tkz-linknodes 1.1 c

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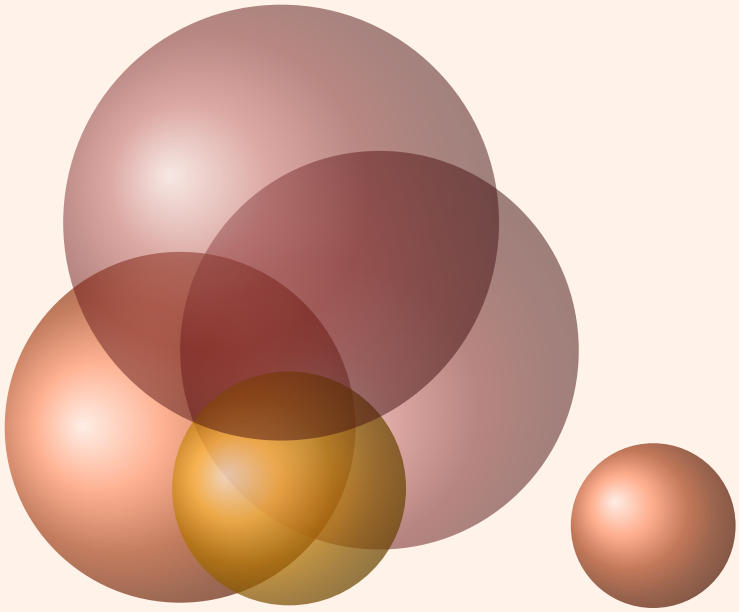

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http://altermundus.fr http://altermundus.com

tkz-linknodes

AlterMundus

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Tkz-linknodes.sty *arose from a question of* ***Philippe Ivaldi****, about* ***TikZ****. It was a question of knowing if we could easily create links between the lines of an environment as* ***aligned*** *or still* ***align*** *by indicating the operation made between the two lines. With the Philippe's acute remarks and his active collaboration, I hope I can bring you a useful tool.*

☞ Firstly, I would like to thank **Till Tantau** for the beautiful LATEX package, namely **TikZ**.

☞ I am grateful to **Michel Bovani** for providing the **fourier** font.

☞ Finally, I would like to thank **Herbert Voß** for providing a very good document **MathMode.pdf**, I used some examples from it. You can find **MathMode.pdf** here:
http://dante.ctan.org/indexes/info/math/voss/mathmode/

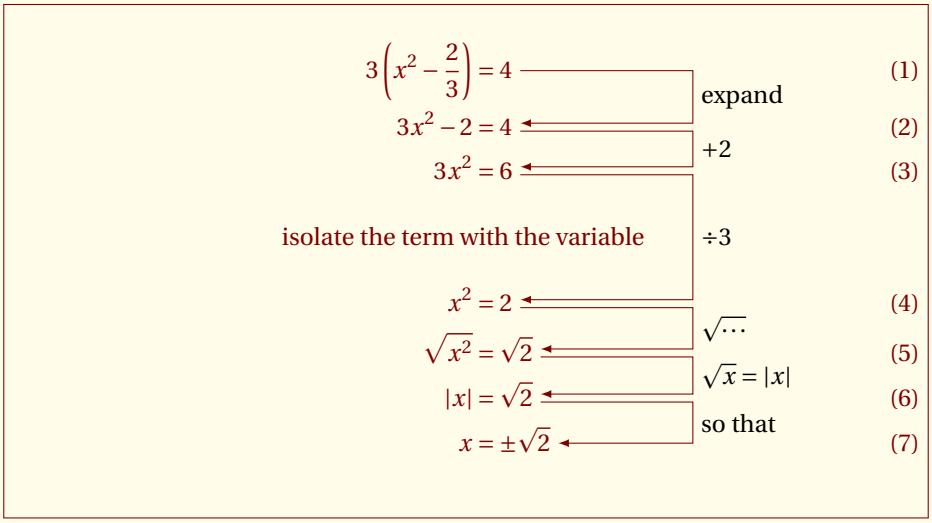
☞ Vous trouverez de nombreux exemples sur mes sites : altermundus.fr ou altermundus.com

Contents

SECTION 1

Introduction

Here is an example of what Philippe wanted when he used the environment **aligned** [1].



tkz-linknodes.sty is based on Ti*kZ*, constituted by an environment **NodesList** and two macros **\AddNode** and **\LinkNodes**.

