The package witharrows for plain-TeX and LaTeX*

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Abstract

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

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). This package loads the packages l3keys2e, 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 \Arrow{we expand} \\
&= a^2 + 2a + 1 % <-------- don’t put \ here
\end{WithArrows}$

$A = (a + 1)^2$
\begin{itemize}
\item $a^2 + 2a + 1$ \textit{we expand}
\end{itemize}

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

The environment \{WithArrows\} bears similarities with the environment \{aligned\} of amsmath (and mathtools). The extension witharrows also provides an environment \{DispWithArrows\} which is similar to the environment \{align\} of amsmath: cf. p. 17.

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¹This document corresponds to the version 2.8a of witharrows, at the date of 2023/02/14.

¹If you use Overleaf, Overleaf will do automatically the right number of compilations.
1 Options for the shape of the arrows

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

The option \texttt{jump} gives the number\footnote{It’s not possible to give a non-positive value to \texttt{jump}. See below (p. 2) the way to draw an arrow which goes backwards.} of rows the arrow must jump (the default value is, of course, 1).

\begin{WithArrows}
A &= \bigl((a+b)+1\bigr)^2 \\Arrow\{we expand\} \quad \& = (a+b)^2 + 2(a+b) +1 \quad \\
& = a^2 + 2ab + b^2 + 2a + 2b +1 \end{WithArrows}

\begin{itemize}
\item It’s possible to put several arrows starting from the same row.
\end{itemize}

\begin{WithArrows}
A &= \bigl((a+b)+1\bigr)^2 \Arrow\{jump=2\} \Arrow\{\texttt{jump=2}\} \quad \\
& = (a+b)^2 + 2(a+b) +1 \quad \\
& = a^2 + 2ab + b^2 + 2a + 2b +1 \end{WithArrows}

The option \texttt{xoffset} shifts the arrow to the right (we usually don’t want the arrows to be stucked on the text). The initial value of \texttt{xoffset} is 3 mm.

\begin{WithArrows}
A &= \bigl((a+b)+1\bigr)^2 \\Arrow\{xoffset=1cm\} \quad \\
& = (a+b)^2 + 2(a+b) +1 \end{WithArrows}

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

\begin{WithArrows}
A &= (a+1)^2 \\Arrow\{tikz=thick\} \quad \\
& = a^2 + 2a + 1 \end{WithArrows}

It’s also possible to change the arrowheads. For example, we can draw an arrow which goes backwards with the \texttt{Tikz} option \texttt{<--}.

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

\begin{align*}
A &= (a+1)^2 \\
&= a^2 + 2a + 1
\end{align*}

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{align*}
A &= (a+1)^2 \\
&= a^2 + 2a + 1
\end{align*}

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{align*}
A &= (a+1)^2 \\
&= a^2 + 2a + 1
\end{align*}

we expand

In fact, it’s possible to change more drastically the shape or the arrows with the option \texttt{tikz-code} (presented on p. 23).

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{align*}
A &= ((a+b)+1)^2 \\
&= (a+b)^2 + 2(a+b) +1 \\
&= a^2 + 2ab + b^2 + 2a + 2b +1
\end{align*}

We have done a two-stages expansion but it would have been clever to expand with the multinomial theorem.

In the environments \texttt{DispWithArrows} and \texttt{DispWithArrows*}, there is an option \texttt{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 \texttt{\bfseries}, \texttt{\large} or \texttt{\sffamily} at the beginning of the text. But, by default, the texts are composed with a combination of \texttt{\small} and \texttt{\itshape}. When adding \texttt{\bfseries} at the beginning of the text, we won’t suppress the \texttt{\small} and the \texttt{\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}$
\[ A = (a + 1)^2 \]
\[ = a^2 + 2a + 1 \quad \text{we expand} \]

It’s possible to put commands \ in the text to force new lines\(^3\). 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 \texttt{tabular}). That’s why Tikz gives an option \texttt{font} to modify the font of the whole text. Nevertheless, if we use the option \texttt{tikz=\{font={\bfseries}\}}, the default specification of \texttt{small} and \texttt{itshape} will be overwritten.

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

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

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

The options can be given directly between square brackets to the environment \texttt{WithArrows}. There must be no space between the \texttt{\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 & = b(\{(a+b)+1\})^2 \Arrow{first expansion.} \\\n& = (a+b)^2 + 2(a+b) + 1 \Arrow{second expansion.} \\\n& = a^2 + 2ab + b^2 + 2a + 2b + 1 \end{WithArrows}

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

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

Without the option \texttt{displaystyle}:

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

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

\(^3\)By default, this is not possible in a Tikz node. However, in \texttt{witharrows}, the nodes are created with the option \texttt{align=left}, and, thus, it becomes possible.

\(^4\)They also apply to the nested environments \texttt{WithArrows} (with the logical exceptions of \texttt{interline}, \texttt{code-before} and \texttt{code-after}).
The same example with the option \texttt{displaystyle}:
\[
\int_0^1 (x+1)^2 \, dx = \int_0^1 (x^2 + 2x + 1) \, dx \\
= \int_0^1 x^2 \, dx + 2 \int_0^1 x \, dx + \int_0^1 1 \, dx \\
= \frac{1}{3} + \frac{2}{2} + 1 \\
= \frac{7}{3}
\]

Almost all the options can also be set at the document level with the command \texttt{\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 \texttt{displaystyle} with blue arrows, we can write \texttt{\WithArrowsOptions\{displaystyle,tikz=blue\}}.\footnote{It’s also possible to configure \texttt{witharrows} by modifying the Tikz style \texttt{WithArrows/arrow} which is the style used by \texttt{witharrows} when drawing an arrow. For example, to have the labels in blue with roman (upright) types, one can use the following instruction: \texttt{\tikzset{WithArrows/arrow/.append style = {blue,font = \textsc{}}}}.}

\begin{WithArrows}
\[\text{command-name=Explanation}\]
\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}$

The command \texttt{\Arrow} is recognized only in the environments \{WithArrows\}. If we have a command \texttt{\Arrow} previously defined, it’s possible to go on using it outside the environments \{WithArrows\}. However, a previously defined command \texttt{\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 \texttt{\Arrow} of the package \texttt{witharrows}: there is an option \texttt{command-name} for this purpose. The new name of the command must be given to the option \texttt{without} the leading backslash.

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

The environment \{WithArrows\} provides also two options \texttt{code-before} and \texttt{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}
\[\text{code-before = \color{blue}}\]
A & = (a+b)^2 \ Arrow{we expand} \\
& = a^2 + 2ab + b^2
\end{WithArrows}$
\[ A = (a + b)^2 = a^2 + 2ab + b^2 \] we expand

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`: these 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 `1`, 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`.

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

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

```latex
\begin{DispWithArrows*}[format = cCcCc, wrap-lines, interline=1mm]
k & \le t & \le k+1 \\
\frac{1}{k+1} & \le \frac{1}{t} & \le \frac{1}{k} \\
\int_k^{k+1} \frac{d t}{t} & \le \int_k^{k+1} \frac{d t}{k} \le \int_k^{k+1} \frac{d t}{k} \\\n\frac{1}{k+1} & \le \ln(k+1) - \ln(k) \le \frac{1}{k} \end{DispWithArrows*}
```

we can integrate the inequalities since \(k \leq k+1\)
3 Precise positioning of the arrows

The environment \texttt{WithArrows} defines, during the composition of the array, two series of nodes materialized in red in the following example.\footnote{The option \texttt{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 \texttt{south} anchor of the first node and arrives at the \texttt{north} anchor of the second node.}

\[
I = \int_{\frac{\pi}{4}}^{0} \ln \left( 1 + \tan \left( \frac{\pi}{4} - u \right) \right) (-du) \quad ,
\]

\[
= \int_{0}^{\frac{\pi}{4}} \ln \left( 1 + \tan \left( \frac{\pi}{4} - u \right) \right) du \quad ,
\]

\[
= \int_{0}^{\frac{\pi}{4}} \ln \left( 1 + \frac{1 - \tan u}{1 + \tan u} \right) du \quad ,
\]

\[
= \int_{0}^{\frac{\pi}{4}} \ln \left( \frac{1 + \tan u + 1 - \tan u}{1 + \tan u} \right) du \\ 
= \int_{0}^{\frac{\pi}{4}} \ln \left( \frac{2}{1 + \tan u} \right) du \quad ,
\]

\[
= \int_{0}^{\frac{\pi}{4}} (\ln 2 - \ln(1 + \tan u)) du \quad ,
\]

\[
= \frac{\pi}{4} \ln 2 - \int_{0}^{\frac{\pi}{4}} \ln(1 + \tan u) du \\ 
= \frac{\pi}{4} \ln 2 - I .
\]

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

By default, the arrows use the right nodes. We will say that they are in \texttt{rr} mode (\texttt{r} for \textit{right}). These arrows are vertical (we will say that an arrow is \textit{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 \texttt{lr}, \texttt{rl} and \texttt{ll} (\texttt{l} for \textit{left}). Those arrows are, usually, not vertical.

Therefore

\[
I = \int_{\frac{\pi}{4}}^{0} \ln \left( 1 + \tan \left( \frac{\pi}{4} - u \right) \right) (-du) \quad \text{This arrow uses the \texttt{lr} option.}
\]

\[
= \int_{0}^{\frac{\pi}{4}} \ln \left( 1 + \tan \left( \frac{\pi}{4} - u \right) \right) du \\ 
= \int_{0}^{\frac{\pi}{4}} \ln \left( 1 + \frac{1 - \tan u}{1 + \tan u} \right) du \\ 
= \int_{0}^{\frac{\pi}{4}} \ln \left( \frac{1 + \tan u + 1 - \tan u}{1 + \tan u} \right) du \\ 
= \int_{0}^{\frac{\pi}{4}} \ln \left( \frac{2}{1 + \tan u} \right) du \\ 
= \int_{0}^{\frac{\pi}{4}} (\ln 2 - \ln(1 + \tan u)) du \\ 
= \frac{\pi}{4} \ln 2 - \int_{0}^{\frac{\pi}{4}} \ln(1 + \tan u) du \\ 
= \frac{\pi}{4} \ln 2 - I
\]

There is also an option called \texttt{i} (\textit{i} for \textit{intermediate}). With this option, the arrow is vertical and at the leftmost position.
$(a+b)(a+ib)(a-b)(a-ib)$ \& $=(a+b)(a-b)\cdot(a+ib)(a-ib)$ \& $=(a^2-b^2)(a^2+b^2)$ \& because $(x-y)(x+y)=x^2-y^2$\& $=a^4-b^4$

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]
\begin{align*}
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 2x K'y_0 = \sqrt{x} \text{ we replace } y_0 \text{ by its value} \\
&\iff 2x K'x^\frac{1}{2} = x^\frac{1}{2} \text{ simplification of the } x \\
&\iff K' = \frac{\sqrt{x}}{2x} \text{ antiderivation}
\end{align*}
\end{WithArrows}$

The environment \{WithArrows\} gives also a **groups** option (with a \textit{s} in the name). With this option, the arrows are divided into several “groups”. Each group is a set of connected\textsuperscript{7} arrows. All the arrows of a given group are grouped on a same vertical line and at a leftmost position.

\begin{itemize}
\item $A = B$
\item $= C + D \tikzarrow{\text{one}}$
\item $= D' \tikzarrow{\text{two}}$
\item $= E + F + G + H + I$
\item $= K + L + M \tikzarrow{\text{three}}$
\item $= N \tikzarrow{\text{four}}$
\end{itemize}

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 arrow\textsuperscript{8}. 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 \texttt{\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 \texttt{rr}: \begin{WithArrows}[rr]
\end{WithArrows}

\textsuperscript{7}More precisely: for each arrow \textit{a}, we note \textit{i}(\textit{a}) the number of its initial row and \textit{f}(\textit{a}) the number of its final row; for two arrows \textit{a} and \textit{b}, we say that \textit{a} \sim \textit{b} when \([i(a), f(a)] \cap [i(b), f(b)] \neq \emptyset\); the groups are the equivalence classes of the transitive closure of \sim.

\textsuperscript{8}Such arrow will be called independent in the technical documentation.
In the following example, we have used the option \textbf{groups} for the environment and the option \textbf{new-group} for the last arrow (that’s why the last arrow is not aligned with the others).

\[
\begin{align*}
\sum_{k=0}^{n} \cos(kz) &= \sum_{k=0}^{n} \Re(e^{ikz}) \\
&= \sum_{k=0}^{n} \Re\left( \frac{e^{ikz}}{(\cos z)^k} \right) \\
&= \Re\left( \sum_{k=0}^{n} \frac{(\cos z)^{k}}{1 - e^{ikz}} \right) \\
&= \frac{1 - (\frac{e^{iz}}{1 - e^{iz}})^{n+1}}{1 - \frac{e^{iz}}{1 - e^{iz}}} \\
&= \Re\left( \frac{\cos^{n+1}x - e^{i(n+1)x}}{\cos x - e^{ix}} \right) \\
&= \frac{1}{\cos^2 x} \Re\left( \frac{\cos^{n+1}x - e^{i(n+1)x}}{\cos x - e^{ix}} \right) \\
&= \frac{1}{\cos^2 x} \Re\left( \frac{\cos^{n+1}x - \cos(n+1)x + i\sin(n+1)x}{\cos x - \cos x + i\sin x} \right) \\
&= \frac{1}{\cos^2 x} \Re\left( \frac{\cos^{n+1}x - \cos(n+1)x - i\sin(n+1)x}{\sin x} \right) \\
&= \frac{1}{\cos^2 x} \frac{\sin(n+1)x}{\sin x}
\end{align*}
\]

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

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 \(a\) \textit{covers} the arrow \(b\) when \(i_a \leq i_b \leq f_b\) \(f_a\). We will also say that the arrow \(a\) is \textit{over} the arrow \(b\).

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

\[
\begin{array}{c}
A = B \\
= C \\
= D \\
= E
\end{array}
\]

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

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

\begin{verbatim}
\begin{WithArrows}[groups]
A & = B \\
& = C + C \\
& = D + D + D \\
& = E + E \\
& = F + F
\end{WithArrows}$
\end{verbatim}
Arrows of type \( o \) may themselves be covered by other arrows of type \( o \).

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

The horizontal space between an arrow of type \( o \) and the arrows immediately covered is fixed by the dimension \texttt{xoffset-for-o-arrows} which can be set which the command \texttt{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:

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

The options \texttt{up} and \texttt{down} require the Tikz library \texttt{calc}. It it has not been previously loaded by the user, an error will be raised.

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

- The key \texttt{radius} is the radius of the rounded corner of the arrow.\(^{10}\)
- The key \texttt{width} is the width of the (horizontal part of) the arrow:
  - with the value \texttt{max}, the width of the arrow is adjusted with respect of the position of the nodes (that's the behaviour by default of the arrows \texttt{up} and \texttt{down} as shown in the previous example);

\(^{10}\)The initial value of this parameter is 4 pt, which is the default value of the “\texttt{rounded corners}” of Tikz.
– with a numerical value, the width of the arrow is directly fixed to that numerical value;
– with the value \texttt{min}, the width of the arrow is adjusted with respect to the contents of the label of the arrow.

\begin{WithArrows}
A & = B \\
\Arrow[up={radius=0pt,width=2cm}]{we try} & = C + C + C + C + C + C + C + C \\
\end{WithArrows}

\begin{WithArrows}
A & = B \\
\Arrow[up={width=min}]{we try} & = C + C + C + C + C + C + C + C \\
\end{WithArrows}

The options relative to the arrows \texttt{up} and \texttt{down} can be fixed at the global or environment level with the key \texttt{up-and-down}. This key may also be used as prefix as illustrated now.

\WithArrowsOptions{up-and-down/width=min}

\section{Comparison with the environment \{aligned\}}

\{WithArrows\} bears similarities with the environment \{aligned\} of the extension \texttt{amsmath}. These are only similarities because \{WithArrows\} has not been written upon the environment \{aligned\}.$^{11}$

As in the environments of \texttt{amsmath}, it’s possible to change the spacing between two given rows with the option of the command \texttt{\textbackslash \textbackslash} of end of line (it’s also possible to use \texttt{\textbackslash \textbackslash *} but it has exactly the same effect as \texttt{\textbackslash \textbackslash} since an environment \{WithArrows\} is always unbreakable). This option is designed to be used with positive values only.

