\begin{array}{l}
\left. \begin{array}{l} \text{we use the formula for a sum of terms of a geometric} \\ \text{progression of ratio } e^{i \frac{2\pi}{n}} \end{array} \right\} \\
\left. \begin{array}{l} \left(e^{i \frac{\pi}{2n}} \right)^n = e^{i \frac{\pi}{2}} = i \end{array} \right\}
\end{array}
\tag{13}$$

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}` cannot be inserted in an environment `{gather}` of `amsmath`.

¹⁹It's possible to disable this feature with the option `standard-behaviour-with-items`.

- An environment `{DispWithArrows}` is always unbreakable (even with `\allowdisplaybreaks` of `amsmath`).
- The commands `\label`, `\tag`, `\notag` and `\nonumber` are allowed only in the last column.
- After an `\item` of a LaTeX list, no vertical space is added (this can be changed with the option `standard-behaviour-with-items`).
- **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`, `listbls`, `prettyref`, `refcheck`, `refstyle`, `showlabels`, `smartref`, `typedref` and `varioref`, and with the options `showonlyrefs` and `showmanualtags` of `mathtools`.²⁰ It is not compatible with `showkeys` (not all the labels are shown).

9.1 The option `<...>` of `DispWithArrows`

The environment `{DispWithArrows}` provides an option `left-brace`. When present, the value of this option is composed on the left, followed by a curly brace (hence the name) and the body of the environment.²¹

For lisibility, this option `left-brace` is also available with a special syntax: it's possible to give this option between angle brackets (`<` and `>`) just after `{DispWithArrows}` (before the optional arguments between square brackets).

The following code is an example of multi-case equations.²²

```
\begin{DispWithArrows}< \binom{n}{p} = >[format = ll,fleqn,displaystyle]
0 & \quad \text{if } p > n
\Arrow{if fact, it's a special case\\ of the following one} \\\
\frac{n(n-1)\cdots(n-p+1)}{p!} & \quad \text{if } 0 \leq p \leq n \\\
0 & \quad \text{if } p < 0
\end{DispWithArrows}
```

$$\binom{n}{p} = \begin{cases} 0 & \text{if } p > n \\ \frac{n(n-1)\cdots(n-p+1)}{p!} & \text{if } 0 \leq p \leq n \\ 0 & \text{if } p < 0 \end{cases} \quad \begin{matrix} \left. \begin{matrix} \text{if fact, it's a special case} \\ \text{of the following one} \end{matrix} \right\} \end{matrix} \quad \begin{matrix} (14) \\ (15) \\ (16) \end{matrix}$$

In the following example, we subnumerate the equations with the option `subequations` (available when the package `amsmath` is loaded).

```
\begin{DispWithArrows}< \label{system} \ref*{system} \Leftrightarrow >[
format = l, subequations ]
x+y+z = -3 \Arrow[tikz=--,jump=2]{3 equations} \\\
xy+xz+yz=-2 \\\
xyz = -15 \label{last-equation}
\end{DispWithArrows}
```

²⁰We recall that `varioref`, `hyperref`, `cleveref` and `autonum` must be loaded in this order. The package `witharrows` can be loaded anywhere.

²¹The option `left-brace` can also be used without value: in this case, only the brace is drawn...

²²The environment `{cases}` of `amsmath` is a way to compose such multi-cases equations. However, it's not possible to use the automatic numbering of equations with this environment. The environment `{numcases}` of the extension `cases` (written by Donald Arseneau) provides this possibility but, of course, it's not possible to draw arrows with this extension.

$$(17) \Leftrightarrow \left\{ \begin{array}{l} x + y + z = -3 \\ xy + xz + yz = -2 \\ xyz = -15 \end{array} \right. \begin{array}{l} (17a) \\ (17b) \\ (17c) \end{array} \quad \begin{array}{l} \\ \\ 3 \text{ equations} \end{array}$$

The whole system is the equation (17) (this reference has been coded by `\ref{system}`) whereas the last equation is the equation (17c) (this reference has been coded by `\ref{last-equation}`). The command `\ref*` used in the code above is a variant of the command `\ref` which does not create interactive link (even when `hyperref` is loaded).

With the option `replace-left-brace-by`, it's possible to replace the left curly brace by another extensible delimiter. For example, “`replace-left-brace-by = [\enskip`” will compose with a bracket and add also a `\enskip` after this bracket.

10 Advanced features

10.1 Utilisation with Beamer

New 2.9

If `witharrows` is used with Beamer, the command `\Arrow` takes in as argument between angular brackets (after the optional argument in square brackets) to specify the *overlays* which are implied (internally, `witharrows` merely uses the command `\only` of Beamer).

```
\Arrow[jump=2]<3->{Example}
```

10.2 Use with plain-Tex

The extension `witharrows` can be used with plain-Tex. In this case, the extension must be loaded with `\input`:

```
\input{witharrows}
```

In plain-Tex, there is not environments as in LaTeX. Instead of using the environment `{Witharrows}`, with `\begin{WithArrows}` and `\end{WithArrows}`, one should use a pseudo-environment delimited by `\WithArrows` and `\endWithArrows` (idem for `{DispWithArrows}`).

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

The version of `witharrows` for plain-Tex doesn't provide all the functionalities of the LaTeX version. In particular, the functionalities which deal with the number of the equations are not available (since they rely upon the system of tags of LaTeX).

10.3 The option `tikz-code` : how to change the shape of the arrows

The option `tikz-code` allows the user to change the shape of the arrows.²³

For example, the options “up” and “down” described previously (cf. p. 10) are programmed internally with `tikz-code`.

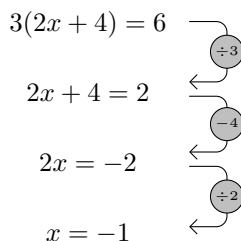
The value of this option must be a valid Tikz drawing instruction (with the final semicolon) with three markers #1, #2 and #3 for the start point, the end point and the label of the arrow.

The initial 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}[format=c,ygap=5pt,interline=4mm,
  tikz-code = {\draw[rounded corners]
    (#1) -- ([xshift=5mm]#1)
    -- node[circle,
      draw,
      auto = false,
      fill = gray!50,
      inner sep = 1pt] {\tiny #3}
    ([xshift=5mm]#2)
    -- (#2) ; }]
3 (2x+4) = 6   \Arrow{$\div 3$} \\
2x+4 = 2       \Arrow{$-4$}    \\
2x = -2        \Arrow{$\div 2$} \\
x = -1
\end{WithArrows}
```



The environments `{DispWithArrows}` and its starred version `{DispWithArrows*}` provide a command `\WithArrowsRightX` which can be used in a definition of `tikz-code`. This command gives the x -value of the right side of the composition box (taking into account the eventual tags of the equations). For an example of use, see p. 30.

10.4 The command `\WithArrowsNewStyle`

The extension `witharrows` provides a command `\WithArrowsNewStyle` to define styles in a way similar to the “styles” of Tikz.

The command `\WithArrowsNewStyle` takes two mandatory arguments. The first is the name of the style and the second is a list of key-value pairs. The scope of the definition done by `\WithArrowsNewStyle` is the current TeX scope.²⁴

²³If the option `wrap-lines` is used in an environment `{DispWithArrows}` or `{DispWithArrows*}`, the option `tikz-code` will have no effect for the arrows of this environment but only for the arrows in the nested environments `{WithArrows}`.

²⁴We recall that, in particular, every LaTeX environment is a TeX group.

The style can be used as a key at the document level (with `\WithArrowsOptions`) or at the environment level (in the optional arguments of `{WithArrows}` and `{DispWithArrows}`). The style can also be used in another command `\WithArrowsNewStyle`.

For an example of use, see p. 30.

At this time, there is no style for individual arrows. However, it's, of course, possible to define new commands based upon the command `\Arrow`. For example :

```
\newcommand{\ThickArrow}{\Arrow[tikz=thick]}
```

This new command `\ThickArrow` still accepts options between square brackets. It's possible to write `\ThickArrow[jump=2]` because, in fact, `\Arrow[tikz=thick][jump=2]` is an allowed syntax for the command `\Arrow` (it's possible to put an arbitrary number of optional arguments between square brackets after `\Arrow`).

10.5 The key right-overlap

The key `right-overlap` is a boolean key whose initial value is `true`. It deals with the environments `{WithArrows}` only.

When the key `right-overlap` is in force, the arrows (and their labels) are drawn in an overlapping position and are not relevant for the computation of the dimensions of the TeX box containing the environment `{WithArrows}`.

When the key `right-overlap` is set to `false` (with `\WithArrowsOptions` or within an individual environment `{WithArrows}`), the overlapping on the right is taken into account in the dimensions of the encompassing box.

```
\left{\begin{WithArrows}[c,format = rCrCl,right-overlap=false]
2x & + & 3y & = & 5 \Arrow{we add $L_1$ to $L_2$}\\
-2x & - & 5y & = & 2
\end{WithArrows}\right.$\quad
\left{\begin{WithArrows}[c,format = rCrCl]
2x & + & 3y & = & 5 \\
& - & 2y & = & 7
\end{WithArrows}\right.$
```

$$\left\{ \begin{array}{l} 2x + 3y = 5 \\ -2x - 5y = 2 \end{array} \right\} \begin{array}{l} \text{we add } L_1 \text{ to } L_2 \\ \end{array} \left\{ \begin{array}{l} 2x + 3y = 5 \\ -2y = 7 \end{array} \right.$$

The tuning `right-overlap = false` may also be useful in conjunction with the class `standalone`.

10.6 Vertical positioning of the arrows

There are four parameters for fine tuning of the vertical positioning of the arrows : `ygap`, `ystart`, `start-adjust` and `end-adjust`.

We first explain the behaviour when the parameters `start-adjust` and `end-adjust` are equal to zero:

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

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

However, for aesthetic reasons, when it's possible, `witharrows` starts the arrow a bit higher (by an amount `start-adjust`) and ends the arrow a bit lower (by an amount `end-adjust`). By default, both parameters `start-adjust` and `end-adjust` are equal to 0.4 ex.

Here is for example the behaviour without the mechanism of `start-adjust` and `end-adjust`:

```
\begin{WithArrows}[start-adjust=0pt, end-adjust=0pt]
A & = (a+1)^2 \Arrow{we expand} \\\
& = a^2 + 2a + 1
\end{WithArrows}$
```

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

Here is the standard behaviour (the parameters `start-adjust` and `end-adjust` are used with the initial value 0.4 ex). The arrow is longer and the result is more aesthetic.

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

It's also possible to use the option `adjust` which sets both `start-adjust` and `end-adjust`.

An arrow of jump equal to 1 has a maximal length²⁵ equal to the parameter `max-length-of-arrow`. The initial value of this parameter is 2 cm.

In the following example, the value of `max-length-of-arrow` has been fixed to 1.5 cm.

```
\[ \begin{WithArrows}[max-length-of-arrow = 1.5cm]
A
& =
\begin{vmatrix}
1 & a & a^2 & a^3 & a^4 \\
1 & b & b^2 & b^3 & b^4 \\
1 & c & c^2 & c^3 & c^4 \\
1 & d & d^2 & d^3 & d^4 \\
1 & e & e^2 & e^3 & e^4
\end{vmatrix}
\Arrow{
$L_2 \backslash gets L_2-L_1$ \\\
$L_3 \backslash gets L_3-L_1$ \\\
$L_4 \backslash gets L_4-L_1$ \\\
$L_5 \backslash gets L_5-L_1$ % don't put \\\ here
} \\\
& =
\begin{vmatrix}
1 & a & a^2 & a^3 & a^4 \\
0 & b-a & b^2-a^2 & b^3-a^3 & b^4-a^4 \\
0 & c-a & c^2-a^2 & c^3-a^3 & c^4-a^4 \\
0 & d-a & d^2-a^2 & d^3-a^3 & d^4-a^4 \\
0 & e-a & e^2-a^2 & e^3-a^3 & e^4-a^4
\end{vmatrix}
\end{WithArrows}]
```

²⁵We call *length* of an arrow the difference between the *y*-value of its start point and the *y* value of its end point.

$$\begin{aligned}
A &= \begin{vmatrix} 1 & a & a^2 & a^3 & a^4 \\ 1 & b & b^2 & b^3 & b^4 \\ 1 & c & c^2 & c^3 & c^4 \\ 1 & d & d^2 & d^3 & d^4 \\ 1 & e & e^2 & e^3 & e^4 \end{vmatrix} \\
&= \begin{vmatrix} 1 & a & a^2 & a^3 & a^4 \\ 0 & b-a & b^2-a^2 & b^3-a^3 & b^4-a^4 \\ 0 & c-a & c^2-a^2 & c^3-a^3 & c^4-a^4 \\ 0 & d-a & d^2-a^2 & d^3-a^3 & d^4-a^4 \\ 0 & e-a & e^2-a^2 & e^3-a^3 & e^4-a^4 \end{vmatrix} \quad \left. \begin{array}{l} L_2 \leftarrow L_2 - L_1 \\ L_3 \leftarrow L_3 - L_1 \\ L_4 \leftarrow L_4 - L_1 \\ L_5 \leftarrow L_5 - L_1 \end{array} \right\}
\end{aligned}$$

10.7 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:

$$\begin{aligned}
A &= (a+b)^2 \\
&= a^2 + b^2 + 2ab \quad \searrow \text{We expand}^{26}
\end{aligned}$$

10.8 Option no-arrows

The option `no-arrows` is a convenience given to the user. With this option the arrows are not drawn. However, an analyse of the arrows is done and some errors can be raised, for example if an arrow would arrive after the last row of the environment.

10.9 Note for the users of AUCTeX

In a editor of text with a LaTeX-oriented mode, the environments `{DispWithArrows}` and `{DispWithArrows*}` should be formatted like the environment `equation` of LaTeX, that is to say with a formatting adapted to the math mode of TeX.

In Emacs with the AUCTeX mode, it's possible to achieve such a customization by adding the strings "DispWithArrows" and "DispWithArrows*" to the variable `font-latex-math-environments`. It's possible to do that with the "easy customization" interface of Emacs:

```
M-x customize > [Text] > [TeX] > [Font LaTeX]
```

²⁶A footnote.

10.10 Note for the developers

If you want to construct an environment upon an environment of `witharrows`, we recommend to call the environment with the construction `\WithArrows\endWithArrows` (and not `\begin{WithArrows}` and `\end{WithArrows}`).

By doing so, the error messages generated by `witharrows` will (usually) mention the name of your environment and they will be easier to understand by the final user.

By example, you can define an environment `{DWA}` which is an alias of `{DispWithArrows}`:
`\NewDocumentEnvironment {DWA} {} {\DispWithArrows}\endDispWithArrows`

If you use this environment `{DWA}` in math mode, you will have the following error message:
 The environment `{DWA}` should be used only outside math mode.

Another example is the definition of the environment `{DispWithArrows*}` internally in the package `witharrows` by the following code:

```
\NewDocumentEnvironment {DispWithArrows*} {}
  {\WithArrowsOptions{notag}%
   \DispWithArrows}
  {\endDispWithArrows}
```

11 Examples

11.1 \MoveEqLeft

It's possible to use `\MoveEqLeft` of `mathtools`. Don't forget that `\MoveEqLeft` has also the value of an ampersand (&). That's important for the placement of an eventual command `\Arrow`.

```
$\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(\arcsin \frac{4}{5} + \arcsin \frac{5}{13}) \\\
& \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 - (\frac{5}{13})^2} + \frac{5}{13} \sqrt{1 - (\frac{4}{5})^2}
+ \frac{5}{13} \sqrt{1 - \bigl(\frac{4}{5}\bigr)^2}
\end{WithArrows}$
```

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

11.2 A command \DoubleArrow

By using the key `o` (cf. p. 9) available at the local level, it's easy to write a command `\DoubleArrow` for two arrows going in opposite directions.

```
\NewDocumentCommand \DoubleArrow { 0 {} m m }
{
  \Arrow[tikz=>,#1]{#2}%
  \Arrow[o,tikz=<-,#1]{#3}
}
```

Example of use:

```
$\begin{WithArrows}[groups]
A & = (a+b)^2 \DoubleArrow[tikz={font=\bfseries}]{expansion}{factorization} \\
& = a^2 + 2ab + b^2
\end{WithArrows}$
```

$$\begin{array}{lcl}
 A = (a+b)^2 & & \\
 = a^2 + 2ab + b^2 & \searrow \text{expansion} & \nearrow \text{factorization}
 \end{array}$$

11.3 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}%
[format = c,
 interline = 4mm,
 tikz = {every node/.style = {circle,
                             draw,
                             auto = false,
                             fill = gray!50,
                             inner sep = 1pt,
                             font = \tiny}}]

3 (2x+4) = 6 \Arrow{$\div 3$} \\
2x+4 = 2 \Arrow{$-4$} \\
2x = -2 \Arrow{$\div 2$} \\
2x = -1
\end{WithArrows}
```

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

11.4 Examples with the option tikz-code

We recall that the option `tikz-code` is the Tikz code used by `witharrows` to draw the arrows.²⁷

The value by default of `tikz-code` 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.

²⁷If an environment `{DispWithArrows}` or `{DispWithArrows*}` is used with the option `wrap-lines`, the value of the option `tikz-code` is not used for this environment (but is used for the environments nested inside).

11.4.1 Example 1

In the following example, we define the value of `tikz-code` 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{DispWithArrows*}%
[displaystyle,
ygap = 2mm,
ystart = 0mm,
tikz-code = {\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 \bigl( \tfrac{\pi}{2} \cdot \tfrac{k}{n} \bigr)
.....

```

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

11.4.2 Example 2

It's possible to modify the previous example to have the “`text width`” automatically computed with the right margin (in a way similar as the `wrap-lines` option) in the environments `{DispWithArrows}` and `{DispWithArrows*}`. In the definition of `tikz-code`, we use the command `\WithArrowsRightX` which is the x -value of the right margin of the current composition box (it's a TeX command and not a dimension). For lisibility, we use a style. This example requires the Tikz library `calc`.

```

\WithArrowsNewStyle{MyStyle}
{displaystyle,
  ygap = 2mm,
  xoffset = 0pt,
  ystart = 0mm,
  tikz-code = {\path let \p1 = (#1)
                in (#1)
                -- node [anchor = west,
                        text width = {\WithArrowsRightX - \x1 - 0.5 em}]
                        {#3}
                (#2) ;
  \draw let \p1 = (#1)
  in (#1) -- ++(\WithArrowsRightX - \x1,0) |- (#2) ; }}

```

```

begin{DispWithArrows}[MyStyle]
  S_n
  & = \frac{1}{n} \sum_{k=0}^{n-1} \cos\bigl(\tfrac{\pi}{2} \cdot \tfrac{k}{n}\bigr)
  \Arrow{$\cos x = \operatorname{Re}(e^{ix})$}\
  .....

```

$$S_n = \frac{1}{n} \sum_{k=0}^{n-1} \cos\left(\frac{\pi}{2} \cdot \frac{k}{n}\right) \quad (18)$$

$$= \frac{1}{n} \sum_{k=0}^{n-1} \Re\left(e^{i \frac{k\pi}{2n}}\right) \quad (19)$$

$$= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} e^{i \frac{k\pi}{2n}}\right) \quad (20)$$

$$= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} \left(e^{i \frac{\pi}{2n}}\right)^k\right) \quad (21)$$

$$= \frac{1}{n} \Re\left(\frac{1 - \left(e^{i \frac{\pi}{2n}}\right)^n}{1 - e^{i \frac{\pi}{2n}}}\right) \quad (22)$$

$$= \frac{1}{n} \Re\left(\frac{1 - i}{1 - e^{i \frac{\pi}{2n}}}\right) \quad (23)$$

11.4.3 Example 3

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}[11,interline=5mm,xoffset=5mm,
  tikz-code = {\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} + \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}

```

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

11.5 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 `code-after`. In the following example, we write this command with `\NewDocumentCommand` (of L3) and `\foreach` of `pgffor` (which is loaded when `witharrows` is loaded).

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

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

```


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


```

- 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 round brackets, the best way is to change the value of `tikz-code`:

```
tikz-code = {\draw (#1) to node {\footnotesize (#3)} (#2) ;}
```

- $$\begin{array}{ll}
 a. f \text{ est continuous on } E & \uparrow (1) \\
 b. f \text{ est continuous in } 0 & \uparrow (2) \\
 c. f \text{ is bounded on the unit sphere} & \uparrow (3) \\
 d. \exists K > 0 \quad \forall x \in E \quad \|f(x)\| \leq K\|x\| & \uparrow (4) \\
 e. f \text{ is lipschitzian} & \uparrow (5)
 \end{array}$$

12 Implementation

The development of the extension `witharrows` is done on the following GitHub depot:
<https://github.com/fpantigny/witharrows>

12.1 Declaration of the package and extensions loaded

The prefix `witharrows` has been registered for this extension.

See: <http://mirrors.ctan.org/macros/latex/contrib/l3kernel/l3prefixes.pdf>

`<@@=witharrows>`

First, `tikz` and some Tikz libraries are loaded before the `\ProvidesExplPackage`. They are loaded this way because `\usetikzlibrary` in L3 code fails.²⁸

```
1 <*LaTeX>
2 \RequirePackage{tikz}
3 </LaTeX>
4 <*plain-TeX>
5 \input tikz.tex
6 \input expl3-generic.tex
7 </plain-TeX>
8 \usetikzlibrary{arrows.meta}
9 \usepgfmodule{bending} % https://texnique.fr/osqa/questions/12199
```

Then, we can give the traditional declaration of a package written with L3:

```
10 <*LaTeX>
11 \ProvidesExplPackage
12   {witharrows}
13   {\myfiledate}
14   {\myfileversion}
15   {Draws arrows for explanations on the right}
16 \msg_new:nnn { witharrows } { latex-too-old }
17   {
18     Your~LaTeX~release~is~too~old. \\
19     You~need~at~least~a~the~version~of~2023-11-01
20   }
21 \IfFormatAtLeastTF
22   { 2023-11-01 }
23   { }
24   { \msg_fatal:nn { witharrows } { latex-too-old } }
25 \RequirePackage { varwidth }
26 </LaTeX>
27 <*plain-TeX>
28 \ExplSyntaxOn
29 \catcode ` \@ = 11
30 </plain-TeX>
31 <*LaTeX>
32 \ProvideDocumentCommand{\IfPackageLoadedT}{mm}
33   {\IfPackageLoadedTF{#1}{#2}{}}
34 \ProvideDocumentCommand{\IfPackageLoadedF}{mm}
35   {\IfPackageLoadedTF{#1}{#2}}
36 </LaTeX>
```

²⁸cf. tex.stackexchange.com/questions/57424/using-of-usetikzlibrary-in-an-expl3-package-fails

12.2 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 2.9a), 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 `\c_@@_footnotehyper_bool` will indicate if the option `footnotehyper` is used.

```
37 <*LaTeX>
38 \bool_new:N \c_@@_footnotehyper_bool
```

The boolean `\c_@@_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.

```
39 \bool_new:N \c_@@_footnote_bool
40 </LaTeX>
```

```
41 \cs_new_protected:Npn \@@_msg_new:nn { \msg_new:nnn { witharrows } }
42 \cs_new_protected:Npn \@@_msg_new:nnn #1 #2 #3
43 {
44   \bool_if:NTF \c_@@_messages_for_Overleaf_bool
45     { \msg_new:nnn { witharrows } { #1 } { #2 \\\ #3 } }
46     { \msg_new:nnnn { witharrows } { #1 } { #2 } { #3 } }
47 }
48 \cs_new_protected:Npn \@@_msg_redirect_name:nn
49 { \msg_redirect_name:nnn { witharrows } }
50 \cs_new_protected:Npn \@@_error:n { \msg_error:nn { witharrows } }
51 \cs_new_protected:Npn \@@_warning:n { \msg_warning:nn { witharrows } }
52 \cs_new_protected:Npn \@@_fatal:n { \msg_fatal:nn { witharrows } }
53 \cs_new_protected:Npn \@@_error:nn { \msg_error:nnn { witharrows } }
54 \cs_generate_variant:Nn \@@_error:nn { n e }
```

We also create a command which will generate usually an error but only a warning on Overleaf. The argument is given by currying.

```
55 \cs_new_protected:Npn \@@_error_or_warning:n
56 { \bool_if:NTF \c_@@_messages_for_Overleaf_bool \@@_warning:n \@@_error:n }
```

We try to detect whether the compilation is done on Overleaf. We use `\c_sys_jobname_str` because, with Overleaf, the value of `\c_sys_jobname_str` is always “output”.

```
57 \bool_set:Nn \c_@@_messages_for_Overleaf_bool
58 {
59   \str_if_eq_p:on \c_sys_jobname_str { _region_ } % for Emacs
60   || \str_if_eq_p:on \c_sys_jobname_str { output } % for Overleaf
61 }
```

```
62 \bool_new:N \g_@@_beamer_bool
```

We define a set of keys `WithArrows/package` for these options.

```
63 <*LaTeX>
64 \keys_define:nn { WithArrows / package }
65 {
66   footnote .bool_set:N = \c_@@_footnote_bool ,
67   footnotehyper .bool_set:N = \c_@@_footnotehyper_bool ,
68   footnote .usage:n = load ,
69   footnotehyper .usage:n = load ,
70   beamer .bool_gset:N = \g_@@_beamer_bool ,
71   beamer .default:n = true ,
72   beamer .usage:n = load ,
73   unknown .code:n = \@@_fatal:n { Option-unknown-for~package }
74 }
```

```

75 \@@_msg_new:nn { Option-unknown-for-package }
76 {
77   You~can't~use~the~option~'\l_keys_key_str'~when~loading~the~
78   package~witharrows.~Try~to~use~the~command~
79   \token_to_str:N\WithArrowsOptions.
80 }

```

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

```

81 \ProcessKeyOptions [ WithArrows / package ]

82 \IfClassLoadedT { beamer } { \bool_gset_true:N \g_@@_beamer_bool }
83 \IfPackageLoadedT { beamerarticle } { \bool_gset_true:N \g_@@_beamer_bool }

84 \@@_msg_new:nn { footnote-with-footnotehyper-package }
85 {
86   Footnote~forbidden.\.
87   You~can't~use~the~option~'footnote'~because~the~package~
88   footnotehyper~has~already~been~loaded.~
89   If~you~want,~you~can~use~the~option~'footnotehyper'~and~the~footnotes~
90   within~the~environments~of~witharrows~will~be~extracted~with~the~tools~
91   of~the~package~footnotehyper.\.
92   If~you~go~on,~the~package~footnote~won't~be~loaded.
93 }

94 \@@_msg_new:nn { footnotehyper-with-footnote-package }
95 {
96   You~can't~use~the~option~'footnotehyper'~because~the~package~
97   footnote~has~already~been~loaded.~
98   If~you~want,~you~can~use~the~option~'footnote'~and~the~footnotes~
99   within~the~environments~of~witharrows~will~be~extracted~with~the~tools~
100   of~the~package~footnote.\.
101   If~you~go~on,~the~package~footnotehyper~won't~be~loaded.
102 }

103 \bool_if:NT \c_@@_footnote_bool
104 {

```

The class `beamer` has its own system to extract footnotes and that's why we have nothing to do if `beamer` is used.

```

105 \@ifclassloaded { beamer }
106 { \bool_set_false:N \c_@@_footnote_bool }
107 {
108   \@ifpackageloaded { footnotehyper }
109   { \@_error:n { footnote-with-footnotehyper-package } }
110   { \usepackage { footnote } }
111 }
112 }

113 \bool_if:NT \c_@@_footnotehyper_bool
114 {

```

The class `beamer` has its own system to extract footnotes and that's why we have nothing to do if `beamer` is used.

```

115 \@ifclassloaded { beamer }
116 { \bool_set_false:N \c_@@_footnote_bool }
117 {
118   \@ifpackageloaded { footnote }
119   { \@_error:n { footnotehyper-with-footnote-package } }
120   { \usepackage { footnotehyper } }
121   \bool_set_true:N \c_@@_footnote_bool
122 }
123 }

```

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

12.3 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).

```

124 \bool_new:N \c_@@_leqno_bool
125 \DeclareOption { leqno } { \bool_set_true:N \c_@@_leqno_bool }
126 \DeclareOption* { }
127 \ProcessOptions*
128 \</LaTeX>

```

12.4 Collecting options

The following technic allows to create user commands with the ability to put an arbitrary number of `[list of (key=val)]` after the name of the command.