Philippe and I wanted a maximum of simplicity in the syntax and wish that it so stays even if developments occur. Without another word, it's the simplicity itself.

1 The **aligned** environment is similar to the array environment, there exists no starred version and it has only one equation number and has to be part of another math environment, which should be equation environment.

SECTION 2

Installation

2.1 How to install the package linknodes.sty

It is possible that when you will read this document, **tkz-tab** is present on the **CTAN**[2] server. If **tkz-tab** is not still a part of your distribution, this chapter shows you how to install it.

2.2 With TeXLive under OS X and Linux

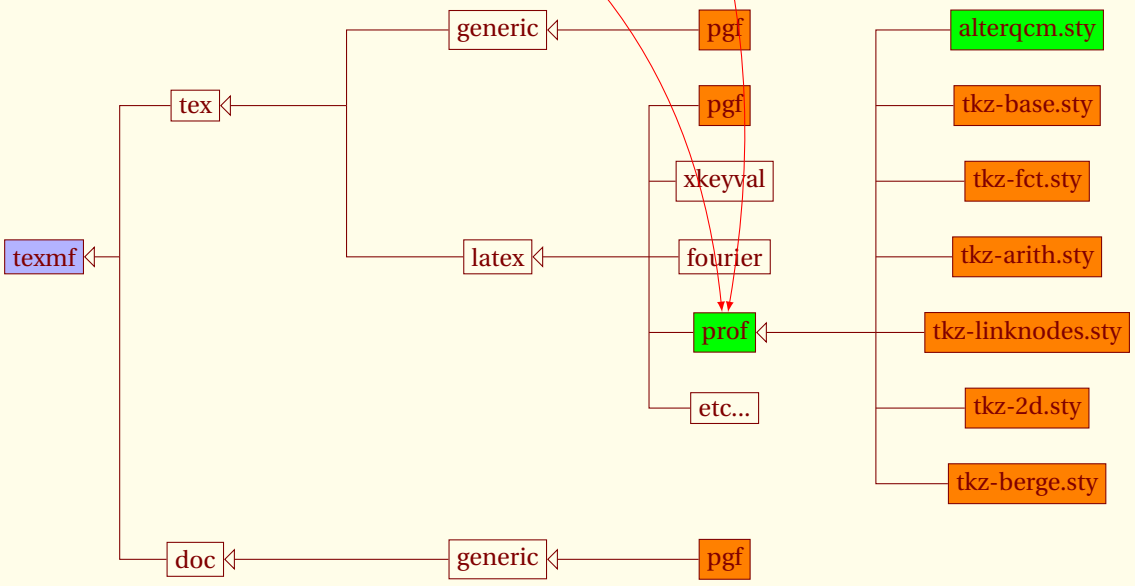
You could simply create a folder prof which path is : texmf/tex/latex/prof. texmf is generally the personnal folder. For example the paths of this folder on my two computers are

- with OS X **/Users/ego/Library/texmf** ;
- with Ubuntu **/home/ego/texmf**.

If you choose a custom location for your files, I suppose that you know why! The installation that I propose, is valid only for one user.

1. Store the file tkz-linknodes.sty in the folder prof.
2. Open a terminal, then type `sudo texhash`
3. Check that xkeyval(>=2.5) and tikz 2.0 are installed.

My folder texmf is structured as in the diagram below because I use the **CVS**[3] version of **TikZ**. You don't need all the **pgf** folders.