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

$^{11}$In fact, it’s possible to use the package \texttt{witharrows} without the package \texttt{amsmath}.
\[ A = (a + 1)^2 \]
\[ = a^2 + 2a + 1 \]

In the environments of \texttt{amsmath} (or \texttt{mathtools}), the spacing between rows is fixed by a parameter called \texttt{jot} (it’s a dimension and not a skip). That’s also the case for the environment \texttt{WithArrows}. An option \texttt{jot} has been given to the environment \texttt{WithArrows} in order to change the value of this parameter \texttt{jot} for a given environment.\footnote{\textquote{It’s also possible to change \texttt{jot} with the environment \texttt{spreadlines} of \texttt{mathtools}.}}

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

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

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

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

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

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

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

So \[ A = (a + 1)^2 = a^2 + 2a + 1 \]

we expand

The value \texttt{c} may be useful, for example, if we want to add curly braces:

\begin{itemize}
\item Let’s set \[ f(x) = 3x^3 + 2x^2 - x + 4 \]
\item \( g(x) = 5x^2 - 5x + 6 \)
\item \[ \begin{align*}
\end{align*} \]
\end{itemize}

\texttt{WithArrowsOptions\{c,displaystyle\}}.

The following example is composed with \{aligned\}:
\[ \begin{aligned}
\sum_{i=1}^{n} (x_i + 1)^2 &= \sum_{i=1}^{n} (x_i^2 + 2x_i + 1) \\
&= \sum_{i=1}^{n} x_i^2 + 2 \sum_{i=1}^{n} x_i + n
\end{aligned} \]

The following is composed with \{WithArrows\}[c,displaystyle]. The results are strictly identical.\(^\text{13}\)
\[ \begin{aligned}
\sum_{i=1}^{n} (x_i + 1)^2 &= \sum_{i=1}^{n} (x_i^2 + 2x_i + 1) \\
&= \sum_{i=1}^{n} x_i^2 + 2 \sum_{i=1}^{n} x_i + n
\end{aligned} \]

\(^\text{13}\)In versions of \texttt{amsmath} older than the 5 nov. 2016, a thin space was added on the left of an environment \{aligned\}. The new versions do not add this space and neither do \{WithArrows\}.
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 \texttt{interline}, \texttt{code-before} and \texttt{code-after}). The command \texttt{Arrow} can be used as usual in each environment \{WithArrows\}.

$$\begin{WithArrows}
\varphi(x,y) = 0 \iff (x+2y)^2 + (2x+4y)^2 = 0 \Arrow\text{the numbers are real}\\\n& \begin{align*}
\left\{ & \begin{align*}
x + 2y &= 0 \\
2x + 4y &= 0
\end{align*} \\
& \begin{align*}
x + 2y &= 0 \\
x + 2y &= 0
\end{align*}
\right. \\
& \text{the same equation}\\\n& \text{the same equation}\\\n& x + 2y = 0
\end{align*}
\right. \\right. \\
& \Arrow\text{the same equation}\\\n& \text{the same equation}\\\n& x + 2y = 0
\end{WithArrows}$$

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:

$$\varphi(x,y) = 0 \iff (x+2y)^2 + (2x+4y)^2 = 0 \left\{ \begin{array}{l}
x + 2y = 0 \\
2x + 4y = 0 \\
x + 2y = 0 \\
x + 2y = 0
\end{array} \right\} \text{division by 2}$$

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

A command \texttt{\Arrow} in \texttt{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\}.
\[ \varphi(x,y) = 0 \iff (x + 2y)^2 + (2x + 4y)^2 = 0 \]
\[ \iff \begin{cases} 
  x + 2y = 0 \\
  2x + 4y = 0 
\end{cases} \quad \text{environment number 1} \]
\[ \iff \begin{cases} 
  x + 2y = 0 \\
  x + 2y = 0 
\end{cases} \quad \text{division by 2} \]
\[ \iff x + 2y = 0 \]

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 \texttt{\arrow in code-after}:

\begin{verbatim}
\begin{WithArrows}
\begin{align*}
\varphi(x,y) = 0 & \iff (x + 2y)^2 + (2x + 4y)^2 = 0 \\&
\end{align*}
\end{WithArrows}
\end{verbatim}

The options allowed for a command \texttt{\arrow in code-after} are: \texttt{ll}, \texttt{lr}, \texttt{rl}, \texttt{rr}, \texttt{v}, \texttt{xoffset}, \texttt{tikz} and \texttt{tikz-code}. Except \texttt{v}, which is specific to \texttt{\arrow in code-after}, all these options have their usual meaning.

With the option \texttt{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 \texttt{i}. Currently, the option \texttt{i} is not available for the command \texttt{\arrow in code-after}. However, it's always possible to translate an arrow with \texttt{xoffset} (or \texttt{xshift} of Tikz).

\begin{verbatim}
\begin{WithArrows}[tikz = rounded corners, code-after = \{\MultiArrow{1,...,4}{text}\}]
\begin{align*}
\varphi(x,y) = 0 & \iff (x + 2y)^2 + (2x + 4y)^2 = 0 \\&
\end{align*}
\end{WithArrows}
\end{verbatim}

The package \texttt{witharrows} gives also another command available only in \texttt{code-after}: the command \texttt{\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 \texttt{\multiarrow}. This list is given with the syntax of the list in a \texttt{\foreach} command of \texttt{pgf}.
& = D \\  
& = E \\  
& = F 
\end{WithArrows}

\[ A = B \quad \begin{array}{c} \leftrightarrow \\
= C \\
= D \\
= E \\
= F 
\end{array} \]

As of now, there is no option available for the command $\texttt{\textbackslash MultiArrow}$ (maybe in a future release).

8 Arrows from outside environments \{WithArrows\}

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

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

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

\[ A \triangleright B + B + B + B + B + B + B + B + B + B + B + Bwaw-45-1-r \]
\[ \triangleright \begin{cases} C \triangleright Dwaw-45-1-1-r \\ E \triangleright Fwaw-45-1-2-r \end{cases} \]
\[ G \triangleright H + H + H + H + H + Hwaw-45-2-1-r \]
\[ \triangleright \begin{cases} J \triangleright Kwaw-45-2-1-1-r \\ L \triangleright Mwaw-45-2-1-2-r \end{cases} \]
\[ N \triangleright Owaw-45-3-1-r \]
\[ P \triangleright Qwaw-45-3-2-r \]

The package \texttt{witharrows} provides some tools facilitating the use of these nodes:

- the command $\texttt{\textbackslash WithArrowsLastEnv}$ gives the number of the last environment of level 0 (i.e. which is not included in another environment of the package \texttt{witharrows});
- a name can be given to a given environment with the option \texttt{name} and, in this case, the nodes created in the environment will have aliases constructed with this name;
- the TikZ style \texttt{WithArrows/arrow} is the style used by \texttt{witharrows} when drawing an arrow\(^\text{15}\);  
- the TikZ style \texttt{WithArrows/arrow/tips} is the style for the tip of the arrow (loaded by \texttt{WithArrows/arrow}).

For example, we can draw an arrow from \texttt{wa-45-2-1-2-r.south} to \texttt{wa-45-3-2-r.north} with the following TikZ command.

\(^{14}\)There is an option \texttt{show-node-names} to show the names of these nodes.  
\(^{15}\)More precisely, this style is given to the TikZ option “\texttt{every path}” before drawing the arrow with the code of the option \texttt{tikz-code}. This style is modified (in TeX scopes) by the option \texttt{tikz} of \texttt{witharrows}. 

16
\begin{tikzpicture}[remember picture, overlay]
\draw [WithArrows/arrow]
  (\[xshift=3mm\]wa-\{WithArrows\}LastEnv-2-1-2-r.south)
to (\[xshift=3mm\]wa-\{WithArrows\}LastEnv-3-2-r.north);
\end{tikzpicture}

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

In this case, it would be easier to use a command \textbackslash Arrow in \texttt{code-after} but this is an example to explain how the Tikz nodes created by \texttt{witharrows} can be used.

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

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

\begin{WithArrows}[name=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}{r}
A = B \\
= C
\end{array}
\begin{array}{r}
A' = B' \\
= C'
\end{array}

9 The environment \{DispWithArrows\}

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

The environment \{DispWithArrows\} must be used \textit{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{equation}
A = (a + 1)^2 \\
   = a^2 + 2a + 1 \quad \text{we expand}
\end{equation}

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}

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

\end{DispWithArrows}


A link to the equation (\star).\footnote{In this document, the references have been customized with \labelformat{equation}{(#1)} in the preamble.}

If \texttt{amsmath} (or \texttt{mathtools}) is loaded, it’s also possible to use \texttt{\tag*} which, as in \texttt{amsmath}, typesets the tag without the parentheses. For example, it’s possible to use it to put the symbol \texttt{\square} of amssymb. This symbol is often used to mark the end of a proof.\footnote{Notice that the environment \texttt{DispWithArrows} is compatible with the command \texttt{\qedhere} of \texttt{amsthm}.}

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

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

\end{DispWithArrows}

It’s also possible to suppress all the autogenerated numbers with the boolean option \texttt{notag} (or \texttt{nonumber}), at the global or environment level. There is also an environment \texttt{DispWithArrows*} which suppresses all these numbers.\footnote{Even in this case, it’s possible to put a “manual tag” with the command \texttt{\tag}.}

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

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

\end{DispWithArrows*}

In fact, there is also another option \texttt{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 \texttt{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 \texttt{all} which means that all the lines will be tagged.

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

16 In this document, the references have been customized with \texttt{\labelformat{equation}{(#1)}} in the preamble.
17 Notice that the environment \texttt{DispWithArrows} is compatible with the command \texttt{\qedhere} of \texttt{amsthm}.
18 Even in this case, it’s possible to put a “manual tag” with the command \texttt{\tag}.
\[ A = A_1 \]
\[ = A_2 \]
\[ = A_3 \]

first stage

second stage

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

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

\[ a^2 + 2a + 1 \]

Remark: By design, the option \texttt{fleqn} of \texttt{witharrows} is independent of the option \texttt{fleqn} of LaTeX. Indeed, since the environments of \texttt{witharrows} are meant to be used with arrows on the right side, the user may want to use \texttt{witharrows} with the option \texttt{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 \texttt{leqno} is used as a class option, the labels will be composed on the left also for the environments \{DispWithArrows\} and \{DispWithArrows*\}.

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

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

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

First environment.
\[ A = B \quad (6a) \]
\[ = C \quad (6b) \]

Second environment.
\[ D = E \quad (7a) \]
\[ = F \quad (7b) \]

\footnote{The package \texttt{amsmath} has an option \texttt{leqno} but \texttt{witharrows}, of course, is not aware of that option: \texttt{witharrows} only checks the option \texttt{leqno} of the document class.}
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 \texttt{\textbackslash 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)^kk}
+(-1)^{(2p+1)}(2p+1)^2+(-1)^{(2p+2)}(2p+2)^2 \tag{8}
\end{DispWithArrows}

\begin{DispWithArrows*}[displaystyle, wrap-lines]
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) \tag{9}
\end{DispWithArrows*}

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

The option \texttt{wrap-lines} doesn’t apply to the environments \{WithArrows\} nested in an environment \{DispWithArrows\} or \{DispWithArrows*\}. However, it applies to the instructions \texttt{\Arrow} and \texttt{\MultiArrow} of the \texttt{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.\footnote{It’s possible to disable this feature with the option \texttt{standard-behaviour-with-items}.}

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

\begin{enumerate}
\item
\begin{DispWithArrows}\
\[displaystyle, wrap-lines, tagged-lines = last, fleqn, mathindent = 0 pt\]
S_n & = \frac1n \Re \left(\sum_{k=0}^{n-1}\left(e^{i\frac{\pi}{2n}}\right)^k\right) \\
& = \frac1n \Re \left(1 - \left(e^{i\frac{\pi}{2n}}\right)^n\right) \\
& = \frac1n \Re \left(\frac{1 - i}{1 - e^{i\frac{\pi}{2n}}}\right) \\
\Arrow{$\left(e^{i\frac{\pi}{2n}}\right)^n = e^{i\frac{\pi}2} = i$} \end{DispWithArrows}
\end{enumerate}

\begin{align}
1. \quad S_n &= \frac1n \Re \left(\sum_{k=0}^{n-1}\left(e^{i\frac{\pi}{2n}}\right)^k\right) \\
&= \frac1n \Re \left(\frac{1 - e^{i\frac{\pi}{2n}}}{1 - e^{i\frac{\pi}{2n}}}\right) \\
&= \frac1n \Re \left(\frac{1 - i}{1 - e^{i\frac{\pi}{2n}}}\right)
\end{align}

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

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

- The environment \{DispWithArrows\} cannot be inserted in an environment \{gather\} of \texttt{amsmath}.
- An environment \{DispWithArrows\} is always unbreakable (even with \texttt{allowdisplaybreaks} of \texttt{amsmath}).
- The commands \texttt{\label, \tag, \notag} and \texttt{\nonumber} are allowed only in the last column.
- After an \texttt{\item} of a \LaTeX{} list, no vertical space is added (this can be changed with the option \texttt{standard-behaviour-with-items}).
- Last but not least, by default, the elements of a \{DispWithArrows\} are composed in \texttt{textstyle} and not in \texttt{displaystyle} (it’s possible to change this point with the option \texttt{displaystyle}).

Concerning the references, the package \texttt{witharrows} is compatible with the extensions \texttt{autonum}, \texttt{cleveref}, \texttt{fancyref}, \texttt{hyperref}, \texttt{listlts}, \texttt{prettyst}, \texttt{refcheck}, \texttt{refstyle}, \texttt{showlabels}, \texttt{smartref}, \texttt{typedref} and \texttt{varioref}, and with the options \texttt{showonlyrefs} and \texttt{showmanualtags} of \texttt{mathtools}.\footnote{We recall that \texttt{varioref}, \texttt{hyperref}, \texttt{cleveref} and \texttt{autonum} must be loaded in this order. The package \texttt{witharrows} can be loaded anywhere.}

It is not compatible with \texttt{showkeys} (not all the labels are shown).
9.1 The option <...> of DispWithArrows

The environment \{DispWithArrows\} provides an option \textit{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.\footnote{The option \textit{left-brace} can also be used without value: in this case, only the brace is drawn...}

For legibility, this option \textit{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.\footnote{The 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.}

\begin{DispWithArrows}< \binom{n}{p} = > [format = ll,fleqn,displaystyle]
0 & \quad \text{if } p > n \\
\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}

(14)

\begin{align}
\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}
\end{align}

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

\begin{DispWithArrows}< \label{system} \ref*{system} \Leftrightarrow > [
\quad \begin{array}{l}
x+y+z = -3 \\
xy+xz+yz=-2 \\
xyz = -15
\end{array}
\end{DispWithArrows}

(17)

\begin{align}
\begin{split}
x+y+z &= -3 \\
xy+xz+yz &= -2 \\
xyz &= -15
\end{split} \\
& 3 \text{ equations}
\end{align}

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 \texttt{\ref*} used in the code above is a variant of the command \texttt{\ref} which does not create interactive link (even when hyperref is loaded).

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

10.1 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).

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

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).

10.2 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.\footnote{If 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.}

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.

By default, the value is the following:

\begin{verbatim}
\draw (#1) to node {\#3} (#2) ;
\end{verbatim}

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 \begin{aligned}
  \begin{align*}
  & (2x+4) = 6 \\
  & 2x+4 = 2 \\
  & 2x = -2 \\
  & x = -1 \\
\end{align*}
\end{aligned} \Arrow{$\div 3$} \\
\end{WithArrows}
The environments \{DispWithArrows\} and its starred version \{DispWithArrows*\} provide a command \WithArrowsRightX which can be used in a definition of \texttt{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. 29.

10.3 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.

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. 29.

10.4 The key right-overlap

New 2.8

The key right-overlap is a boolean key whose initial value is \texttt{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 \texttt{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.

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

The tuning right-overlap = \texttt{false} may also be useful in conjunction with the class \texttt{standalone}.
10.5 Vertical positioning of the arrows

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

We first explain the behaviour when the parameters \texttt{start-adjust} and \texttt{end-adjust} are equal to zero:

- the option \texttt{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 \texttt{ygap} sets the vertical distance between two consecutive arrows (initial value: 0.4 ex).

\[
\begin{align*}
\cos x + \sin x &= \cos^2 x + 2 \cos x \sin x + \sin^2 x \quad \text{ystart} \\
&= \cos^2 x + \sin^2 x + 2 \sin x \cos x \quad \text{ygap} \\
&= 1 + \sin(2x)
\end{align*}
\]

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

Here is for example the behaviour without the mechanism of \texttt{start-adjust} and \texttt{end-adjust}:

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

Here is the standard behaviour since version 1.13 (the parameters \texttt{start-adjust} and \texttt{end-adjust} are used with the initial value 0.4 ex). The arrow is longer and the result is more aesthetic.

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

It’s also possible to use the option \texttt{adjust} which sets both \texttt{start-adjust} and \texttt{end-adjust}.

Since the version 2.1 of \texttt{witharrows}, an arrow of \texttt{jump} equal to 1 has a maximal length equal to the parameter \texttt{max-length-of-arrow}. The initial value of this parameter is 2 cm.