Exemple :

`\@@_collect_options:n { \F } [x=a,y=b] [z=c,t=d] { arg }`
will be transformed in : `\F{x=a,y=b,z=c,t=d}{arg}`

Therefore, by writing : `\def\G{\@@_collect_options:n{\F}}`,
the command `\G` takes in an arbitrary number of optional arguments between square brackets.

```

129 \<LaTeX>
130 \cs_new_protected:Npn \@@_collect_options:n #1
131 {
132   \peek_meaning:NTF [
133     { \@@_collect_options:nw { #1 } }
134     { #1 { } }
135   }

```

We use `\NewDocumentCommand` in order to be able to allow nested brackets within the argument between `[` and `]`.

```

136 \NewDocumentCommand \@@_collect_options:nw { m r[] }
137 { \@@_collect_options:nn { #1 } { #2 } }
138
139 \cs_new_protected:Npn \@@_collect_options:nn #1 #2
140 {
141   \peek_meaning:NTF [
142     { \@@_collect_options:nnw { #1 } { #2 } }
143     { #1 { #2 } }
144   }
145
146 \cs_new_protected:Npn \@@_collect_options:nnw #1#2[#3]
147 { \@@_collect_options:nn { #1 } { #2 , #3 } }
148 \</LaTeX>

```

12.5 Some technical definitions

```

149 \cs_generate_variant:Nn \seq_set_split:Nnn { N e e }
150 \cs_generate_variant:Nn \keys_precompile:nnN { n n c }
151 \prg_generate_conditional_variant:Nnn \tl_if_novalue:n { o } { F }
152 \exp_args_generate:n { N N N n o }

```

We define a command `\@@_sort_seq:N` which will sort a sequence.

```

153 \cs_new_protected:Npn \@@_sort_seq:N #1
154 {
155   \seq_sort:Nn #1
156   {
157     \str_compare:eNeTF
158     { \str_lowercase:n { ##1 } } < { \str_lowercase:n { ##2 } }
159     \sort_return_same:
160     \sort_return_swapped:
161   }
162 }

```

The following command creates a sequence of strings (`str`) from a `clist`.

```

163 \cs_new_protected:Npn \@@_set_seq_of_str_from_clist:Nn #1 #2
164 {
165   \seq_set_from_clist:Nn #1 { #2 }
166   \seq_set_map_e:NnNn #1 #1 { \tl_to_str:n { ##1 } }
167 }

```

The command `\@@_save:N` saves a L3 variable by creating a global version of the variable. For a variable named `\l_name_type`, the corresponding global variable will be named `\g_name_type`. The type of the variable is determined by the suffix *type* and is used to apply the corresponding L3 commands.

```

168 \cs_new_protected:Npn \@@_save:N #1
169 {
170   \seq_set_split:Nee \l_tmpa_seq
171   { \char_generate:nn { ` _ } { 12 } }
172   { \cs_to_str:N #1 }
173   \seq_pop_left:NN \l_tmpa_seq \l_tmpa_tl

```

The string `\l_tmpa_str` will contain the *type* of the variable.

```

174   \str_set:Ne \l_tmpa_str { \seq_item:Nn \l_tmpa_seq { -1 } }
175   \use:c { \l_tmpa_str _if_exist:cF }
176   { g _\seq_use:Nnnn \l_tmpa_seq _ _ _ }
177   {
178     \use:c { \l_tmpa_str _new:c }
179     { g _\seq_use:Nnnn \l_tmpa_seq _ _ _ }
180   }
181   \use:c { \l_tmpa_str _gset_eq:cN }
182   { g _\seq_use:Nnnn \l_tmpa_seq _ _ _ } #1
183 }

```

The command `\@@_restore:N` affects to the L3 variable the value of the (previously) set value of the corresponding *global* variable.

```

184 \cs_new_protected:Npn \@@_restore:N #1
185 {
186   \seq_set_split:Nee \l_tmpa_seq
187   { \char_generate:nn { ` _ } { 12 } }
188   { \cs_to_str:N #1 }
189   \seq_pop_left:NN \l_tmpa_seq \l_tmpa_tl
190   \str_set:Ne \l_tmpa_str { \seq_item:Nn \l_tmpa_seq { -1 } }
191   \use:c { \l_tmpa_str _set_eq:Nc }
192   #1 { g _\seq_use:Nnnn \l_tmpa_seq _ _ _ }
193 }

```

We define a Tikz style `@@_node_style` for the `l`-nodes and `r`-nodes that will be created in the `\halign`. These 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.

```

194 \tikzset
195 {
196   @@_node_style / .style =
197   {
198     above = \l_@@_ystart_dim ,
199     inner~sep = \c_zero_dim ,
200     minimum~width = \c_zero_dim ,
201     minimum~height = \l_@@_ygap_dim
202   }
203 }
```

If the user uses the option `show-nodes` (it’s a `l3keys` option), the Tikz options `draw` and `red` will be appended to this style. This feature may be useful for debugging.²⁹

The style `@@_standard` is loaded 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.

```

204 \tikzset
205 {
206   @@_standard / .style =
207   {
208     remember~picture ,
209     overlay ,
210     name~prefix = wa - \l_@@_prefix_str -
211   } ,
212   @@_standard_arrow / .style =
213   {
214     @@_standard ,
215     every~path / .style = WithArrows / arrow
216   }
217 }
```

The following line is a security when using `xelatex` and RTL language (cf. question 683570 on TeX StackExchange).

```

218 \sys_if_engine_xetex:T
219 {
220   \tikzset
221   {
222     @@_standard_arrow / .append~style =
223     { every~node / .append~style = { text = . } }
224   }
225 }
```

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`). This style is documented in the documentation of `witharrows`.

```

226 \tikzset
227 {
228   WithArrows / arrow / tips / .style =
229   { > = { Straight~Barb [ scale = 1.2 , bend ] } }
230 }
```

The style `WithArrows/arrow` will be used to draw the arrows (more precisely, it will be passed to `every~path`). This style is documented in the documentation of `witharrows`.

```

231 \tikzset
```

²⁹The `v`-nodes, created near the end of line in `{DispWithArrows}` and `{DispWithArrows*}` are not shown with the option `show-nodes`.

```

232 {
233   WithArrows / arrow / .style =
234   {
235     align = flush~left ,
Before the version 2.7, it was align = left.
236     auto = left ,
237   (*LaTeX)
238     font = \small \itshape ,
239   (/LaTeX)
240     WithArrows / arrow / tips ,
241     bend~left = 45 ,
242     ->
243   }
244 }

```

The option `subequations` is an option which uses the environment `{subequations}` of `amsmath`. That's why, if `amsmath` is loaded, we add the key `subequations` to the list of the keys available in `\WithArrowsOptions` and `{DispWithArrows}`.

```

245 (*LaTeX)
246 \AtBeginDocument
247 {
248   \IfPackageLoadedTF { amsmath }
249   {
250     \seq_put_right:Nn \l_@@_options-WithArrowsOptions_seq { subequations }
251     \seq_put_right:Nn \l_@@_options-DispWithArrows_seq { subequations }
252   }

```

In order to increase the interline in the environments `{WithArrows}`, `{DispWithArrows}`, etc., 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.

```

253 {
254   (/LaTeX)
255     \cs_new_protected:Npn \spread@equation
256     {
257       \openup \jot
258       \cs_set_eq:NN \spread@equation \prg_do_nothing:
259     }
260   (*LaTeX)
261   }
262 }
263 (/LaTeX)

264 \tl_new:N \l_@@_left_brace_tl
265 \tl_set_eq:NN \l_@@_left_brace_tl \c_novalue_tl

```

12.6 Variables

The boolean `\l_@@_in-WithArrows_bool` will be raised in an environment `{WithArrows}` and the boolean `\l_@@_in-DispWithArrows_bool` will be raised in an environment `{DispWithArrows}` or `{DispWithArrows*}`. The boolean `\l_@@_in_code_after_bool` will be raised during the execution of the code-after (option `code-after`).

```

266 \bool_new:N \l_@@_in-WithArrows_bool
267 \bool_new:N \l_@@_in-DispWithArrows_bool
268 \bool_new:N \l_@@_in_code_after_bool

```

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

```
269 \seq_new:N \g_@@_position_in_the_tree_seq
270 \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`.

```
271 \int_new:N \g_@@_last_env_int
```

The following integer indicates the position of the box that will be created for an environment `{WithArrows}` (not an environment `{DispWithArrows}`) : 0 (`=t=\vtop`), 1 (`=c=\vcenter`) or 2 (`=b=\vbox`).

```
272 \int_new:N \l_@@_pos_env_int
```

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

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

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

```
273 \int_new:N \l_@@_pos_arrow_int
274 \int_set:Nn \l_@@_pos_arrow_int 3
```

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

- `\g_@@_arrow_int` to count the arrows created in the environment ;
- `\g_@@_line_int` to count the lines of the `\halign` ;
- `\g_@@_col_int` to count the columns of the `\halign`.

These 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.

```
275 \seq_new:N \g_@@_arrow_int_seq
276 \int_new:N \g_@@_arrow_int
277 \seq_new:N \g_@@_line_int_seq
278 \int_new:N \g_@@_line_int
279 \seq_new:N \g_@@_col_int_seq
280 \int_new:N \g_@@_col_int
```

We will also use a “static” version of the counter of columns, called `\g_@@_static_col_int`. The value will be set directly in each cell of the array by an instruction in the template of the `\halign`. The aim of this programming is to try to detect some use of `\omit` (which should be forbidden) in the cells of the `\halign`.

```
281 \seq_new:N \g_@@_static_col_int_seq
282 \int_new:N \g_@@_static_col_int
```

For the environment `{DispWithArrows}`, the comma list `\l_@@_tags_clist` will be the list of the numbers of lines to be tagged (with the counter equation of LaTeX). In fact, `\l_@@_tags_clist` may contain non negative integers but also three special values: `first`, `last` and `all`.

```
283 {*LaTeX}
284 \clist_new:N \l_@@_tags_clist
285 \clist_set:Nn \l_@@_tags_clist { all }
```


During the execution of an environment `{DispWithArrows}`, if a row must be tagged, the (local) value of `\l_@@_tags_clist` will be put (by convention) to `all`.

```

286 \cs_new_protected:Npn \@@_test_if_to_tag:
287 {
288   \clist_if_in:NoT \l_@@_tags_clist \g_@@_line_int
289   { \clist_set:Nn \l_@@_tags_clist { all } }
290 }
291 \</LaTeX>

```

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

```

292 \str_new:N \l_@@_command_name_str
293 \str_set:Nn \l_@@_command_name_str { Arrow }

```

The string `\l_@@_string_Arrow_for_msg_str` is only a string that will be displayed in some error messages. For example, if `command-name` is defined to be `Explanation`, this string will contain “`\Arrow alias \Explanation`”.

```

294 \str_new:N \l_@@_string_Arrow_for_msg_str
295 \str_set:Ne \l_@@_string_Arrow_for_msg_str { \token_to_str:N \Arrow }

```

The sequence `\g_@@_names_seq` will be the list of all the names of environments used (via the option `name`) in the document: two environments must not have the same name. However, it’s possible to use the option `allow-duplicate-names`.

```

296 \seq_new:N \g_@@_names_seq

```

The boolean `\l_@@_sbwi_bool` corresponds to the option `standard-behaviour-with-items`. Since the version 1.16 of `witharrows`, no vertical space is added between an `\item` of a LaTeX list and an environment `{DispWithArrows}`. With the option `standard-behaviour-with-items`, it’s possible to restore the previous behaviour (which corresponds to the standard behaviour of `{align}` of `amsmath`). `\l_@@_sbwi_bool` is the boolean corresponding to this option.

```

297 \<LaTeX>
298 \bool_new:N \l_@@_sbwi_bool
299 \</LaTeX>

300 \<LaTeX>
301 \bool_new:N \l_@@_tag_star_bool
302 \bool_new:N \l_@@_tag_next_line_bool
303 \bool_new:N \l_@@_qedhere_bool
304 \</LaTeX>
305 \bool_new:N \l_@@_in_first_columns_bool
306 \bool_new:N \l_@@_new_group_bool
307 \bool_new:N \l_@@_initial_r_bool
308 \bool_new:N \l_@@_final_r_bool
309 \tl_new:N \l_@@_initial_tl
310 \tl_new:N \l_@@_final_tl
311 \int_new:N \l_@@_nb_cols_int

```

The string `\l_@@_format_str` will contain the *format* of the array which is a succession of letters `r`, `c` and `l` specifying the type of the columns of the `\halign` (except the column for the labels of the equations in the environment `{DispWithArrows}`).

```

312 \str_new:N \l_@@_format_str

```

The option `\l_@@_subequations_bool` corresponds to the option `subequations`.

```

313 \<LaTeX>
314 \bool_new:N \l_@@_subequations_bool
315 \</LaTeX>

```

The dimension `\l_@@_arrow_width_dim` is only for the arrows of type `up` and `down`. A value of `\c_max_dim` means that the arrow has the maximal possible width. A value of 0 pt means that the arrow has a width adjusted to the content of the node.

```
316 \dim_new:N \l_@@_arrow_width_dim
317 \dim_set_eq:NN \l_@@_arrow_width_dim \c_max_dim
```

The parameter `\l_@@_up_and_down_radius_dim` corresponds to option `radius_for_up_and_down`.

```
318 \dim_new:N \l_@@_up_and_down_radius_dim
319 \dim_set:Nn \l_@@_up_and_down_radius_dim { 4 pt }
```

The sequence `\l_@@_o_arrows_seq` will be used to store the numbers of the arrows which are of type `o` (for *over*) (they are drawn *after* the other arrows).

```
320 \seq_new:N \l_@@_o_arrows_seq
```

The dimension `\l_@@_xoffset_for_o_arrows_dim` is the xoffset added when drawing an arrow of type `o` (for *over*).

```
321 \dim_new:N \l_@@_xoffset_for_o_arrows_dim
322 \dim_set:Nn \l_@@_xoffset_for_o_arrows_dim { 2 mm }
```

The following boolean corresponds to the key `right-overlap`. When that key is `false`, the overlap on the right of the arrows (and their labels) is computed and it is used to change the width of the environment `{WithArrows}` in order to include the arrows on the right (and, hence, there is no overlap).

```
323 \bool_new:N \l_@@_right_overlap_bool
324 \bool_set_true:N \l_@@_right_overlap_bool
```

12.7 The definition of the options

There are four levels where options can be set:

- with `\usepackage[...]{witharrows}`: this level will be called *package* level;
- with `\WithArrowsOptions{...}`: this level will be called *global* level³⁰;
- with `\begin{WithArrows}[...]`: this level will be called *environment* level;
- with `\Arrow[...]` (included in `code-after`): this level will be called *local* level.

When we scan a list of options, we want to be able to raise an error if two options of position (1l, r1, i, etc.) of the arrows are present. That's why we keep the first option of position in a variable called `\l_@@_previous_key_str`. The following function `\@@_eval_if_allowed:n` will execute its argument only if a first key of position has not been set (and raise an error elsewhere).

```
325 \cs_new_protected:Npn \@@_eval_if_allowed:n #1
326 {
327   \str_if_empty:NTF \l_@@_previous_key_str
328   {
329     \str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
330     #1
331   }
332   { \@@_error:n { Incompatible~options } }
333 }

334 \cs_new_protected:Npn \@@_fix_pos_option:n #1
335 { \@@_eval_if_allowed:n { \int_set:Nn \l_@@_pos_arrow_int { #1 } } }
```

³⁰This level is called *global level* but the settings done by `\WithArrowsOptions` are local in the TeX sense: their scope corresponds to the current TeX group.

First a set of keys that will be used at the global or environment level of options.

```

336 \keys_define:nn { WithArrows / Global }
337 {
338   max-length-of-arrow .dim_set:N = \l_@@_max_length_of_arrow_dim ,
339   max-length-of-arrow .value_required:n = true ,
340   max-length-of-arrow .initial:n = 2 cm ,
341   ygap .dim_set:N = \l_@@_ygap_dim ,
342   ygap .initial:n = 0.4 ex ,
343   ygap .value_required:n = true ,
344   ystart .dim_set:N = \l_@@_ystart_dim ,
345   ystart .value_required:n = true ,
346   ystart .initial:n = 0.4 ex ,
347   more-columns .code:n =
348     \@@_msg_redirect_name:nn { Too-much-columns-in-WithArrows } { none } ,
349   more-columns .value_forbidden:n = true ,
350   command-name .code:n =
351     \str_set:Nn \l_@@_command_name_str { #1 }
352     \str_set:Ne \l_@@_string_Arrow_for_msg_str
353       { \c_backslash_str Arrow-alias~\c_backslash_str #1 } ,
354   command-name .value_required:n = true ,
355   tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
356   tikz-code .initial:n = \draw~(##1)~to~node{##3}~(##2)~; ,
357   tikz-code .value_required:n = true ,
358   displaystyle .bool_set:N = \l_@@_displaystyle_bool ,
359   displaystyle .default:n = true ,
360   show-nodes .code:n =
361     \tikzset { @@_node_style / .append~style = { draw , red } } ,
362   show-node-names .bool_set:N = \l_@@_show_node_names_bool ,
363   show-node-names .default:n = true ,
364   group .code:n =
365     \str_if_empty:NTF \l_@@_previous_key_str
366     {
367       \str_set:Nn \l_@@_previous_key_str { group }
368       \seq_remove_all:Nn \l_@@_options_Arrow_seq { xoffset }
369       \int_set:Nn \l_@@_pos_arrow_int 7
370     }
371     { \@@_error:n { Incompatible~options } } ,
372   group .value_forbidden:n = true ,
373   groups .code:n =
374     \str_if_empty:NTF \l_@@_previous_key_str
375     {
376       \str_set:Nn \l_@@_previous_key_str { groups }
377       \seq_if_in:NnF \l_@@_options_Arrow_seq { new-group }
378         { \seq_put_right:Nn \l_@@_options_Arrow_seq { new-group } }
379       \seq_remove_all:Nn \l_@@_options_Arrow_seq { xoffset }
380       \int_set:Nn \l_@@_pos_arrow_int 6
381     }
382     { \@@_error:n { Incompatible~options } } ,
383   groups .value_forbidden:n = true ,
384   tikz .code:n = \tikzset { WithArrows / arrow / .append~style = { #1 } } ,
385   tikz .value_required:n = true ,
386   rr .code:n = \@@_fix_pos_option:n 3 ,
387   rr .value_forbidden:n = true ,
388   ll .code:n = \@@_fix_pos_option:n 1 ,
389   ll .value_forbidden:n = true ,
390   rl .code:n = \@@_fix_pos_option:n 2 ,
391   rl .value_forbidden:n = true ,
392   lr .code:n = \@@_fix_pos_option:n 0 ,
393   lr .value_forbidden:n = true ,
394   i .code:n = \@@_fix_pos_option:n 5 ,
395   i .value_forbidden:n = true ,
396   xoffset .dim_set:N = \l_@@_xoffset_dim ,
397   xoffset .value_required:n = true ,

```

```

398 xoffset .initial:n = 3 mm ,
399 jot .dim_set:N = \jot ,
400 jot .value_required:n = true ,
401 interline .skip_set:N = \l_@@_interline_skip ,
402 start-adjust .dim_set:N = \l_@@_start_adjust_dim ,
403 start-adjust .initial:n = 0.4 ex ,
404 start-adjust .value_required:n = true ,
405 end-adjust .dim_set:N = \l_@@_end_adjust_dim ,
406 end-adjust .initial:n = 0.4 ex ,
407 end-adjust .value_required:n = true ,
408 adjust .meta:n = { start-adjust = #1 , end-adjust = #1 } ,
409 adjust .value_required:n = true ,
410 up-and-down .code:n = \keys_set:nn { WithArrows / up-and-down } { #1 } ,
411 up-and-down .value_required:n = true ,

```

With the option `no-arrows`, the arrows won't be drawn. However, the “first pass” of the arrows is done and some errors may be detected. The nullification of `\@@_draw_arrows:nn` is for the standard arrows and the nullification of `\@@_draw_arrow:nnn` is for “Arrow in code-after”.

```

412 no-arrows .code:n =
413   \cs_set_eq:NN \@@_draw_arrows:nn \use_none:nn
414   \cs_set_eq:NN \@@_draw_arrow:nnn \use_none:nnn ,
415 no-arrows .value_forbidden:n = true
416 }

```

Now a set of keys specific to the environments `{WithArrows}` (and not `{DispWithArrow}`). Despite its name, this set of keys will also be used in `\WithArrowsOptions`.

```

417 \keys_define:nn { WithArrows / WithArrowsSpecific }
418 {
419   t .code:n          = \int_set:Nn \l_@@_pos_env_int 0 ,
420   t .value_forbidden:n = true ,
421   c .code:n          = \int_set:Nn \l_@@_pos_env_int 1 ,
422   c .value_forbidden:n = true ,
423   b .code:n          = \int_set:Nn \l_@@_pos_env_int 2 ,
424   b .value_forbidden:n = true ,
425   right-overlap .bool_set:N      = \l_@@_right_overlap_bool ,
426   right-overlap .value_required:n = true
427 }

```

The following list of the (left) extensible delimiters of LaTeX is only for the validation of the key `replace-left-brace-by`.

```

428 \clist_new:N \c_@@_ext_delimiters_clist
429 \clist_set:Nn \c_@@_ext_delimiters_clist
430 {
431   ., \{, (, [, \lbrace, \lbrack, \lgroup, \langle, \lmoustache, \lceil, \lfloor
432 }
433 <LaTeX>
434 \AtBeginDocument
435 {
436   \bool_set_false:N \l_tmpa_bool
437   \IfPackageLoadedT { amsmath } { \bool_set_true:N \l_tmpa_bool }
438   \IfPackageLoadedT { unicode-math } { \bool_set_true:N \l_tmpa_bool }
439   \bool_if:NT \l_tmpa_bool
440     { \clist_put_right:Nn \c_@@_ext_delimiters_clist { \lvert, \lVert } }
441 }
442 </LaTeX>

```

Now a set of keys specific to the environments `{DispWithArrows}` and `{DispWithArrows*}` (and not `{WithArrows}`). Despite its name, this set of keys will also be used in `\WithArrowsOptions`.

```

443 \keys_define:nn { WithArrows / DispWithArrowsSpecific }
444 {
445   fleqn .bool_set:N = \l_@@_fleqn_bool ,

```

```

446   fleqn .default:n = true ,
447   mathindent .skip_set:N = \l_@@_mathindent_skip ,
448   mathindent .initial:n = 25 pt ,
449   mathindent .value_required:n = true ,
450 <LaTeX>
451   notag .code:n =
452     \str_if_eq:nnTF { #1 } { true }
453     { \clist_clear:N \l_@@_tags_clist }
454     { \clist_set:Nn \l_@@_tags_clist { all } } ,
455   notag .default:n = true ,

```

Since the option `subequations` is an option which insert the environment `{DispWithArrows}` in an environment `{subequations}` of `amsmath`, we must test whether the package `amsmath` is loaded.