2 **tkz-tab** is not still a part of **TeXLive** but it will be soon possible to install it with **tlmgr**
3 You can find the cvs version here : http://www.texample.net/tikz/builds/ without CVS or here with CVS http://sourceforge.net/projects/pgf/

2.3 How to work with the tkz-LaTeX-package under Windows?

Download and install the following files (if not yet done):

1. the LaTeX-system MiKTeX from

   http://www.miktex.org/.

   What file you need (e.g. basic-miktex-2.7.2904.exe) and how to install this program is explained there in the "Download" section of the respective version (current version is 2.7). In general and as usual in windows, you run the setup process by starting the setup file :
   (e.g.basic-miktex-2.7.2904.exe).

2. Till Tantau's LaTeX-package pgf-tikZ from

   http://sourceforge.net/projects/pgf/

   "For MiKTeX, use the update wizard [of MiKTeX] to install the (latest versions of the) packages called pgf, xcolor, and xkeyval." (cited from the pgf manual, contained in the files downloaded).

3. the sty-files and the doc-files of Alain's tkz-package from

   http://www.altermundus.fr/pages/download.html.

   or

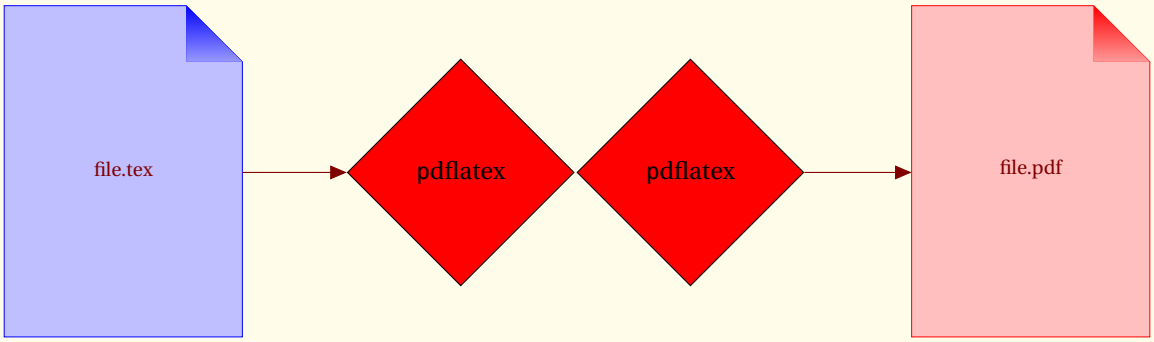
   http://altermundus.com/pages/download.html. To add the files to MiKTeX:

   - add a directory prof in the directory [MiKTeX-dir]/tex/latex', e.g. in windows explorer,
   - copy the sty-files in this directory prof,
   - update the MiKTeX system, ether by running in a DOS shell the command
     "mktexlsr -u"
     or by clicking
     "Start/Programs/Miktex/Settings/General", then push the button "Refresh FNDB".

SECTION 3

How to use the package linknodes.sty

You can compile with pdflatex but you have to compile your document twice! It's possible to compile with latex but only if the version of pdftex is equal to or greater than 1.40.



The package loads,tries to load **xkeyval**[2005/11/25], **tikz**[2007/06/07] version 2.00, **amsmath**, **etex** and **ifthen**.

3.1 Minimal example but complete

```
\documentclass[]{article}
\usepackage[utf8]{inputenc}
\usepackage[upright]{fourier}
\usepackage{tkz-linknodes}
\begin{document}
 \begin{NodesList}
 \[ % formula no "inline"
   \begin{aligned}
       2x     &= 8                                    \AddNode\\
       x      &= 4                                    \AddNode
   \end{aligned}
 \]
 \LinkNodes{$\div 2$}
 \end{NodesList}
\end{document}
```

3.2 Result

$$\begin{aligned} 2x &= 8 \\ x &= 4 \end{aligned} \quad \div 2$$

SECTION 4

Essential environment NodesList and macros \LinkNodes and \AddNode

4.1 The environment NodesList

\begin{NodesList}[⟨*options*⟩] ⟨*environment contents*⟩ **\end{NodesList}**

options	default	definition
margin	2cm	right margin
dy	1.5pt	2 × dy is the space between two adjacent arrows on the same node.