In the following example, the value of \texttt{max-length-of-arrow} has been fixed to 1.5 cm.

\[
\begin{WithArrows}[\texttt{max-length-of-arrow = 1.5cm}]
A & = \\
& \begin{vmatrix}
1 & a & a^2 & a^3 & a^4 \\
1 & b & b^2 & b^3 & b^4 \\
1 & c & c^2 & c^3 & c^4 \\
1 & d & d^2 & d^3 & d^4 \\
1 & e & e^2 & e^3 & e^4
\end{vmatrix} \\
\Arrow{$L_2 \gets L_2-L_1$}
\end{WithArrows}
\]

\footnote{We call length of an arrow the difference between the y-value of its start point and the y value of its end point.}
\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}

10.6 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 preferentially. 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{align*}
A &= (a + b)^2 \\
    &= a^2 + b^2 + 2ab & \text{We expand}^{26}
\end{align*}

10.7 Option no-arrows

The option no-arrows is a convenience given to the user. With this option the arrows are not drawn. However, an analysis 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.

\footnotetext{26}{A footnote.}
10.8 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 formating 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]
```

10.9 Note for 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}}-{\end{WithArrows}`, etc.).

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`.

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

\[ \arccos(x) = \arcsin \frac{4}{5} + \arcsin \frac{5}{13}\% \]
\[ \leftrightarrow x = \sin (\arcsin \frac{4}{5} + \arcsin \frac{5}{13}) \% \]
\[ \leftrightarrow x = \frac{4}{5} \cos \arcsin \frac{5}{13} + \frac{5}{13} \cos \arcsin \frac{4}{5}\% \]
\[ \leftrightarrow x = \frac{4}{5} \sqrt{1 - \left(\frac{5}{13}\right)^2} + \frac{5}{13} \sqrt{1 - \left(\frac{4}{5}\right)^2}\% \]
\[ \forall x \in [-1,1], \cos(\arcsin x) = \sqrt{1-x^2}\% \]
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 { O {} m m } { \Arrow[tikz=->,#1]{#2}% \Arrow[o,tikz=<-,#1]{#3} }

Example of use:

```latex
A & = (a+b)^2 \DoubleArrow[tikz={font=\bfseries}]{expansion}{factorization} \\
& = a^2 + 2ab+b^2
```

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.

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

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.

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*}[
\begin{array}{ll}
\text{displaystyle},
\text{ygap} = 2\text{mm},
\text{ystart} = 0\text{mm},
\text{tikz-code} = \{\text{\draw (#1) -- ++(4.5cm,0) |- (#2) ;}
\\path (#1) -- (#2)
\text{node[text width = 4.2cm, right, midway] {#3 ;}}\}\end{array}\]

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

\begin{itemize}
\item \(\cos x = \Re(e^{ix})\)
\item \(\Re(z + z') = \Re(z) + \Re(z')\)
\item \(\exp\) is a morphism for \(\times\) and \(+\)
\item sum of terms of a geometric progression of ratio \(e^{i\frac{\pi}{n}}\)
\end{itemize}

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 \textit{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`. 

\begin{DispWithArrows*}[
\begin{array}{ll}
\text{displaystyle},
\text{ygap} = 2\text{mm},
\text{ystart} = 0\text{mm},
\text{tikz-code} = \{\text{\draw (#1) -- ++(4.5cm,0) |- (#2) ;}
\\path (#1) -- (#2)
\text{node[text width = 4.2cm, right, midway] {#3 ;}}\}\end{array}\]

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

\begin{itemize}
\item \(\cos x = \Re(e^{ix})\)
\item \(\Re(z + z') = \Re(z) + \Re(z')\)
\item \(\exp\) is a morphism for \(\times\) and \(+\)
\item sum of terms of a geometric progression of ratio \(e^{i\frac{\pi}{n}}\)
\end{itemize}
\begin{DispWithArrows}[MyStyle]
\[S_n = \frac{1}{n} \sum_{k=0}^{n-1} \cos\left(\frac{\pi}{2} \cdot \frac{k}{n}\right)\]
\end{DispWithArrows}

\begin{align}
S_n &= \frac{1}{n} \sum_{k=0}^{n-1} \cos\left(\frac{\pi}{n} \cdot k\right) \quad (18) \\
&= \frac{1}{n} \sum_{k=0}^{n-1} \Re(e^{i\frac{\pi}{n}k}) \quad (19) \\
&= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} e^{i\frac{\pi}{n}k}\right) \quad (20) \\
&= \frac{1}{n} \Re\left(\sum_{k=0}^{n-1} (e^{i\frac{\pi}{n}})^k\right) \quad (21) \\
&= \frac{1}{n} \Re\left(\frac{1 - (e^{i\frac{\pi}{n}})^n}{1 - e^{i\frac{\pi}{n}}}\right) \quad (22) \\
&= \frac{1}{n} \Re\left(\frac{1 - i}{1 - e^{i\frac{\pi}{n}}}\right) \quad (23)
\end{align}

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,
  \text{tikz-code} = \{\text{draw[rounded corners,}
    \text{every node/.style = \{circle,}
    \text{draw,}
    \text{auto = false,}
    \text{inner sep = 1pt,}
    \text{fill = gray!50,}
    \text{font = \tiny \}}\]
  \text{let } \p1 = (#1),
  \p2 = (#2)
  \text{in } \text{ifdim } \x1 > \x2
  (\p1) \text{ -- node } \{#3\} (\x1,\y2) \text{ -- } (\p2)
  \text{else}
\end{WithArrows}
\[ E \iff \frac{(x+4)}{3} + \frac{5x+3}{5} = 7 \]
\[ \iff 5(x+4) + 3(5x+3) = 105 \]
\[ \iff 5x + 20 + 15x + 9 = 105 \]
\[ \iff 20x + 29 = 105 \]
\[ \iff 20x = 76 \]
\[ \iff x = \frac{38}{10} \]

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 \texttt{\NumberedLoop} which will do the job when used in \texttt{code-after}. In the following example, we write this command with \texttt{\NewDocumentCommand} (of L3) and \texttt{\foreach} of \texttt{pgffor} (which is loaded when \texttt{witharrows} is loaded).

\begin{WithArrows}
\[
\begin{array}{c}
\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 \text{quad } \forall x \in E \text{quad } \|f(x)\| \le K \|x\| \\
\text{e. } f \text{ is lipschitzian}
\end{array}
\end{WithArrows}

\begin{itemize}
\item a. \text{f est continuous on } E
\item b. \text{f est continuous in } 0
\item c. \text{f is bounded on the unit sphere}
\item d. \exists K > 0 \forall x \in E \|f(x)\| \le K \|x\|
\item e. \text{f is lipschitzian}
\end{itemize}
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`:

```latex
\begin{align*}
tikz-code &= \{\text{\footnotesize (1)}\} \to \text{\footnotesize (2)}; \\
n. f &\text{ is continuous on } E \\
b. f &\text{ is continuous in } 0 \\
c. f &\text{ is bounded on the unit sphere} \\
d. \exists K > 0 \quad \forall x \in E \quad \|f(x)\| \leq K\|x\|
\end{align*}
```

12 Implementation

12.1 Declaration of the package and extensions loaded

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

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

```latex
\begin{verbatim}
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,bending}
\end{verbatim}
```

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