```

456   subequations .code:n =
457     \IfPackageLoadedTF { amsmath }
458     { \bool_set_true:N \l_@@_subequations_bool }
459     {
460       \@@_error:n { amsmath~not~loaded }
461       \group_begin:
462       \globaldefs = 1
463       \@@_msg_redirect_name:nn { amsmath~not~loaded } { info }
464       \group_end:
465     } ,
466   subequations .default:n = true ,
467   subequations .value_forbidden:n = true ,
468   nonumber .meta:n = notag ,
469   allow-multiple-labels .code:n =
470     \@@_msg_redirect_name:nn { Multiple~labels } { none } ,
471   allow-multiple-labels .value_forbidden:n = true ,
472   tagged-lines .code:n =
473     \clist_set:Nn \l_@@_tags_clist { #1 }
474     \clist_if_in:NnT \l_@@_tags_clist { first }
475     {
476       \clist_remove_all:Nn \l_@@_tags_clist { first }
477       \clist_put_left:Nn \l_@@_tags_clist 1
478     } ,
479   tagged-lines .value_required:n = true ,
480 </LaTeX>
481   wrap-lines .bool_set:N = \l_@@_wrap_lines_bool ,
482   wrap-lines .default:n = true ,
483   replace-left-brace-by .code:n =
484     {
485       \tl_set:Nc \l_tmpa_tl { \tl_head:n { #1 } }
486       \clist_if_in:NoTF
487       \c_@@_ext_delimiters_clist
488       \l_tmpa_tl
489       { \tl_set:Nn \l_@@_replace_left_brace_by_tl { #1 } }
490       { \@@_error:n { Bad~value~for~replace~brace~by } }
491     } ,
492   replace-left-brace-by .initial:n = \lbrace ,

```

Since the version 1.16 of `witharrows`, no vertical space is added between an `\item` of a LaTeX list and an environment `{DispWithArrows}`. With the option `standard-behaviour-with-items`, it's possible to restore the previous behaviour (which corresponds to the standard behaviour of `{align}` of `amsmath`).

```

493 <LaTeX>
494   standard-behaviour-with-items .bool_set:N = \l_@@_sbwi_bool ,
495   standard-behaviour-with-items .default:n = true
496 </LaTeX>
497 }

```

Now a set of keys which will be used in all the environments (but not in `\WithArrowsOptions`).

```

498 \keys_define:nn { WithArrows / Env }

```

```

499 {
500   name .code:n =

```

First, we convert the value in a `str` because the list of the names will be a list of `str`.

```

501   \str_set:Nn \l_tmpa_str { #1 }
502   \seq_if_in:NoTF \g_@@_names_seq \l_tmpa_str
503     { \@@_error:n { Duplicate-name } }
504     { \seq_gput_left:No \g_@@_names_seq \l_tmpa_str }
505   \str_set_eq:NN \l_@@_name_str \l_tmpa_str ,
506   name .value_required:n = true ,
507   code-before .code:n = \tl_put_right:Nn \l_@@_code_before_tl { #1 } ,
508   code-before .value_required:n = true ,
509   CodeBefore .meta:n = { code-before = #1 } ,
510   code-after .code:n = \tl_put_right:Nn \l_@@_code_after_tl { #1 } ,
511   code-after .value_required:n = true ,
512   CodeAfter .meta:n = { code-after = #1 } ,
513   format .code:n =
514     \tl_if_empty:nTF { #1 }
515       { \@@_error:n { Invalid-option-format } }
516       {
517         \regex_match:nnTF { \A[rclRCL]*\Z } { #1 }
518         { \tl_set:Nn \l_@@_format_str { #1 } }
519         { \@@_error:n { Invalid-option-format } }
520       } ,
521   format .value_required:n = true
522 }

```

Now, we begin the construction of the major sets of keys, named “WithArrows / WithArrows”, “WithArrows / DispWithArrows” and “WithArrows / WithArrowsOptions”. Each of these sets of keys will be completed after.

```

523 \keys_define:nn { WithArrows }
524 {
525   WithArrows .inherit:n =
526   {
527     WithArrows / Global ,
528     WithArrows / WithArrowsSpecific ,
529     WithArrows / Env
530   } ,
531   WithArrows / up-and-down .inherit:n = WithArrows / up-and-down ,
532   DispWithArrows .inherit:n =
533   {
534     WithArrows / DispWithArrowsSpecific ,
535     WithArrows / Global ,
536     WithArrows / Env ,
537   } ,
538   DispWithArrows / up-and-down .inherit:n = WithArrows / up-and-down ,
539   WithArrowsOptions .inherit:n =
540   {
541     WithArrows / Global ,
542     WithArrows / WithArrowsSpecific ,
543     WithArrows / DispWithArrowsSpecific ,
544   } ,
545   WithArrowsOptions / up-and-down .inherit:n = WithArrows / up-and-down
546 }

```

A sequence of `str` for the options available in `{WithArrows}`. This sequence will be used in the error messages and can be modified dynamically.

```

547 \seq_new:N \l_@@_options-WithArrows_seq
548 \@@_set_seq_of_str_from_clist:Nn \l_@@_options-WithArrows_seq
549 {
550   adjust, b, c, code-after, code-before, command-name,
551   right-overlap, displaystyle, end-adjust,

```

```

552     format, group, groups, i,
553     interline, jot, ll,
554     lr, max-length-of-arrow, more-columns, name,
555     no-arrows, rl, rr, up-and-down,
556     show-node-names, show-nodes, start-adjust,
557     t, tikz, tikz-code,
558     xoffset, ygap, ystart
559 }

560 \keys_define:nn { WithArrows / WithArrows }
561 {
562     unknown .code:n =
563         \@@_sort_seq:N \l_@@_options_WithArrows_seq
564         \@@_error:n { Unknown~option-WithArrows }
565 }

566 \keys_define:nn { WithArrows / DispWithArrows }
567 {
568     left-brace .tl_set:N = \l_@@_left_brace_tl ,
569     unknown .code:n =
570         \@@_sort_seq:N \l_@@_options_DispWithArrows_seq
571         \@@_error:n { Unknown~option-DispWithArrows } ,
572 }

```

A sequence of the options available in {DispWithArrows}. This sequence will be used in the error messages and can be modified dynamically.

```

573 \seq_new:N \l_@@_options_DispWithArrows_seq
574 \@@_set_seq_of_str_from_clist:Nn \l_@@_options_DispWithArrows_seq
575 {
576     code-after, code-before, command-name, tikz-code, adjust,
577     displaystyle, end-adjust, fleqn, group, format, groups, i, interline, jot,
578     left-brace, ll, lr, max-length-of-arrow, mathindent, name, no-arrows,
579     up-and-down, replace-left-brace-by, rl, rr, show-node-names,
580     show-nodes, start-adjust, tikz, wrap-lines, xoffset, ygap, ystart,
581     (*LaTeX)
582     allow-multiple-labels, tagged-lines, nonumber, notag
583     (/LaTeX)
584 }

585 \keys_define:nn { WithArrows / WithArrowsOptions }
586 {
587     allow-duplicate-names .code:n =
588         \@@_msg_redirect_name:nn { Duplicate-name } { none } ,
589     allow-duplicate-names .value_forbidden:n = true ,
590     xoffset-for-o-arrows .dim_set:N = \l_@@_xoffset_for_o_arrows_dim ,
591     xoffset-for-o-arrows .value_required:n = true ,
592     unknown .code:n =
593         \@@_sort_seq:N \l_@@_options_WithArrowsOptions_seq
594         \@@_error:n { Unknown~option-WithArrowsOptions }
595 }

```

A sequence of the options available in \WithArrowsOptions. This sequence will be used in the error messages and can be modified dynamically.

```

596 \seq_new:N \l_@@_options_WithArrowsOptions_seq
597 \@@_set_seq_of_str_from_clist:Nn \l_@@_options_WithArrowsOptions_seq
598 {
599     allow-duplicate-names, b, c, command-name, right_overlap,
600     more-columns, tikz-code, adjust,
601     displaystyle, end-adjust, fleqn, group, groups, i, interline, jot, ll, lr,
602     mathindent, max-length-of-arrow, no-arrows, up-and-down, rl, rr,
603     show-node-names, show-nodes, start-adjust, t, tikz, wrap-lines, xoffset,

```

```

604     xoffset-for-o-arrows, ygap, ystart,
605 (*LaTeX)
606     allow-multiple-labels, nonumber, notag, standard-behaviour-with-items,
607     tagged-lines
608 
```

The command `\@@_set_independent:` is a command without argument that will be used to specify that the arrow will be “independent” (of the potential groups of the option `group` or `groups`). This information will be stored in the field “status” of the arrow. Another possible value of the field “status” is “new-group”.

```

610 \cs_new_protected:Npn \@@_set_independent:
611 {
612     \str_if_eq:onF \l_keys_value_tl { NoValue }
613     { \@@_error:n { Value-for-a-key } }
614     \@@_set_independent_bis:
615 }
```

The command `\@@_set_independent_bis:` is the same as `\@@_set_independent:` except that the key may be used with a value.

```

616 \cs_new_protected:Npn \@@_set_independent_bis:
617 {
618     \str_if_empty:NTF \l_@@_previous_key_str
619     {
620         \str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
621         \str_set:Nn \l_@@_status_arrow_str { independent }
622     }
623     { \@@_error:n { Incompatible-options-in-Arrow } }
624 }
```

The options of an individual arrow are parsed twice. The first pass is when the command `\Arrow` is read. The second pass is when the arrows are drawn (after the end of the environment `{WithArrows}` or `{DispWithArrows}`). Now, we present the set of keys for the first pass. The main goal is to extract informations which will be necessary during the scan of the arrows. For instance, we have to know if some arrows are “independent” or use the option “new-group”.

```

625 \keys_define:nn { WithArrows / Arrow / FirstPass }
626 {
627     jump .code:n =
628         \int_compare:nNnTF { #1 } > \c_zero_int
629         { \int_set:Nn \l_@@_jump_int { #1 } }
630         { \@@_error:n { Negative-jump } } ,
631     jump .value_required:n = true,
632     rr .code:n = \@@_set_independent: ,
633     ll .code:n = \@@_set_independent: ,
634     rl .code:n = \@@_set_independent: ,
635     lr .code:n = \@@_set_independent: ,
636     i .code:n = \@@_set_independent: ,
637     rr .default:n = NoValue ,
638     ll .default:n = NoValue ,
639     rl .default:n = NoValue ,
640     lr .default:n = NoValue ,
641     i .default:n = NoValue ,
642     new-group .value_forbidden:n = true ,
643     new-group .code:n =
644         \int_compare:nTF { \l_@@_pos_arrow_int = 6 }
645         { \str_set:Nn \l_@@_status_arrow_str { new-group } }
646         { \@@_error:n { new-group-without-groups } } ,
647     o .code:n =
648         \str_if_empty:NTF \l_@@_previous_key_str
649         {
650             \int_compare:nNnTF \l_@@_pos_arrow_int < 6
```



```

651         { \@@_error:n { invalid-key-o } }
652     {
653         \str_set:Nn \l_@@_status_arrow_str { over }
654         \str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
655     }
656 }
657 { \@@_error:n { Incompatible-options-in-Arrow } } ,

```

The other keys don't give any information necessary during the scan of the arrows. However, you try to detect errors and that's why all the keys are listed in this keys set. An unknown key will be detected at the point of the command `\Arrow` and not at the end of the environment.

```

658     tikz-code .code:n = \prg_do_nothing: ,
659     tikz-code .value_required:n = true ,
660     tikz .code:n = \prg_do_nothing: ,
661     tikz .value_required:n = true ,
662     start-adjust .code:n = \prg_do_nothing: ,
663     start-adjust .value_required:n = true ,
664     end-adjust .code:n = \prg_do_nothing: ,
665     end-adjust .value_required:n = true ,
666     adjust .code:n = \prg_do_nothing: ,
667     adjust .value_required:n = true ,
668     xoffset .code:n = ,
669     unknown .code:n =
670     \@@_sort_seq:N \l_@@_options_Arrow_seq
671     \seq_if_in:NoTF \l_@@_options_WithArrows_seq \l_keys_key_str
672     {
673         \str_set:Nn \l_tmpa_str
674         { ~However,~this~key~can~be~used~in~the~options~of~{WithArrows}. }
675     }
676     { \str_clear:N \l_tmpa_str }
677     \@@_error:n { Unknown-option-in-Arrow }
678 }

```

A sequence of the options available in `\Arrow`. This sequence will be used in the error messages and can be modified dynamically.

```

679 \seq_new:N \l_@@_options_Arrow_seq
680 \@@_set_seq_of_str_from_clist:Nn \l_@@_options_Arrow_seq
681 {
682     adjust, end-adjust, i, jump, ll, lr, o , rl, rr, start-adjust, tikz,
683     tikz-code, xoffset
684 }

685 \cs_new_protected:Npn \@@_fix_pos_arrow:n #1
686 {
687     \str_if_empty:NT \l_@@_previous_key_str
688     {
689         \str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
690         \int_set:Nn \l_@@_pos_arrow_int { #1 }
691     }
692 }

```

The options of the individual commands `\Arrows` are scanned twice. The second pass is just before the drawing of the arrow. In this set of keys, we don't put an item for the unknown keys because an unknown key would have been already detected during the first pass.

```

693 \keys_define:nn {WithArrows / Arrow / SecondPass }
694 {
695     tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
696     tikz-code .initial:n = \draw-({#1})-to~node{#3}~({#2})~; ,
697     tikz .code:n = \tikzset { WithArrows / arrow / .append-style = { #1 } } ,
698     rr .code:n = \@@_fix_pos_arrow:n 3 ,
699     ll .code:n = \@@_fix_pos_arrow:n 1 ,

```

```

700   rl .code:n = \@@_fix_pos_arrow:n 2 ,
701   lr .code:n = \@@_fix_pos_arrow:n 0 ,
702   i .code:n = \@@_fix_pos_arrow:n 5 ,
703   o .code:n = \str_set:Nn \l_@@_previous_key_str { o } ,

```

The option `xoffset` is not allowed when the option `group` or the option `groups` is used except, if the arrow is independent or if there is only one arrow.

```

704   xoffset .code:n =
705     \bool_lazy_all:nTF
706     {
707       { \int_compare_p:nNn \g_@@_arrow_int > 1 }
708       { \int_compare_p:nNn \l_@@_pos_arrow_int > 5 }
709       { ! \str_if_eq_p:on \l_@@_status_arrow_str { independent } }
710     }
711     { \@@_error:n { Option~xoffset~forbidden } }
712     { \dim_set:Nn \l_@@_xoffset_dim { #1 } } ,
713   xoffset .value_required:n = true ,
714   start-adjust .dim_set:N = \l_@@_start_adjust_dim,
715   end-adjust .dim_set:N = \l_@@_end_adjust_dim,
716   adjust .code:n =
717     \dim_set:Nn \l_@@_start_adjust_dim { #1 }
718     \dim_set:Nn \l_@@_end_adjust_dim { #1 } ,
719 }

```

`\WithArrowsOptions` is the command of the `witharrows` package to fix options at the document level. It's possible to fix in `\WithArrowsOptions` some options specific to `{WithArrows}` (in contrast with `{DispWithArrows}`) or specific to `{DispWithArrows}` (in contrast with `{WithArrows}`). That's why we have constructed a set of keys specific to `\WithArrowsOptions`.

```

720 <*LaTeX>
721 \NewDocumentCommand \WithArrowsOptions { m }
722 </LaTeX>
723 <*plain-TeX>
724 \cs_set_protected:Npn \WithArrowsOptions #1
725 </plain-TeX>
726 {
727   \str_clear_new:N \l_@@_previous_key_str
728   \keys_set:nn { WithArrows / WithArrowsOptions } { #1 }
729 }

```

12.8 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 `command-name` and the user command for `\@@_Arrow` will be different. This mechanism can be useful when the user already has a command named `\Arrow` that he still wants to use in the environments `{WithArrows}` or `{DispWithArrows}`.

```

730 <*LaTeX>
731 \cs_new_protected:Npn \@@_Arrow
732 { \@@_collect_options:n { \@@_Arrow_iii } }
733 \bool_if:NTF \g_@@_beamer_bool
734 {
735   \NewDocumentCommand \@@_Arrow_iii { m d < > m ! 0 { } }
736   {
737     \tl_if_novalue:nTF { #2 }
738     { \@@_Arrow_ii { #1 } { #3 } [ #4 ] }
739     { \only <#2> { \@@_Arrow_ii { #1 } { #3 } [ #4 ] } }
740   }
741 }
742 {

```

```

743 \NewDocumentCommand \@@_Arrow_iii { m m ! O { } }
744 { \@@_Arrow_ii { #1 } { #2 } [ #3 ] }
745 }
746 \NewDocumentCommand \@@_Arrow_ii { m m ! O { } }
747 { \LaTeX }
748 { *plain-TeX }
749 \cs_new_protected:Npn \@@_Arrow
750 {
751   \peek_meaning:NTF [
752     { \@@_Arrow_i }
753     { \@@_Arrow_i [ ] }
754   }
755   \cs_new_protected:Npn \@@_Arrow_i [ #1 ] #2
756   {
757     \peek_meaning:NTF [
758       { \@@_Arrow_ii [ #1 ] { #2 } }
759       { \@@_Arrow_ii [ #1 ] { #2 } [ ] }
760     }
761     \cs_new_protected:Npn \@@_Arrow_ii [ #1 ] #2 [ #3 ]
762     { \plain-TeX }
763   }

```

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.

```

764 \int_gincr:N \g_@@_arrow_int

```

We will construct a global property list to store the informations of the considered arrow. The six fields of this property list are “initial”, “final”, “status”, “options”, “label” and “input-line”. In order to compute the value of “final” (the destination row of the arrow), we have to take into account a potential option jump. In order to compute the value of the field “status”, we have to take into account options `ll`, `rl`, `rr`, `lr`, etc. or `new-group`.

We will do that job with a first analyze of the options of the command `\Arrow` with a dedicated set of keys called `WithArrows/Arrow/FirstPass`.

```

765 \str_clear_new:N \l_@@_previous_key_str
766 \keys_set:nn { WithArrows / Arrow / FirstPass } { #1 , #3 }
767 \prop_clear_new_linked:N \l_tmpa_linked_prop

```

We construct now a global property list to store the informations of the considered arrow with the six fields “initial”, “final”, “status”, “options”, “label” and “input-line”.

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

```

768 \prop_put:NnV \l_tmpa_linked_prop { initial } \g_@@_line_int

```

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

```

769 \int_set:Nn \l_tmpa_int { \g_@@_line_int + \l_@@_jump_int }
770 \prop_put:NnV \l_tmpa_linked_prop { final } \l_tmpa_int

```

3. The “status” of the arrow, with 4 possible values: empty, independent, `new-group` or `over`.

```

771 \prop_put:Nno \l_tmpa_linked_prop { status } \l_@@_status_arrow_str

```

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

```

772 \prop_put:Nnn \l_tmpa_linked_prop { options } { #1 , #3 }

```

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

```

773 \prop_put:Nnn \l_tmpa_linked_prop { label } { #2 }

```

6. The number of the line where the command `\Arrow` is issued in the TeX source (as of now, this is only useful for some error messages).

```
774 \prop_put:Nne \l_tmpa_linked_prop { input-line } \msg_line_number:
```

7. The total width of the arrow (with the label)... but we don't know it now and that's why we put 0 pt. There are used for the arrows of type o.

```
775 \prop_put:Nnn \l_tmpa_linked_prop { width } { 0 pt }
```

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.

```
776 \prop_gclear_new_linked:c
777 { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \g_@@_arrow_int _ prop }
778 \prop_gset_eq:cN
779 { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \g_@@_arrow_int _ prop }
780 \l_tmpa_linked_prop
781 }
```

The command `\Arrow` (or the corresponding command with a name given by the user with the option `command-name`) will be available only in the last column of the environments `{WithArrows}` and `{DispWithArrows}`. In the other columns, the command will be linked to the following command `\@@_Arrow_first_columns:` which will raise an error.

```
782 \cs_new_protected:Npn \@@_Arrow_first_columns:
783 { \@@_error:n { Arrow-not-in-last-column } \@@_Arrow }
```

12.9 The environments `{WithArrows}` and `{DispWithArrows}`

12.9.1 Code before the `\halign`

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

```
784 \cs_new_protected:Npn \@@_pre_halign:n #1
```

First, the initialization of `\l_@@_type_env_str` which is the name of the encompassing environment. In fact, this token list is used only in the error messages.

```
785 {
786 {*LaTeX}
787 \str_clear_new:N \l_@@_type_env_str
788 \str_set:NV \l_@@_type_env_str \currenenv
789 {/LaTeX}
```

We deactivate the potential externalization of Tikz. The Tikz elements created by `witharrows` can't be externalized since they are created in Tikz pictures with `overlay` and `remember picture`.

```
790 \cs_if_exist:NT \tikz@library@external@loaded
791 { \tikzset { external / export = false } }
```

```
792 \tikzset { arrows = [ flex ] } % https://texnique.fr/osqa/questions/12199
```

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

```
793 \str_clear_new:N \l_@@_name_str
```

The parameter `\l_@@_status_arrow_str` will be used to store the “status” of an individual arrow. It will be used to fill the field “status” in the property list describing an arrow.

```
794 \str_clear_new:N \l_@@_status_arrow_str
```

The dimension `\l_@@_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_arrow_int`) is used.

```
795 \dim_zero_new:N \l_@@_x_dim
```

The variable `\l_@@_input_line_str` will be used only to store, for each command `\Arrow` the line (in the TeX file) where the command is issued. This information will be stored in the field “input-line” of the arrow. As of now, this information is used only in some error messages.

```
796 \str_clear_new:N \l_@@_input_line_str
```

Initialization of `\g_@@_arrow_int`, `\g_@@_line_int`, `\g_@@_col_int` and `\g_@@_static_col_int`. However, we have to save their previous values with the stacks created for this end.

```
797 \seq_gput_right:NV \g_@@_arrow_int_seq \g_@@_arrow_int
798 \int_gzero:N \g_@@_arrow_int
799 \seq_gput_right:NV \g_@@_line_int_seq \g_@@_line_int
800 \int_gzero:N \g_@@_line_int
801 \seq_gput_right:NV \g_@@_col_int_seq \g_@@_col_int
802 \int_gzero:N \g_@@_col_int
803 \seq_gput_right:NV \g_@@_static_col_int_seq \g_@@_static_col_int
804 \int_gzero:N \g_@@_static_col_int
```

In the preamble of the `\halign`, there will be *two* counters of the columns. The aim of this programming is to detect the use of a command `\omit` in a cell of the `\halign` (it should be forbidden). For example, in the part of the preamble concerning the third column (if there is a third column in the environment), we will have the following instructions :

```
\int_gincr:N \g_@@_col_int
\int_set:Nn \g_@@_static_col_int 3
```

The counter `\g_@@_col_int` is incremented dynamically and the second is static. If the user has used a command `\omit`, the dynamic incrementation is not done in the cell and, at the end of the row, the difference between the counters may infer the presence of `\omit` at least once.

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

```
805 \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 six 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).

```
806 \seq_set_eq:NN \l_tmpa_seq \g_@@_position_in_the_tree_seq
807 \seq_pop_right:NN \l_tmpa_seq \l_tmpa_tl
808 \str_clear_new:N \l_@@_prefix_str
809 \str_set:N \l_@@_prefix_str { \seq_use:Nnnn \l_tmpa_seq - - - }
```

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

```
810 \cs_set_eq:NN \ \@@_cr:
811 \dim_zero:N \mathsurround
```

These counters will be used later as variables.

```
812 \int_zero_new:N \l_@@_initial_int
813 \int_zero_new:N \l_@@_final_int
814 \int_zero_new:N \l_@@_arrow_int
815 \int_zero_new:N \l_@@_pos_of_arrow_int
816 \int_zero_new:N \l_@@_jump_int
```

The counter `\l_@@_jump_int` corresponds to the option `jump`. Now, we set the initial value for this option.

```
817 \int_set:Nn \l_@@_jump_int 1
```

The string `\l_@@_format_str` corresponds to the option `format`. Now, we set the initial value for this option.

```
818 \str_set:Nn \l_@@_format_str { rL }
```

In (the last column of) `{DispWithArrows}`, it's possible to put several labels (for the same number of equation). That's why these labels will be stored in a sequence `\l_@@_labels_seq`.

```
819 (*LaTeX)
820 \seq_clear_new:N \l_@@_labels_seq
821 \bool_set_false:N \l_@@_tag_next_line_bool
822 (/LaTeX)
```

The value corresponding to the key `interline` is put to zero before the treatment of the options of the environment.³¹

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

The value corresponding to the key `code-before` 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 `code-after`.

```
824 \tl_clear_new:N \l_@@_code_before_tl
825 \tl_clear_new:N \l_@@_code_after_tl
```

We process the options given to the environment `{WithArrows}` or `{DispWithArrows}`.

```
826 \str_clear_new:N \l_@@_previous_key_str
827 \bool_if:NT \l_@@_in_WithArrows_bool
828 { \keys_set:nn { WithArrows / WithArrows } { #1 } }
829 \bool_if:NT \l_@@_in_DispWithArrows_bool
830 { \keys_set:nn { WithArrows / DispWithArrows } { #1 } }
```

The dimension `\g_@@_overlap_x_dim` will be the maximal overlap on the right of the arrows (and their labels) drawn in the environment `{WithArrows}`. The dimension `\l_@@_delta_x_dim` will be the difference of abscissa between the right side of the alignment (`\halign`) and the left side of the arrow.

```
831 \bool_if:NF \l_@@_right_overlap_bool
832 {
833   \bool_if:NT \l_@@_in_WithArrows_bool
834   {
835     \dim_gzero_new:N \g_@@_overlap_x_dim
836     \dim_zero_new:N \l_@@_delta_x_dim
837   }
838 }
```

Now we link the command `\Arrow` (or the corresponding command with a name given by the user with the option `command-name`: that's why the following line must be after the loading of the options) to the command `\@@_Arrow_first_columns`: which will raise an error.

```
839 \cs_set_eq:cN \l_@@_command_name_str \@@_Arrow_first_columns:
```

It's only in the last column of the environment that it will be linked to the command `\@@_Arrow:`.