The use of this environment is obligatory. It admits options which we are going to detail in the following examples. These options are not obligatory and the values by default are given in the table above.

4.2 The command \AddNode

\AddNode[⟨***options***⟩]

options	default	definition
number	1	It defines to which group belongs this node

An optional argument is possible, thus placed between hooks if it is present, and it is an integer superior to 1. It defines to which group belongs this node.

This macro allows to ask that a link can leave or arrive of the node which we have just created. Really, it is not a node, I would say rather an anchor either another a reference point.
A group is a set of links (arrows). The origin of the one is the extremity of the precedent. The first group is noted 1 which is the value by default.

4.3 The command \LinkNodes

\LinkNodes[⟨***options***⟩]{⟨***expression***⟩}

options	default	definition
margin	2 cm	right margin
dy	1.5 pt	2 × dy is the space between two adjacent arrows on the same node.

This macro allows the representation of the link between nodes and the label the contents of which are "expression" placed on this link. These links are created by following the order of their creation.

The style of these links is determined by the default following styles :

- **\tikzset{ArrowStyle/.style={>=latex,->,text=black}}**
- **\tikzset{LabelStyle/.style={pos=0.25,right}}**

- **\tikzset{NodeStyle/.style={}}**

The first style is for the arrows then we have a style for the labels and the last style is for the node, by default it is empty.

As you notice it, the macro are simple and the syntax is LaTeXsyntax. It will be necessary to you to study a little **TikZ** only to modify the styles but some examples should be sufficient to realize what you wish.

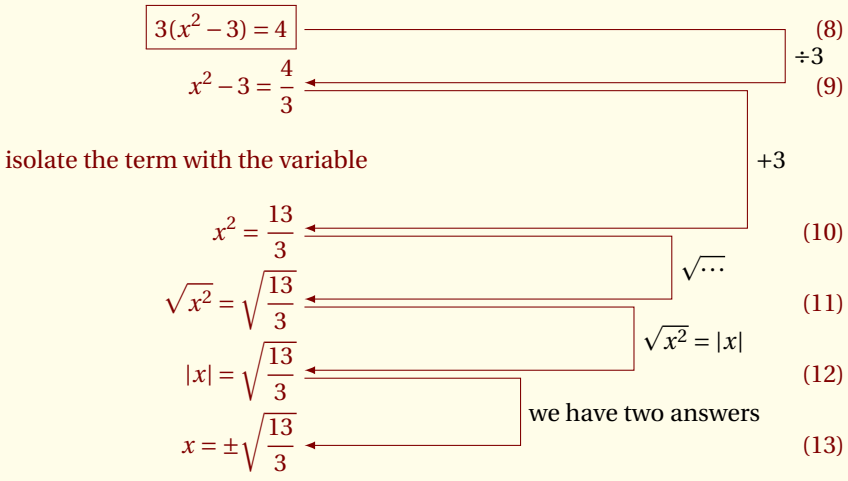
SECTION 5

The code of the example in the introduction

5.1 The code of the first example

Let us see first of all, the example of the introduction but placed in a more general frame, that of a page A4. Four nodes are created at the end of every line, then three links, both first ones have a personalized margin.

The environment **aligned** is placed in an environment **displaymath** that is "in display mathematical mode". It means that the equations are placed in a box having the width of the page and that the sign equals is situated in the center of a line.