```latex
\begin{verbatim}
9 \LaTeX\ \\
10 \RequirePackage{l3keys2e} \\
11 \ProvidesExplPackage{witharrows}{\myfiledate}{\myfileversion}{Draws arrows for explanations on the right} \\
12 \LaTeX\ \\
13 \plain TeX\ \\
14 \ExplSyntaxOn \\
15 \catcode`\@ = 11 \\
16 \catcode`\@ = 11
\end{verbatim}
```

\[28\text{cf. tex.stackexchange.com/questions/57424/using-of-usetikzlibrary-in-an-expl3-package-fails}\]
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 2.8a), 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.

\begin{verbatim}
\bool_new:N \c_@@_footnotehyper_bool
\end{verbatim}

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.

\begin{verbatim}
\bool_new:N \c_@@_footnote_bool
\end{verbatim}

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

\begin{verbatim}
\cs_new_protected:Npn \@@_msg_new:nn { \msg_new:nnn { witharrows } }
\cs_new_protected:Npn \@@_msg_new:nnn #1 #2 #3
{ \bool_if:NTF \c_@@_messages_for_Overleaf_bool
  { \msg_new:nnn { witharrows } { #1 } { #2 \ \ #3 } }
  { \msg_new:nnnn { witharrows } { #1 } { #2 } { #3 } }
}
\cs_new_protected:Npn \@@_msg_redirect_name:nn
{ \msg_redirect_name:nnn { witharrows } }
\cs_new_protected:Npn \@@_error:n { \msg_error:nn { witharrows } }
\cs_new_protected:Npn \@@_warning:n { \msg_warning:nn { witharrows } }
\cs_new_protected:Npn \@@_fatal:n { \msg_fatal:nn { witharrows } }
\cs_generate_variant:Nn \@@_error:nn { n x }
\cs_new_protected:Npn \@@_error_or_warning:n 
{ \bool_if:NTF \c_@@_messages_for_Overleaf_bool \@@_warning:n \@@_error:n }
\end{verbatim}

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”.

\begin{verbatim}
\bool_set:Nn \c_@@_messages_for_Overleaf_bool
{ \str_if_eq_p:Vn \c_sys_jobname_str { _region_ } % for Emacs \\
|| \str_if_eq_p:Vn \c_sys_jobname_str { output } % for Overleaf }
\end{verbatim}

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

\begin{verbatim}
\keys_define:nn { WithArrows \ package }
{ footnote .bool_set:N = \c_@@_footnote_bool ,
footnotehyper .bool_set:N = \c_@@_footnotehyper_bool ,
unknown .code:n = \@@_fatal:n { Option-unknown-for-package } }
\@@_msg_new:nn { Option-unknown-for-package }
{ You-can't-use-the-option-`\l_keys_key_str'-when-loading-the-
package-witharrows.-Try-to-use-the-command-
\token_to_str:N\WithArrowsOptions. }
\end{verbatim}

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

\begin{verbatim}
\ProcessKeysOptions { WithArrows \ package }
\end{verbatim}
\@ifclassloaded { beamer }
\{ \bool_set_false:N \c_@@_footnote_bool 
\{ \@ifpackageloaded { footnotehyper } 
\{ \@@_error:n { footnote-with-footnotehyper-package } \} 
\{ \usepackage { footnote } \} 
\} 
\} 
\bool_if:NT \c_@@_footnotehyper_bool 
\{ 
\} 

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\}).

\section{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 programmation, leqno can't be given as an option of witharrows (by design).
12.4 Some technical definitions

We create booleans in order to know if some packages are loaded. For example, for the package \texttt{amsmath}, the boolean is called \texttt{\_\_\_amsmath\_loaded\_bool}.

We define a command \texttt{\_\_\_sort\_seq:N} which will sort a sequence.

The following command creates a sequence of strings (\texttt{str}) from a \texttt{clist}.

The command \texttt{\_\_\_save:N} saves a L3 variable by creating a global version of the variable. For a variable named \texttt{\_\_name\_type}, the corresponding global variable will be named \texttt{\_\_g\_name\_type}. The

\footnote{It's not possible to use \texttt{\_\_ifpackage\_loaded} in the core of the functions because \texttt{\_\_ifpackage\_loaded} is available only in the preamble.}
type of the variable is determined by the suffix \textit{type} and is used to apply the corresponding L3 commands.

The string $\backslash \text{\texttt{\textbackslash l\_tmpa\_str}}$ will contains the \textit{type} of the variable.

The command $\backslash \text{\texttt{\textbackslash _restore\_N}}$ affects to the L3 variable the value of the (previously) set value of the corresponding \textit{global} variable.

We define a Tikz style $\backslash \text{\texttt{\textbackslash _node\_style}}$ for the l-nodes and r-nodes that will be created in the $\backslash \text{\texttt{\textbackslash halign}}$. These nodes are Tikz nodes of shape “rectangle” but with zero width. An arrow between two nodes starts from the \textit{south} anchor of the first node and arrives at the \textit{north} anchor of the second node.

If the user uses the option \textit{show-nodes} (it’s a \texttt{l3keys} option), the Tikz options \texttt{draw} and \texttt{red} will be appended to this style. This feature may be useful for debugging.\footnote{The v-nodes, created near the end of line in \texttt{DispWithArrows} and \texttt{DispWithArrows*} are not shown with the option \textit{show-nodes}.}

The style $\backslash \text{\texttt{\textbackslash standard}}$ is loaded in standard in the \texttt{tikzpicture} we need. The names of the nodes are prefixed by \texttt{wa} (by security) but also by a prefix which is the position-in-the-tree of the nested environments.
We also define a style for the tips of arrow. The final user of the extension \texttt{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 \texttt{WithArrows} in the \texttt{\halign}). This style is documented in the documentation of \texttt{witharrows}.

\begin{verbatim}
\tikzset
\{ 
  WithArrows / arrow / tips / .style = 
  { > = { Straight-Barb [ scale = 1.2 , bend ] } }
\}
\end{verbatim}

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

\begin{verbatim}
\tikzset
\{ 
  WithArrows / arrow / .style = 
  { 
    align = flush-left , 
    auto = left ,
    \langle*LaTeX\rangle 
    font = \small \itshape ,
    \langle/LaTeX\rangle
    WithArrows / arrow / tips ,
    bend-left = 45 ,
    ->
  }
\}
\end{verbatim}

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

\begin{verbatim}
\langle*LaTeX\rangle
\AtBeginDocument
\{ 
  \bool_if:NTF \c_@@_amsmath_loaded_bool 
  \{ 
    \seq_put_right:Nn \l_@@_options_WithArrowsOptions_seq \{ subequations \}
    \seq_put_right:Nn \l_@@_options_DispWithArrows_seq \{ subequations \}
  \}
\}
\end{verbatim}

In order to increase the interline in the environments \texttt{\{WithArrows\}}, \texttt{\DispWithArrows}, etc., we will use the command \texttt{\spread@equation} of \texttt{amsmath}. When used, this command becomes no-op (in the current TeX group). Therefore, it will be possible to use the environments of \texttt{amsmath} (e.g. \texttt{aligned}) in an environment \texttt{\WithArrows}. Nevertheless, we want the extension \texttt{witharrows} available without \texttt{amsmath}. That's why we give a definition of \texttt{\spread@equation} if \texttt{amsmath} is not loaded (we put the code in the hook \texttt{begindocument} because the flag \texttt{\c_@@_amsmath_loaded_bool} is itself set in the hook \texttt{begindocument}).

\begin{verbatim}
\langle/LaTeX\rangle
\cs_new_protected:Npn \spread@equation
\{ 
  \openup \jot 
  \cs_set_eq:NN \spread@equation \prg_do_nothing:
\}
\end{verbatim}
\texttt{\tl_new:N \l_@@_left_brace_tl} \\texttt{\tl_set_eq:NN \l_@@_left_brace_tl \c_novalue_tl}

\subsection{Variables}

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

\texttt{\bool_new:N \l_@@_in_WithArrows_bool} \\texttt{\bool_new:N \l_@@_in_DispWithArrows_bool} \\texttt{\bool_new:N \l_@@_in_code_after_bool}

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

\texttt{\seq_new:N \g_@@_position_in_the_tree_seq} \texttt{\seq_gput_right:Nn \g_@@_position_in_the_tree_seq 1}

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

\texttt{\int_new:N \g_@@_last_env_int}

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

\texttt{\int_new:N \l_@@_pos_env_int}

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

<table>
<thead>
<tr>
<th>option</th>
<th>lr</th>
<th>ll</th>
<th>rl</th>
<th>rr</th>
<th>v</th>
<th>i</th>
<th>groups</th>
<th>group</th>
</tr>
</thead>
<tbody>
<tr>
<td>\l_@@_pos_arrow_int</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

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

\texttt{\int_new:N \l_@@_pos_arrow_int} \\texttt{\int_set:Nn \l_@@_pos_arrow_int 3}

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

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

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

\texttt{\seq_new:N \g_@@_arrow_int_seq} \\texttt{\int_new:N \g_@@_arrow_int} \\texttt{\seq_new:N \g_@@_line_int_seq} \\texttt{\int_new:N \g_@@_line_int} \\texttt{\seq_new:N \g_@@_col_int_seq} \\texttt{\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 programmation is to try to detect some use of \omit (which should be forbidden) in the cells of the \halign.

\seq_new:N \g_@@_static_col_int_seq
\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.

\clist_new:N \l_@@_tags_clist
\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.

\cs_new_protected:Npn \@@_test_if_to_tag:
{\clist_if_in:NVT \l_@@_tags_clist \g_@@_line_int
{ \clist_set:Nn \l_@@_tags_clist { all } }
}

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.

\str_new:N \l_@@_command_name_str
\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”.

\str_new:N \l_@@_string_Arrow_for_msg_str
\str_set:Nx \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.

\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.

\bool_new:N \l_@@_sbwi_bool
\bool_new:N \l_@@_tag_star_bool
\bool_new:N \l_@@_tag_next_line_bool
\bool_new:N \l_@@_qedhere_bool
\bool_new:N \l_@@_in_first_columns_bool
\bool_new:N \l_@@_new_group_bool
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}).

The option \l@@_subequations_bool corresponds to the option subequations.

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.

The parameter \l@@_up_and_down_radius_dim corresponds to option radius_for_up_and_down.

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).

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

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).

12.6 The definition of the options

There are four levels where options can be set:

- with \usepackage[...]{witharrows}: this level will be called package level;
- with \WithArrowsOptions{...}: this level will be called global level;\(^{31}\)
- with \begin{WithArrows}[...]: this level will be called environment level;
- with \Arrow[...] (included in code-after): this level will be called local level.

\(^{31}\)This 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.
When we scan a list of options, we want to be able to raise an error if two options of position (ll, rl, 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).

\cs_new_protected:Npn \@@_eval_if_allowed:n #1
\str_if_empty:NTF \l_@@_previous_key_str
\str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
\#1
\\@@_error:n { Incompatible-options } }

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

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

\keys_define:nn { WithArrows / Global }
{ max-length-of-arrow .dim_set:N = \l_@@_max_length_of_arrow_dim ,
  max-length-of-arrow .value_required:n = true ,
  max-length-of-arrow .initial:n = 2 cm ,
  ygap .dim_set:N = \l_@@_ygap_dim ,
  ygap .initial:n = 0.4 ex ,
  ygap .value_required:n = true ,
  ystart .dim_set:N = \l_@@_ystart_dim ,
  ystart .value_required:n = true ,
  ystart .initial:n = 0.4 ex ,
  more-columns .code:n =
  \@@_msg_redirect_name:nn { Too~much~columns~in~WithArrows } { none } ,
  more-columns .value_forbidden:n = true ,
  command-name .code:n =
  \str_set:Nn \l_@@_command_name_str { #1 }
  \str_set:Nx \l_@@_string_Arrow_for_msg_str { \c_backslash_str Arrow~alias~\c_backslash_str #1 } ,
  command-name .value_required:n = true ,
  tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
  tikz-code .initial:n = \draw~(#1)~to~node{#3}~(#2)~; ,
  tikz-code .value_required:n = true ,
  displaystyle .bool_set:N = \l_@@_displaystyle_bool ,
  displaystyle .default:n = true ,
  show-nodes .code:n =
  \tikzset { @@_node_style / .append~style = { draw , red } } ,
  show-node-names .bool_set:N = \l_@@_show_node_names_bool ,
  show-node-names .default:n = true ,
  group .code:n =
  \str_if_empty:NTF \l_@@_previous_key_str
  \str_set:Nn \l_@@_previous_key_str { group }
  \seq_remove_all:Nn \l_@@_options_Arrow_seq { xoffset }
  \int_set:Nn \l_@@_pos_arrow_int 7
  \\@@_error:n { Incompatible-options } ,
  group .value_forbidden:n = true ,
  groups .code:n =
  \str_if_empty:NTF \l_@@_previous_key_str
  \seq_set_right:Nn \l_@@_options_Arrow_seq { new-group }
  \seq_remove_all:Nn \l_@@_options_Arrow_seq { xoffset }
  \int_set:Nn \l_@@_pos_arrow_int 6

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With the option \texttt{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 \texttt{\@@_draw_arrows:nn} is for the standard arrows and the nullification of \texttt{\@@_draw_arrow:nnn} is for “Arrow in code-after”.

\begin{verbatim}
\no-arrows .code:n = \cs_set_eq:NN \@@_draw_arrows:nn \use_none:nn
\cs_set_eq:NN \@@_draw_arrow:nnn \use_none:nnn ,
\no-arrows .value_forbidden:n = true
\end{verbatim}

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

\begin{verbatim}
\keys_define:nNn { WithArrows / WithArrowsSpecific }
{ t .code:n = \int_set:Nn \l_@@_pos_env_int 0 ,
  t .value_forbidden:n = true ,
  c .code:n = \int_set:Nn \l_@@_pos_env_int 1 ,
  c .value_forbidden:n = true ,
  b .code:n = \int_set:Nn \l_@@_pos_env_int 2 ,
  b .value_forbidden:n = true ,
  right-overlap .bool_set:N = \l_@@_right_overlap_bool ,
  right-overlap .value_required:n = true
}
\end{verbatim}

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

\begin{verbatim}
\clist_new:N \c_@@_extensible_delimiters_clist
\clist_set:Nn \c_@@_extensible_delimiters_clist { , \{ , \[, \lbrace, \lbrack, \lgroup, \langle, \lmoustache, \lceil, \lfloor}
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\}. 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.
\l_tmpa_tl
\l_set:Nn \l_@@_replace_left_brace_by_tl { #1 }
\l_@@_error:n { Bad-value-for-replace-brace-by }

\l_replace-left-brace-by .initial:n = \ibrace ,

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

\LaTeX
\texttt{standard-behaviour-with-items .bool_set:N = \l_@@_sbwi_bool ,}
\texttt{standard-behaviour-with-items .default:n = true}

\LaTeX

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

\keys_define:nn { WithArrows / Env }
{ name .code:n =
\str_set:Nn \l_tmpa_str { #1 }
\seq_if_in:NVTF \g_@@_names_seq \l_tmpa_str
{ \l_@@_error:n { Duplicate-name } }
{ \seq_gput_left:NV \g_@@_names_seq \l_tmpa_str }
\str_set_eq:NN \l_@@_name_str \l_tmpa_str ,
name .value_required:n = true ,
\l_@@_name_str
code-before .code:n = \tl_put_right:Nn \l_@@_code_before_tl { #1 } ,
code-before .value_required:n = true ,
\l_@@_code_before_tl
CodeBefore .meta:n = { code-before = #1 } ,
\l_@@_code_before_tl
code-after .code:n = \tl_put_right:Nn \l_@@_code_after_tl { #1 } ,
code-after .value_required:n = true ,
\l_@@_code_after_tl
CodeAfter .meta:n = { code-after = #1 } ,
\l_@@_code_after_tl
format .code:n =
\tl_if_empty:nTF { #1 }
{ \l_@@_error:n { Invalid-option-format } }
{ \regex_match:nnTF { \A[rclRCL]*\Z } { #1 }
{ \tl_set:Nn \l_@@_format_str { #1 } }
{ \l_@@_error:n { Invalid-option-format } }
\l_@@_format_str
format .value_required:n = true
}

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

\keys_define:nn { WithArrows }
{ \WithArrows .inherit:n =
\WithArrows / Global ,
\WithArrows / WithArrowsSpecific ,
\WithArrows / Env
},
\WithArrows / up-and-down .inherit:n = \WithArrows / up-and-down ,
\DispWithArrows .inherit:n =
\DispWithArrows / DispWithArrowsSpecific ,
\DispWithArrows / Global ,
\DispWithArrows / Env ,
\DispWithArrows / Env

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\keys_define:nn { WithArrows / WithArrows }
{ unknown .code:n = \@@_sort_seq:N \l_@@_options_WithArrows_seq \@@_error:n \{ Unknown-option-WithArrows \} }
\keys_define:nn { WithArrows / DispWithArrows }
{ left-brace .tl_set:N = \l_@@_left_brace_tl , unknown .code:n = \@@_sort_seq:N \l_@@_options_DispWithArrows_seq \@@_error:n \{ Unknown-option-DispWithArrows \} }
\keys_define:nn { WithArrows / WithArrowsOptions }
{ allow-duplicate-names .code:n = \@@_msg_redirect_name:nn \{ Duplicate-name \} \{ none \} ,
A sequence of the options available in \{DispWithArrows\}. This sequence will be used in the error messages and can be modified dynamically.
\keys_define:nn { WithArrows / WithArrowsOptions }
{ allow-duplicate-names .code:n = \@@_msg_redirect_name:nn \{ Duplicate-name \} \{ none \} ,
A sequence of the options available in \{DispWithArrows\}. This sequence will be used in the error messages and can be modified dynamically.
\keys_define:nn { WithArrows / WithArrowsOptions }
{ allow-duplicate-names .code:n = \@@_msg_redirect_name:nn \{ Duplicate-name \} \{ none \} ,
A sequence of the options available in \WithArrowsOptions. This sequence will be used in the error messages and can be modified dynamically.

\seq_new:N \l_@@_options_WithArrowsOptions_seq
\@@_set_seq_of_str_from_clist:Nn \l_@@_options_WithArrowsOptions_seq
{ allow-duplicate-names, b, c, command-name, right_overlap,
more-columns, tikz-code, adjust,
displaystyle, end-adjust, fleqn, group, groups, i, interline, jot, ll, lr,
mathindent, max-length-of-arrow, no-arrows, up-and-down, rl, rr,
show-node-names, show-nodes, start-adjust, t, tikz, wrap-lines, xoffset,
xoffset-for-o-arrows, ygap, ystart,
\langle∗LaTeX\rangle
allow-multiple-labels, nonumber, notag, standard-behaviour-with-items,
tagged-lines
\langle/LaTeX\rangle
}

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”.

\cs_new_protected:Npn \@@_set_independent:
{ \str_if_eq:VnF \l_keys_value_tl { NoValue } { \@@_error:n { Value~for~a~key } } \@@_set_independent_bis: }

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

\cs_new_protected:Npn \@@_set_independent_bis:
{ \str_if_empty:NTF \l_@@_previous_key_str
{ \str_set_eq:NN \l_@@_previous_key_str \l_keys_key_str
\str_set:Nn \l_@@_status_arrow_str { independent } }
{ \@@_error:n { Incompatible~options~in~Arrow } }
}

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”.

\keys_define:nn { WithArrows / Arrow / FirstPass }
{ jump .code:n = \int_compare:nTF { #1 > 0 } \{ \int_set:Nn \l_@@_jump_int { #1 } \}
\{ \@@_error:n { Negative~jump } \},
jump .value_required:n = true,
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.

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

\keys_define:nn {WithArrows / Arrow / SecondPass}
\{  \tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
\tikz-code .initial:n = \draw-(#1)-to-node(#3)-(#2)-; ,
\tikz-code .code:n = \tikzset { WithArrows / arrow / .append-style = { #1 } } ,
\rr .code:n = \@@_fix_pos_arrow:n 3 ,
\ll .code:n = \@@_fix_pos_arrow:n 1 ,
\rl .code:n = \@@_fix_pos_arrow:n 2 ,
\lr .code:n = \@@_fix_pos_arrow:n 0 ,
\i .code:n = \@@_fix_pos_arrow:n 5 ,
o .code:n = \str_set:Nn \l_@@_previous_key_str { o } ,
\}

\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.

\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.
12.7 The command \Arrow

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

\begin{verbatim}
\NewDocumentCommand \@@_Arrow { O { } m ! O { } } \cs_new_protected:Npn \@@_Arrow {
\peek_meaning:NTF [ \@@_Arrow_i \@@_Arrow_i [ ] } \cs_new_protected:Npn \@@_Arrow_i [ #1 ] #2
{ \peek_meaning:NTF [ \@@_Arrow_ii [ #1 ] { #2 } \@@_Arrow_ii [ #1 ] { #2 } [ ] } \cs_new_protected:Npn \@@_Arrow_ii [ #1 ] #2 [ #3 ] \keys_set:nn { WithArrows / Arrow / FirstPass } { #1 , #3 }

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 \texttt{jump}. In order to compute the value of the field “status”, we have to take into account options \texttt{ll}, \texttt{rl}, \texttt{rr}, \texttt{lr}, etc. or \texttt{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.

\begin{verbatim}
\str_clear_new:N \l_@@_previous_key_str
\keys_set:nn { WithArrows / Arrow / FirstPass } { #1 , #3 }
\end{verbatim}

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:

\begin{verbatim}
\prop_put:NnV \l_tmpa_prop { initial } \g_@@_line_int
\end{verbatim}

2. The row where the arrow ends (that’s why it was necessary to analyze the key \texttt{jump}):

\begin{verbatim}
\int_set:Nn \l_tmpa_int { \g_@@_line_int + \l_@@_jump_int }
\prop_put:NnV \l_tmpa_prop { final } \l_tmpa_int
\end{verbatim}

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

\begin{verbatim}
\prop_put:NnV \l_tmpa_prop { status } \l_@@_status_arrow_str
\end{verbatim}

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

\begin{verbatim}
\prop_put:Nnn \l_tmpa_prop { options } { #1 , #3 }
\end{verbatim}

\end{verbatim}
5. The label of the arrow (it’s also a token list):

\prop_put:Nnn \l_tmpa_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).

\prop_put:Nnx \l_tmpa_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.

\prop_put:Nnn \l_tmpa_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.

\prop_gclear_new:c
\prop_gset_eq:cN \l_tmpa_prop
\l_tmpa_prop

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.

\cs_new_protected:Npn \@@_Arrow_first_columns:
{ \@@_error:n { Arrow~not~in~last~column } \@@_Arrow }

12.8 The environments \{WithArrows\} and \{DispWithArrows\}

12.8.1 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.

\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.

\str_clear_new:N \l_@@_type_env_str
\str_set:NV \l_@@_type_env_str \@currenvir

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.

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

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.

\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.

\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 \texttt{i}, \texttt{group} and \texttt{groups} (values 5, 6 and 7 of \l_@@_pos_arrow_int) is used.

\dim_zero_new:N \l_@@_x_dim

The variable \l_@@_input_line_str will be used only to store, for each command \texttt{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.

\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.

\seq_gput_right:NV \g_@@_arrow_int_seq \g_@@_arrow_int
\int_gzero:N \g_@@_arrow_int
\seq_gput_right:NV \g_@@_line_int_seq \g_@@_line_int
\int_gzero:N \g_@@_line_int
\seq_gput_right:NV \g_@@_col_int_seq \g_@@_col_int
\int_gzero:N \g_@@_col_int
\seq_gput_right:NV \g_@@_static_col_int_seq \g_@@_static_col_int
\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 \texttt{\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 \texttt{\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 \texttt{\omit} at least once.

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

\seq_gput_right:NN \g_@@_position_in_the_tree_seq 1

We define the command \texttt{\\} to be the command \texttt{\@@_cr}: (defined below).

\cs_set_eq:NN \\ \@@_cr:
\dim_zero:N \mathsurround

These counters will be used later as variables.

\int_zero_new:N \l_@@_initial_int
\int_zero_new:N \l_@@_final_int
\int_zero_new:N \l_@@_arrow_int
\int_zero_new:N \l_@@_pos_of_arrow_int
\int_zero_new:N \l_@@_jump_int

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

\int_set:Nn \l_@@_jump_int 1

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

```latex
\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.

```latex
\seq_clear_new:N \l_@@_labels_seq
\bool_set_false:N \l_@@_tag_next_line_bool
```

 supérieur

The value corresponding to the key interline is put to zero before the treatment of the options of the environment.\footnote{It’s recalled that, by design, the option interline of an environment doesn’t apply in the nested environments.}

```latex
\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.

```latex
\tl_clear_new:N \l_@@_code_before_tl
\tl_clear_new:N \l_@@_code_after_tl
```

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

```latex
\str_clear_new:N \l_@@_previous_key_str
\bool_if:NT \l_@@_in_WithArrows_bool
{ \keys_set:nn { WithArrows / WithArrows } { #1 } }
\bool_if:NT \l_@@_in_DispWithArrows_bool
{ \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.

```latex
\bool_if:NF \l_@@_right_overlap_bool
{ \bool_if:NT \l_@@_in_WithArrows_bool
{ \dim_gzero_new:N \g_@@_overlap_x_dim
\dim_zero_new:N \l_@@_delta_x_dim
}\dim_zero_new:N \l_@@_delta_x_dim
}
```

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.

```latex
\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).