The counter `\l_@@_nb_cols_int` is the number of columns in the `\halign` (excepted the column for the labels of equations in `{DispWithArrows}` and excepted eventuals other columns in `{WithArrows}` allowed by the option `more-columns`).

```
840 \int_set:Nn \l_@@_nb_cols_int { \str_count:N \l_@@_format_str }
```

Be careful! The following counter `\g_@@_col_int` will be used for two usages:

- during, the construction of the preamble of the `\halign`, it will be used as counter for the number of the column under construction in the preamble (since the preamble is constructed backwards, `\g_@@_col_int` will go decreasing from `\l_@@_nb_cols_int` to 1) ;

³¹It's recalled that, by design, the option `interline` of an environment doesn't apply in the nested environments.

- once the preamble constructed, the primitive `\halign` is executed, and, in each row of the `\halign`, the counter `\g_@@_col_int` will be increased from column to column.

```
841 \int_gset_eq:NN \g_@@_col_int \l_@@_nb_cols_int
```

We convert the format in a sequence because we use it as a stack (with the top of the stack at the end of the sequence) in the construction of the preamble.

```
842 \seq_clear_new:N \l_@@_format_seq
843 \seq_set_split:NnV \l_@@_format_seq { } \l_@@_format_str
```

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`).

```
844 <*LaTeX>
845 \bool_if:NT \c_@@_footnote_bool { \begin { savenotes } }
846 </LaTeX>
```

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

```
847 \l_@@_code_before_tl
848 <*LaTeX>
849 \cs_set_eq:NN \notag \@@_notag:
850 \cs_set_eq:NN \nonumber \@@_nonumber:
851 \cs_set_eq:NN \tag \@@_tag
852 \cs_set_eq:NN \@@_old_label \label
853 \cs_set_eq:NN \label \@@_label:n
854 \cs_set_eq:NN \tagnextline \@@_tagnextline:
855 </LaTeX>
856 }
```

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

12.9.2 The construction of the preamble of the `\halign`

The control sequence `\@@_construct_halign:` will “start” the `\halign` and the preamble. In fact, it constructs all the preamble excepted the end of the last column (more precisely: except the part concerning the construction of the left node and the right node).

The same function `\@@_construct_halign:` will be used both for the environment `{WithArrows}` and the environment `{DispWithArrows}`.

Several important points must be noted concerning that construction of the preamble.

- The construction of the preamble is done by reading backwards the format `\l_@@_format_str` and adding the corresponding tokens in the input stream of TeX. That means that the part of the preamble concerning the last cell will be constructed first.
- The function `\@@_construct_halign:` is recursive in order to treat successively all the letters of the preamble.
- Each part of the preamble is created with a `\use:e` function. This expansion of the preamble gives the ability of controlling which parts of the code will be expanded during the construction of the preamble (other parts will be expanded and executed only during the execution of the `\halign`).
- The counter `\g_@@_col_int` is used during the loop of the construction of the preamble but, it will also appears in the preamble (we could have chosen two different counters but this way saves a counter).

```
857 \cs_new_protected:Npn \@@_construct_halign:
858 {
859 \seq_pop_right:NNTF \l_@@_format_seq \l_@@_type_col_str
860 {
```

Here is the `\use:e` which is fundamental: it will really construct the part of the preamble corresponding to a column by expanding only some parts of the following code.

```
861 \use:e
862 {
```

Before the recursive call of `\@@_construct_halign:`, we decrease the integer `\g_@@_col_bool`. But, during the construction of the column which is constructed first (that is to say which is the last column of the `\halign`), it is *not* lowered because `\int_decr:N`, which is protected, won't be expanded by the `\use:e`.

We begin the construction of a generic column.

```
863 \int_gdecr:N \g_@@_col_int
864 \@@_construct_halign:
865 \int_compare:nNnT \g_@@_col_int = \l_@@_nb_cols_int
866 {
```

We redefine the command `\Arrow` (or the name given to the corresponding command by the option `command-name`) in each cell of the last column. The braces around `\l_@@_command_name_str` are mandatory because `\l_@@_command_name_str` will be expanded by the `\use:e` and the command `\cs_set_eq:cn` must still be efficient during the execution of the `\halign`.

```
867 \cs_set_eq:cn { \l_@@_command_name_str } \@@_Arrow
868 <*LaTeX>
869 \bool_if:NT \l_@@_in_DispWithArrows_bool
870 {
```

The command `\@@_test_if_to_tag:` (which is protected and, thus, will not be expanded during the construction of the preamble) will test, at each row, whether the current row must be tagged (and the tag will be put in the very last column).

```
871 \@@_test_if_to_tag:
```

The command `\@@_set_qedhere:` will do a redefinition of `\qedhere` in each cell of the last column.

```
872 \IfPackageLoadedT { amsmath } { \@@_set_qedhere: }
873 }
874 </LaTeX>
875 }
876 \str_if_eq:onT \l_@@_type_col_str { c } \hfil
877 \str_if_eq:onT \l_@@_type_col_str { C } \hfil
878 \str_if_eq:onT \l_@@_type_col_str { r } \hfill
879 \str_if_eq:onT \l_@@_type_col_str { R } \hfill
880 \int_gincr:N \g_@@_col_int
881 \int_gset:Nn \g_@@_static_col_int { \int_use:N \g_@@_col_int }
882 \c_math_toggle_token
883 \str_if_eq:onT \l_@@_type_col_str { C } { { } }
884 \str_if_eq:onT \l_@@_type_col_str { L } { { } }
885 \bool_if:NT \l_@@_displaystyle_bool \displaystyle
886 ##
887 \str_if_eq:onT \l_@@_type_col_str { C } { { } }
888 \str_if_eq:onT \l_@@_type_col_str { R } { { } }
889 \c_math_toggle_token
890 \int_compare:nNnTF \g_@@_col_int = \l_@@_nb_cols_int
891 \@@_construct_nodes:
892 {
```

The following glue (`\hfil`) will be added only if we are not in the last cell because, in the last cell, a glue (`=skip`) is added between the nodes (in `\@@_construct_nodes:`).

```
893 \str_if_eq:onT \l_@@_type_col_str { l } \hfil
894 \str_if_eq:onT \l_@@_type_col_str { L } \hfil
895 \str_if_eq:onT \l_@@_type_col_str { c } \hfil
896 \str_if_eq:onT \l_@@_type_col_str { C } \hfil
897 \bool_if:NT \l_@@_in_DispWithArrows_bool { \tabskip = \c_zero_skip }
898 &
899 }
900 }
901 }
```


Now the tokens that will be inserted after the analyze of all the tokens of the format: here is the token `\halign`.

```

902     {
903         \bool_if:NTF \l_@@_in_WithArrows_bool
904         {
905             \ialign
906             \bgroup
907         }
908         {
909             \halign to \l_@@_linewidth_dim
910             \bgroup
911             \bool_if:NT \l_@@_fleqn_bool
912             { \skip_horizontal:N \l_@@_mathindent_skip }
913         }
914         \int_gincr:N \g_@@_line_int
915         \int_gzero:N \g_@@_col_int
916         \tl_if_eq:NNF \l_@@_left_brace_tl \c_novalue_tl
917         {
918             \skip_horizontal:n
919             { \box_wd:N \l_@@_left_brace_box + \l_@@_delim_wd_dim }
920         }
921         \strut
922     }
923 }

```

The command `\@@_construct_nodes:` is only for the lisibility of the code because, in fact, it is used only once. It constructs the “left node” and the “right node” at the end of each row of the arrow.

```

924 \cs_new_protected:Npn \@@_construct_nodes:
925 {

```

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

```

926     \tikz [ remember~picture , overlay ]
927     \node
928     [
929         node~contents = { } ,
930         @@_node_style ,
931         name = wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - l ,
932     ]
933     ;
934     \hfil

```

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

```

935     \tikz [ remember~picture , overlay ]
936     \node
937     [
938         node~contents = { } ,
939         @@_node_style ,
940         name = wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - r ,
941     ]
942     ;
943     \str_if_empty:NF \l_@@_name_str
944     {
945         \pgfpicture
946         \pgfnodealias
947         { \l_@@_name_str - \int_use:N \g_@@_line_int - l }
948         { wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - l }
949         \pgfnodealias
950         { \l_@@_name_str - \int_use:N \g_@@_line_int - r }
951         { wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - r }
952         \endpgfpicture

```

```

953     }
954     \bool_if:NT \l_@@_show_node_names_bool
955     {
956         \hbox_overlap_right:n
957         { \small wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - r }
958     }
959 }

```

12.9.3 The environment `{WithArrows}`

```

960 <*LaTeX>
961 \NewDocumentEnvironment { WithArrows } { ! 0 { } }
962 </LaTeX>
963 <*plain-TeX>
964 \cs_new_protected:Npn \WithArrows
965 {
966     \group_begin:
967     \peek_meaning:NTF [
968     { \WithArrows_i }
969     { \WithArrows_i [ ] }
970 }
971 \cs_new_protected:Npn \WithArrows_i [ #1 ]
972 </plain-TeX>
973 {
974     \bool_set_true:N \l_@@_in_WithArrows_bool
975     \bool_set_false:N \l_@@_in_DispWithArrows_bool
976 <*plain-TeX>
977     \str_clear_new:N \l_@@_type_env_str
978     \str_set:Nn \l_@@_type_env_str { WithArrows }
979 </plain-TeX>
980     \@@_pre_halign:n { #1 }
981     \if_mode_math: \else:
982         \@@_error:n { WithArrows~outside~math~mode }
983     \fi:
984     \box_clear_new:N \l_@@_env_box
985     \hbox_set:Nw \l_@@_env_box

```

The environment begins with a `\vtop`, a `\vcenter` or a `\vbox`³² 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 mode³³ and therefore, we can use `\vcenter`.

```

986     \int_compare:nNnT \l_@@_pos_env_int = 1 \c_math_toggle_token
987     \int_case:nn \l_@@_pos_env_int { 0 \vtop 1 \vcenter 2 \vbox }
988     \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).

```

989     \spread@equation

```

We begin the `\halign` and the preamble. During the construction of the preamble, `\l_tmpa_int` will be incremented during each column constructed.

```

990     \@@_construct_halign:

```

In fact, the construction of the preamble is not finished. We add a little more.

³²Notice that the use of `\vtop` seems color-safe here...

³³An error is raised if the environment is used outside math mode.

An environment `{WithArrows}` should have a number of columns equal to the length of its format (by default, 2 since the default format is `rl`). Nevertheless, if the user wants to use more columns (without arrows) it's possible with the option `more-columns`.

```

991    &&
992    \@@_error:n { Too~much~columns~in~WithArrows }
993    \c_math_toggle_token
994    \bool_if:NT \l_@@_displaystyle_bool \displaystyle
995    { ## }
996    \c_math_toggle_token
997    \cr
998  }

```

We begin the second part of the environment `{WithArrows}`. We have three `\egroup`: one for the `\halign`, one for the `\vtop` (or `\vcenter` or `\vbox`) and one for the `\hbox_set:Nn \l_@@_env_box`.

```

999  <*plain-TeX>
1000 \cs_new_protected:Npn \endWithArrows
1001 </plain-TeX>
1002 {
1003   \\\
1004   \egroup
1005   \egroup
1006   \int_compare:nNnT \l_@@_pos_env_int = 1 \c_math_toggle_token
1007   \hbox_set_end:
1008   \@@_post_halign:

```

We want to add white space on the right side of the box in order to take into account the arrows and their labels.

```

1009   \bool_if:NF \l_@@_right_overlap_bool
1010   {
1011     \box_set_wd:Nn \l_@@_env_box
1012     { \g_@@_overlap_x_dim + \box_wd:N \l_@@_env_box }
1013   }
1014   \box_use_drop:N \l_@@_env_box

```

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`).

```

1015 <*LaTeX>
1016   \bool_if:NT \c_@@_footnote_bool { \end { savenotes } }
1017 </LaTeX>
1018 <*plain-TeX>
1019   \group_end:
1020 </plain-TeX>
1021 }

```

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

12.9.4 After the construction of the `\halign`

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

```

1022 \cs_new_protected:Npn \@@_post_halign:

```

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

```

1023 {
1024   \cs_set:Npn \WithArrowsRightX { \g_@@_right_x_dim }

```

We use `\normalbaselines` of `plain-TeX` because we have used `\spread@equation` (of `amsmath` or defined directly if `amsmath` is not loaded) and you don't want `\spread@equation` to have effects in the labels of the arrows.

```

1025   \normalbaselines

```

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

```
1026 \int_if_zero:nF \g_@@_arrow_int
1027 {
```

If there is only one arrow, the options `group` and `groups` do not really make sense and it will be quicker to act as if we were in option `i` (moreover, it allows the option `xoffset` for the unique arrow).

```
1028 \int_compare:nNnT \g_@@_arrow_int = 1
1029 {
1030     \int_compare:nNnT \l_@@_pos_arrow_int > 5
1031     { \int_set:Nn \l_@@_pos_arrow_int 5 }
1032 }
1033 \@@_scan_arrows:
1034 }
```

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

```
1035 \group_begin:
1036 \tikzset { every~picture / .style = @@_standard }
```

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

```
1037 \cs_set:Npn \WithArrowsNbLines { \int_use:N \g_@@_line_int }
```

The command `\MultiArrow` is available in `code-after`, and we have a special version of `\Arrow`, called “`\Arrow` in `code-after`” in the documentation.³⁴

```
1038 \cs_set_eq:NN \MultiArrow \@@_MultiArrow:nn
1039 \cs_set_eq:cN \l_@@_command_name_str \@@_Arrow_code_after
1040 \bool_set_true:N \l_@@_in_code_after_bool
1041 \l_@@_code_after_tl
1042 \group_end:
```

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

```
1043 \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
1044 \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
1045 \seq_gput_right:Ne \g_@@_position_in_the_tree_seq
1046 { \int_eval:n { \l_tmpa_tl + 1 } }
```

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

```
1047 \int_compare:nNnT { \seq_count:N \g_@@_position_in_the_tree_seq } = 1
1048 { \int_gincr:N \g_@@_last_env_int }
```

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

```
1049 \seq_gpop_right:NN \g_@@_arrow_int_seq \l_tmpa_tl
1050 \int_gset:Nn \g_@@_arrow_int \l_tmpa_tl
1051 \seq_gpop_right:NN \g_@@_line_int_seq \l_tmpa_tl
1052 \int_gset:Nn \g_@@_line_int \l_tmpa_tl
1053 \seq_gpop_right:NN \g_@@_col_int_seq \l_tmpa_tl
1054 \int_gset:Nn \g_@@_col_int \l_tmpa_tl
1055 \seq_gpop_right:NN \g_@@_static_col_int_seq \l_tmpa_tl
1056 \int_gset:Nn \g_@@_static_col_int \l_tmpa_tl
1057 }
```

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

³⁴As of now, `\MultiArrow` has no option, and that's why its internal name is a name of L3 with the signature `:nn` whereas `\Arrow` in `code-after` provides options and has the name of a function defined with `\NewDocumentCommand`.

12.9.5 The command of end of row

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

First, we remove an eventual token `*` (just after the `\`: there should not be space between the two) since the commands `\` and `*` are equivalent in an environment `{WithArrows}` (an environment `{WithArrows}`, like an environment `{aligned}` of `amsmath`, is always unbreakable).

```
1058 \cs_new_protected:Npn \@@_cr:
1059 {
1060   \scan_stop:
```

We try to detect some `\omit` (as of now, an `\omit` in the last column is not detected).

```
1061   \int_compare:nNnF \g_@@_col_int = \g_@@_static_col_int
1062     { \@@_error:n { omit~probably~used } }
1063   \prg_replicate:nn { \l_@@_nb_cols_int - \g_@@_static_col_int } { & { } }
1064   \group_align_safe_begin:
1065   \peek_meaning_remove:NTF * \@@_cr_i: \@@_cr_i:
1066 }
```

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.

```
1067 \cs_new_protected:Npn \@@_cr_i:
1068 { \peek_meaning:NTF [ \@@_cr_ii: { \@@_cr_ii: [ \c_zero_dim ] } }
```

Now, we test if the next token is the token `\end`. Indeed, we want to test if the following tokens are `\end{WithArrows}` (or `\end{Code}`, etc). In this case, we raise an error because the user must not put `\` at the end of its alignment.

```
1069 <*LaTeX>
1070 \cs_new_protected:Npn \@@_cr_ii: [ #1 ]
1071 {
1072   \peek_remove_spaces:n
1073   {
1074     \peek_meaning:NTF \end
1075     {
1076       \@@_cr_iii:n { #1 }
```

The analyse of the argument of the token `\end` must be after the `\group_align_safe_end:` which is the beginning of `\@@_cr_iii:n`.

```
1077       \@@_analyze_end:Nn
1078     }
1079     { \@@_cr_iii:n { #1 } }
1080   }
1081 }
1082 \cs_new_protected:Npn \@@_cr_iii:n #1
1083 </LaTeX>
1084 <*plain-TeX>
1085 \cs_new_protected:Npn \@@_cr_ii: [ #1 ]
1086 </plain-TeX>
1087 {
1088   \group_align_safe_end:
```

For the environment `{DispWithArrows}`, the behaviour of `\` is different because we add the last column which is the column for the tag (number of the equation). Even if there is no tag, this column is used for the v-nodes.³⁵

```
1089   \bool_if:NT \l_@@_in_DispWithArrows_bool
```

³⁵The v-nodes are used to compute the abscissa of the right margin, used by the option `wrap-lines`.

At this stage, we know that we have a tag to put if (and only if) the value of `\l_@@_tags_clist` is the comma list `all` (only one element). Maybe, previously, the value of `\l_@@_tags_clist` was, for example, `1,last` (which means that only the first line and the last line must be tagged). However, in this case, the comparison with the number of line has been done before and, now, if we are in a line to tag, the value of `\l_@@_tags_clist` is `all`.

```

1090 {
1091 (*LaTeX)
1092 \clist_if_in:NnTF \l_@@_tags_clist { all }
1093 {

```

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).

```

1094 \tl_if_empty:NT \l_@@_tag_tl { \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 `&`).

```

1095 \cs_gset:Npe \g_tmpa_tl
1096 { \tl_if_empty:NTF \l_@@_tag_tl \theequation \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`.

```

1097 \seq_if_empty:NF \l_@@_labels_seq
1098 {

```

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`.

```

1099 \cs_set:Npe \@currentlabel { \p@equation \g_tmpa_tl }

```

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

```

1100 \IfPackageLoadedT { hyperref }
1101 {
1102 % the following line is probably pointless (2022/05/16)
1103 % \str_set:Nn \This@name { equation }
1104 \hyper@refstepcounter { equation }
1105 }

```

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.

```

1106 \IfPackageLoadedT { cleveref }
1107 {
1108 \cref@constructprefix { equation } \cref@result
1109 \protected@edef \cref@currentlabel
1110 {
1111 [
1112 \cs_if_exist:NTF \cref@equation@alias
1113 \cref@equation@alias
1114 { equation }
1115 ]
1116 [ \arabic { equation } ] [ \cref@result ]
1117 \p@equation \g_tmpa_tl
1118 }
1119 }

```

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

```

1120 \seq_map_function:NN \l_@@_labels_seq \@_old_label
1121 }

```

We save the booleans `\l_@@_tag_star_bool` and `\l_@@_qedhere_bool` because they will be used in the *next* cell (after the `&`). We recall that the cells of a `\halign` are TeX groups.

```

1122         \@@_save:N \l_@@_tag_star_bool
1123         \@@_save:N \l_@@_qedhere_bool
1124         \bool_if:NT \l_@@_tag_next_line_bool
1125         {
1126             \openup -\jot
1127             \bool_set_false:N \l_@@_tag_next_line_bool
1128             \notag \\\ &
1129         }
1130     &
1131     \@@_restore:N \l_@@_tag_star_bool
1132     \@@_restore:N \l_@@_qedhere_bool
1133     \bool_if:NT \l_@@_qedhere_bool
1134     { \hbox_overlap_left:n \@@_qedhere_i: }
1135     \cs_set_eq:NN \theequation \g_tmpa_tl
1136     \bool_if:NT \l_@@_tag_star_bool
1137     { \cs_set_eq:NN \tagform@ \prg_do_nothing: }

```

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`.

```

1138         \hbox_overlap_left:n
1139         {
1140             \bool_if:NF \c_@@_leqno_bool
1141             {
1142                 \pgfpicture
1143                 \pgfrememberpicturepositiononpagetrue
1144                 \pgfcoordinate
1145                 { wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - v }
1146                 \pgfpointorigin
1147                 \endpgfpicture
1148             }
1149             \quad
1150             \@eqnnum
1151         }
1152     \bool_if:NT \c_@@_leqno_bool
1153     {
1154         \pgfpicture
1155         \pgfrememberpicturepositiononpagetrue
1156         \pgfcoordinate
1157         { wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - v }
1158         \pgfpointorigin
1159         \endpgfpicture
1160     }
1161 }
1162 {
1163     \@@_save:N \l_@@_qedhere_bool
1164 </LaTeX>
1165     &
1166 <*LaTeX>
1167     \@@_restore:N \l_@@_qedhere_bool
1168     \bool_if:NT \l_@@_qedhere_bool
1169     { \hbox_overlap_left:n \@@_qedhere_i: }
1170 </LaTeX>
1171     \pgfpicture
1172     \pgfrememberpicturepositiononpagetrue
1173     \pgfcoordinate
1174     { wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - v }
1175     \pgfpointorigin
1176     \endpgfpicture
1177 <*LaTeX>
1178 }

```

```

1179 </LaTeX>
1180 }
1181 \dim_compare:nNt { #1 } < \c_zero_dim
1182 { \@@_error:n { option~of~cr~negative } }
1183
1184 \cr
1185 \noalign
1186 {
1187   \dim_set:Nn \l_tmpa_dim { \dim_max:nn { #1 } \c_zero_dim }
1188   \skip_vertical:N \l_tmpa_dim
1189   \skip_vertical:N \l_@@_interline_skip
1190   \scan_stop:
1191 }
1192 }

```

According to the documentation of L3, the previous addition in “#1 + \l_@@_interline_skip” is really an addition of skips (=glues).

The following command will be used when, after a `\` (and its optional arguments) there is a `\end`. You want to know if this is the end of the environment `{WithArrows}` (or `{DispWithArrows}`, etc.) because, in this case, we will explain that the environment must not be ended by `\`. If it is not the case, that means it’s a classical situation of LaTeX environments not correctly imbricated and there will be a LaTeX error.

```

1193 <*LaTeX>
1194 \cs_new_protected:Npn \@@_analyze_end:Nn #1 #2
1195 {
1196   \str_if_eq:onT \l_@@_type_env_str { #2 }
1197   {
1198     \@@_error:n { newline~at~the~end~of~env }
1199     \group_begin:
1200     \globaldefs = 1
1201     \@@_msg_redirect_name:nn { newline~at~the~end~of~env } { none }
1202     \group_end:
1203   }

```

We repeat in the stream the `\end{...}` we have extracted.

```

1204   \end { #2 }
1205 }
1206 </LaTeX>

```

12.9.6 The environment `{DispWithArrows}`

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

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

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

However, if we are just after an item of a LaTeX list or at the beginning of a `{minipage}`, the construction is slightly different:

```
\[\vtop{\halign to \linewidth {...}}\]
```

The boolean `\l_@@_in_label_or_minipage_bool` will be raised if we are just after a `\item` of a list of LaTeX or at the beginning of a `{minipage}`.

```

1207 <*LaTeX>
1208 \bool_new:N \l_@@_in_label_or_minipage_bool
1209 </LaTeX>
1210 <*LaTeX>
1211 \NewDocumentEnvironment { DispWithArrows } { ! d < > ! 0 { } }
1212 </LaTeX>
1213 <*plain-TeX>
1214 \cs_new_protected:Npn \DispWithArrows
1215 {
1216   \group_begin:
1217   \peek_meaning:NTF <

```



```

1218     { \DispWithArrows_i }
1219     { \DispWithArrows_i < \c_novalue_tl > }
1220   }
1221   \cs_new_protected:Npn \DispWithArrows_i < #1 >
1222   {
1223     \peek_meaning:NTF [
1224       { \DispWithArrows_ii < #1 > }
1225       { \DispWithArrows_ii < #1 > [ ] }
1226     }
1227     \cs_new_protected:Npn \DispWithArrows_ii < #1 > [ #2 ]
1228     </plain-TeX>
1229     {
1230       \bool_set_true:N \l_@@_in_DispWithArrows_bool
1231       <*plain-TeX>
1232       \str_clear_new:N \l_@@_type_env_str
1233       \str_set:Nn \l_@@_type_env_str { DispWithArrows }
1234       </plain-TeX>

```

Since the version 1.16 of `witharrows`, no space is added between an `\item` of a LaTeX list and an environment `{DispWithArrows}` except with the option `standard-behaviour-with-items` stored in the boolean `\l_@@_sbwi_bool`. We have to know if we are just after an `\item` and this information will be stored in `\l_@@_in_label_or_minipage_bool`. We have to do this test quickly after the beginning of the environment (in particular, because it must be done before the execution of the `code-before`³⁶).

```

1235 <*LaTeX>
1236   \bool_if:NF \l_@@_sbwi_bool
1237   {
1238     \legacy_if:nT { @inlabel }
1239     { \bool_set_true:N \l_@@_in_label_or_minipage_bool }
1240     \legacy_if:nT { @minipage }
1241     { \bool_set_true:N \l_@@_in_label_or_minipage_bool }
1242   }
1243 </LaTeX>

```

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).