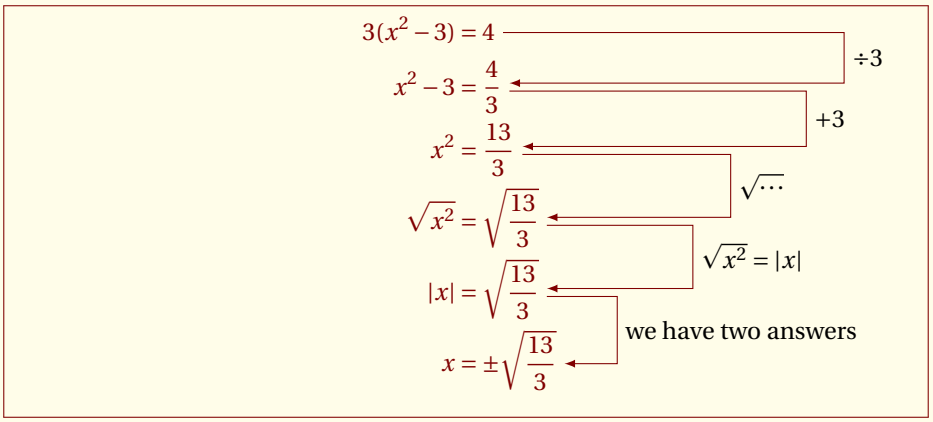

```
\begin{NodesList}
  \begin{align}
     \boxed{ 3(x^2-3) =4 }                                    \AddNode\\
     x^2-3  =\frac{4}{3}                                      \AddNode\\
     \intertext{\hfil isolate the term with the variable \hfil}
     x^2    =\frac{13}{3}                                     \AddNode\\
     \sqrt{x^2}    =\sqrt{\frac{13}{3}}                       \AddNode\\
      |x|   =\sqrt{\frac{13}{3}}                              \AddNode\\
     x      =\pm\sqrt{\frac{13}{3}}                           \AddNode
  \end{align}
  \LinkNodes[margin=1cm]{$\div 3$}%
  \LinkNodes[margin=1.5cm]{$+3$}%
  \LinkNodes[margin=2.5cm]{$\sqrt{\ldots}$}
  \LinkNodes[margin=3cm]{$\sqrt{x^2}=|x|$}
  \LinkNodes[margin=4.5cm]{we have two answers}
\end{NodesList}
```

That the environment **NodesList** makes exactly. It tracks down the width of the line of the page which goes the receive here this width is the width of the text because we are in a display mathematical mode. The example of the introduction is placed in an environment **minipage** of LaTeX, thus the width will be the one attributed to minipage.

Then, it prepares a list of counters to attribute automatically names to the nodes that the user will have placed with the macro **\AddNode**. The macro **\LinkNodes** represents a link between two successive nodes.

5.2 With the environment minipage

Thus we go to see what arrives at our environment in the case of an environment **minipage**. In that case the width of the page is given by **minipage**. The result can be seen below, we need to modify the last margin :




```
\documentclass[]{article}
\usepackage[utf8]{inputenc}     % My favorite encoding but not indispensable.
\usepackage[upright]{fourier}   % My favorite font.
\usepackage{LinkNodes}
\begin{document}
\begin{center}\fbox{\begin{minipage}{12cm}
  \begin{NodesList}
  \begin{displaymath}
   \begin{aligned}
      3(x^2-3) &=4                                                    \AddNode\\
      x^2-3  &=\frac{4}{3}                                           \AddNode\\
      x^2    &=\frac{13}{3}                                          \AddNode\\
      \sqrt{x^2}    &=\sqrt{\frac{13}{3}}                            \AddNode\\
       |x|   &=\sqrt{\frac{13}{3}}                                   \AddNode\\
      x      &=\pm\sqrt{\frac{13}{3}}                                \AddNode
      \end{aligned}
   \end{aligned}
  \end{displaymath}
  \LinkNodes[margin=4 cm]{$\div 3$}
  \LinkNodes[margin=3 cm]{$+3$}
  \LinkNodes{$\sqrt{\ldots}$}
  \end{NodesList}
  \end{minipage}}\end{center}
\end{document}
```

SECTION 6

Options with effects on the structure

6.1 One link between the first two lines

I take the same example and I try to modify it. I want only the first link so I create only two nodes and one link.