```latex
\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);
• 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.

\[\int_{\text{get_eq:NN}} \g_@@_col_int \ \l_@@_nb_cols_int\]

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.

\[\seq\text{clear_new:N} \l_@@_format_seq\]
\[\seq\text{set_split:NnV} \l_@@_format_seq { } \l_@@_format_str\]

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`).

\[\langle \text{LaTeX} \rangle\]
\[\text{\begin{savenotes}}\]
\[\langle /\text{LaTeX} \rangle\]

We execute the code `\l_@@_code_before_tl` of the option `code-before` of the environment after the potential `\begin{savenotes}` and, symmetrically, 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`).

\[\langle \text{LaTeX} \rangle\]
\[\text{\begin{savenotes}}\]
\[\langle /\text{LaTeX} \rangle\]

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

12.8.2 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).

\[\text{\begin{verbatim}
\cs\text{new\_protected:Npn} \@@\_construct\_halign:\n
\{\n
\seq\text{pop\_right:NNTF} \l_@@\_format\_seq \l_@@\_type\_col\_str\n
\{\n
\end{verbatim}\]
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.

\begin{verbatim}
\use:e
\begin{verbatim}
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.

\begin{verbatim}
\int_gdecr:N \g_@@_col_int \\
\@@_construct_halign: \\
\int_compare:nNnT \g_@@_col_int = \l_@@_nb_cols_int \\
{ \\
\end{verbatim}

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`.

\begin{verbatim}
\cs_set_eq:cN { \l_@@_command_name_str } \@@_Arrow \\
\langle∗LaTeX⟩ \\
\bool_if:NT \l_@@_in_DispWithArrows_bool { \@@_test_if_to_tag: } \\
\langle/\LaTeX⟩ \\
\str_if_eq:VnT \l_@@_type_col_str { c } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { C } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { r } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { R } \hfil \\
\int_gincr:N \g_@@_col_int \\
\int_gset:Nn \g_@@_static_col_int { \int_use:N \g_@@_col_int } \\
\c_math_toggle_token \\
\str_if_eq:VnT \l_@@_type_col_str { C } { { } } \\
\str_if_eq:VnT \l_@@_type_col_str { L } { { } } \\
\bool_if:NT \l_@@_displaystyle_bool \displaystyle \\
\int_compare:nNnTF \g_@@_col_int = \l_@@_nb_cols_int \\
\@@_construct_nodes: \\
{ \\
\end{verbatim}

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:`).

\begin{verbatim}
\str_if_eq:VnT \l_@@_type_col_str { l } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { L } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { c } \hfil \\
\str_if_eq:VnT \l_@@_type_col_str { C } \hfil \\
\bool_if:NT \l_@@_in_DispWithArrows_bool \tabskip = \c_zero_skip \\
\end{verbatim}

\end{verbatim}

\end{verbatim}

\end{verbatim}

\end{verbatim}

\end{verbatim}

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

\begin{verbatim}
\bool_if:NTF \l_@@_in_WithArrows_bool
  { \ialign \bgroup
  \halign to \l_@@_linewidth_dim \bgroup
  \bool_if:NT \l_@@_fleqn_bool
  { \skip_horizontal:N \l_@@_mathindent_skip }
  \int_gincr:N \g_@@_line_int
  \int_gzero:N \g_@@_col_int
  \tl_if_eq:NNF \l_@@_left_brace_tl \c_novalue_tl
  { \skip_horizontal:n
    \box_wd:N \l_@@_left_brace_box + \l_@@_delim_wd_dim }
  \int_gzero:N \g_@@_col_int
  \tl_if_eq:NNF \l_@@_right_brace_tl \c_novalue_tl
  { \skip_horizontal:n
    \box_wd:N \l_@@_right_brace_box + \l_@@_delim_wd_dim }
  \strut
  \egroup
  \hfil
  \egroup
  \int_gzero:N \g_@@_col_int
  \tl_if_eq:NNF \l_@@_left_brace_tl \c_novalue_tl
  { \skip_horizontal:n
    \box_wd:N \l_@@_left_brace_box + \l_@@_delim_wd_dim }
  \int_gzero:N \g_@@_col_int
  \tl_if_eq:NNF \l_@@_right_brace_tl \c_novalue_tl
  { \skip_horizontal:n
    \box_wd:N \l_@@_right_brace_box + \l_@@_delim_wd_dim }
  \strut
  \egroup
\end{verbatim}

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.

\begin{verbatim}
\cs_new_protected:Npn \@@_construct_nodes:
  {
  \tikz [ remember-picture , overlay ]
  \node
  [ node-contents = { }, \@@_node_style ,
    name = wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - l ,
  ];
  \hfil
  \end{verbatim}

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).

\begin{verbatim}
\tikz [ remember-picture , overlay ]
\node
[ node-contents = { }, \@@_node_style ,
  name = wa - \l_@@_prefix_str - \int_use:N \g_@@_line_int - r ,
 ]
;
\str_if_empty:NF \l_@@_name_str
  { \pgfpicture
  \pgfnodealias{ \l_@@_name_str - \int_use:N \g_@@_line_int - l }
  \pgfnodealias{ \l_@@_name_str - \int_use:N \g_@@_line_int - r }
  \endpgfpicture
\end{verbatim}
12.8.3 The environment \{WithArrows\}

\begin{verbatim}
\NewDocumentEnvironment { WithArrows } { ! O { } }
\cs_new_protected:Npn \WithArrows
{ \group_begin:
\peek_meaning:NTF \[
{ \WithArrows_i }
{ \WithArrows_i \[ \] }
\bgroup }
\mathcal{\text{WithArrows}} \end{verbatim}

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

\begin{verbatim}
\int_compare:nNnT \_\_\_pos_env_int = 1 \c_math_toggle_token
\int_case:nn \_\_\_pos_env_int { 0 \texttt{\textbackslash vtop} 1 \texttt{\textbackslash vcenter} 2 \texttt{\textbackslash vbox} }
\bgroup
\end{verbatim}

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

\begin{verbatim}
\\stretch{1}
\end{verbatim}

We begin the \texttt{\textbackslash halign} and the preamble. During the construction of the preamble, \texttt{\_\_\_tmpa_int} will be incremented during each column constructed.

\begin{verbatim}
\_\_\_construct_halign:
\end{verbatim}

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

\Footnote{\texttt{\textbackslash vtop} seems color-safe here...}{\texttt{\textbackslash vtop} seems color-safe here...}

\Footnote{An error is raised if the environment is used outside math mode.}{An 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.

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.

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

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).

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

12.8.4 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\}.

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

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

\int_compare:nNnT \g_@@_arrow_int > 0
{
  \int_compare:nNnT \g_@@_arrow_int = 1
  {
    \int_compare:nNnT \l_@@_pos_arrow_int > 5
    { \int_set:Nn \l_@@_pos_arrow_int 5 }
  }
  \@@_scan_arrows:
}

We will execute the code specified in the option code-after, after some settings.
\group_begin:
  \tikzset { every-picture / .style = @@_standard }
\cs_set:Npn \WithArrowsNbLines { \int_use:N \g_@@_line_int }

The command \WithArrowsNbLines is not used by witharrows. It’s only a convenience given to the user.
\cs_set:NNn \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.\footnote{As 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.}
\cs_set_eq:NN \MultiArrow \@@_MultiArrow:nn
\cs_set_eq:cN \l_@@_command_name_str \@@_Arrow_code_after
\bool_set_true:N \l_@@_in_code_after_bool
\l_@@_code_after_tl
\group_end:

We update the position-in-the-tree. First, we drop the last component and then we increment the last element.
\seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
\seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
\seq_gput_right:Nx \g_@@_position_in_the_tree_seq { \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.
\int_compare:nNnT { \seq_count:N \g_@@_position_in_the_tree_seq } = 1
  { \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.
\seq_gpop_right:NN \g_@@_arrow_int_seq \l_tmpa_tl
\int_gset:Nn \g_@@_arrow_int \l_tmpa_tl
\seq_gpop_right:NN \g_@@_line_int_seq \l_tmpa_tl
\int_gset:Nn \g_@@_line_int \l_tmpa_tl
\seq_gpop_right:NN \g_@@_col_int_seq \l_tmpa_tl
\int_gset:Nn \g_@@_col_int \l_tmpa_tl
\seq_gpop_right:NN \g_@@_static_col_int_seq \l_tmpa_tl
\int_gset:Nn \g_@@_static_col_int \l_tmpa_tl
}

That’s the end of the command \@@_post_halign.:
12.8.5  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).

\inputverbatim
\cs_new_protected:Npn \cr: \
\scan_stop:
\We try to detect some \omit (as of now, an \omit in the last column is not detected).
\int_compare:nNnF \g@@_col_int = \g@@_static_col_int
{ \@@_error:n { omit~probably~used } }
\prg_replicate:nn { \l@@_nb_cols_int - \g@@_static_col_int } { & { } }
\group_align_safe_begin:
\peek_meaning_remove:NTF * \cr_i: \cr_i:
\Then, we peek the next token to see if it’s a [. In this case, the command \ has an optional argument which is the vertical skip (=glue) to put.
\cs_new_protected:Npn \cr_i: \bracket
{ \peek_meaning:NTF \end 
{ \@@_cr_iii:n { \bracket } }
\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.
\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.\footnote{The v-nodes are used to compute the abscissa of the right margin, used by the option \wraplines.}
\bool_if:NT \l@DispWithArrows_bool
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 be done before and, now, if we are in a line to tag, the value of \l_@@_tags_clist is all.

\begin{verbatim}
\clist_if_in:NnTF \l_@@_tags_clist { all }
{ \refstepcounter{equation} }
\end{verbatim}

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).

\begin{verbatim}
\tl_if_empty:NT \l_@@_tag_tl { \int_gincr:N \c@equation }
\end{verbatim}

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 &).

\begin{verbatim}
\cs_gset:Npx \g_tmpa_tl { \tl_if_empty:NTF \l_@@_tag_tl \theequation \l_@@_tag_tl }
\end{verbatim}

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.

\begin{verbatim}
\seq_if_empty:NF \l_@@_labels_seq { \refstepcounter{equation} }
\end{verbatim}

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.

\begin{verbatim}
\cs_set:Npx \@currentlabel { \p@equation \g_tmpa_tl }
\end{verbatim}

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

\begin{verbatim}
\bool_if:NT \c_@@_hyperref_loaded_bool { \p@equation \g_tmpa_tl }
\end{verbatim}

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.

\begin{verbatim}
\bool_if:NT \c_@@_cleveref_loaded_bool { \cref@constructprefix { equation } \cref@result \protected@edef \cref@currentlabel { \cs_if_exist:NTF \cref@equation@alias \cref@equation@alias { equation } \hyper@refstepcounter { equation } } }
\end{verbatim}

Now, we can issue the command \label (some packages may have redefined \label, for example typedef) 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).

\begin{verbatim}
\seq_map_function:NN \l_@@_labels_seq \@@_old_label
\end{verbatim}
We save the booleans \_@@_tag_star_bool and \_@@_qedhere_bool because they will be used in the next cell (after the &). We recall that the cells of a \halign are TeX groups.

\begin{verbatim}
\@@_save:N \_@@_tag_star_bool
\@@_save:N \_@@_qedhere_bool
\bool_if:NT \_@@_tag_next_line_bool
{
  \openup -\jot
  \bool_set_false:N \_@@_tag_next_line_bool
  \notag \&
}
\@@_restore:N \_@@_tag_star_bool
\@@_restore:N \_@@_qedhere_bool
\bool_if:NT \_@@_tag_star_bool
{ \hbox_overlap_left:n \@@_tag_next_line_i: }
\cs_set_eq:NN \theequation \g_tmpa_tl
\bool_if:NT \_@@_tag_star_bool
{ \cs_set_eq:NN \tagform@ \prg_do_nothing: }
\end{verbatim}

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 \_@@_leqno_bool.

\begin{verbatim}
\bbox_overlap_left:n
{
  \bool_if:NF \c_@@_leqno_bool
  {
    \pgfpicture
    \pgfrememberpicturepositiononpagetrue
    \pgfcoordinate{wa - \_@@_prefix_str - \int_use:N \g_@@_line_int - v}
    \pgfpointorigin
    \endpgfpicture
  }
  \quad \_@@_eqnnum
}
\bool_if:NT \c_@@_leqno_bool
{
  \pgfpicture
    \pgfrememberpicturepositiononpagetrue
    \pgfcoordinate{wa - \_@@_prefix_str - \int_use:N \g_@@_line_int - v}
    \pgfpointorigin
    \endpgfpicture
}
\end{verbatim}

\begin{verbatim}
{/LaTeX}
&
{/LaTeX}
\end{verbatim}
\begin{verbatim}
{\LaTeX}
\newcommand{\dim_compare:nNnT}{\#1 < \c_zero_dim}
{\@_error:n {option-of-cr-negative}}
\cr
\malign
{\dim_set:Nn \l_tmpa_dim {\dim_max:nn {\#1} \c_zero_dim}
 \skip_vertical:N \l_tmpa_dim
 \skip_vertical:N \l_@@_interline_skip
 \scan_stop:}
\end{verbatim}

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 known 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 \end. 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.

\begin{verbatim}
{\LaTeX}
\cs_new_protected:Npn \@@_analyze_end:Nn {#1 #2}{
 \str_if_eq:VnT \l_@@_type_env_str {#2}{
 \@@_error:n {newline at the end of env}
 \group_begin:
 \globaldefs = 1
 \@@_msg_redirect_name:nn {newline at the end of env} {none}
 \group_end:
}
\end {#2} }
\end{verbatim}

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

\begin{verbatim}
{\LaTeX}
\bool_new:N \l_@@_in_label_or_minipage_bool
{plain-\TeX}
\cs_new_protected:Npn \DispWithArrows{! d < > ! O {}}
{\LaTeX}
\NewDocumentEnvironment{DispWithArrows}{{! d < > ! O {}}}
\end{verbatim}

\subsection{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\}. 

\begin{verbatim}
{\LaTeX}
\bool_new:N \l_@@_in_label_or_minipage_bool
{/\LaTeX}
{\LaTeX}
\NewDocumentEnvironment {DispWithArrows}{!! d < > ! O {}}
{/\LaTeX}
{/\LaTeX}
{/plain-\TeX}
\cs_new_protected:Npn \DispWithArrows
{\group_begin:
 \peek_meaning:NTF <
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`).

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).

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`.

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

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

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

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

The token list \texttt{\l_@@_tag_tl} will contain the argument of the command \texttt{\tag}.

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

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

\if_mode_vertical:
 \nointerlineskip
 \hbox_to_wd:nn { .6 \linewidth } { }
 \fi:
 \c_math_toggle_token \c_math_toggle_token

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).

\spread@equation
 \@@_construct_halign:
 { \tabskip = \c_zero_skip
 \if@fleqn
 \c_zero_skip
 { 0 pt plus 1000 pt minus 1000 pt }
\else
\if@inlabel
\tabskip = 0 pt plus 1000 pt minus 1000 pt
\fi
\fi
\cr
}

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.

\$##$
 \tabskip = \c_zero_skip
 &
 \if@fleqn
 { Too-much-columns-in-DispWithArrows }
 \else
 \tabskip = 0 pt plus 1000 pt minus 1000 pt
 &
\fi
 \cr
}

We begin the second part of the environment {DispWithArrows}.
The following \egroup is for the \align.

\box_set_to_last:N \l_tmpa_box
\box_use:N \l_tmpa_box
\dim_gzero_new:N \g_@@_alignment_dim
\dim_gset:Nn \g_@@_alignment_dim \{ \box_wd:N \l_tmpa_box \}
\box_clear_new:N \l_@@_new_box
\box_set:Nn \l_@@_new_box \{ \bbox_unpack_drop:N \l_tmpa_box \}
\dim_compare:nNnT \{ \box_wd:N \l_@@_new_box \} \g_@@_alignment_dim
\tl_if_eq:NNTF \l_@@_left_brace_tl \c_novalue_tl
{ \bbox_use_drop:N \l_@@_halign_box }
{ \hbox_to_wd:nn \l_@@_linewidth_dim
{ \bool_if:NTF \l_@@_fleqn_bool
{ \skip_horizontal:N \l_@@_mathindent_skip }
\hfil
\bbox_to_wd:nn \g_@@_alignment_dim
{ \bbox_use_drop:N \l_@@_left_brace_box } }
\hfil
\skip_horizontal:N -\l_@@_linewidth_dim
\vcenter { \bbox_use_drop:N \l_@@_halign_box }
}

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

\box_set_to_last:N \l_tmpa_box
\box_use:N \l_tmpa_box
\dim_gzero_new:N \g_@@_right_x_dim
\dim_gset_eq:NN \g_@@_right_x_dim \c_max_dim
\pgfpicture
\pgfrememberpicturepositiononpagetrue
\int_step_variable:nNn \g_@@_line_int \l_tmpa_int
{ \cs_if_free:cTF { pgf @ sh @ ns @ wa - \l_@@_prefix_str - \l_tmpa_int - v } \@@_fatal:n \{ Inexistent-v-node \} }
\left \l_@@_replace_left_brace_by_tl
\vcenter to \l_tmpa_dim { \vfil }
\right.
\c_math_toggle_token
\group_end:
\hfil
\skip_horizontal:N -\l_@@_linewidth_dim
\vcenter { \bbox_use_drop:N \l_@@_halign_box }

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.
The code in \@@_post_halign: is common to \{WithArrows\} and \{DispWithArrows\}. If \texttt{mathtools} has been loaded with the option \texttt{showonlyrefs}, we reactivate the code of \texttt{mathtools} for the option \texttt{showonlyrefs} with the command \texttt{MT_showonlyrefs_true}: (it has been deactivated in the beginning of the environment).