```

1244 <*LaTeX>
1245   \IfPackageLoadedT { mathtools }
1246   {
1247     \MH_if_boolean:nT { show_only_refs }
1248     {
1249       \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`.

```

1250       \MH_set_boolean:T:n { show_only_refs }
1251     }
1252   }

```

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`.

```

1253   \IfPackageLoadedT { typedref }
1254   { \str_set:Nn \sr@name { equation } }

```

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

```

1255   \IfPackageLoadedT { amsmath } { \intertext@ }
1256 </LaTeX>
1257   \tl_if_novalue:oF { #1 }

```

³⁶The `code-before` is not meant to contains typesetting material. However, it may contain, for example, a `{tikzpicture}` with options `overlay` and `remember picture` in order to draw nodes *under* some elements of the environment `{DispWithArrows}`.

```

1258      { \cs_set_nopar:Npn \l_@@_left_brace_tl { #1 } }
1259      \@@_pre_halign:n { #2 }

```

If `subequations` is used, we encapsulate the environment in an environment `{subequations}` of `amsmath`.

```

1260 <*LaTeX>
1261      \bool_if:NT \l_@@_subequations_bool { \begin { subequations } }
1262 </LaTeX>

1263      \tl_if_eq:NMF \l_@@_left_brace_tl \c_novalue_tl
1264      {

```

We compute the value of the width of the left delimiter.

```

1265          \hbox_set:Nn \l_tmpa_box
1266          {

```

Even if the default value of `\nulldelimiterspace` is 1.2 pt, we take it into account.

```

1267              \group_begin:
1268              \dim_zero:N \nulldelimiterspace
1269              \c_math_toggle_token
1270              \left \l_@@_replace_left_brace_by_tl \vcenter to 1 cm { } \right.
1271              \c_math_toggle_token
1272              \group_end:
1273          }
1274      \dim_zero_new:N \l_@@_delim_wd_dim
1275      \dim_set:Nn \l_@@_delim_wd_dim { \box_wd:N \l_tmpa_box }
1276      \box_clear_new:N \l_@@_left_brace_box
1277      \hbox_set:Nn \l_@@_left_brace_box
1278      {
1279          \group_begin:
1280          \cs_set_eq:NN \label \@@_old_label
1281          \c_math_toggle_token
1282          \bool_if:NT \l_@@_displaystyle_bool \displaystyle
1283          \l_@@_left_brace_tl
1284          { }
1285          \c_math_toggle_token
1286          \group_end:
1287      }
1288  }

```

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

```

1289 <*LaTeX>
1290      \tl_clear_new:N \l_@@_tag_tl

```

```

1291      \bool_set_false:N \l_@@_qedhere_bool

```

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

```

1292      \bool_set_false:N \l_@@_tag_star_bool
1293 </LaTeX>

1294      \if_mode_math:
1295          \@@_fatal:n { DisWithArrows~in~math~mode }
1296      \fi:

```

The construction is not exactly the same whether we are just after an `\item` of a LaTeX list or not. We know if we are after an `\item` thanks to the boolean `\l_@@_in_label_or_minipage_bool`.

```

1297 <*plain-TeX>
1298      \dim_zero_new:N \linewidth
1299      \dim_set_eq:NN \linewidth \displaywidth
1300 </plain-TeX>
1301 <*LaTeX>
1302      \bool_if:NTF \l_@@_in_label_or_minipage_bool
1303      {

```

```

1304     \noindent
1305     \c_math_toggle_token
1306   }
1307   {
1308 </LaTeX>

```

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.

```

1309     \if_mode_vertical:
1310     \nointerlineskip
1311     \hbox_to_wd:nn { .6 \linewidth } { }
1312     \fi:
1313     \c_math_toggle_token \c_math_toggle_token
1314 <*LaTeX>
1315   }
1316 </LaTeX>
1317     \dim_zero_new:N \l_@@_linewidth_dim
1318 <*LaTeX>
1319     \bool_if:NTF \l_@@_in_label_or_minipage_bool
1320     { \dim_set_eq:NN \l_@@_linewidth_dim \linewidth }
1321     { \dim_set_eq:NN \l_@@_linewidth_dim \displaywidth }
1322 </LaTeX>
1323 <*plain-TeX>
1324     \dim_set_eq:NN \l_@@_linewidth_dim \displaywidth
1325 </plain-TeX>
1326     \box_clear_new:N \l_@@_halign_box
1327     \setbox \l_@@_halign_box \vtop \bgroup
1328     \tabskip =
1329     \bool_if:NTF \l_@@_fleqn_bool
1330     \c_zero_skip
1331     { 0 pt plus 1000 pt minus 1000 pt }

```

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).

```

1332     \spread@equation
1333     \@@_construct_halign:
1334     \tabskip = 0 pt plus 1000 pt minus 1000 pt
1335     &

```

If the user tries to use more columns than the length of the format, we have to raise an error. However, the error won't be in the next column which is the columns for the labels of the equations. The error will be after... and it must be after. That means that we must not have an error in the next column simply because we are not in math mode. That's why this column, even if it is for the labels, is in math mode.

```

1336     $ ## $
1337     \tabskip = \c_zero_skip
1338     &&
1339     \@@_fatal:n { Too~much~columns~in~DispWithArrows }
1340     \bool_if:nT \c_false_bool { ## }
1341     \cr
1342   }

```

We begin the second part of the environment `{DispWithArrows}`.

```

1343 <*plain-TeX>
1344 \cs_new_protected:Npn \endDispWithArrows
1345 </plain-TeX>
1346 {
1347 <*LaTeX>
1348     \clist_if_in:NnT \l_@@_tags_clist { last }
1349     { \clist_set:Nn \l_@@_tags_clist { all } }
1350 </LaTeX>
1351   \

```

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

```

1352 \egroup
1353 \unskip \unpenalty \unskip \unpenalty
1354 \box_set_to_last:N \l_tmpa_box
1355 \nointerlineskip
1356 \box_use:N \l_tmpa_box
1357 \dim_gzero_new:N \g_@@_alignment_dim
1358 \dim_gset:Nn \g_@@_alignment_dim { \box_wd:N \l_tmpa_box }
1359 \box_clear_new:N \l_@@_new_box
1360 \hbox_set:Nn \l_@@_new_box { \hbox_unpack_drop:N \l_tmpa_box }
1361 \dim_compare:nNnT
1362   { \box_wd:N \l_@@_new_box } < \g_@@_alignment_dim
1363   { \dim_gset:Nn \g_@@_alignment_dim { \box_wd:N \l_@@_new_box } }

```

The `\egroup` is for the box `\l_@@_halign_box`.

```

1364 \egroup
1365 \tl_if_eq:NNTF \l_@@_left_brace_tl \c_novalue_tl
1366   { \box_use_drop:N \l_@@_halign_box }
1367   {
1368     \hbox_to_wd:nn \l_@@_linewidth_dim
1369     {
1370       \bool_if:NTF \l_@@_fleqn_bool
1371         { \skip_horizontal:N \l_@@_mathindent_skip }
1372         \hfil
1373       \hbox_to_wd:nn \g_@@_alignment_dim
1374       {
1375         \box_use_drop:N \l_@@_left_brace_box

```

Here, you should use `\box_ht_plus_dp:N` when TeXLive 2021 will be available on Overleaf.

```

1376     \dim_set:Nn \l_tmpa_dim
1377     {
1378       \box_ht:N \l_@@_halign_box
1379       + \box_dp:N \l_@@_halign_box
1380     }
1381     \group_begin:
1382     \dim_zero:N \nulldelimiterspace
1383     \c_math_toggle_token
1384     \left \l_@@_replace_left_brace_by_tl
1385     \vcenter to \l_tmpa_dim { \vfil }
1386     \right.
1387     \c_math_toggle_token
1388     \group_end:
1389     \hfil
1390   }
1391   \hfil
1392 }
1393 \skip_horizontal:N -\l_@@_linewidth_dim
1394 \vcenter { \box_use_drop:N \l_@@_halign_box }
1395 }

```

We compute the dimension `\g_@@_right_x_dim`. As a first approximation, `\g_@@_right_x_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_@@_right_x_dim` with the v -nodes of each row specifically built in this goal. `\g_@@_right_x_dim` is the minimal value of the x -value of these nodes.

```

1396 \dim_gzero_new:N \g_@@_right_x_dim
1397 \dim_gset_eq:NN \g_@@_right_x_dim \c_max_dim
1398 \pgfpicture
1399 \pgfrememberpicturepositiononpagetrue
1400 \int_step_variable:nNn \g_@@_line_int \l_tmpa_int
1401 {
1402   \cs_if_free:cTF
1403     { pgf @ sh @ ns @ wa - \l_@@_prefix_str - \l_tmpa_int - v }
1404     { \@@_fatal:n { Inexistent-v-node } }

```

```

1405         {
1406             \pgfpointanchor
1407             { wa - \l_@@_prefix_str - \l_tmpa_int - v }
1408             { center }
1409             \dim_compare:nNt \pgf@x < \g_@@_right_x_dim
1410             { \dim_gset_eq:NN \g_@@_right_x_dim \pgf@x }
1411         }
1412     }
1413 \endpgfpicture

```

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

```

1414 \@@_post_halign:

```

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).

```

1415 <*LaTeX>
1416 \IfPackageLoadedT { mathtools }
1417 { \MH_if_boolean:nT { show_only_refs } \MT_showonlyrefs_true: }
1418 \bool_if:NTF \l_@@_in_label_or_minipage_bool
1419 {
1420     \c_math_toggle_token
1421     \skip_vertical:N \belowdisplayskip
1422 }
1423 { \c_math_toggle_token \c_math_toggle_token }
1424 </LaTeX>
1425 <*plain-TeX>
1426     \c_math_toggle_token \c_math_toggle_token
1427 </plain-TeX>
1428 <*LaTeX>
1429 \bool_if:NT \l_@@_subequations_bool { \end { subequations } }

```

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`).

```

1430 \bool_if:NT \c_@@_footnote_bool { \end { savenotes } }
1431 </LaTeX>
1432 <*plain-TeX>
1433 \group_end:
1434 </plain-TeX>
1435 <*LaTeX>
1436 \ignorespacesafterend
1437 </LaTeX>
1438 }

```

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

```

1439 <*LaTeX>
1440 \NewDocumentEnvironment { DispWithArrows* } { }
1441 {
1442     \WithArrowsOptions { notag }
1443     \DispWithArrows
1444 }
1445 \endDispWithArrows
1446 </LaTeX>

```

12.10 The commands `\tag`, `\notag`, `\label`, `\tagnextline` and `\qedhere` for `{DispWithArrows}`

Some commands are allowed only in the last column of the environment `{DispWithArrows}`. We write a command `\@@_if_in_last_col_of_disp:Nn` to execute this command only if we are in the last column. If we are in another column, an error is raised. The first argument of `\@@_if_in_last_col_of_disp:Nn` is the name of the command used in the error message and the second is the code to execute.

```

1447 \cs_new_protected:Npn \@@_if_in_last_col_of_disp:Nn #1 #2
1448 {
1449   \bool_if:NTF \l_@@_in-WithArrows_bool
1450     { \@@_error:nn { Not~allowed~in~WithArrows } { #1 } }
1451   {
1452     \int_compare:nNnTF \g_@@_col_int < \l_@@_nb_cols_int
1453       { \@@_error:nn { Not~allowed~in~DispWithArrows } { #1 } }
1454       { #2 }
1455   }
1456 }
```

The command `\@@_notag:` will be linked to the command `\notag` in the environments `{WithArrows}` and `{DispWithArrows}`.

```

1457 ⟨*LaTeX⟩
1458 \cs_new_protected:Npn \@@_notag:
1459 { \@@_if_in_last_col_of_disp:Nn \notag { \clist_clear:N \l_@@_tags_clist } }
```

The command `\@@_nonumber:` will be linked to the command `\nonumber` in the environments `{WithArrows}` and `{DispWithArrows}`.

```

1460 \cs_new_protected:Npn \@@_nonumber:
1461 { \@@_if_in_last_col_of_disp:Nn \nonumber { \clist_clear:N \l_@@_tags_clist } }
```

The command `\@@_tag` will be linked to `\tag` in `{WithArrows}` and `{DispWithArrows}`. We do the definition with `\NewDocumentCommand` because this command has a starred version.

```

1462 \NewDocumentCommand \@@_tag { s m }
1463 {
1464   \@@_if_in_last_col_of_disp:Nn \tag
1465   {
1466     \tl_if_empty:NF \l_@@_tag_tl
1467     { \@@_error:nn { Multiple~tags } { #2 } }
1468     \clist_set:Nn \l_@@_tags_clist { all }
1469     \IfPackageLoadedT { mathtools }
1470     {
1471       \MH_if_boolean:nT { show_only_refs }
1472       {
1473         \MH_if_boolean:nF { show_manual_tags }
1474         { \clist_clear:N \l_@@_tags_clist }
1475       }
1476     }
1477     \tl_set:Nn \l_@@_tag_tl { #2 }
1478     \bool_set:Nn \l_@@_tag_star_bool { #1 }

```

The starred version `\tag*` can't be used 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`.³⁷

```

1479   \bool_if:nT { #1 }
1480   {
1481     \IfPackageLoadedF { amsmath }
1482     { \@@_error:n { tag*~without~amsmath } }
1483   }
```

³⁷There are two versions of `@eqnnum`, a standard version and a version for the option `leqno`.

```

1484 }
1485 }

```

The command `\@@_label:n` will be linked to `\label` in the environments `{WithArrows}` and `{DispWithArrows}`. In these environments, 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`.

```

1486 \cs_new_protected:Npn \@@_label:n #1
1487 {
1488   \@@_if_in_last_col_of_disp:Nn \label
1489   {
1490     \seq_if_empty:NF \l_@@_labels_seq
1491     {
1492       \IfPackageLoadedTF { cleveref }
1493       { \@@_error:n { Multiple~labels~with~cleveref } }
1494       { \@@_error:n { Multiple~labels } }
1495     }
1496     \seq_put_right:Nn \l_@@_labels_seq { #1 }
1497     \IfPackageLoadedT { mathtools }
1498     {
1499       \MH_if_boolean:nT { show_only_refs }
1500       {
1501         \cs_if_exist:cTF { MT_r_#1 }
1502         { \clist_set:Nn \l_@@_tags_clist { all } }
1503         { \clist_clear:N \l_@@_tags_clist }
1504       }
1505     }
1506     \IfPackageLoadedT { autonum }
1507     {
1508       \cs_if_exist:cTF { autonum@#1Referenced }
1509       { \clist_set:Nn \l_@@_tags_clist { all } }
1510       { \clist_clear:N \l_@@_tags_clist }
1511     }
1512   }
1513 }

```

The command `\@@_tagnextline:` will be linked to `\tagnextline` in `{DispWithArrows}`.

```

1514 \cs_new_protected:Npn \@@_tagnextline:
1515 {
1516   \@@_if_in_last_col_of_disp:Nn \tagnextline
1517   { \bool_set_true:N \l_@@_tag_next_line_bool }
1518 }

```

The environments `{DispWithArrows}` and `{DispWithArrows*}` are compliant with the command `\qedhere` of `amsthm`. However, this compatibility requires a special version of `\qedhere`. This special version is called `\@@_qedhere:` and will be linked with `\qedhere` in the last column of the environment `{DispWithArrows}` (only if the package `amsthm` has been loaded). `\@@_qedhere:` raises the boolean `\l_@@_qedhere_bool`.

```

1519 \cs_new_protected:Npn \@@_qedhere: { \bool_set_true:N \l_@@_qedhere_bool }
1520 \cs_new_protected:Npn \@@_set_qedhere: { \cs_set_eq:NN \qedhere \@@_qedhere: }

```

In the last column of the `\halign` of `{DispWithArrows}` (column of the labels, that is to say the numbers of the equations), a command `\@@_qedhere_i:` will be issued if the flag `\l_@@_qedhere_bool` has been raised. The code of this command is an adaptation of the code of `\qedhere` in `amsthm`.

```

1521 \cs_new_protected:Npn \@@_qedhere_i:
1522 {
1523   \group_begin:
1524   \cs_set_eq:NN \qed \qedsymbol

```

The line `\cs_set_eq:NN \qed@elt \setQED@elt` is a preparation for an action on the QED stack. Despite its form, the instruction `\QED@stack` executes an operation on the stack. This operation prints the QED symbol and nullify the top of the stack.

```

1525     \cs_set_eq:NN \qed@elt \setQED@elt
1526     \QED@stack \relax \relax
1527   \group_end:
1528 }
1529 </LaTeX>

```

12.11 We draw the arrows

The arrows are divided in groups. There is two reasons for this division.

- If the option `group` or the option `groups` is used, all the arrows of a group are drawn on a same vertical at an abscissa of `\l_@@_x_dim`.
- For aesthetic reasons, the starting point of all the starting arrows of a group is raised upwards by the value `\l_@@_start_adjust_dim`. Idem for the ending arrows.

If the option `group` is used (`\l_@@_pos_arrow_int = 7`), we scan the arrows twice: in the first step we only compute the value of `\l_@@_x_dim` for the whole group, and, in the second step (`\l_@@_pos_arrow_int` is set to 8), we divide the arrows in groups (for the vertical ajustement) and we actually draw the arrows.

```

1530 \cs_new_protected:Npn \@@_scan_arrows:
1531 {
1532   \group_begin:
1533   \int_compare:nNnT \l_@@_pos_arrow_int = 7
1534   {
1535     \@@_scan_arrows_i:
1536     \int_set:Nn \l_@@_pos_arrow_int 8
1537   }
1538   \@@_scan_arrows_i:
1539   \group_end:
1540 }

1541 \cs_new_protected:Npn \@@_scan_arrows_i:
1542 {

```

`\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_@@_first_arrows_seq` will be the list of the arrows of the group starting at the first line of the group (we may have several arrows starting from the same line). We have to know all these arrows because of the ajustement by `\l_@@_start_adjust_dim`.

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

`\l_@@_last_arrows_seq` will be the list of all the arrows of the group ending at the last line of the group (impossible to guess in advance).

```

1543   \int_zero_new:N \l_@@_first_arrow_of_group_int
1544   \int_zero_new:N \l_@@_first_line_of_group_int
1545   \int_zero_new:N \l_@@_last_line_of_group_int
1546   \seq_clear_new:N \l_@@_first_arrows_seq
1547   \seq_clear_new:N \l_@@_last_arrows_seq

```

The boolean `\l_@@_new_group_bool` is a switch that we will use to indicate that a group is finished (and the lines of that group have to be drawn). This boolean is not directly connected to the option `new-group` of an individual arrow.

```

1548   \bool_set_true:N \l_@@_new_group_bool

```


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

```

1549   \int_set:Nn \l_@@_arrow_int 1
1550   \int_until_do:nNnn \l_@@_arrow_int > \g_@@_arrow_int
1551   {

```

We extract from the property list of the current arrow the fields “initial”, “final”, “status” and “input-line”. For the two former, we have to do conversions to integers.

```

1552       \prop_get:cnN
1553       { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1554       { initial } \l_tmpa_tl
1555       \int_set:Nn \l_@@_initial_int \l_tmpa_tl
1556       \prop_get:cnN
1557       { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1558       { final } \l_tmpa_tl
1559       \int_set:Nn \l_@@_final_int \l_tmpa_tl
1560       \prop_get:cnN
1561       { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1562       { status } \l_@@_status_arrow_str
1563       \prop_get:cnN
1564       { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1565       { input-line } \l_@@_input_line_str

```

We recall that, after the construction of the `\halign`, `\g_@@_line_int` is the total number of lines of the environment. Therefore, the conditionnal `\l_@@_final_int > \g_@@_line_int` tests whether an arrow arrives after the last line of the environment. In this case, we raise an error (except in the second step of treatment for the option `group`). The arrow will be completely ignored, even for the computation of `\l_@@_x_dim`.

```

1566       \int_compare:nNnTF \l_@@_final_int > \g_@@_line_int
1567       {
1568         \int_compare:nNnF \l_@@_pos_arrow_int = 8
1569         { \@@_error:n { Too-few-lines-for-an-arrow } }
1570       }
1571       \@@_treat_an_arrow_in_scan:

```

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

```

1572       \int_incr:N \l_@@_arrow_int
1573   }

```

After the last arrow of the environment, we have to draw the last group of arrows. If we are in option `group` and in the first step of treatment (`\l_@@_pos_arrow_int = 7`), we don’t draw because, in the first step, we don’t draw anything. If there is no arrow in the group, we don’t draw (this situation occurs when all the arrows of the potential group arrive after the last line of the environment).

```

1574   \bool_lazy_and:nnT
1575   { ! \int_compare_p:nNn \l_@@_pos_arrow_int = 7 }
1576   { \int_compare_p:nNn \l_@@_first_arrow_of_group_int > \c_zero_int }
1577   { \@@_draw_arrows:nn \l_@@_first_arrow_of_group_int \g_@@_arrow_int }
1578 }

```

The following command is only for the lisibility of the code. It’s used only once. Its name may be misleading. Indeed, it treats an arrow in the scan but it *may* trigger the construction of all arrows of a group if it detects that a group has just been completed (with `\@@_draw_arrows:nn`)

```

1579 \cs_new_protected:Npn \@@_treat_an_arrow_in_scan:
1580 {

```

We test whether 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, except if we are with the option `group` and in the first step of treatment (`\l_@@_pos_arrow_int = 7`).

```

1581   \bool_lazy_and:nnT

```

```

1582     { \int_compare_p:nNn \l_@@_arrow_int > 1 }
1583     {
1584         \bool_lazy_or_p:nn
1585         {
1586             \bool_lazy_and_p:nn
1587             {
1588                 \int_compare_p:nNn
1589                 \l_@@_initial_int > \l_@@_last_line_of_group_int
1590             }
1591             { \bool_not_p:n { \int_compare_p:nNn \l_@@_pos_arrow_int = 7 } }
1592         }
1593         { \str_if_eq_p:on \l_@@_status_arrow_str { new-group } }
1594     }
1595     {
1596         \int_if_zero:nF \l_@@_first_arrow_of_group_int
1597         {
1598             \@@_draw_arrows:nn
1599             \l_@@_first_arrow_of_group_int
1600             { \l_@@_arrow_int - 1 }
1601         }
1602         \bool_set_true:N \l_@@_new_group_bool
1603     }

```

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 three circumstances: if we are at the first arrow of the environment (that's why the flag is raised before the beginning of the loop), if we have just finished a group (that's why the flag is raised in the previous conditional, for topological reasons or if the previous arrows had the status "new-group"). At the beginning of a group, we have to initialize the following variables: `\l_@@_first_arrow_int`, `\l_@@_first_line_of_group_int`, `\l_@@_last_line_of_group`, `\l_@@_first_arrows_seq`, `\l_@@_last_arrows_seq`.

```

1604     \bool_if:nTF \l_@@_new_group_bool
1605     {
1606         \bool_set_false:N \l_@@_new_group_bool
1607         \int_set_eq:NN \l_@@_first_arrow_of_group_int \l_@@_arrow_int
1608         \int_set_eq:NN \l_@@_first_line_of_group_int \l_@@_initial_int
1609         \int_set_eq:NN \l_@@_last_line_of_group_int \l_@@_final_int
1610         \seq_clear:N \l_@@_first_arrows_seq
1611         \seq_put_left:NV \l_@@_first_arrows_seq \l_@@_arrow_int
1612         \seq_clear:N \l_@@_last_arrows_seq
1613         \seq_put_left:NV \l_@@_last_arrows_seq \l_@@_arrow_int

```

If we are in option `group` and in the second step of treatment (`\l_@@_pos_arrow_int = 8`), we don't initialize `\l_@@_x_dim` because we want to use the same value of `\l_@@_x_dim` (computed during the first step) for all the groups.

```

1614         \int_compare:nNnF \l_@@_pos_arrow_int = 8
1615         { \dim_set:Nn \l_@@_x_dim { - \c_max_dim } }
1616     }

```

If we are not at the beginning of a new group.

```

1617     {

```

If the arrow is independent, we don't take into account that arrow for the detection of the end of the group.

```

1618         \str_if_eq:onF \l_@@_status_arrow_str { independent }
1619         {

```

If the arrow is not independent, the arrow belongs to the current group and we have to take it into account in some variables.

```

1620             \int_compare:nNnT \l_@@_initial_int = \l_@@_first_line_of_group_int
1621             { \seq_put_left:NV \l_@@_first_arrows_seq \l_@@_arrow_int }
1622             \int_compare:nNnTF \l_@@_final_int > \l_@@_last_line_of_group_int
1623             {

```

```

1624         \int_set_eq:NN \l_@@_last_line_of_group_int \l_@@_final_int
1625         \seq_clear:N \l_@@_last_arrows_seq
1626         \seq_put_left:NV \l_@@_last_arrows_seq \l_@@_arrow_int
1627     }
1628     {
1629         \int_compare:nNnT \l_@@_final_int = \l_@@_last_line_of_group_int
1630         { \seq_put_left:NV \l_@@_last_arrows_seq \l_@@_arrow_int }
1631     }
1632 }
1633 }

```

If the arrow is not independent, we update the current x -value (in $\l_@@_x_dim$) with the dedicated command $\@@_update_x:nn$. If we are in option `group` and in the second step of treatment ($\l_@@_pos_arrow_int = 8$), we don't initialize $\l_@@_x_dim$ because we want to use the same value of $\l_@@_x_dim$ (computed during the first step) for all the groups.

```

1634     \str_if_eq:onF \l_@@_status_arrow_str { independent }
1635     {
1636         \int_compare:nNnF \l_@@_pos_arrow_int = 8
1637         { \@@_update_x:nn \l_@@_initial_int \l_@@_final_int }
1638     }
1639 }

```

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). This macro is nullified by the option `no-arrows`.

```

1640 \cs_new_protected:Npn \@@_draw_arrows:nn #1 #2
1641 {
1642     \group_begin:
1643     \int_zero_new:N \l_@@_first_arrow_int
1644     \int_set:Nn \l_@@_first_arrow_int { #1 }
1645     \int_zero_new:N \l_@@_last_arrow_int
1646     \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.

```

1647     \int_set:Nn \l_@@_arrow_int \l_@@_first_arrow_int
1648     \int_until_do:nNnn \l_@@_arrow_int > \l_@@_last_arrow_int
1649     {

```

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.

```

1650         \prop_get:cnN
1651         { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1652         { initial } \l_tmpa_tl
1653     \int_set:Nn \l_@@_initial_int \l_tmpa_tl
1654     \prop_get:cnN
1655     { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1656     { final } \l_tmpa_tl
1657     \int_set:Nn \l_@@_final_int \l_tmpa_tl
1658     \prop_get:cnN
1659     { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1660     { status } \l_@@_status_arrow_str

```

If the arrow ends after the last line of the environment, we don't draw the arrow (an error has already been raised in $\@@_scan_arrows:$). We recall that, after the construction of the \halign , $\g_@@_line_int$ is the total number of lines of the environment).