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

With the environment \texttt{DispWithArrows*}, the equations are not numbered. We don’t put \texttt{\begin{DispWithArrows}} and \texttt{\end{DispWithArrows}} because there is a \texttt{@currenvir} in some error messages.
12.9 The commands \texttt{\textbackslash tag, \textbackslash notag, \textbackslash label, \textbackslash tagnextline and \textbackslash qedhere for} \{DispWithArrows\}

Some commands are allowed only in the last column of the environment \{DispWithArrows\}. We write a command \texttt{\@@_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 \texttt{\@@_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.

\begin{verbatim}
\cs_new_protected:Npn \@@_if_in_last_col_of_disp:Nn #1 #2
  { \bool_if:NTF \l_@@_in_WithArrows_bool
      { \@@_error:nn { Not allowed in WithArrows } { #1 } }
      { \int_compare:nNnTF \g_@@_col_int < \l_@@_nb_cols_int
          { \@@_error:nn { Not allowed in DispWithArrows } { #1 } }
          { #2 } } }
\end{verbatim}

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

\begin{verbatim}
\cs_new_protected:Npn \@@_notag:
  { \@@_if_in_last_col_of_disp:Nn \notag { \clist_clear:N \l_@@_tags_clist } }
\end{verbatim}

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

\begin{verbatim}
\cs_new_protected:Npn \@@_nonumber:
  { \@@_if_in_last_col_of_disp:Nn \nonumber { \clist_clear:N \l_@@_tags_clist } }
\end{verbatim}

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

\begin{verbatim}
\NewDocumentCommand \@@_tag { s m }
  { \@@_if_in_last_col_of_disp:Nn \tag
      { \tl_if_empty:NF \l_@@_tag_tl
          { \@@_error:nn { Multiple tags } { #2 } }
          \clist_set:Nn \l_@@_tags_clist { all }
          \bool_if:nT \c_@@_mathtools_loaded_bool
            { \MH_if_boolean:nT { show_only_refs }
                { \MH_if_boolean:nF { show_manual_tags }
                    { \clist_clear:N \l_@@_tags_clist } } }
          \tl_set:Nn \l_@@_tag_tl { #2 }
          \bool_set:Nn \l_@@_tag_star_bool { #1 }
          \bool_if:nTF { #1 && ! \bool_if_p:N \c_@@_amsmath_loaded_bool }
            { \@@_error:n { tag* without amsmath } }
            }
  }
\end{verbatim}

The starred version \texttt{\textbackslash tag\*} can’t be used if amsmath has not been loaded because this version does the job by deactivating the command \texttt{\tagform@} inserted by amsmath in the (two versions of the) command \texttt{@eqnnum}.\footnote{There are two versions of \texttt{@eqnnum}, a standard version and a version for the option \texttt{leqno}.}
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.

\begin{lstlisting}[language=TeX]
1435 \cs_new_protected:Npn \@@_label:n #1
1436 { \@@_if_in_last_col_of_disp:Nn \label
1437  { \seq_if_empty:NF \l_@@_labels_seq
1438   { \bool_if:NTF \c_@@_cleveref_loaded_bool
1439     { \@@_error:n { Multiple~labels~with~cleveref } }
1440     { \@@_error:n { Multiple~labels } }
1441   }
1442   \seq_put_right:Nn \l_@@_labels_seq { #1 }
1443   \bool_if:nT \c_@@_mathtools_loaded_bool
1444   { \MH_if_boolean:nT { show_only_refs }
1445     { \cs_if_exist:cTF { MT_r_#1 }
1446       { \clist_set:Nn \l_@@_tags_clist { all } }
1447       { \clist_clear:N \l_@@_tags_clist }
1448     }
1449   }
1450   \bool_if:nT \c_@@_autonum_loaded_bool
1451   { \cs_if_exist:cTF { autonum@#1Referenced }
1452     { \clist_set:Nn \l_@@_tags_clist { all } }
1453     { \clist_clear:N \l_@@_tags_clist }
1454   }
1455 } \bool_set_true:N \l_@@_tag_next_line_bool
1456 { \cs_set_eq:NN \qedsymbol \qedhere_i: }
1457 \group_end:
\end{lstlisting}

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

\begin{lstlisting}[language=TeX]
1460 \cs_new_protected:Npn \@@_qedhere: { \bool_set_true:N \l_@@_qedhere_bool }
1461 \cs_new_protected:Npn \@@_set_qedhere: { \cs_set_eq:NN \qedhere \@@_qedhere: }
\end{lstlisting}

In the last column of the \texttt{\halign} of \{DispWithArrows\} (column of the labels, that is to say the numbers of the equations), a command \texttt{\@@_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 \texttt{\textbackslash qedhere} in amsthm.

\begin{lstlisting}[language=TeX]
1470 \cs_new_protected:Npn \@@_qedhere_i: 
1471 { \group_begin:
1472 \cs_set_eq:NN \qedsymbol \textbackslash qed
1473 \group_end:
\end{lstlisting}

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

\begin{lstlisting}[language=TeX]
1474 \cs_set_eq:NN \qedsymbol \setQED@elt
1475 \QED@stack\relax\relax
1476 \group_end:
\end{lstlisting}

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12.10 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 adjustment) and we actually draw the arrows.

\begin{verbatim}
\cs_new_protected:Npn \@@_scan_arrows:
\{\group_begin:\int_compare:nNnT \l_@@_pos_arrow_int = 7
\{\@@_scan_arrows_i:\int_set:Nn \l_@@_pos_arrow_int 8\}\\group_end:\}
\cs_new_protected:Npn \@@_scan_arrows_i:n
\{\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 adjustement 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).
\int_zero_new:N \l_@@_first_arrow_of_group_int
\int_zero_new:N \l_@@_first_line_of_group_int
\int_zero_new:N \l_@@_last_line_of_group_int
\seq_clear_new:N \l_@@_first_arrows_seq
\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.

\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.
\end{verbatim}
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.

```
\prop_get:cnN { g_@@_arrow_ \l_@@_prefix_str_ \int_use:N \l_@@_arrow_int_ prop } \l_tmpa_tl
\int_set:Nn \l_@@_initial_int \l_tmpa_tl
\prop_get:cnN { g_@@_arrow_ \l_@@_prefix_str_ \int_use:N \l_@@_arrow_int_ prop } \l_tmpa_tl
\int_set:Nn \l_@@_final_int \l_tmpa_tl
\prop_get:cnN { g_@@_arrow_ \l_@@_prefix_str_ \int_use:N \l_@@_arrow_int_ prop } \l_@@_status_arrow_str
\prop_get:cnN { g_@@_arrow_ \l_@@_prefix_str_ \int_use:N \l_@@_arrow_int_ prop } \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 conditional \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.

```
\int_compare:nNnTF \l_@@_final_int > \g_@@_line_int
\int_compare:nNnF \l_@@_pos_arrow_int = 8
{ \@@_error:n { Too~few~lines~for~an~arrow } }
\@@_treat_an_arrow_in_scan:
```

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

```
\int_incr:N \l_@@_arrow_int
```

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).

```
\bool_if:nT { \int_compare_p:nNn \l_@@_pos_arrow_int = 7 & \int_compare_p:nNn \l_@@_first_arrow_of_group_int > 0 }
{ \@@_draw_arrows:nn \l_@@_first_arrow_of_group_int \g_@@_arrow_int }
```

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).

```
\cs_new_protected:Npn \@@_treat_an_arrow_in_scan:
\bool_if:nT { \int_compare_p:nNn \l_@@_pos_arrow_int = 7 & \int_compare_p:nNn \l_@@_first_arrow_of_group_int > 0 }
{ \@@_draw_arrows:nn \l_@@_first_arrow_of_group_int \g_@@_arrow_int }
```

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).

```
\bool_lazy_and:nnT { \int_compare_p:nNn \l_@@_pos_arrow_int > 1 }
{ \bool_lazy_or_p:nn {\bool_lazy_and:nnT { \int_compare_p:nNn \l_@@_pos Arrow_int = 7 } }
```

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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 conditionnal, 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: $\l_@@_{first\_arrow\_of\_group\_int}$, $\l_@@_{first\_line\_of\_group\_int}$, $\l_@@_{last\_line\_of\_group\_int}$, $\l_@@_{first\_arrows\_seq}$, $\l_@@_{last\_arrows\_seq}$.

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.

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

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

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

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

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.

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.

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. 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).
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).

```latex
\str_if_eq:VnTF \l_@@_status_arrow_str { over } \{
  \seq_put_right:NV \l_@@_o_arrows_seq \l_@@_arrow_int \}
\@@_draw_arrow:
\int_incr:N \l_@@_arrow_int
\}
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).

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

```latex
\prop_get:cnN \l_@@_arrow_\l_@@_prefix_str _ \int_use:N \l_@@_arrow_int _ prop \{
\prop_set:cn \l_@@_arrow_prefix_str _ \int_use:N \l_@@_arrow_int _ prop \}
\str_clear_new:N \l_tmpa_tl
\exp_args:NNo \exp_args:No \@@_keys_set: { \l_tmpa_tl , tikz = { xshift = \l_@@_xoffset_dim } }
We create two booleans to indicate the position of the initial node and final node of the arrow in cases of options `rr`, `rl`, `lr` or `ll`:

```latex
\int_case:nn \l_@@_pos_arrow_int
0 \{ \bool_set_true:N \l_@@_final_r_bool \}
2 \{ \bool_set_true:N \l_@@_initial_r_bool \}
3 \{
  \bool_set_true:N \l_@@_initial_r_bool
  \bool_set_true:N \l_@@_final_r_bool
\}
```

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).
\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.

\tl_set:Nx \l_@@_initial_tl
\{ \int_use:N \l_@@_initial_int - \bool_if:NTF \l_@@_initial_r_bool rl \}
\tl_set:Nx \l_@@_final_tl
\{ \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.

\prop_get:cnN \l_@@_arrow_int \l_@@_prefix_str \l_@@_arrow_int prop \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.

\seq_if_in:NxTF \l_@@_first_arrows_seq \{ \int_use:N \l_@@_arrow_int \}
\{ \bool_set_true:N \l_tmpa_bool \}
\seq_if_in:NxTF \l_@@_last_arrows_seq \{ \int_use:N \l_@@_arrow_int \}
\{ \bool_set_true:N \l_tmpb_bool \}
\int_compare:nNnT \l_@@_pos_arrow_int = 5
\{ \bool_set_true:N \l_tmpa_bool \}
\bool_set_true:N \l_tmpb_bool
\bool_set_true:N \l_tmpb_bool

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 adjustment 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).

\dim_gzero_new:N \g_@@_x_initial_dim
\dim_gzero_new:N \g_@@_x_final_dim
\dim_gzero_new:N \g_@@_y_initial_dim
\dim_gzero_new:N \g_@@_y_final_dim
\pgfpicture
\pgfrememberpicturepositionnonpagetrue
\pgfpointanchor { wa \l_@@_prefix_str \l_@@_initial_tl } { south }
\dim_gset:Nn \g_@@_x_initial_dim \pgf@x
\dim_gset:Nn \g_@@_y_initial_dim \pgf@y
\pgfpointanchor { wa \l_@@_prefix_str \l_@@_final_tl } { north }
\dim_gset:Nn \g_@@_x_final_dim \pgf@x
\dim_gset:Nn \g_@@_y_final_dim \pgf@y
\endpgfpicture
\bool_lazy_and:nnTF
\{ \dim_compare_p:nNn \g_@@_y_initial_dim \g_@@_y_final_dim \}
\{ \l_@@_max_length_of_arrow_dim \}
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.
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.\footnote{There were other solutions: use another name without underscore (like \ltmpatl) or use the package underscore (with this package, the characters underscore will be rescanned without errors, even in text mode).}

\@@_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).

\group_end:

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

\cs_new_protected:Npn \@@_def_function_tmpa:n #1
\begin{tikzpicture}
\tikzpicture
\pgf@relevantforpicturesizetrue
\dim_compare:nNnTF \pgf@picminx = { 16000 pt }
\dim_set:Nn \l_tmpa_dim { \pgf@picmaxx - \pgf@picminx }
\dim_add:Nn \l_tmpa_dim \l@@_xoffset_dim
\prop_gput:cnV
\l@@_arrow_int \l@@_prefix_str \l@@_arrow_int_prop
\l_tmpa_dim
\bool_if:NF \l@@_right_overlap_bool
\dim_gset:Nn \g@@_overlap_x_dim \l@@_arrow_int_prop
\dim_max:nn

Now, the actualization of \g@@_overlap_x_dim.

\bool_if:NT \l@@_in_WithArrows_bool
\l@@_xoffset_dim
\l@@_arrow_int
\l@@_arrow_int_prop
\prop_gput:cnV
\g@@_overlap_x_dim
\dim_max:nn

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

\cs_new_protected:Npn \@@_draw_arrow:nnn #1 #2 #3
{
  \bool_lazy_and:nnT \l_@@_wrap_lines_bool \l_@@_in_DispWithArrows_bool
  { \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_wrap_lines_tl }

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

\exp_args:NV \@@_def_function_tmpa:n \l_@@_tikz_code_tl
\@@_tmpa:nnn { #1 } { #2 } { #3 }
\cs_generate_variant:Nn \@@_draw_arrow:nnn { n n o }

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).

\tl_const:Nn \c_@@_tikz_code_wrap_lines_tl
{ \pgfset { inner~sep = 0pt}
  First, we draw the arrow without the label.
  \draw ( #1 ) to node ( @@_label ) { } ( #2 ) ;
  We retrieve in \pgf@x the abscissa of the left-side of the label we will put.
  \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.
  \dim_set:Nn \l_tmpa_dim { \g_@@_right_x_dim - \pgf@x - 0.3333 ex }
  We retrieve in \g_tmpa_tl the current value of the Tikz parameter “text width”.\footnote{In 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.}
  \path [pgfextra { \tl_set:Nx \g_tmpa_tl \tikz@text@width } ]
  Maybe the current value of the parameter “text width” is shorter than \l_tmpa_dim. In this case, we must use “text width” (we update \l_tmpa_dim).
Now, we can put the label with the right value for “text width”.

\begin{verbatim}
\dim_compare:nNnT \l_tmpa_dim > \c_zero_dim
\path ( @@_label.west )
\node [ anchor = west ]
\{ \skip_horizontal:n { 0.3333 ex } \begin { minipage } { \l_tmpa_dim } \tikz@text@action \pgfkeysgetvalue { / tikz / node~halign~header } \l_tmpa_tl
\tl_if_eq:NnTF \l_tmpa_tl { \tikz@align@left@header }
{ \pgfutil@raggedright }
\tl_if_eq:NnTF \l_tmpa_tl { \tikz@align@right@header }
{ \pgfutil@raggedleft }
\tl_if_eq:NnTF \l_tmpa_tl { \tikz@align@center@header }
{ \centering }
\} #3 \end { minipage }
\cstyle{LaTeX}
\node [ anchor = west , text~width = \dim_use:N \l_tmpa_dim ]
\{ #3 \};
\cstyle{plain-TeX}
\end{verbatim}

\section{The command \texttt{update} \_x}

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

\begin{verbatim}
\cs_new_protected:Npn \@@_update_x:nn #1 #2
{ \dim_gset_eq:NN \g_tmpa_dim \l_@@_x_dim \pgfpicture
\pgfrememberpicturepositiononpagetrue \int_step_inline:nnn { #1 } { #2 }
{ \pgfpointanchor { wa - \l_@@_prefix_str - ##1 - 1 } { center }
\dim_gset:Nn \g_tmpa_dim { \dim_max:nn \g_tmpa_dim \pgf@x }
\endpgfpicture \dim_set_eq:NN \l_@@_x_dim \g_tmpa_dim }
\end{verbatim}

\section{We draw the arrows of type \texttt{o}}

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

\begin{verbatim}
\cs_new_protected:Npn \@@_draw_o_arrows_of_the_group:
{ }
\end{verbatim}
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}

Now, we can draw the arrows of type o of the group in the order of the sequence.

We retrieve the initial row and the final row of the arrow.
The string \_@@\_input\_line\_str will be used only in some error messages.

\prop_get:cnN
\{ g\_@@\_arrow \_ \_l\_@@\_prefix\_str \_ ##1 \_ prop \}
\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 \pgf\picture.

\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 error\footnote{Maybe we will change that in future versions.}).

\bool_set_false:N \_g\_tmpa\_bool
\pgfpicture
\pgfrememberpicturepositiononpagetrue
\int_step_inline:nnn \_l\_@@\_first\_arrow\_int \_ \_l\_@@\_last\_arrow\_int
\{
\prop_get:cnN
\{ g\_@@\_arrow \_ \_l\_@@\_prefix\_str \_ ##1 \_ prop \}
\{ initial \} \_l\_tmpa\_tl
\prop_get:cnN
\{ g\_@@\_arrow \_ \_l\_@@\_prefix\_str \_ ##1 \_ prop \}
\{ final \} \_l\_tmpb\_tl
\prop_get:cnN
\{ g\_@@\_arrow \_ \_l\_@@\_prefix\_str \_ ##1 \_ prop \}
\{ status \} \_l\_@@\_status\_arrow\_str
\bool_if:nNT
\{
! \int_compare_p:n \{ ##1 = ##1 \}
& & \int_compare_p:n \{ \_l\_@@\_initial\_int <= \_l\_tmpa\_tl \}
& & \int_compare_p:n \{ \_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.

& & ! \str_if_eq_p:Vn \_l\_@@\_status\_arrow\_str \{ independent \}
\}
\}
\}

The total width of the arrow (with its label) has been stored in a “field” of the arrow.

\bool_gset_true:N \_g\_tmpa\_bool
\prop_get:cnN
\{ g\_@@ \_arrow \_ \_l\_@@\_prefix\_str \_ ##1 \_ prop \}
\{ width \} \_l\_tmpa\_tl
\dim_gset:Nn \_g\_tmpa\_dim \{ \dim_max:nn \_g\_tmpa\_dim \_l\_tmpa\_tl \}
\}
\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\_).

\bool_if:NTF \_g\_tmpa\_bool
\{
\int_set:Nn \_l\_@@\_arrow\_int \{ ##1 \}
\dim_set_eq:NN \_l\_@@\_offset\_dim \_g\_tmpa\_dim
\dim_add:NN \_l\_@@\_offset\_dim \_l\_@@\_offset\_for\_o\_arrows\_dim
\_@@\_draw\_arrow:
\}
\{ \_@@\_error:n \{ o\_arrow\_with\_no\_arrow\_under \} \}
\}
\}
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.

\begin{verbatim}
\NewExpandableDocumentCommand \WithArrowsLastEnv { } \int_use:N \g_@@_last_env_int
\end{verbatim}

12.11 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`.

\begin{verbatim}
\keys_define:nn { WithArrows / Arrow / code-after }
{
tikz .code:n = \tikzset { WithArrows / arrow / .append-style = { #1 } } ,
tikz .value_required:n = true ,
rr .value_forbidden:n = true ,
rr .code:n = \@@_fix_pos_option:n 0 ,
ll .value_forbidden:n = true ,
ll .code:n = \@@_fix_pos_option:n 1 ,
rl .value_forbidden:n = true ,
rl .code:n = \@@_fix_pos_option:n 2 ,
lr .value_forbidden:n = true ,
lr .code:n = \@@_fix_pos_option:n 3 ,
v .value_forbidden:n = true ,
v .code:n = \@@_fix_pos_option:n 4 ,
tikz-code .tl_set:N = \l_@@_tikz_code_tl ,
tikz-code .value_required:n = true ,
offset .dim_set:N = \l_@@_xoffset_dim ,
offset .value_required:n = true ,
unknown .code:n = \@@_sort_seq:N \l_@@_options_Arrow_code_after_seq
\@@_error:n { Unknown-option-Arrow-in-code-after }
}
\end{verbatim}

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.

\begin{verbatim}
\seq_new:N \l_@@_options_Arrow_code_after_seq
\@@_set_seq_of_str_from_clist:Nn \l_@@_options_Arrow_code_after_seq
{ ll, lr, rl, rr, tikz, tikz-code, v, x, offset }
\end{verbatim}

\begin{verbatim}
\NewDocumentCommand \@@_Arrow_code_after { O { } m m m ! O { } }
\cs_new_protected:Npn \@@_Arrow_code_after { \peek_meaning:NTF [ \@@_Arrow_code_after_i }
\@@_Arrow_code_after_i [ ] }
\end{verbatim}
We prevent drawing an arrow from a line to itself.

\tl_if_eq:nnTF { #2 } { #3 } { \@@_error:nn { Both~lines~are~equal } { #2 } }

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

{ \cs_if_free:cTF { pgf@sh@ns@wa - \l_@@_prefix_str - #2 - l } { \@@_error:nx { Wrong~line~in~Arrow } { #2 } } }

{ \cs_if_free:cTF { pgf@sh@ns@wa - \l_@@_prefix_str - #3 - l } { \@@_error:nx { Wrong~line~in~Arrow } { #3 } } }

{ \int_compare:nNnTF \l_@@_pos_arrow_int = 4 }

\begin{pgfpicture}
\pgfpointanchor { wa - \l_@@_prefix_str - r l }{ south }
\dim_set_eq:NN \l_tmpa_dim \pgf@x
\dim_set_eq:NN \l_tmpb_dim \pgf@y
\pgfpointanchor { wa - \l_@@_prefix_str - r l }{ north }
\dim_set:Nn \l_tmpa_dim \dim_max:nn \l_tmpa_dim \pgf@x
\tl_gset:Nx \g_tmpa_tl { \dim_use:N \l_tmpa_dim , \dim_use:N \l_tmpb_dim }
\tl_gset:Nx \g_tmpb_tl { \dim_use:N \l_tmpa_dim , \dim_use:N \pgf@y }
\endpgfpicture

{ \pgfpicture
\pgfpointanchor { wa - \l_@@_prefix_str - r l }{ south }
\dim_set:Nn \l_tmpa_dim \dim_max:nn \l_tmpa_dim \pgf@x
\tl_gset:Nx \g_tmpa_tl { \dim_use:N \l_tmpa_dim , \dim_use:N \l_tmpb_dim }
\tl_gset:Nx \g_tmpb_tl { \dim_use:N \l_tmpa_dim , \dim_use:N \pgf@y }
\endpgfpicture


12.12 The command \texttt{\textbackslash MultiArrow} in code-after

The command \texttt{\textbackslash\texttt{@@_MultiArrow:nn}} will be linked to \texttt{\textbackslash MultiArrow} when the code-after is executed.

\begin{verbatim}
\cs_new_protected:Npn \@@_MultiArrow:nn #1 #2
\exp_args:Nnx \regex_match:nnTF { \A \d+ (,\d+)* ( , \ldots (,\d+)+ )* \Z } { #1 } { \@@_MultiArrow_i:nn { #1 } { #2 } } { \@@_error:nx { Invalid specification for MultiArrow } { #1 } }
\end{verbatim}

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 \texttt{\foreach} and that's why we will construct the list in \texttt{\_gtmpa_clist}.

\begin{verbatim}
\foreach \x in { #1 }
\{ \cs_if_free:cTF { pgf@sh@ns@wa - \_l_@@_prefix_str - \x - l } { \@@_error:nx { Wrong-line-specification-in-MultiArrow } \x } { \clist_gput_right:Nx \_gtmpa_clist \x } \}
\end{verbatim}

We sort the list \texttt{\_gtmpa_clist} because we want to extract the minimum and the maximum.
We extract the minimum in \l_tmpa_tl (it must be an integer but we store it in a token list of L3).

\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...

\clist_reverse:N \g_tmpa_clist
\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).

\exp_args:NV \@@_MultiArrow_i:n \g_tmpa_clist

Now, we draw the rest of the structure.

\begin{tikzpicture}
\foreach \k in {#1}
\draw [coordinate]
\foreach \k in {#1}
\end{tikzpicture}
\begin{tikzpicture}
\draw [<-]
([xshift = \l_@@_xoffset_dim]\k-r.south) -- ++(5mm,0);
\end{tikzpicture}
\end{tikzpicture}

\section*{12.13 The error messages of the package}
\bool_if:NTF \c_@@_messages_for_Overleaf_bool
\{ \str_const:Nn \c_@@_available_keys_str { } \}
\{
\str_const:Nn \c_@@_available_keys_str
{ For-a-list-of-the-available-keys,-type-H<return>. }
\}
\str_new:N \l_witharrows_body_str
The following commands must \textit{not} be protected since they will be used in error messages.
\cs_new:Npn \@@_potential_body_i:
{ \str_if_empty:NF \l_witharrows_body_str
{ \Ifyou-want-to-see-the-body-of-the-environment,-type-H<return>. }
}
\cs_new:Npn \@@_potential_body_ii:
{ \str_if_empty:NTF \l_witharrows_body_str
{ No-further-help-available }
\{
The-body-of-your-environment-was:\
\l_witharrows_body_str
\}
}
\str_const:Nn \c_@@_option_ignored_str
{ If-you-go-on,this-option-will-be-ignored. }
\str_const:Nn \c_@@_command_ignored_str
{ If-you-go-on,this-command-will-be-ignored. }
\@@_msg_new:nn { amsmath~not~loaded }
{ amsmath~not~loaded.\You~can't\textquoteleft\textquoteleft use\textquoteright\textquoteright~the\textquoteleft\textquoteleft\l_keys_key_str\textquoteright\textquoteright\textquoteleft\textquoteleft\textquoteleft~because\textquoteleft\textquoteleft the\textquoteleft\textquoteleft package\textquoteleft\textquoteleft amsmath\textquoteleft\textquoteleft\textquoteleft~has\textquoteleft\textquoteleft~not\textquoteleft\textquoteleft~been\textquoteleft\textquoteleft~loaded.\Ifyou-go-on,this-option-will-be-ignored-in-the-rest-of-the-document. }
}
\@@_msg_new:nn { Bad~value~for~replace~brace~by }
{ Incorrect-value.\Bad-value-for-the-option\textquoteleft\l_keys_key_str\textquoteright\textquoteleft\textquoteleft-The-value-must-begin-with-an-extensible-left-delimiter.-The-possible-values-are:\texttt{\{,\(,\[,\{,\langle,\[,\lgroup,\langle,\lfloor\~and\~\lceil\~(and\~\lfloor\~\lvert\~\and\~\lceil\}}
if-\text{amsmath-or-unicode-math-is-loaded-in-LaTeX}).\ 
\c_@@_option_ignored_str

\c_@@_option_ignored_str

\@@_msg_new:nn { option-of-cr-negative }
{ Bad-value.\\
\text{The-argument-of-the-command-}token_to_str:N\\
\text{should-be-positive-in-the-row-}int_use:N \g_@@_line_int\\
\text{of-your-environment-}l_@@_type_env_str.\\
\c_@@_option_ignored_str
}

\@@_msg_new:nn { omit-probably-used }
{ Strange-problem.\\
\text{Maybe-you-have-used-a-command-}\\
\text{or-another-line-of-your-environment-}l_@@_type_env_str.\\
\text{You-can-go-on-but-you-may-have-others-errors.}
}

\langle \LaTeX \rangle

\@@_msg_new:nnn { newline-at-the-end-of-env }
{ Incorrect-end.\\
The-environments-of-witharrows-(\{WithArrows\})-and-\\
(\{DispWithArrows\})-should-not-end-by-}token_to_str:N \g_@@_line_int\\
\text{However,-you-can-go-on-for-this-time.-No-similar-error-will-be-}\\
\text{raised-in-this-document.}
\c_@@_option_ignored_str
\c_@@_option_ignored_str

\langle /\LaTeX \rangle

\@@_msg_new:nnn { Invalid-option-format }
{ Invalid-value.\\
The-key-}format-should-contain-only-letters-r,-c-and-l-and-\\
\text{must-not-be-empty.}\\
\c_@@_option_ignored_str
\c_@@_option_ignored_str

\langle /\LaTeX \rangle

\@@_msg_new:nnn { invalid-key-o }
{ Invalid-use-of-a-key.\\
The-key-}o\text{-for-individual-arrows-can-be-used-only-in-mode-}\\
\text{group'-or-in-mode-'groups'.}\\
\c_@@_option_ignored_str
\c_@@_option_ignored_str

\langle /\LaTeX \rangle

\@@_msg_new:nnn { Value-for-a-key }
{ Misuse-of-a-key.\\
The-key-}l_keys_key_str\text{-should-be-used-without-value.}\\
\text{However,-you-can-go-on-for-this-time.}
\c_@@_option_ignored_str
\c_@@_option_ignored_str

\langle /\LaTeX \rangle

\@@_msg_new:nnn { Unknown-option-in-Arrow }
{ Unknown-option.\\
The-key-}l_keys_key_str\text{-is-unknown-for-the-command-}
The available keys are (in alphabetic order):
\seq_use:Nnnn \l_@@_options_Arrow_seq {and} {,} {and}.

\@@_msg_new:nnn { Unknown option WithArrows }
{ Unknown option.\}
The key '\l_keys_key_str' is unknown in \token_to_str:N \WithArrows. \}
\seq_use:Nnnn \l_@@_options_WideArrows_seq {and} {,} {and}.

\@@_msg_new:nnn { Unknown option DispWithArrows }
{ Unknown option.\}
The key '\l_keys_key_str' is unknown in \token_to_str:N \DispWithArrowsOptions. \}
\seq_use:Nnnn \l_@@_options_DispWithArrows_seq {and} {,} {and}.

\@@_msg_new:nnn { Unknown option WithArrowsOptions }
{ Unknown option.\}
The key '\l_keys_key_str' is unknown in \token_to_str:N \WithArrowsOptions. \}
\seq_use:Nnnn \l_@@_options_WideArrowsOptions_seq {and} {,} {and}.

\@@_msg_new:nnn { Unknown option Arrow in code-after }
{ Unknown option.\}
The key '\l_keys_key_str' is unknown in \token_to_str:N \Arrow in code-after. \}
\seq_use:Nnnn \l_@@_options_WideArrowsCodeAfter_seq {and} {,} {and}.

\@@_msg_new:nnn { Too much columns in WithArrows }
{ Too much columns.\}
Your environment \token_to_str:N \WithArrows has \int_use:N \l_@@_nb_cols_int columns and you try to use one more.\}
Maybe you have forgotten a \backslash_str \backslash_str\backslash_str
If you really want to use more columns (after the arrows) you should use
the option 'more-columns' at a global level or for an environment. \ \ 
However, you can go one for this time.
\@@_potential_body_i:
\@@@@potential_body_ii:
\@@_msg_new:nn { Too-much-columns-in-DispWithArrows }
{ 
Too-much-columns. \ \ 
Your environment \{$\backslash_@@_type_env_str\}$ has \$\int_use:N \backslash_@@_nb_cols_use_int \$ columns and you try to use one more. - 
Maybe you have forgotten a \$\backslash_@@_backslash_str\backslash_@@_backslash_str\$ at the end of row \$\backslash_@@_line_int. \ \ \$ 
This error is fatal. 
\@@_potential_body_i:
\@@@@potential_body_ii:
\@@_msg_new:nn { Negative-jump }
{ 
Incorrect value. \ \ 
You can’t use a negative value for the option 'jump' of command
\{$\backslash_@@_string_Arrow_for_msg_str\}$ in the row \$\backslash_@@_line_int\$ of your environment \{$\backslash_@@_type_env_str\}$.
- 
You can create an arrow going backwards with the option '<-' of Tikz. \ \ 
\_\@@_option_ignored_str
\@@_msg_new:nn { new-group-without-groups }
{ 
Misuse of a key. \ \ 
You can’t use the option 'new-group' for the command
\{$\backslash_@@_string_Arrow_for_msg_str\}$ because you are not in 'groups' mode. Try to use the option
'groups' in your environment \{$\backslash_@@_type_env_str\}$.
\_\@@_option_ignored_str
\@@_msg_new:nn { Too-few-lines-for-an-arrow }
{ 
Impossible arrow. \ \ 
Line \$\backslash_@@_input_line_str\$ 
\$\backslash_@@_arrow specified \$ \$\backslash_@@_line_int\$ 
of your environment \{$\backslash_@@_type_env_str\}$ can’t be drawn 
because it arrives after the last row of the environment. \ \ 
If you go on, this arrow will be ignored. 
\@@_potential_body_i:
\@@@@potential_body_ii:
\@@_msg_new:nn { o-arrow-with-no-arrow-under }
{ 
Problem with the key 'o'. \ \ 
Line \$\backslash_@@_input_line_str\$ 
\$\backslash_@@_arrow \$ \$\backslash_@@_line_int\$ 
of your environment \{$\backslash_@@_type_env_str\}$ 
there is no arrow 'under' your arrow of type 'o'. \ \ 
If you go on, this arrow won’t be drawn.
\@@_msg_new:nn { WithArrows-outside-math-mode }
{ 
You are outside math mode. \ \ 
The environment \{$\backslash_@@_type_env_str\}$ should be used only in math mode like the environment \{$\backslash_@@_aligned\$ of amsmath. \ \ 
Nevertheless, you can go on.
You are in math mode.\ \ The environment `{\l_@@_type_env_str}` should be used only outside math mode like the environments `{align}` and `{align*}` of amsmath. \ This error is fatal.

Incompatible options.\ \ You try to use the option `'{\l_keys_key_str}'` but this option is incompatible or redundant with the option `'{\l_@@_previous_key_str}'` set in the same command `'{\l_@@_string_Arrow_for_msg_str}'` in the code after of your environment `{\l_@@_type_env_str}`.\ \ However you can go on for this time.

Bad use of `'{\l_@@_string_Arrow_for_msg_str}'` only in the last column (column `\int_use:N\l_@@_nb_cols_int`) in the row `\int_use:N\g_@@_line_int` of your environment `{\l_@@_type_env_str}`.\ \ However you can go on for this time.

Wrong line specification in `MultiArrow`
Wrong-line-specification.\ \ The-specification-of-line-`#1'-doesn't-exist. \ \ If-you-go-on,-it-will-be-ignored-for-\token_to_str:N \MultiArrow.
}
\@@_msg_new:nn { Too-small-specification-for-MultiArrow }
{ Too-small-specification.\ \ The-specification-of-lines-you-gave-to-\token_to_str:N \MultiArrow\ is-too-small:-you-need-at-least-two-lines. \ \ \c_@@_command_ignored_str
}
\@@_msg_new:nn { Not-allowed-in-DispWithArrows }
{ Forbidden-command.\ \ The-command-`\token_to_str:N #1\ \ is-allowed-only-in-the-last-column-\langle\text{column-}\int_use:N\l_@@_nb_cols_int\rangle\text{-of-}`\l_@@_type_env_str\langle\text{DispWithArrows}\rangle. \ \ \c_@@_option_ignored_str
}
\@@_msg_new:nn { Not-allowed-in-WithArrows }
{ Forbidden-command.\ \ The-command-`\token_to_str:N #1\ \ is-not-allowed-in-`\l_@@_type_env_str\langle\text{DispWithArrows}\rangle. \ \ \c_@@_option_ignored_str
}
\@@_msg_new:nn { tag*-without-amsmath }
{ amsmath-not-loaded.\ \ We-can't-use-`\token_to_str:N \tag*-because-you-haven't-loaded-amsmath-\langle\text{or-mathtools}\rangle. \ \ If-you-go-on,-the-command-`\token_to_str:N \tag\ \ will-be-used-instead.
}
\@@_msg_new:nn { Multiple-tags }
{ Multiple-tags.\ \ You-can't-use-twice-the-command-`\token_to_str:N \tag\ \ in-a-line-of-the-environment-`\l_@@_type_env_str\langle\text{DispWithArrows}\rangle. \ \ If-you-go-on,-the-tag-`#1'-will-be-used.
}
\@@_msg_new:nn { Multiple-labels }
{ Multiple-labels.\ \ Normally,-we-can't-use-the-command-`\token_to_str:N \label\ \ twice-in-a-line-of-the-environment-`\l_@@_type_env_str\langle\text{DispWithArrows}\rangle. \ \ However,-you-can-go-on.-\ \ \bool_if:NT \c_@@_showlabels_loaded_bool\ \ { However,-only-the-last-label-will-be-shown-by-showlabels,- }\ \ If-you-don't-want-to-see-this-message-again,-you-can-use-the-option-\langle\text{`allow-multiple-labels'}\text{-at-the-global-or-environment-level.}\ \ \}
\@@_msg_new:nn { Multiple-labels-with-cleveref }
{ Multiple-labels.\ \ Since-you-use-cleveref,-you-can't-use-the-command-`\token_to_str:N \label\ \ twice-in-a-line-of-the-environment-`\l_@@_type_env_str\langle\text{DispWithArrows}\rangle. \ \ If-you-go-on,-you-may-have-undefined-references.
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`).