```

1661     \int_compare:nNnF \l_@@_final_int > \g_@@_line_int

```

If the arrow is of type `over` (key `o`), we don't draw that arrow now (those arrows will be drawn after all the other arrows).

```

1662     {
1663         \str_if_eq:onTF \l_@@_status_arrow_str { over }
1664         { \seq_put_right:NV \l_@@_o_arrows_seq \l_@@_arrow_int }
1665         \@@_draw_arrow:
1666     }
1667     \int_incr:N \l_@@_arrow_int
1668 }
1669 \@@_draw_o_arrows_of_the_group:
1670 \group_end:
1671 }

```

The first `\group_begin:` is for the options of the arrows (but we remind that the options `ll`, `rr`, `rl`, `lr`, `i` and `jump` have already been extracted and are not present in the field `options` of the property list of the arrow).

```

1672 \cs_new_protected:Npn \@@_draw_arrow:
1673 {
1674     \group_begin:

```

We process the options of the current arrow.

```

1675     \prop_get:cnN
1676     { g_@@_arrow _\l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1677     { options }
1678     \l_tmpa_tl
1679     \str_clear_new:N \l_@@_previous_key_str

```

We will expand the second argument of `\keys_set_known:nn` exactly three times. Maybe that an e-expansion would be possible but, in the past, there were problems with fragile commands such as `\bfseries` in the option `font` of the option `tikz` (it seems that this no longer the case).

```

1680     \exp_args:NNnno \exp_args:NNno \exp_args:Nno
1681     \keys_set_known:nn
1682     { WithArrows / Arrow / SecondPass }
1683     { \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`:

```

1684     \bool_set_false:N \l_@@_initial_r_bool
1685     \bool_set_false:N \l_@@_final_r_bool
1686     \int_case:nn \l_@@_pos_arrow_int
1687     {
1688         0 { \bool_set_true:N \l_@@_final_r_bool }
1689         2 { \bool_set_true:N \l_@@_initial_r_bool }
1690         3
1691         {
1692             \bool_set_true:N \l_@@_initial_r_bool
1693             \bool_set_true:N \l_@@_final_r_bool
1694         }
1695     }

```

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

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

In case of option `i` at a local or global level (`\l_@@_pos_arrow_int = 5`), we have to compute the x -value of the arrow (which is vertical). The computed x -value is stored in `\l_@@_x_dim` (the same variable used when the option `group` or the option `groups` is used).

```

1696     \int_compare:nNnT \l_@@_pos_arrow_int = 5
1697     {

```

```

1698     \dim_set:Nn \l_@@_x_dim { - \c_max_dim }
1699     \@@_update_x:nn \l_@@_initial_int \l_@@_final_int
1700 }

```

`\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`.

```

1701     \tl_set:Nc \l_@@_initial_tl
1702     { \int_use:N \l_@@_initial_int - \bool_if:NTF \l_@@_initial_r_bool rl }
1703     \tl_set:Nc \l_@@_final_tl
1704     { \int_use:N \l_@@_final_int - \bool_if:NTF \l_@@_final_r_bool rl }

```

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

```

1705     \prop_get:cnN
1706     { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1707     { label }
1708     \l_tmpa_tl

```

Now, we have to know if the arrow starts at the first line of the group and/or ends at the last line of the group. That's the reason why we have stored in `\l_@@_first_arrows_seq` the list of all the arrows starting at the first line of the group and in `\l_@@_last_arrows_seq` the list of all the arrows ending at the last line of the group. We compute these values in the booleans `\l_tmpa_bool` and `\l_tmpb_bool`. These computations can't be done in the following `{tikzpicture}` because of the command `\seq_if_in:NnTF` which is *not* expandable.

```

1709     \seq_if_in:NcTF \l_@@_first_arrows_seq
1710     { \int_use:N \l_@@_arrow_int }
1711     { \bool_set_true:N \l_tmpa_bool }
1712     { \bool_set_false:N \l_tmpa_bool }
1713     \seq_if_in:NcTF \l_@@_last_arrows_seq
1714     { \int_use:N \l_@@_arrow_int }
1715     { \bool_set_true:N \l_tmpb_bool }
1716     { \bool_set_false:N \l_tmpb_bool }
1717     \int_compare:nNnT \l_@@_pos_arrow_int = 5
1718     {
1719         \bool_set_true:N \l_tmpa_bool
1720         \bool_set_true:N \l_tmpb_bool
1721     }

```

We compute and store in `\g_tmpa_tl` and `\g_tmpb_tl` the exact coordinates of the extremities of the arrow.

- Concerning the x -values, the abscissa computed in `\l_@@_x_dim` will be used if the option of position is `i`, `group` or `groups`.
- Concerning the y -values, an ajustement is done for each arrow starting at the first line of the group and each arrow ending at the last line of the group (with the values of `\l_@@_start_adjust_dim` and `\l_@@_end_adjust_dim`).

```

1722     \dim_gzero_new:N \g_@@_x_initial_dim
1723     \dim_gzero_new:N \g_@@_x_final_dim
1724     \dim_gzero_new:N \g_@@_y_initial_dim
1725     \dim_gzero_new:N \g_@@_y_final_dim
1726     \pgfpicture
1727     \pgfrememberpicturepositiononpagetrue
1728     \pgfpointanchor { wa - \l_@@_prefix_str - \l_@@_initial_tl } { south }
1729     \dim_gset:Nn \g_@@_x_initial_dim \pgf@x
1730     \dim_gset:Nn \g_@@_y_initial_dim \pgf@y
1731     \pgfpointanchor { wa - \l_@@_prefix_str - \l_@@_final_tl } { north }
1732     \dim_gset:Nn \g_@@_x_final_dim \pgf@x
1733     \dim_gset:Nn \g_@@_y_final_dim \pgf@y
1734     \endpgfpicture

```

```

1735 \bool_lazy_and:nNTF
1736 {
1737     \dim_compare_p:nNn { \g_@@_y_initial_dim - \g_@@_y_final_dim }
1738         > \l_@@_max_length_of_arrow_dim
1739 }
1740 { \int_compare_p:nNn { \l_@@_final_int - \l_@@_initial_int } = 1 }
1741 {
1742     \tl_gset:Ne \g_tmpa_tl
1743     {
1744         \int_compare:nNnTF \l_@@_pos_arrow_int < 5
1745         { \dim_use:N \g_@@_x_initial_dim }
1746         { \dim_use:N \l_@@_x_dim } ,
1747         \dim_eval:n
1748         {
1749             ( \g_@@_y_initial_dim + \g_@@_y_final_dim ) / 2
1750             + 0.5 \l_@@_max_length_of_arrow_dim
1751         }
1752     }
1753     \tl_gset:Ne \g_tmpb_tl
1754     {
1755         \int_compare:nNnTF \l_@@_pos_arrow_int < 5
1756         { \dim_use:N \g_@@_x_final_dim }
1757         { \dim_use:N \l_@@_x_dim } ,
1758         \dim_eval:n
1759         {
1760             ( \g_@@_y_initial_dim + \g_@@_y_final_dim ) / 2
1761             - 0.5 \l_@@_max_length_of_arrow_dim
1762         }
1763     }
1764 }
1765 {
1766     \tl_gset:Ne \g_tmpa_tl
1767     {
1768         \int_compare:nNnTF \l_@@_pos_arrow_int < 5
1769         { \dim_use:N \g_@@_x_initial_dim }
1770         { \dim_use:N \l_@@_x_dim } ,
1771         \bool_if:NNTF \l_tmpa_bool
1772         { \dim_eval:n { \g_@@_y_initial_dim + \l_@@_start_adjust_dim } }
1773         { \dim_use:N \g_@@_y_initial_dim }
1774     }
1775     \tl_gset:Ne \g_tmpb_tl
1776     {
1777         \int_compare:nNnTF \l_@@_pos_arrow_int < 5
1778         { \dim_use:N \g_@@_x_final_dim }
1779         { \dim_use:N \l_@@_x_dim } ,
1780         \bool_if:NNTF \l_tmpb_bool
1781         { \dim_eval:n { \g_@@_y_final_dim - \l_@@_end_adjust_dim } }
1782         { \dim_use:N \g_@@_y_final_dim }
1783     }
1784 }

```

The dimension `\l_@@_delta_x_dim` is the difference of abscissa between the right side of the alignment (`\halign`) and the left side of the arrow.

```

1785 \bool_if:NF \l_@@_right_overlap_bool
1786 {
1787     \bool_if:NT \l_@@_in-WithArrows_bool
1788     {
1789         \pgfpicture
1790         \pgfrememberpicturepositiononpagetrue
1791         \pgfpointanchor { wa - \l_@@_prefix_str - 1 - r } { south }
1792         \int_compare:nNnTF \l_@@_pos_arrow_int < 5
1793         {
1794             \dim_set:Nn \l_@@_delta_x_dim
1795             {

```

```

1796         \pgf@x -
1797         ( \dim_min:nn \g_@@_x_initial_dim \g_@@_x_final_dim )
1798     }
1799 }
1800 { \dim_set:Nn \l_@@_delta_x_dim { \pgf@x - \l_@@_x_dim } }
1801 \endpgfpicture
1802 }
1803 }

```

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 `tikz-code`. 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*.³⁸

```

1804     @@_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).

```

1805     \group_end:
1806 }

```

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_arrow:n` which will create the function `@@_arrow:nnn`.

```

1807 \cs_generate_variant:Nn \@@_def_function_arrow:n { o }
1808 \cs_new_protected:Npn \@@_def_function_arrow:n #1
1809 {
1810     \cs_set:Npn \@@_arrow:nnn ##1 ##2 ##3
1811     {
1812         <LaTeX>
1813         \begin{tikzpicture}
1814         </LaTeX>
1815         <plain-TeX>
1816         \tikzpicture
1817         </plain-TeX>
1818         [ @@_standard_arrow ]

```

You keep track of the bounding box because we want to compute the total width of the arrow (with the label) for the arrows of type `over` and also for the actualization of `\g_@@_overlap_x_dim`.

```

1819     \pgf@relevantforpicturesize true
1820     #1
1821     \dim_compare:nNnTF \pgf@picminx = { 16000 pt }
1822     { \dim_zero:N \l_tmpa_dim }
1823     { \dim_set:Nn \l_tmpa_dim { \pgf@picmaxx - \pgf@picminx } }
1824     \dim_add:Nn \l_tmpa_dim \l_@@_xoffset_dim

```

`\l_@@_arrow_int = 0` probably means that we have an arrow in the `code-after`.

```

1825     \int_compare:nNnT \l_@@_arrow_int > 0 % added 2024/10/01
1826     {
1827         \prop_gput:cnV
1828         { g_@@_arrow _ \l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop }
1829         { width }
1830         \l_tmpa_dim
1831     }

```

³⁸There were other solutions: use another name without *underscore* (like `\l_tmpat1`) or use the package `underscore` (with this package, the characters *underscore* will be rescanned without errors, even in text mode).

Now, the actualization of `\g_@@_overlap_x_dim`.

```

1832     \bool_if:NF \l_@@_right_overlap_bool
1833     {
1834         \bool_if:NT \l_@@_in_WithArrows_bool
1835         {
1836             \dim_gset:Nn \g_@@_overlap_x_dim
1837             {
1838                 \dim_max:nn
1839                 \g_@@_overlap_x_dim
1840                 { \l_tmpa_dim - \l_@@_delta_x_dim }
1841             }
1842         }
1843     }
1844     \pgfresetboundingbox
1845     <LaTeX>
1846     \end{tikzpicture}
1847 </LaTeX>
1848 <plain-TeX>
1849     \endtikzpicture
1850 </plain-TeX>
1851 }
1852 }

```

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

```

1853 \cs_generate_variant:Nn \@@_draw_arrow:nnn { n n o }
1854 \cs_new_protected:Npn \@@_draw_arrow:nnn #1 #2 #3
1855 {

```

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

```

1856     \bool_lazy_and:nnT \l_@@_wrap_lines_bool \l_@@_in_DisWithArrows_bool
1857     { \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_wrap_lines_tl }

```

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

```

1858     \@@_def_function_arrow:o \l_@@_tikz_code_tl
1859     \@@_arrow:nnn { #1 } { #2 } { #3 }
1860 }

```

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

```

1861 \tl_const:Nn \c_@@_tikz_code_wrap_lines_tl
1862 {
1863     \pgfset { inner~sep = 0pt }

```

First, we draw the arrow without the label.

```

1864     \draw ( #1 ) to node ( @@_label ) { } ( #2 ) ;

```

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

```

1865     \pgfpointanchor { wa - \l_@@_prefix_str - @@_label } { west }

```

We compute in `\l_tmpa_dim` the maximal width possible for the label. Here is the use of `\g_@@_right_x_dim` which has been computed previously with the v-nodes.

```

1866     \dim_set:Nn \l_tmpa_dim { \g_@@_right_x_dim - \pgf@x - 0.33333 em }

```

We retrieve in `\g_tmpa_tl` the current value of the Tikz parameter “text width”.³⁹

```

1867     \path \pgfextra { \tl_gset:Ne \g_tmpa_tl \tikz@text@width } ;

```

³⁹In 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.

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`).

```

1868 \tl_if_empty:NF \g_tmpa_tl
1869 {
1870   \dim_set:Nn \l_tmpb_dim \g_tmpa_tl
1871   \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
1872     { \dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim }
1873 }

```

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

```

1874 \dim_compare:nNnT \l_tmpa_dim > \c_zero_dim
1875 {
1876   \path ( @@_label.west )
1877   (*LaTeX)
1878     node [ anchor = west ]
1879     {
1880       \skip_horizontal:n { 0.33333 em }
1881       \begin { minipage } { \l_tmpa_dim }
1882       \tikz@text@action
1883       \pgfkeysgetvalue { / tikz / node-halign~header } \l_tmpa_tl
1884       \tl_if_eq:NnTF \l_tmpa_tl { \tikz@align@left@header }
1885         { \pgfutil@raggedright }
1886         {
1887           \tl_if_eq:NnTF \l_tmpa_tl { \tikz@align@right@header }
1888             { \pgfutil@raggedleft }
1889             {
1890               \tl_if_eq:NnT \l_tmpa_tl { \tikz@align@center@header }
1891                 { \centering }
1892             }
1893         }
1894       #3
1895       \end { minipage }
1896     } ;
1897   (/LaTeX)
1898   (*plain-TeX)
1899     node [ anchor = west , text-width = \dim_use:N \l_tmpa_dim ]
1900     { \skip_horizontal:n { 0.33333 em } #3 } ;
1901   (/plain-TeX)
1902 }
1903 }

```

12.11.1 The command `update_x`

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

```

1904 \cs_new_protected:Npn \@@update_x:nn #1 #2
1905 {
1906   \dim_gset_eq:NN \g_tmpa_dim \l_@@_x_dim
1907   \pgfpicture
1908   \pgfrememberpicturepositiononpagetrue
1909   \int_step_inline:nnn { #1 } { #2 }
1910   {
1911     \pgfpointanchor { wa - \l_@@_prefix_str - ##1 - 1 } { center }
1912     \dim_gset:Nn \g_tmpa_dim { \dim_max:nn \g_tmpa_dim \pgf@x }
1913   }
1914   \endpgfpicture
1915   \dim_set_eq:NN \l_@@_x_dim \g_tmpa_dim
1916 }

```

12.11.2 We draw the arrows of type o

We recall that the arrows of type o will be drawn *over* (hence the letter o) the other arrows. The arrows of type o are available only when the option `group` or the option `groups` is in force. The arrows of type o will be drawn group by group. The command `\@@_draw_o_arrows_of_the_group:` is called after the construction of the (other) arrows of the group.

```

1917 \cs_new_protected:Npn \@@_draw_o_arrows_of_the_group:
1918 {
1919   \bool_lazy_all:nTF
1920   {
1921     \l_@@_wrap_lines_bool
1922     \l_@@_in_DispWithArrows_bool
1923     { ! \seq_if_empty_p:N \l_@@_o_arrows_seq }
1924   }
1925   { \@@_error:n { o-arrow-with-wrap-lines } }
1926   { \@@_draw_o_arrows_of_the_group_i: }
1927 }
1928 \cs_new_protected:Npn \@@_draw_o_arrows_of_the_group_i:
1929 {

```

The numbers of the arrows of type o we have to draw are in the sequence `\l_@@_o_arrows_seq`. We have to sort that sequence because the order in which these arrows will be drawn matters.

- The arrows which arrive first must be drawn first.
- For arrows with the same final line, the arrows with lower initial line must be drawn after (because they encompass the previous ones).

The second point ensures the expected output in situations such as in the following example:

```

$\begin{WithArrows}[groups]
A & = B \Arrow{o,jump=3}{one}\\
& = C \Arrow{o,jump=2}{two}\\
& = D \Arrow{three} \\
& = E + E
\end{WithArrows}$

```

$$\begin{array}{lcl}
 A & = & B \\
 & = & C \\
 & = & D \\
 & = & E + E
 \end{array}
 \begin{array}{c}
 \nearrow \text{one} \\
 \nearrow \text{two} \\
 \searrow \text{three}
 \end{array}$$

```

1930   \seq_sort:Nn \l_@@_o_arrows_seq
1931   {
1932     \prop_get:cnN
1933     { g_@@_arrow _ \l_@@_prefix_str _ ##1 _ prop }
1934     { final } \l_tmpa_tl

```

We recall that `\prop_get:cnN` retrieves token lists (here `\l_tmpa_tl` and `\l_tmpb_tl`). We don't need to do an explicit conversion in L3 integers because such token lists can be used directly in `\int_compare:nNnTF`.

```

1935   \prop_get:cnN
1936   { g_@@_arrow _ \l_@@_prefix_str _ ##2 _ prop }
1937   { final } \l_tmpb_tl
1938   \int_compare:nNnTF \l_tmpa_tl < \l_tmpb_tl
1939   \sort_return_same:
1940   {
1941     \int_compare:nNnTF \l_tmpa_tl > \l_tmpb_tl
1942     \sort_return_swapped:
1943     {
1944       \prop_get:cnN
1945       { g_@@_arrow _ \l_@@_prefix_str _ ##1 _ prop }
1946       { initial } \l_tmpa_tl
1947       \prop_get:cnN
1948       { g_@@_arrow _ \l_@@_prefix_str _ ##2 _ prop }
1949       { initial } \l_tmpb_tl
1950       \int_compare:nNnTF \l_tmpa_tl < \l_tmpb_tl
1951       \sort_return_swapped:

```

```

1952         \sort_return_same:
1953     }
1954 }
1955 }

```

Now, we can draw the arrows of type o of the group in the order of the sequence.

```

1956 \seq_map_inline:Nn \l_@@_o_arrows_seq
1957 {

```

We retrieve the initial row and the final row of the arrow.

```

1958     \prop_get:cnN
1959     { g_@@_arrow _ \l_@@_prefix_str _ ##1 _ prop }
1960     { initial } \l_tmpa_tl
1961     \int_set:Nn \l_@@_initial_int \l_tmpa_tl
1962     \prop_get:cnN
1963     { g_@@_arrow _ \l_@@_prefix_str _ ##1 _ prop }
1964     { final } \l_tmpa_tl
1965     \int_set:Nn \l_@@_final_int \l_tmpa_tl

```

The string `\l_@@_input_line_str` will be used only in some error messages.

```

1966     \prop_get:cnN
1967     { g_@@_arrow _ \l_@@_prefix_str _ ##1 _ prop }
1968     { input-line } \l_@@_input_line_str

```

We have to compute the maximal width of all the arrows (with their labels) which are covered by our arrow. We will compute that dimension in `\g_tmpa_dim`. We need a global dimension because we will have to exit a `\pgfpicture`.

```

1969     \dim_gzero:N \g_tmpa_dim

```

We will raise the boolean `\g_tmpa_bool` if we find an arrow “under” our arrow (we should find at least once since you are drawing an arrow of type o: if not, we will raise an error⁴⁰).

```

1970     \bool_set_false:N \g_tmpa_bool
1971     \pgfpicture
1972     \pgfrememberpicturepositiononpagetrue
1973     \int_step_inline:nnn \l_@@_first_arrow_int \l_@@_last_arrow_int
1974     {
1975         \prop_get:cnN
1976         { g_@@_arrow _ \l_@@_prefix_str _ #####1 _ prop }
1977         { initial } \l_tmpa_tl
1978         \prop_get:cnN
1979         { g_@@_arrow _ \l_@@_prefix_str _ #####1 _ prop }
1980         { final } \l_tmpb_tl
1981         \prop_get:cnN
1982         { g_@@_arrow _ \l_@@_prefix_str _ #####1 _ prop }
1983         { status } \l_@@_status_arrow_str
1984         \bool_lazy_any:nF
1985         {
1986             { \int_compare_p:n { ##1 = #####1 } }
1987             { \int_compare_p:nNn \l_@@_initial_int > \l_tmpa_tl }
1988             { \int_compare_p:nNn \l_tmpb_tl > \l_@@_final_int }

```

We don’t take into account the independent arrows because we have only computed the *width* of the arrows and that’s why our arrow of type o will be positionned only relatively to the current group.

```

1989         { \str_if_eq_p:on \l_@@_status_arrow_str { independent } }
1990     }
1991 {

```

The total width of the arrow (with its label) has been stored in a “field” of the arrow.

```

1992     \bool_gset_true:N \g_tmpa_bool
1993     \prop_get:cnN
1994     { g_@@ _ arrow _ \l_@@_prefix_str _ #####1 _ prop }
1995     { width }
1996     \l_tmpa_tl

```

⁴⁰Maybe we will change that in future versions.

We have to do a global affectation in order to exit the `pgfpicture`.

```

1997         \dim_gset:Nn \g_tmpa_dim { \dim_max:nn \g_tmpa_dim \l_tmpa_tl }
1998     }
1999 }
2000 \endpgfpicture

```

The boolean `\g_tmpa_bool` is raised if at least one arrow has been found “under” our arrow (it should be the case since we are drawing an arrow of type `o`).

```

2001     \bool_if:NTF \g_tmpa_bool
2002     {
2003         \int_set:Nn \l_@@_arrow_int { ##1 }
2004         \dim_set_eq:NN \l_@@_xoffset_dim \g_tmpa_dim
2005         \dim_add:Nn \l_@@_xoffset_dim \l_@@_xoffset_for_o_arrows_dim
2006
2007         \@@_draw_arrow:
2008     }
2009     { \@@_error:n { o~arrow~with~no~arrow~under } }
2010 }

```

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 sense of the nested environments). This macro is fully expandable and, thus, can be used directly in the name of a Tikz node.

```

2011 < *LaTeX >
2012 \NewExpandableDocumentCommand \WithArrowsLastEnv { }
2013 { \int_use:N \g_@@_last_env_int }
2014 < /LaTeX >
2015 < *plain-TeX >
2016 \cs_new:Npn \WithArrowsLastEnv { \int_use:N \g_@@_last_env_int }
2017 < /plain-TeX >

```

12.12 The command `\Arrow` in code-after

The option `code-after` is an option of the environment `{WithArrows}` (this option is only available at the environment level). In the option `code-after`, 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/Arrow/code-after`.

```

2018 \keys_define:nn { WithArrows / Arrow / code-after }
2019 {
2020     tikz .code:n =
2021         \tikzset { WithArrows / arrow / .append-style = { #1 } } ,
2022     tikz .value_required:n = true ,
2023     rr .value_forbidden:n = true ,
2024     rr .code:n = \@@_fix_pos_option:n 0 ,
2025     ll .value_forbidden:n = true ,
2026     ll .code:n = \@@_fix_pos_option:n 1 ,
2027     rl .value_forbidden:n = true ,
2028     rl .code:n = \@@_fix_pos_option:n 2 ,
2029     lr .value_forbidden:n = true ,
2030     lr .code:n = \@@_fix_pos_option:n 3 ,
2031     v .value_forbidden:n = true ,
2032     v .code:n = \@@_fix_pos_option:n 4 ,
2033     tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
2034     tikz-code .value_required:n = true ,
2035     xoffset .dim_set:N = \l_@@_xoffset_dim ,
2036     xoffset .value_required:n = true ,
2037     unknown .code:n =
2038         \@@_sort_seq:N \l_@@_options_Arrow_code_after_seq
2039         \@@_error:n { Unknown-option-Arrow-in-code-after }
2040 }

```

A sequence of the options available in `\Arrow` in `code-after`. This sequence will be used in the error messages and can be modified dynamically.

```

2041 \seq_new:N \l_@@_options_Arrow_code_after_seq
2042 \@@_set_seq_of_str_from_clist:Nn \l_@@_options_Arrow_code_after_seq
2043   { ll, lr, rl, rr, tikz, tikz-code, v, x, offset }

2044 <*LaTeX>
2045 \NewDocumentCommand \@@_Arrow_code_after { 0 { } m m m ! 0 { } }
2046 </LaTeX>
2047 <*plain-TeX>
2048 \cs_new_protected:Npn \@@_Arrow_code_after
2049   {
2050     \peek_meaning:NTF [
2051       { \@@_Arrow_code_after_i }
2052       { \@@_Arrow_code_after_i [ ] }
2053     ]
2054     \cs_new_protected:Npn \@@_Arrow_code_after_i [ #1 ] #2 #3 #4
2055     {
2056       \peek_meaning:NTF [
2057         { \@@_Arrow_code_after_ii [ #1 ] { #2 } { #3 } { #4 } }
2058         { \@@_Arrow_code_after_ii [ #1 ] { #2 } { #3 } { #4 } [ ] }
2059       ]
2060       \cs_new_protected:Npn \@@_Arrow_code_after_ii [ #1 ] #2 #3 #4 [ #5 ]
2061       </plain-TeX>
2062       {
2063         \int_set_eq:NN \l_@@_pos_arrow_int \c_one_int
2064         \str_clear_new:N \l_@@_previous_key_str
2065         \group_begin:
2066         \keys_set:nn { WithArrows / Arrow / code-after }
2067           { #1, #5, tikz = { xshift = \l_@@_xoffset_dim } }
2068         \bool_set_false:N \l_@@_initial_r_bool
2069         \bool_set_false:N \l_@@_final_r_bool
2070         \int_case:nn \l_@@_pos_arrow_int
2071           {
2072             0
2073             {
2074               \bool_set_true:N \l_@@_initial_r_bool
2075               \bool_set_true:N \l_@@_final_r_bool
2076             }
2077             2 { \bool_set_true:N \l_@@_initial_r_bool }
2078             3 { \bool_set_true:N \l_@@_final_r_bool }
2079           }

```

We prevent drawing an arrow from a line to itself.

```

2080 \tl_if_eq:nnTF { #2 } { #3 }
2081   { \@@_error:nn { Both-lines~are~equal } { #2 } }

```

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

```

2082 {
2083   \cs_if_free:cTF { pgf@sh@ns@wa - \l_@@_prefix_str - #2 - 1 }
2084     { \@@_error:ne { Wrong~line~in~Arrow } { #2 } }
2085     {
2086       \cs_if_free:cTF { pgf@sh@ns@wa - \l_@@_prefix_str - #3 - 1 }
2087         { \@@_error:ne { Wrong~line~in~Arrow } { #3 } }
2088         {
2089           \int_compare:nNnTF \l_@@_pos_arrow_int = 4
2090             {
2091               \pgfpicture
2092               \pgfrememberpicturepositiononpagetrue
2093               \pgfpointanchor { wa - \l_@@_prefix_str - #2 - 1 }
2094                 { south }
2095               \dim_set_eq:NN \l_tmpa_dim \pgf@x

```

```

2096         \dim_set_eq:NN \l_tmpb_dim \pgf@y
2097         \pgfpointanchor { wa - \l_@@_prefix_str - #3 - 1 }
2098             { north }
2099         \dim_set:Nn \l_tmpa_dim
2100             { \dim_max:nn \l_tmpa_dim \pgf@x }
2101         \tl_gset:Ne \g_tmpa_tl
2102             { \dim_use:N \l_tmpa_dim , \dim_use:N \l_tmpb_dim }
2103         \tl_gset:Ne \g_tmpb_tl
2104             { \dim_use:N \l_tmpa_dim , \dim_use:N \pgf@y }
2105     \endpgfpicture
2106 }
2107 {
2108     \pgfpicture
2109     \pgfrememberpicturepositiononpagetrue
2110     \pgfpointanchor
2111         {
2112             wa - \l_@@_prefix_str -
2113             #2 - \bool_if:NTF \l_@@_initial_r_bool r l
2114         }
2115         { south }
2116     \tl_gset:Ne \g_tmpa_tl
2117         { \dim_use:N \pgf@x , \dim_use:N \pgf@y }
2118     \pgfpointanchor
2119         {
2120             wa - \l_@@_prefix_str -
2121             #3 - \bool_if:NTF \l_@@_final_r_bool r l
2122         }
2123         { north }
2124     \tl_gset:Ne \g_tmpb_tl
2125         { \dim_use:N \pgf@x , \dim_use:N \pgf@y }
2126     \endpgfpicture
2127 }
2128 \@@_draw_arrow:nnn \g_tmpa_tl \g_tmpb_tl { #4 }
2129 }
2130 }
2131 }
2132 \group_end:
2133 }

```

12.13 The command `\MultiArrow` in code-after

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

```

2134 \cs_new_protected:Npn \@@_MultiArrow:nn #1 #2
2135 {

```

The user of the command `\MultiArrow` (in code-after) will be able to specify the list of lines with the same syntax as the loop `\foreach` of `pgffor`. First, we test with a regular expression whether the format of the list of lines is correct.

```

2136     \exp_args:Nne
2137     \regex_match:nnTF
2138     { \A \d+ (\,\d+)* ( \, \.\.\. (\,\d+)+ )* \Z }
2139     { #1 }
2140     { \@@_MultiArrow_i:nn { #1 } { #2 } }
2141     { \@@_error:ne { Invalid~specification~for~MultiArrow } { #1 } }
2142 }
2143 \cs_new_protected:Npn \@@_MultiArrow_i:nn #1 #2
2144 {

```

That’s why we construct a “clist” of L3 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 will construct the list in `\g_tmpa_clist`.

```

2145 \foreach \x in { #1 }
2146 {
2147   \cs_if_free:cTF { pgf@sh@ns@wa - \l_@@_prefix_str - \x - 1 }
2148   { \@@_error:ne { Wrong-line-specification-in-MultiArrow } \x }
2149   { \clist_gput_right:Ne \g_tmpa_clist \x }
2150 }

```

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

```

2151 \int_compare:nTF { \clist_count:N \g_tmpa_clist < 2 }
2152 { \@@_error:n { Too-small-specification-for-MultiArrow } }
2153 {
2154   \clist_sort:Nn \g_tmpa_clist
2155   {
2156     \int_compare:nNnTF { ##1 } > { ##2 }
2157     \sort_return_swapped:
2158     \sort_return_same:
2159   }

```

We extract the minimum in `\l_tmpa_tl` (it must be an integer but we store it in a token list of L3).

```

2160 \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...

```

2161 \clist_reverse:N \g_tmpa_clist
2162 \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).

```

2163 \exp_args:No \@@_MultiArrow_i:n \g_tmpa_clist

```

Now, we draw the rest of the structure.

```

2164 <LaTeX>
2165 \begin { tikzpicture }
2166 </LaTeX>
2167 <plain-TeX>
2168 \tikzpicture
2169 </plain-TeX>
2170 [
2171   @@_standard ,
2172   every~path / .style = { WithArrows / arrow }
2173 ]
2174 \draw [<->] ([xshift = \l_@@_xoffset_dim]\l_tmpa_tl-r.south)
2175 -- ++(5mm,0)
2176 -- node (@@_label) {}
2177 ([xshift = \l_@@_xoffset_dim+5mm]\l_tmpb_tl-r.south)
2178 -- ([xshift = \l_@@_xoffset_dim]\l_tmpb_tl-r.south) ;
2179 \pgfpointanchor { wa - \l_@@_prefix_str - @@_label } { west }
2180 \dim_set:Nn \l_tmpa_dim { 20 cm }
2181 \path \pgfextra { \tl_gset:Ne \g_tmpa_tl \tikz@text@width } ;
2182 \tl_if_empty:NF \g_tmpa_tl { \dim_set:Nn \l_tmpa_dim \g_tmpa_tl }
2183 \bool_lazy_and:nnT \l_@@_wrap_lines_bool \l_@@_in_DispWithArrows_bool
2184 {
2185   \dim_set:Nn \l_tmpb_dim
2186   { \g_@@_right_x_dim - \pgf@x - 0.3333 em }
2187   \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
2188   { \dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim }
2189 }
2190 \path (@@_label.west)
2191 node [ anchor = west, text~width = \dim_use:N \l_tmpa_dim ] { #2 } ;
2192 <LaTeX>
2193 \end { tikzpicture }
2194 </LaTeX>
2195 <plain-TeX>

```

```

2196         \endtikzpicture
2197 </plain-TeX>
2198     }
2199 }

2200 \cs_new_protected:Npn \@@_MultiArrow_i:n #1
2201 {
2202 <*LaTeX>
2203     \begin { tikzpicture }
2204 </LaTeX>
2205 <*plain-TeX>
2206         \tikzpicture
2207 </plain-TeX>
2208     [
2209         @@_standard ,
2210         every-path / .style = { WithArrows / arrow }
2211     ]
2212     \foreach \k in { #1 }
2213     {
2214         \draw [ <- ]
2215             ( [xshift = \l_@@_xoffset_dim]\k-r.south ) -- ++(5mm,0) ;
2216     } % ;
2217 <*LaTeX>
2218     \end{tikzpicture}
2219 </LaTeX>
2220 <*plain-TeX>
2221     \endtikzpicture
2222 </plain-TeX>
2223 }

```

12.14 The error messages of the package

```

2224 \bool_if:NTF \c_@@_messages_for_Overleaf_bool
2225 { \str_const:Nn \c_@@_available_keys_str { } }
2226 {
2227     \str_const:Nn \c_@@_available_keys_str
2228     { For~a~list~of~the~available~keys,~type~H~<return>. }
2229 }

```

```

2230 \str_new:N \l_witharrows_body_str

```

The following commands must *not* be protected since they will be used in error messages.

```

2231 \cs_new:Npn \@@_potential_body_i:
2232 {
2233     \str_if_empty:NF \l_witharrows_body_str
2234     { \ \ If~you~want~to~see~the~body~of~the~environment,~type~H~<return>. }
2235 }

2236 \cs_new:Npn \@@_potential_body_ii:
2237 {
2238     \str_if_empty:NTF \l_witharrows_body_str
2239     { No~further~help~available }
2240     {
2241         The~body~of~your~environment~was:\\
2242         \l_witharrows_body_str
2243     }
2244 }

2245 \str_const:Nn \c_@@_option_ignored_str
2246 { If~you~go~on,~this~option~will~be~ignored. }
2247 \str_const:Nn \c_@@_command_ignored_str
2248 { If~you~go~on,~this~command~will~be~ignored. }

2249 <*LaTeX>
2250 \@@_msg_new:nn { amsmath-not-loaded }
2251 {

```



```

2252 amsmath~not~loaded.\\
2253 You~can't~use~the~option~'\l_keys_key_str'~because~the~
2254 package~'amsmath'~has~not~been~loaded.\\
2255 If~you~go~on,~this~option~will~be~ignored~in~the~rest~
2256 of~the~document.
2257 }
2258 </LaTeX>

2259 \@@_msg_new:nn { Bad~value~for~replace~brace~by }
2260 {
2261   Incorrect~value.\\
2262   Bad~value~for~the~option~'\l_keys_key_str'.~The~value~must~begin~
2263   with~an~extensible~left~delimiter.~The~possible~values~are:~,~,
2264   \token_to_str:N \{,~(,~[,~\token_to_str:N \lbrace,~
2265   \token_to_str:N \lbrack,~\token_to_str:N \lgroup,~
2266   \token_to_str:N \langle,~\token_to_str:N \lmoustache,~
2267   \token_to_str:N \lfloor~and~\token_to_str:N \lceil~
2268   (and~\token_to_str:N \lvert~and~\token_to_str:N \lVert~
2269   if~amsmath~or~unicode~math~is~loaded~in~LaTeX).\\
2270   \c_@@_option_ignored_str
2271 }

2272 \@@_msg_new:nn { option~of~cr~negative }
2273 {
2274   Bad~value.\\
2275   The~argument~of~the~command~\token_to_str:N\\~
2276   should~be~positive~in~the~row~\int_use:N \g_@@_line_int~
2277   of~your~environment~\{\l_@@_type_env_str\}.\\
2278   \c_@@_option_ignored_str
2279 }

2280 \@@_msg_new:nn { omit~probably~used }
2281 {
2282   Strange~problem.\\
2283   Maybe~you~have~used~a~command~
2284   \token_to_str:N\omit~in~the~line~\int_use:N \g_@@_line_int~
2285   (or~another~line)~of~your~environment~\{\l_@@_type_env_str\}.\\
2286   You~can~go~on~but~you~may~have~others~errors.
2287 }

2288 <*LaTeX>
2289 \@@_msg_new:nnn { newline~at~the~end~of~env }
2290 {
2291   Incorrect~end.\\
2292   The~environments~of~witharrows~(\{WithArrows\}~and~
2293   \{DispWithArrows\})~should~not~end~by~\token_to_str:N \\.\\
2294   However,~you~can~go~on~for~this~time.~No~similar~error~will~be~
2295   raised~in~this~document.
2296   \@@_potential_body_i:
2297 }
2298 { \@@_potential_body_ii: }
2299 </LaTeX>

2300 \@@_msg_new:nnn { Invalid~option~format }
2301 {
2302   Invalide~value.\\
2303   The~key~'format'~should~contain~only~letters~r,~c~and~l~and~
2304   must~not~be~empty.\\
2305   \c_@@_option_ignored_str
2306   \@@_potential_body_i:
2307 }
2308 { \@@_potential_body_ii: }

2309 \@@_msg_new:nnn { invalid~key~o }
2310 {
2311   Invalid~use~of~a~key.\\
2312   The~key~'o'~for~individual~arrows~can~be~used~only~in~mode~

```

```

2313     'group'~or~in~mode~'groups'.\\
2314     \c_@@_option_ignored_str
2315     \@@_potential_body_i:
2316 }
2317 { \@@_potential_body_ii: }
2318 \@@_msg_new:nnn { o~arrow~with~wrap~lines }
2319 {
2320     Arrow~of~type~'o'~with~'wrap~lines'. \\
2321     You~can't~use~arrows~of~type~'o'~when~
2322     'wrap~lines'~is~in~force.\\
2323     If~you~go~on,~these~arrows~will~be~ignored.
2324     \@@_potential_body_i:
2325 }
2326 { \@@_potential_body_ii: }
2327 \@@_msg_new:nnn { Value~for~a~key }
2328 {
2329     Misuse~of~a~key.\\
2330     The~key~'\l_keys_key_str'~should~be~used~without~value. \\
2331     However,~you~can~go~on~for~this~time.
2332     \@@_potential_body_i:
2333 }
2334 { \@@_potential_body_ii: }
2335 \@@_msg_new:nnn { Unknown~option~in~Arrow }
2336 {
2337     Unknown~option.\\
2338     The~key~'\l_keys_key_str'~is~unknown~for~the~command~
2339     \l_@@_string_Arrow_for_msg_str\ in~the~row~
2340     \int_use:N \g_@@_line_int\ of~your~environment~
2341     \{\l_@@_type_env_str\}. \l_tmpa_str \\
2342     \c_@@_option_ignored_str \\
2343     \c_@@_available_keys_str
2344 }
2345 {
2346     The~available~keys~are~(in~alphabetic~order):~
2347     \seq_use:Nnnn \l_@@_options_Arrow_seq {~and~} {,~} {~and~}.
2348 }
2349 \@@_msg_new:nnn { Unknown~option~WithArrows }
2350 {
2351     Unknown~option.\\
2352     The~key~'\l_keys_key_str'~is~unknown~in~\{\l_@@_type_env_str\}. \\
2353     \c_@@_option_ignored_str \\
2354     \c_@@_available_keys_str
2355 }
2356 {
2357     The~available~keys~are~(in~alphabetic~order):~
2358     \seq_use:Nnnn \l_@@_options_WithArrows_seq {~and~} {,~} {~and~}.
2359 }
2360 \@@_msg_new:nnn { Unknown~option~DispWithArrows }
2361 {
2362     Unknown~option.\\
2363     The~key~'\l_keys_key_str'~is~unknown~in~\{\l_@@_type_env_str\}. \\
2364     \c_@@_option_ignored_str \\
2365     \c_@@_available_keys_str
2366 }
2367 {
2368     The~available~keys~are~(in~alphabetic~order):~
2369     \seq_use:Nnnn \l_@@_options_DispatchWithArrows_seq {~and~} {,~} {~and~}.
2370 }
2371 \@@_msg_new:nnn { Unknown~option~WithArrowsOptions }
2372 {
2373     Unknown~option.\\

```

```

2374 The~key~'\l_keys_key_str'~is~unknown~in~
2375 \token_to_str:N \WithArrowsOptions. \
2376 \c_@@_option_ignored_str \
2377 \c_@@_available_keys_str
2378 }
2379 {
2380 The~available~keys~are~(in~alphabetic~order):~
2381 \seq_use:Nnnn \l_@@_options_WithArrowsOptions_seq {~and~} {,~} {~and~}.
2382 }
2383 \@@_msg_new:nnn { Unknown~option~Arrow~in~code~after }
2384 {
2385 Unknown~option.\
2386 The~key~'\l_keys_key_str'~is~unknown~in~
2387 \token_to_str:N \Arrow\ in~code~after. \
2388 \c_@@_option_ignored_str \
2389 \c_@@_available_keys_str
2390 }
2391 {
2392 The~available~keys~are~(in~alphabetic~order):~
2393 \seq_use:Nnnn \l_@@_options_Arrow_code_after_seq {~and~} {,~} {~and~}.
2394 }
2395 \@@_msg_new:nnn { Too~much~columns~in~WithArrows }
2396 {
2397 Too~much~columns.\
2398 Your~environment~\{\l_@@_type_env_str\}~has~\int_use:N
2399 \l_@@_nb_cols_int\ columns~and~you~try~to~use~one~more.~
2400 Maybe~you~have~forgotten~a~\c_backslash_str\c_backslash_str.~
2401 If~you~really~want~to~use~more~columns~(after~the~arrows)~you~should~use~
2402 the~option~'more~columns'~at~a~global~level~or~for~an~environment. \
2403 However,~you~can~go~one~for~this~time.
2404 \@@_potential_body_i:
2405 }
2406 { \@@_potential_body_ii: }
2407 \@@_msg_new:nnn { Too~much~columns~in~DispWithArrows }
2408 {
2409 Too~much~columns.\
2410 Your~environment~\{\l_@@_type_env_str\}~has~\int_use:N
2411 \l_@@_nb_cols_int\ columns~and~you~try~to~use~one~more.~
2412 Maybe~you~have~forgotten~a~\c_backslash_str\c_backslash_str\
2413 at~the~end~of~row~\int_use:N \g_@@_line_int. \
2414 This~error~is~fatal.
2415 \@@_potential_body_i:
2416 }
2417 { \@@_potential_body_ii: }
2418 \@@_msg_new:nn { Negative~jump }
2419 {
2420 Incorrect~value.\
2421 You~can't~use~a~negative~value~for~the~option~'jump'~of~command~
2422 \l_@@_string_Arrow_for_msg_str\
2423 in~the~row~\int_use:N \g_@@_line_int\
2424 of~your~environment~\{\l_@@_type_env_str\}.~
2425 You~can~create~an~arrow~going~backwards~with~the~option~'<'~of~Tikz. \
2426 \c_@@_option_ignored_str
2427 }
2428 \@@_msg_new:nn { new~group~without~groups }
2429 {
2430 Misuse~of~a~key.\
2431 You~can't~use~the~option~'new~group'~for~the~command~
2432 \l_@@_string_Arrow_for_msg_str\
2433 because~you~are~not~in~'groups'~mode.~Try~to~use~the~option~
2434 'groups'~in~your~environment~\{\l_@@_type_env_str\}. \
2435 \c_@@_option_ignored_str

```

```

2436 }
2437 \@@_msg_new:nnn
2438 { Too~few~lines~for~an~arrow }
2439 {
2440   Impossible~arrow.\
2441   Line~\l_@@_input_line_str\
2442   :~an~arrow~specified~in~the~row~\int_use:N \l_@@_initial_int\
2443   of~your~environment~\{\l_@@_type_env_str\}~can't~be~drawn~
2444   because~it~arrives~after~the~last~row~of~the~environment. \
2445   If~you~go~on,~this~arrow~will~be~ignored.
2446   \@@_potential_body_i:
2447 }
2448 { \@@_potential_body_ii: }
2449 \@@_msg_new:nn { o~arrow~with~no~arrow~under }
2450 {
2451   Problem~with~the~key~'o'.\
2452   Line~\l_@@_input_line_str\
2453   :~there~is~no~arrow~'under'~your~arrow~of~type~'o'.\
2454   If~you~go~on,~this~arrow~won't~be~drawn.
2455 }
2456 \@@_msg_new:nnn { WithArrows~outside~math~mode }
2457 {
2458   You~are~outside~math~mode.\
2459   The~environment~\{\l_@@_type_env_str\}~should~be~used~only~in~math~mode~
2460   like~the~environment~\{aligned\}~of~amsmath. \
2461   Nevertheless,~you~can~go~on.
2462   \@@_potential_body_i:
2463 }
2464 { \@@_potential_body_ii: }
2465 \@@_msg_new:nnn { DispWithArrows~in~math~mode }
2466 {
2467   You~are~in~math~mode.\
2468   The~environment~\{\l_@@_type_env_str\}~should~be~used~only~outside~math~
2469   mode~like~the~environments~\{align\}~and~\{align*\}~of~amsmath. \
2470   This~error~is~fatal.
2471   \@@_potential_body_i:
2472 }
2473 { \@@_potential_body_ii: }
2474 \@@_msg_new:nn { Incompatible~options~in~Arrow }
2475 {
2476   Incompatible~options.\
2477   You~try~to~use~the~option~'\l_keys_key_str'~but~
2478   this~option~is~incompatible~or~redundant~with~the~option~
2479   '\l_@@_previous_key_str'~set~in~the~same~command~
2480   \l_@@_string_Arrow_for_msg_str. \
2481   \c_@@_option_ignored_str
2482 }
2483 \@@_msg_new:nn { Incompatible~options a}
2484 {
2485   Incompatible~options.\
2486   You~try~to~use~the~option~'\l_keys_key_str'~but~
2487   this~option~is~incompatible~or~redundant~with~the~option~
2488   '\l_@@_previous_key_str'~set~in~the~same~command~
2489   \bool_if:NT \l_@@_in_code_after_bool
2490   {
2491     \l_@@_string_Arrow_for_msg_str\
2492     in~the~code~after~of~your~environment~\{\l_@@_type_env_str\}
2493   }. \
2494   \c_@@_option_ignored_str
2495 }
2496 \@@_msg_new:nnn { Arrow~not~in~last~column }

```

```

2497 {
2498   Bad~use~of~\l_@@_string_Arrow_for_msg_str.\
2499   You~should~use~the~command~\l_@@_string_Arrow_for_msg_str\
2500   only~in~the~last~column~(column~\int_use:N\l_@@_nb_cols_int)~
2501   in~the~row~\int_use:N \g_@@_line_int\
2502   of~your~environment~\{\l_@@_type_env_str\}.\
2503   However~you~can~go~on~for~this~time.
2504   \@@_potential_body_i:
2505 }
2506 { \@@_potential_body_ii: }
2507 \@@_msg_new:nn { Wrong~line~in~Arrow }
2508 {
2509   Wrong~line.\
2510   The~specification~of~line~'#1'~you~use~in~the~command~
2511   \l_@@_string_Arrow_for_msg_str\
2512   in~the~'code~after'~of~\{\l_@@_type_env_str\}~doesn't~exist. \
2513   \c_@@_option_ignored_str
2514 }
2515 \@@_msg_new:nn { Both~lines~are~equal }
2516 {
2517   Both~lines~are~equal.\
2518   In~the~'code~after'~of~\{\l_@@_type_env_str\}~you~try~to~
2519   draw~an~arrow~going~to~itself~from~the~line~'#1'.~This~is~not~possible. \
2520   \c_@@_option_ignored_str
2521 }
2522 \@@_msg_new:nn { Wrong~line~specification~in~MultiArrow }
2523 {
2524   Wrong~line~specification.\
2525   The~specification~of~line~'#1'~doesn't~exist. \
2526   If~you~go~on,~it~will~be~ignored~for~\token_to_str:N \MultiArrow.
2527 }
2528 \@@_msg_new:nn { Too~small~specification~for~MultiArrow }
2529 {
2530   Too~small~specification.\
2531   The~specification~of~lines~you~gave~to~\token_to_str:N \MultiArrow\
2532   is~too~small:~you~need~at~least~two~lines. \
2533   \c_@@_command_ignored_str
2534 }
2535 \@@_msg_new:nn { Not~allowed~in~DispWithArrows }
2536 {
2537   Forbidden~command.\
2538   The~command~\token_to_str:N #1
2539   is~allowed~only~in~the~last~column~
2540   (column~\int_use:N\l_@@_nb_cols_int)~of~\{\l_@@_type_env_str\}. \
2541   \c_@@_option_ignored_str
2542 }
2543 \@@_msg_new:nn { Not~allowed~in~WithArrows }
2544 {
2545   Forbidden~command.\
2546   The~command~\token_to_str:N #1 is~not~allowed~in~\{\l_@@_type_env_str\}~
2547   (it's~allowed~in~the~last~column~of~\{DispWithArrows\}). \
2548   \c_@@_option_ignored_str
2549 }
2550 <*LaTeX>
2551 \@@_msg_new:nn { tag*~without~amsmath }
2552 {
2553   amsmath~not~loaded.\
2554   We~can't~use~\token_to_str:N\tag*~because~you~haven't~loaded~amsmath~
2555   (or~mathtools). \
2556   If~you~go~on,~the~command~\token_to_str:N\tag\
2557   will~be~used~instead.

```

```

2558 }
2559 \@@_msg_new:nn { Multiple~tags }
2560 {
2561   Multiple~tags.\
2562   You~can't~use~twice~the~command~\token_to_str:N\tag\
2563   in~a~line~of~the~environment~\{\l_@@_type_env_str\}. \
2564   If~you~go~on,~the~tag~'#1'~will~be~used.
2565 }
2566 \@@_msg_new:nn { Multiple~labels }
2567 {
2568   Multiple~labels.\
2569   Normally,~we~can't~use~the~command~\token_to_str:N\label\
2570   twice~in~a~line~of~the~environment~\{\l_@@_type_env_str\}. \
2571   However,~you~can~go~on.~
2572   \IfPackageLoadedT { showlabels }
2573   { However,~only~the~last~label~will~be~shown~by~showlabels.~ }
2574   If~you~don't~want~to~see~this~message~again,~you~can~use~the~option~
2575   'allow-multiple-labels'~at~the~global~or~environment~level.
2576 }
2577 \@@_msg_new:nn { Multiple~labels~with~cleveref }
2578 {
2579   Multiple~labels.\
2580   Since~you~use~cleveref,~you~can't~use~the~command~\token_to_str:N\label\
2581   twice~in~a~line~of~the~environment~\{\l_@@_type_env_str\}. \
2582   If~you~go~on,~you~may~have~undefined~references.
2583 }
2584 </LaTeX>
2585 \@@_msg_new:nn { Inexistent~v-node }
2586 {
2587   There~is~a~problem.\
2588   Maybe~you~have~put~a~command~\token_to_str:N\cr\
2589   instead~of~a~command~\token_to_str:N\\~at~the~end~of~
2590   the~row~\l_tmpa_int\
2591   of~your~environment~\{\l_@@_type_env_str\}. \
2592   This~error~is~fatal.
2593 }

```

The following error when the user tries to use the option `xoffset` in mode `group` or `groups` (in fact, it's possible to use the option `xoffset` if there is only *one* arrow: of course, the option `group` and `groups` do not make sense in this case but, maybe, the option was set in a `\WithArrowsOptions`).