```
\@@_msg_new:nn { Option-xoffset-forbidden }
\{
  Incorrect-key.\"
  You-can't-use-the-option-'xoffset'-in-the-command-\langle\LaTeX\rangle\mbox{in-the-row}'int_use:N\mbox{\g_@@_line_int}\mbox{of-your-environment-\langle\LaTeX\rangle\mbox{\l_@@_type_env_str}\rangle-}
  because-you-are-using-the-option-'int_compare:nNnTF \l_@@_pos_arrow_int = 7
  \{ group \}
  \{ groups \ } '-'It's-possible-for-an-independent-arrow-or-if-there-is-only-one-arrow. \"
\c_@@_option_ignored_str
\}
```

```
\@@_msg_new:nn { Duplicate-name }
\{
  Duplicate-name.\"
  The-name-'\langle\LaTeX\rangle\mbox{\l_keys_value_tl}'-is-already-used-and-you-shouldn't-use-the-same-environment-name-twice.-You-can-go-on,-but,-maybe,-you-will-have-incorrect-results. \"
  For-a-list-of-the-names-already-used,-type-H<return>. \"
  If-you-don't-want-to-see-this-message-again,-use-the-option-'allow-duplicate-names'.
\}
```

```
\@@_msg_new:nn { Invalid-specification-for-MultiArrow }
\{
  Invalid-specification.\"
  The-specification-of-rows-for-\langle\LaTeX\rangle\mbox{\token_to_str:N\MultiArrow}\mbox{(i.e.-#1)}-is-invalid. \"
\c_@@_command_ignored_str
\}
```

### 12.14 The command `\WithArrowsNewStyle`

A new key defined with `\WithArrowsNewStyle` will not be available at the local level.
First, we detect whether there is unknown keys in \#2 by storing in $\texttt{l_tmpa_seq}$ the list of the unknown keys.

\begin{verbatim}
\seq_clear:N \l_tmpa_seq
\keyval_parse:NNn \@@_valid_key:n \@@_valid_key:nn \{ #2 \}
\seq_if_empty:NTF \l_tmpa_seq
\seq_put_right:Nx \l_@@_options_WithArrows_seq
{ \tl_to_str:n \{ #1 \} }
\seq_put_right:Nx \l_@@_options_DisWithArrows_seq
{ \tl_to_str:n \{ #1 \} }
\seq_put_right:Nx \l_@@_options_WithArrowsOptions_seq
{ \tl_to_str:N \{ #1 \} }
\end{verbatim}

When we will consider that $\texttt{\keys_precompile:nnN}$ (introduced in LaTeX on 2022-03-09) is widely available, we will delete that test and keep only the first version.

\begin{verbatim}
\cs_if_exist:NTF \keys_precompile:nnN
\keys_precompile:nnN
{ WithArrows / WithArrowsOptions }
{ \l_tmpa_tl }
\@@_key_define:nV \{ #1 \} \l_tmpa_tl
{ }
\keys_define:nn \{ WithArrows / Global \}
{  \keys_set:nn \{ WithArrows / WithArrowsOptions \} \{ #2 \} }
{ }
\@@_msg_new:nn \{ Impossible-style \} \{ #1 \}
{ Impossible-style.\\
It's-impossible-to-define-the-style-'#1'-
because-it-contains-unknown-keys:.'
\seq_use:Nnnn \l_tmpa_seq \{ '-and-' \} \{ ',' \} \{ '-and'-\}.
}
\cs_new_protected:Npn \@@_valid_key:n \#1
\keys_if_exist:nF \{ WithArrows / Global \} \{ \l_tmpa_seq \{ #1 \} \}
\cs_new_protected:Npn \@@_valid_key:nn \#1 \#2
\keys_if_exist:nF \{ WithArrows / Global \} \{ \l_tmpa_seq \{ #1 \} \}
\cs_new_protected:Npn \@@_key_define:nn \#1 \#2
\keys_define:nn \{ WithArrows / Global \}
{ \keys_set:nn \{ WithArrows / WithArrowsOptions \} \{ #2 \} }
\cs_generate_variant:Nn \@@_key_define:nn \{ n V \}
\@@_msg_new:nn \{ Key-already-defined \}
{ Key-already-defined.\\
The-key-'#1'-is-already-defined. \}
\end{verbatim}

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12.15 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 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.

\keys_define:nn { WithArrows / up-and-down }
{
  radius .dim_set:N = \l_@@_up_and_down_radius_dim ,
  radius .value_required:n = true ,
  width .code:n =
  \str_case:nnF { #1 }
  { { min } { \dim_zero:N \l_@@_arrow_width_dim }
    { max } { \dim_set_eq:NN \l_@@_arrow_width_dim \c_max_dim }
  }
  \dim_set:Nn \l_@@_arrow_width_dim { #1 } ,
  width .value_required:n = true ,
  unknown .code:n = \@@_error:n { Option-unknown-for-up-and-down }
}

\@@_msg_new:nn { Option-unknown-for-up-and-down }
{ Unknown-option.\
  The-option-'\l_keys_key_str'-is-unknown.-\c_@@_option_ignored_str
}

The token list \c_@@_tikz_code_up_tl is the value of tikz-code which will be used for an option up.

⟨LaTeX⟩
\tl_const:Nn \c_@@_tikz_code_up_tl
{ }

First the case when the key up is used with width=\max (that’s the default behaviour).

\dim_compare:nNnTF { \l_@@_arrow_width_dim } = \c_max_dim
{
  \draw [ rounded-corners = \l_@@_up_and_down_radius_dim ]
  let \p1 = ( #1 ) , \p2 = ( #2 )
  in \p1 -- node
  { \dim_set:Nn \l_tempa_dim { \x2 - \x1 }
  \begin { varwidth } \l_tempa_dim
  a \narrowragged is a command of the package varwidth.
  \narrowragged
  \#3
  \end { varwidth }
  \}(\x2,\y1) -- (\p2) ;
}
Now the case where the key \texttt{up} is used with \texttt{width=value} with \texttt{value} equal to \texttt{min} or a numeric value. The instruction \texttt{\path} doesn’t draw anything: its aim is to compute the natural width of the label of the arrow. We can’t use \texttt{\pgfextra} here because of the \texttt{\hbox_gset:Nn}.

\begin{verbatim}
\{ \path
  let \p1 = ( #1 ) , \p2 = ( #2 )
  \node \end
\}

The length $\l_{tma\_dim}$ will be the maximal width of the box composed by the environment \{\texttt{varwidth}\}.

\begin{verbatim}
\dim_set:Nn \l_{tma\_dim}
  \{ \x2 - \x1 - \l_{00\_up\_and\_down\_radius\_dim} \}
\dim_compare:nNnF \l_{00\_arrow\_width\_dim} = \c_zero\_dim
  \{ \dim_set:Nn \l_{tma\_dim}
        \dim_min:nn \l_{tma\_dim} \l_{00\_arrow\_width\_dim} \}
\end{verbatim}

Now, the length $\l_{tma\_dim}$ 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.

\begin{verbatim}
\hbox_gset:Nn \g_{tmpa\_box}
  \begin{varwidth} \l_{tma\_dim}
    \arrowragged
    #3
  \end{varwidth}
\dim_compare:nNnTF \l_{00\_arrow\_width\_dim} > \c_zero\_dim
  \dim_gset_eq:NN \g_{tmpa\_dim} \l_{00\_arrow\_width\_dim}
  \dim_gset:Nn \g_{tmpa\_dim}{ \box_wd:N \g_{tmpa\_box} } ;
\draw
  let \p1 = ( #1 ) , \p2 = ( #2 )
  \in (\x2-\g_{tmpa\_dim},\y1)
  \node { \box_use:N \g_{tmpa\_box} };
\end{verbatim}

The length $\g_{tmpa\_dim}$ will be the width of the arrow (+ the radius of the corner).

\begin{verbatim}
\dim_compare:nNnTF \l_{00\_arrow\_width\_dim} > \c_zero\_dim
  \{ \dim_gset_eq:NN \g_{tmpa\_dim} \l_{00\_arrow\_width\_dim} }\}
\dim_gset:nnN \g_{tmpa\_dim} \l_{00\_up\_and\_down\_radius\_dim}
\dim_case:nnF \l_{00\_arrow\_width\_dim}
  \c_max\_dim
  \{ \draw \[ \text{rounded-corners = \l_{00\_up\_and\_down\_radius\_dim} ]
    let \p1 = ( #1 ) , \p2 = ( #2 )
    \in \text{\{\texttt{\texttt{x2,y1}}\} -- (p2) ;
  \}
\c_zero\_dim
  \{ \path node
    \hbox_gset:Nn \g_{tmpa\_box} \{ #3 \}
    \dim_gset:NN \g_{tmpa\_dim}
    \{ \box_wd:N \g_{tmpa\_box} + \l_{00\_up\_and\_down\_radius\_dim} \}
  \}
\end{verbatim}
The code for an arrow of type \texttt{down} is similar to the previous code (for an arrow of type \texttt{up}).

\begin{verbatim}
\tl_const:Nn \c_@@_tikz_code_down_tl
{
  \dim_compare:nNnTF \l_@@_arrow_width_dim = \c_max_dim
  {
    \draw [ rounded-corners = \l_@@_up_and_down_radius_dim ]
    let \p1 = ( #1 ) , \p2 = ( #2 )
    in (\x1,\y2) -- node
    {
      \begin { varwidth } \l_tmpa_dim
      \narrowragged
      #3
      \end { varwidth }
    }
    \dim_compare:nNnTF \l_@@_arrow_width_dim > \c_zero_dim
    {
      \dim_set:Nn \l_@@_arrow_width_dim \l_@@_up_and_down_radius_dim
      \dim_gset_eq:NN \l_@@_arrow_width_dim \box_wd:N \g_tmpa_box
      \dim_gadd:Nn \l_@@_arrow_width_dim \l_@@_up_and_down_radius_dim
    }
    \draw
  }
}
\end{verbatim}

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.).

\begin{verbatim}
\dim_compare:nNnTF \l_@@_arrow_width_dim > \c_zero_dim
  {
    \begin { varwidth } \l_tmpa_dim
    \narrowragged
    #3
    \end { varwidth }
  }
\dim_gadd:Nn \l_@@_arrow_width_dim \l_@@_up_and_down_radius_dim
}\draw
\end{verbatim}

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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.

\keys_define:nn { WithArrows / Arrow / FirstPass }

\{ 
  up .code:n = \@@_set_independent_bis: ,
  down .code:n = \@@_set_independent_bis: ,
  up .default:n = NoValue ,
  down .default:n = NoValue 
\}

The options are scanned a second time when the arrow is actually drawn. That’s the second pass.
The main action occurs now. We change the value of the \texttt{tikz-code}.

\begin{verbatim}
\tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_up_tl
\}
\end{verbatim}

\begin{verbatim}
\tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_down_tl
\}
\end{verbatim}

\begin{verbatim}
\seq_put_right:Nn \l_@@_options_Arrow_seq { down }
\seq_put_right:Nn \l_@@_options_Arrow_seq { up }
\end{verbatim}

\begin{verbatim}
\@@_msg_new:nn { calc-not-loaded }
\end{verbatim}

\begin{verbatim}
\catcode `@ = 12
\ExplSyntaxOff
\end{verbatim}

\section{History}
\subsection{Changes between 2.7 and 2.8}
New key \texttt{right-overlap}

\subsection{Changes between 2.6b and 2.7}
Correction of a bug: when the key \texttt{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 programmation 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 535089 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`.42

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 `! {}` (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).

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 `listlbls`.

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`.

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*}`.

42Before 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`. 

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Changes between 1.7 and 1.8

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

Changes between 1.6 and 1.7

New environments \texttt{DispWithArrows} and \texttt{DispWithArrows*}.

Changes between versions 1.5 and 1.6

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

Changes between versions 1.4 and 1.5

The Tikz code used to draw the arrows can be changed with the option \texttt{tikz-code}. Two new options \texttt{code-before} and \texttt{code-after} have been added at the environment level. A special version of \texttt{\Arrow} is available in \texttt{code-after} in order to draw arrows in nested environments. A command \texttt{\MultiArrow} is available in \texttt{code-after} to draw arrows of other shapes.

Changes between versions 1.3 and 1.4

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

Changes between versions 1.2 and 1.3

New options \texttt{ygap} and \texttt{ystart} for fine tuning.

Changes between versions 1.1 and 1.2

The package \texttt{witharrows} can now be loaded without having loaded previously \texttt{tikz} and the libraries \texttt{arrow.meta} and \texttt{bending} (this extension and these libraries are loaded silently by \texttt{witharrows}). New option \texttt{groups} (with a \texttt{s})

Changes between versions 1.0 and 1.1

Option for the command \texttt{\} and option \texttt{interline} Compatibility with \texttt{\usetikzlibrary{babel}} Possibility of nested environments \texttt{\{WithArrows\}}

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