```

2594 \@@_msg_new:nn { Option~xoffset~forbidden }
2595 {
2596   Incorrect~key.\
2597   You~can't~use~the~option~'xoffset'~in~the~command~
2598   \l_@@_string_Arrow_for_msg_str\ in~the~row~\int_use:N \g_@@_line_int\
2599   of~your~environment~\{\l_@@_type_env_str\}~
2600   because~you~are~using~the~option~
2601   ' \int_compare:nNnTF \l_@@_pos_arrow_int = 7
2602     { group }
2603     { groups } '.~It's~possible~for~an~independent~arrow~or~if~there~is~
2604     only~one~arrow. \
2605     \c_@@_option_ignored_str
2606 }
2607 \@@_msg_new:nnn { Duplicate~name }
2608 {
2609   Duplicate~name.\
2610   The~name~'\l_keys_value_tl'~is~already~used~and~you~shouldn't~use~
2611   the~same~environment~name~twice.~You~can~go~on,~but,~
2612   maybe,~you~will~have~incorrect~results. \
2613   For~a~list~of~the~names~already~used,~type~H~<return>. \
2614   If~you~don't~want~to~see~this~message~again,~use~the~option~

```

```

2615 'allow-duplicate-names'.
2616 }
2617 {
2618   The~names~already~defined~in~this~document~are:~
2619   \seq_use:Nnnn \g_@@_names_seq { ,~ } { ,~ } { ~and~ }.
2620 }
2621 \@@_msg_new:nn { Invalid~specification~for~MultiArrow }
2622 {
2623   Invalid~specification.\\
2624   The~specification~of~rows~for~\token_to_str:N\MultiArrow\
2625   (i.e.~#1)~is~invalid. \\
2626   \c_@@_command_ignored_str
2627 }

```

12.15 The command \WithArrowsNewStyle

A new key defined with \WithArrowsNewStyle will not be available at the local level.

```

2628 \*LaTeX
2629 \NewDocumentCommand \WithArrowsNewStyle { m m }
2630 \*plain-TeX
2631 \cs_new_protected:Npn \WithArrowsNewStyle #1 #2
2632 \*plain-TeX
2633 {
2634   \keys_if_exist:nnTF { WithArrows / Global } { #1 }
2635   { \@@_error:nn { Key~already~defined } { #1 } }
2636   {

```

First, we detect whether there is unknown keys in #2 by storing in \l_tmpa_seq the list of the unknown keys.

```

2638   \seq_clear:N \l_tmpa_seq
2639   \keyval_parse:NNn \@@_valid_key:n \@@_valid_key:nn { #2 }
2640   \seq_if_empty:NTF \l_tmpa_seq
2641   {
2642     \seq_put_right:Ne \l_@@_options_WithArrows_seq
2643     { \tl_to_str:n { #1 } }
2644     \seq_put_right:Ne \l_@@_options_DispatchWithArrows_seq
2645     { \tl_to_str:n { #1 } }
2646     \seq_put_right:Ne \l_@@_options_WithArrowsOptions_seq
2647     { \tl_to_str:N { #1 } }
2648     \keys_precompile:nnc
2649     { WithArrows / WithArrowsOptions }
2650     { #2 }
2651     { @@ _ style _ #1 _ tl }
2652     \keys_define:nn { WithArrows / Global }
2653     { #1 .code:n = \use:c { @@ _ style _ #1 _ tl } }
2654   }
2655   { \@@_error:nn { Impossible~style } { #1 } }
2656 }
2657 }
2658 \@@_msg_new:nn { Impossible~style }
2659 {
2660   Impossible~style.\\
2661   It's~impossible~to~define~the~style~'#1'~
2662   because~it~contains~unknown~keys:~'
2663   \seq_use:Nnnn \l_tmpa_seq { '~and~' } { ',~' } { ',~and~' }.
2664 }
2665 \cs_new_protected:Npn \@@_valid_key:n #1
2666 {
2667   \keys_if_exist:nnF { WithArrows / Global } { #1 }
2668   { \seq_put_right:Nn \l_tmpa_seq { #1 } }
2669 }
2670 \cs_new_protected:Npn \@@_valid_key:nn #1 #2

```

```

2671 {
2672   \keys_if_exist:nnF { WithArrows / Global } { #1 }
2673   { \seq_put_right:Nn \l_tmpa_seq { #1 } }
2674 }
2675 \@@_msg_new:nn { Key~already-defined }
2676 {
2677   Key~already-defined.\
2678   The~key~'#1'~is~already-defined. \
2679   If~you~go~on,~your~instruction~\token_to_str:N\WithArrowsNewStyle\
2680   will~be~ignored.
2681 }

```

12.16 The options up and down

The options `up` and `down` are available for individual arrows. The corresponding code is given here. It is independent of the main code of the extension `witharrows`.

This code is the only part of the code of `witharrows` which uses the Tikz library `calc`. That's why we have decided not to load by default this library. If it is not loaded, the user will have an error only when using the option `up` or the option `down`.

The keys `up` and `down` can be used with a value. This value is a list of pairs key-value specific to the options `up` and `down`.

- The key `radius` is the radius of the rounded corner of the arrow.
- The key `width` is the width of the horizontal part of the arrow. The corresponding dimension is `\l_@@_arrow_width_dim`. By convention, a value of 0 pt for `\l_@@_arrow_width_dim` means that the option `width` has been used with the special value `min` and a value of `\c_max_dim` means that it has been used with the value `max`.

```

2682 \keys_define:nn { WithArrows / up-and-down }
2683 {
2684   radius .dim_set:N = \l_@@_up_and_down_radius_dim ,
2685   radius .value_required:n = true ,
2686   width .code:n =
2687     \str_case:nnF { #1 }
2688     {
2689       { min } { \dim_zero:N \l_@@_arrow_width_dim }
2690       { max } { \dim_set_eq:NN \l_@@_arrow_width_dim \c_max_dim }
2691     }
2692     { \dim_set:Nn \l_@@_arrow_width_dim { #1 } } ,
2693   width .value_required:n = true ,
2694   unknown .code:n = \@@_error:n { Option~unknown~for~up-and-down }
2695 }
2696 \@@_msg_new:nn { Option~unknown~for~up-and-down }
2697 {
2698   Unknown~option.\
2699   The~option~'\l_keys_key_str'~is~unknown.~\c_@@_option_ignored_str
2700 }

```

The token list `\c_@@_tikz_code_up_tl` is the value of `tikz-code` which will be used for an option `up`.

```

2701 ⟨*LaTeX⟩
2702 \tl_const:Nn \c_@@_tikz_code_up_tl
2703 {

```

First the case when the key `up` is used with `width=max` (that's the default behaviour).

```

2704   \dim_compare:nNnTF \l_@@_arrow_width_dim = \c_max_dim
2705   {
2706     \draw [ rounded-corners = \l_@@_up_and_down_radius_dim ]
2707       let \p1 = ( #1 ) , \p2 = ( #2 )

```



```

2708         in (\p1) -- node
2709         {
2710             \dim_set:Nn \l_tmpa_dim { \x2 - \x1 }
2711             \begin { varwidth } \l_tmpa_dim
\newcommand is a command of the package varwidth.
2712             \narrowragged
2713             #3
2714             \end { varwidth }
2715         }
2716         (\x2,\y1) -- (\p2) ;
2717     }

```

Now the case where the key `up` is used with `width=value` with `value` equal to `min` or a numeric value. The instruction `\path` doesn't draw anything: its aim is to compute the natural width of the label of the arrow. We can't use `\pgfextra` here because of the `\hbox_gset:Nn`.

```

2718     {
2719         \path
2720         let \p1 = ( #1 ) , \p2 = ( #2 )
2721         in node
2722         {

```

The length `\l_tmpa_dim` will be the maximal width of the box composed by the environment `{varwidth}`.

```

2723             \dim_set:Nn \l_tmpa_dim
2724             { \x2 - \x1 - \l_@@_up_and_down_radius_dim }
2725             \dim_compare:nNnF \l_@@_arrow_width_dim = \c_zero_dim
2726             {
2727                 \dim_set:Nn \l_tmpa_dim
2728                 { \dim_min:nn \l_tmpa_dim \l_@@_arrow_width_dim }
2729             }

```

Now, the length `\l_tmpa_dim` is computed. We can compose the label in the box `\g_tmpa_box`. We have to do a global affectation to be able to exit the node.

```

2730             \hbox_gset:Nn \g_tmpa_box
2731             {
2732                 \begin { varwidth } \l_tmpa_dim
2733                 \narrowragged
2734                 #3
2735                 \end { varwidth }
2736             }

```

The length `\g_tmpa_dim` will be the width of the arrow (+ the radius of the corner).

```

2737             \dim_compare:nNnTF \l_@@_arrow_width_dim > \c_zero_dim
2738             { \dim_gset_eq:NN \g_tmpa_dim \l_@@_arrow_width_dim }
2739             { \dim_gset:Nn \g_tmpa_dim { \box_wd:N \g_tmpa_box } }
2740             \dim_gadd:Nn \g_tmpa_dim \l_@@_up_and_down_radius_dim
2741         } ;
2742     \draw
2743     let \p1 = ( #1 ) , \p2 = ( #2 )
2744     in (\x2-\g_tmpa_dim,\y1)
2745     -- node { \box_use:N \g_tmpa_box }
2746     (\x2-\l_@@_up_and_down_radius_dim,\y1)
2747     [ rounded~corners = \l_@@_up_and_down_radius_dim ]
2748     -| (\p2) ;
2749 }
2750 }
2751 \end{LaTeX}
2752 \end{plain-TeX}
2753 \tl_const:Nn \c_@@_tikz_code_up_tl
2754 {
2755     \dim_case:nnF \l_@@_arrow_width_dim
2756     {
2757         \c_max_dim
2758     {

```

```

2759         \draw [ rounded-corners = \l_@@_up_and_down_radius_dim ]
2760             let \p1 = ( #1 ) , \p2 = ( #2 )
2761             in (\p1) -- node { #3 } (\x2,\y1) -- (\p2) ;
2762     }
2763     \c_zero_dim
2764     {
2765         \path node
2766         {
2767             \hbox_gset:Nn \g_tmpa_box { #3 }
2768             \dim_gset:Nn \g_tmpa_dim
2769             { \box_wd:N \g_tmpa_box + \l_@@_up_and_down_radius_dim }
2770         } ;
2771         \draw
2772             let \p1 = ( #1 ) , \p2 = ( #2 )
2773             in (\x2-\g_tmpa_dim,\y1)
2774                 -- node { \box_use:N \g_tmpa_box }
2775                 (\x2-\l_@@_up_and_down_radius_dim,\y1)
2776                 [ rounded-corners = \l_@@_up_and_down_radius_dim ]
2777                 -| (\p2) ;
2778     }
2779 }
2780 {
2781     \draw
2782         let \p1 = ( #1 ) , \p2 = ( #2 )
2783         in (\x2 - \l_@@_arrow_width_dim - \l_@@_up_and_down_radius_dim,\y1)
2784             -- node { #3 } (\x2-\l_@@_up_and_down_radius_dim,\y1)
2785             [ rounded-corners = \l_@@_up_and_down_radius_dim ]
2786             -| (\p2) ;
2787 }
2788 }
2789 \end{plain-TeX}

```

The code for an arrow of type down is similar to the previous code (for an arrow of type up).

```

2790 \begin{LaTeX}
2791 \tl_const:Nn \c_@@_tikz_code_down_tl
2792 {
2793     \dim_compare:nNnTF \l_@@_arrow_width_dim = \c_max_dim
2794     {
2795         \draw [ rounded-corners = \l_@@_up_and_down_radius_dim ]
2796             let \p1 = ( #1 ) , \p2 = ( #2 )
2797             in (\p1) -- (\x1,\y2) -- node
2798             {
2799                 \dim_set:Nn \l_tmpa_dim { \x1 - \x2 }
2800                 \begin { varwidth } \l_tmpa_dim
2801                     \narrowragged
2802                     #3
2803                 \end { varwidth }
2804             }
2805             (\p2) ;
2806     }
2807     {
2808         \path
2809             let \p1 = ( #1 ) , \p2 = ( #2 )
2810             in node
2811             {
2812                 \hbox_gset:Nn \g_tmpa_box
2813                 {
2814                     \dim_set:Nn \l_tmpa_dim

```

The 2 mm are for the tip of the arrow. We don't want the label of the arrow too close to the tip of arrow (we assume that to the tip of the arrow has its standard position, that is at the end of the arrow.).

```

2815         { \x1 - \x2 - \l_@@_up_and_down_radius_dim - 2 mm }

```

```

2816         \begin { varwidth } \l_tmpa_dim
2817         \narrowragged
2818         #3
2819         \end { varwidth }
2820     }
2821     \dim_compare:nNnTF \l_@@_arrow_width_dim > \c_zero_dim
2822     { \dim_gset_eq:Nn \g_tmpa_dim \l_@@_arrow_width_dim }
2823     { \dim_gset:Nn \g_tmpa_dim { \box_wd:N \g_tmpa_box } }
2824     \dim_gadd:Nn \g_tmpa_dim \l_@@_up_and_down_radius_dim
2825 } ;
2826
2827 \draw
2828   let \p1 = ( #1 ) , \p2 = ( #2 )
2829   in (\p1)
2830     { [ rounded~corners = \l_@@_up_and_down_radius_dim ] -- (\x1,\y2) }
2831     -- (\x1-\l_@@_up_and_down_radius_dim,\y2)
2832     -- node { \box_use:N \g_tmpa_box } (\x1-\g_tmpa_dim,\y2)
2833     -- ++ (-2mm,0) ;
2834 }
2835 }
2836 </LaTeX>
2837 %
2838 <*plain-TeX>
2839 \tl_const:Nn \c_@@_tikz_code_down_tl
2840 {
2841   \dim_case:nnF \l_@@_arrow_width_dim
2842   {
2843     \c_max_dim
2844     {
2845       \draw [ rounded~corners = \l_@@_up_and_down_radius_dim ]
2846         let \p1 = ( #1 ) , \p2 = ( #2 )
2847         in (\p1) -- (\x1,\y2) -- node { #3 } (\p2) ;
2848     }
2849     \c_zero_dim
2850     {
2851       \path node
2852       {
2853         \hbox_gset:Nn \g_tmpa_box { #3 }
2854         \dim_gset:Nn \g_tmpa_dim
2855         { \box_wd:N \g_tmpa_box + \l_@@_up_and_down_radius_dim }
2856       } ;
2857       \draw
2858         let \p1 = ( #1 ) , \p2 = ( #2 )
2859         in (\p1)
2860           { [ rounded~corners = \l_@@_up_and_down_radius_dim ] -- (\x1,\y2) }
2861           -- (\x1-\l_@@_up_and_down_radius_dim,\y2)
2862           -- node { \box_use:N \g_tmpa_box } (\x1-\g_tmpa_dim,\y2)
2863           -- ++ (-2mm,0) ;
2864     }
2865   }
2866 }
2867 \draw
2868   let \p1 = ( #1 ) , \p2 = ( #2 )
2869   in (\p1)
2870     { [ rounded~corners = \l_@@_up_and_down_radius_dim ] -- (\x1,\y2) }
2871     -- (\x1-\l_@@_up_and_down_radius_dim,\y2)
2872     -- node { #3 }
2873       (\x1 - \l_@@_arrow_width_dim - \l_@@_up_and_down_radius_dim,\y2)
2874     -- ++ (-2mm,0) ;
2875 }
2876 }
2877 </plain-TeX>

```

We recall that the options of the individual arrows are scanned twice. First, when are scanned when the command `\Arrow` occurs (we try to know whether the arrow is “individual”, etc.). That’s the first pass.

```

2878 \keys_define:nn { WithArrows / Arrow / FirstPass }
2879 {
2880   up .code:n = \@@_set_independent_bis: ,
2881   down .code:n = \@@_set_independent_bis: ,
2882   up .default:n = NoValue ,
2883   down .default:n = NoValue
2884 }

```

The options are scanned a second time when the arrow is actually drawn. That’s the second pass.

```

2885 \keys_define:nn { WithArrows / Arrow / SecondPass }
2886 {
2887   up .code:n =
2888     \str_if_empty:NT \l_@@_previous_key_str
2889     {
2890       \str_set:Nn \l_@@_previous_key_str { up }
2891       \cs_if_exist:NTF \tikz@library@calc@loaded
2892       {
2893         \keys_set:no { WithArrows / up-and-down } \l_keys_value_tl
2894         \int_set:Nn \l_@@_pos_arrow_int 1

```

We have to set `\l_@@_wrap_lines_bool` to false because, otherwise, if the option `wrap_lines` is used at a higher level (global or environment), we will have a special affectation to `tikz-code` that will overwrite our affectation.

```

2895         \bool_set_false:N \l_@@_wrap_lines_bool

```

The main action occurs now. We change the value of the `tikz-code`.

```

2896         \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_up_tl
2897       }
2898       { \@@_error:n { calc-not-loaded } }
2899     } ,
2900   down .code:n =
2901     \str_if_empty:NT \l_@@_previous_key_str
2902     {
2903       \str_set:Nn \l_@@_previous_key_str { down }
2904       \cs_if_exist:NTF \tikz@library@calc@loaded
2905       {
2906         \keys_set:no { WithArrows / up-and-down } \l_keys_value_tl
2907         \int_set:Nn \l_@@_pos_arrow_int 1
2908         \bool_set_false:N \l_@@_wrap_lines_bool
2909         \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_down_tl
2910       }
2911       { \@@_error:n { calc-not-loaded } }
2912     }
2913 }

2914 \seq_put_right:Nn \l_@@_options_Arrow_seq { down }
2915 \seq_put_right:Nn \l_@@_options_Arrow_seq { up }

2916 \@@_msg_new:nn { calc-not-loaded }
2917 {
2918   calc-not-loaded.\
2919   You~can't~use~the~option~'\l_keys_key_str'~because~you~don't~have~loaded~the~
2920   Tikz~library~'calc'.You~should~add~'\token_to_str:N\usetikzlibrary{calc}'~
2921   ~in~the~preamble~of~your~document. \
2922   \c_@@_option_ignored_str
2923 }

2924 <*plain-TeX>
2925 \catcode ` \@ = 12
2926 \ExplSyntaxOff
2927 </plain-TeX>

```

13 History

Changes between 2.8 and 2.9

Argument `<...>` for the command `\Arrow` in the class Beamer.

Changes between 2.7 and 2.8

New key `right-overlap`

Changes between 2.6b and 2.7

Correction of a bug: when the key `wrap-lines` was in force, the content of the annotations was not “flush left” by default as it should be (but justified).

Changes between 2.6 and 2.6a (and 2.6b)

Replacement of `\hbox_unpack_clear:N` by `\hbox_unpack_drop:N` since `\hbox_unpack_clear:N` is now deprecated in L3.

Version 2.6d: correction of a bug (cf. question 628461 on TeX StackExchange).

Changes between 2.5 and 2.5.1

Correction of the erroneous programming of the nodes aliases.

Changes between 2.4 and 2.5

Arrows of type `o` which are *over* other arrows.

`witharrows` now requires and loads `varwidth`

Changes between 2.3 and 2.4

Correction of a bug with `{DispWithArrows}` : cf. question 535989 on TeX StackExchange.

Changes between 2.2 and 2.3

Two options for the arrows of type `up` and `down`: `width` and `radius`.

Changes between 2.1 and 2.2

Addition of `\normalbaselines` at the beginning of `\@@_post_halign:`.

The warning for an environment ending by `\` has been transformed in **error**.

Changes between 2.0 and 2.1

Option `max-length-of-arrow`.

Validation with regular expression for the first argument of `\MultiArrow`.

Changes between 1.18 and 2.0

A version of `witharrows` is available for plain-TeX.

Changes between 1.17 and 1.18

New option `<...>` for `{DispWithArrows}`.

Option `subequations`.

Warning when `{WithArrows}` or `{DispWithArrows}` ends by `\`.

No space before an environment `{DispWithArrows}` if we are at the beginning of a `{minipage}`.

Changes between 1.16 and 1.17

Option `format`.

Changes between 1.15 and 1.16

Option `no-arrows`

The behaviour of `{DispWithArrows}` after an `\item` of a LaTeX list has been changed : no vertical is added. The previous behaviour can be restored with the option `standard-behaviour-with-items`. A given name can no longer be used for two distinct environments. However, it's possible to deactivate this control with the option `allow-duplicate-names`.

Changes between 1.14 and 1.15

Option `new-group` to start a new group of arrows (only available when the environment is composed with the option `groups`).

Tikz externalization is now deactivated in the environments of the extension `witharrows`.⁴¹

Changes between 1.13 and 1.14

New options `up` and `down` for the arrows.

Replacement of some options `0 { }` in commands and environments defined with `xparse` by `! 0 { }` (a recent version of `xparse` introduced the specifier `!` and modified the default behaviour of the last optional arguments: [//www.texdev.net/2018/04/21/xparse-optional-arguments-at-the-end](http://www.texdev.net/2018/04/21/xparse-optional-arguments-at-the-end)).

Modification of the code of `\WithArrowsNewStyle` following a correction of a bug in `l3keys` in the version of `l3kernel` of 2019/01/28.

New error message `Inexistent~v-node` to avoid a `pgf` error.

The error `Option incompatible with 'group(s)'` was suppressed in the version 1.12 but this was a mistake since this error is used with the option `xoffset` at the local level. The error is put back.

Changes between 1.12 and 1.13

Options `start-adjust`, `end-adjust` and `adjust`.

This version is not strictly compatible with previous ones. To restore the behaviour of the previous versions, one has to use the option `adjust` with the value `0 pt`:

```
\WithArrowsOptions{adjust = 0pt}
```

Changes between 1.11 and 1.12

New command `\tagnextline`.

New option `tagged-lines`.

An option of position (`ll`, `lr`, `rl`, `rr` or `i`) is now allowed at the local level even if the option `group` or the option `groups` is used at the global or environment level.

Compatibility of `{DispWithArrows}` with `\qedhere` of `amsthm`.

Compatibility with the packages `refcheck`, `showlabels` and `listbls`.

The option `\AllowLineWithoutAmpersand` is deprecated because lines without ampersands are now always allowed.

Changes between 1.10 and 1.11

New commands `\WithArrowsNewStyle` and `\WithArrowsRightX`.

⁴¹Before this version, there was an error when using `witharrows` with Tikz externalization. In any case, it's not possible to externalize the Tikz elements constructed by `witharrows` because they use the options `overlay` and `remember picture`.

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.

Changes between 1.8 and 1.9

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

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`.

Changes between 1.6 and 1.7

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

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}`.

Changes between versions 1.4 and 1.5

The Tikz code used to draw the arrows can be changed with the option `tikz-code`.

Two new options `code-before` and `code-after` have been added at the environment level.

A special version of `\Arrow` is available in `code-after` in order to draw arrows in nested environments.

A command `\MultiArrow` is available in `code-after` to draw arrows of other shapes.

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`.

Changes between versions 1.2 and 1.3

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

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*)

Changes between versions 1.0 and 1.1

Option for the command `\` and option `interline`

Compatibility with `\usetikzlibrary{babel}`

Possibility of nested environments `{WithArrows}`

Contents

1 Options for the shape of the arrows

2

2	Numbers of columns	6
3	Precise positioning of the arrows	7
4	The option 'o' for individual arrows	9
5	The options 'up' and 'down' for individual arrows	10
6	Comparison with the environment {aligned}	11
7	Arrows in nested environments	14
8	Arrows from outside environments {WithArrows}	16
9	The environment {DispWithArrows}	17
9.1	The option <...> of DispWithArrows	22
10	Advanced features	23
10.1	Utilisation with Beamer	23
10.2	Use with plain-Tex	23
10.3	The option tikz-code : how to change the shape of the arrows	24
10.4	The command \WithArrowsNewStyle	24
10.5	The key right-overlap	25
10.6	Vertical positioning of the arrows	25
10.7	Footnotes in the environments of witharrows	27
10.8	Option no-arrows	27
10.9	Note for the users of AUCTex	27
10.10	Note for the developpers	28
11	Examples	28
11.1	\MoveEqLeft	28
11.2	A command \DoubleArrow	28
11.3	Modifying the shape of the nodes	29
11.4	Examples with the option tikz-code	29
11.4.1	Example 1	30
11.4.2	Example 2	30
11.4.3	Example 3	31
11.5	Automatic numbered loop	32
12	Implementation	33
12.1	Declaration of the package and extensions loaded	33
12.2	The packages footnote and footnotehyper	34
12.3	The class option leqno	36
12.4	Collecting options	36
12.5	Some technical definitions	37
12.6	Variables	39
12.7	The definition of the options	42
12.8	The command \Arrow	50
12.9	The environments {WithArrows} and {DispWithArrows}	52
12.9.1	Code before the \halign	52
12.9.2	The construction of the preamble of the \halign	55
12.9.3	The environment {WithArrows}	58
12.9.4	After the construction of the \halign	59
12.9.5	The command of end of row	61
12.9.6	The environment {DispWithArrows}	64
12.10	The commands \tag, \notag, \label, \tagnextline and \qedhere for {DispWithArrows}	70
12.11	We draw the arrows	72
12.11.1	The command update_x	81
12.11.2	We draw the arrows of type o	82
12.12	The command \Arrow in code-after	84

12.13	The command <code>\MultiArrow</code> in code-after	86
12.14	The error messages of the package	88
12.15	The command <code>\WithArrowsNewStyle</code>	95
12.16	The options <code>up</code> and <code>down</code>	96
13	History	101