$$
\begin{aligned}
3(x^2-3) &= 4 \\
x^2-3 &= \frac{4}{3} \qquad \div 3 \\
x^2 &= \frac{13}{3} \\
\sqrt{x^2} &= \sqrt{\frac{13}{3}} \\
|x| &= \sqrt{\frac{13}{3}} \\
x &= \pm\sqrt{\frac{13}{3}}
\end{aligned}
$$

```
\begin{NodesList}
  \begin{displaymath}
    \begin{aligned}
      3(x^2-3) &= 4                                          \AddNode\\
        x^2-3  &= \frac{4}{3}                               \AddNode\\
        x^2    &= \frac{13}{3}                                    \\
  \sqrt{x^2}  &=\sqrt{\frac{13}{3}}                               \\
       |x|   &=\sqrt{\frac{13}{3}}                               \\
      x      &=\pm\sqrt{\frac{13}{3}}
      \end{aligned}
  \end{displaymath}
  \LinkNodes{$\div 3$}%
\end{NodesList}
```

6.2 One link between the last two lines

$$
\begin{aligned}
3(x^2-3) &= 4 \\
x^2-3 &= \frac{4}{3} \\
x^2 &= \frac{13}{3} \qquad \sqrt{\cdots} \\
\sqrt{x^2} &= \sqrt{\frac{13}{3}} \\
|x| &= \sqrt{\frac{13}{3}} \\
x &= \pm\sqrt{\frac{13}{3}}
\end{aligned}
$$

```
\begin{NodesList}
  \begin{displaymath}
     \begin{aligned}
        3(x^2-3) &= 4                                                    \\
          x^2-3  &= \frac{4}{3}                                          \\
          x^2    &= \frac{13}{3}                                  \AddNode\\
  \sqrt{x^2}  &=\sqrt{\frac{13}{3}}                                \AddNode\\
       |x|   &=\sqrt{\frac{13}{3}}                                       \\
      x      &=\pm\sqrt{\frac{13}{3}}
     \end{aligned}
  \end{displaymath}
  \LinkNodes{$\sqrt{\ldots}$}
\end{NodesList}
```

6.3 How to create a new group

We saw how having a link on the first nodes , as well as on the last ones, now here is an example to have a link on the first and the last nodes.

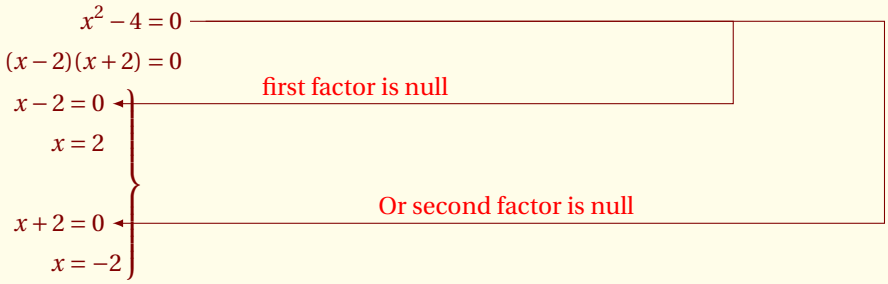
The principle is simple. The argument 2 indicates that we create another chain of links. It was already present but 1 is optional. The arguments must be created in increasing order.

$$
\begin{aligned}
3(x^2-3) &= 4 \\
x^2-3 &= \frac{4}{3} \qquad \div 3 \\
x^2 &= \frac{13}{3} \\
\sqrt{x^2} &= \sqrt{\frac{13}{3}} \qquad \sqrt{\cdots} \\
|x| &= \sqrt{\frac{13}{3}} \\
x &= \pm\sqrt{\frac{13}{3}}
\end{aligned}
$$

```
\begin{NodesList}
 \begin{displaymath}
  \begin{aligned}
   3(x^2-3) &=4                                                  \AddNode   \\
     x^2-3  &= \frac{4}{3}                                       \AddNode   \\
     x^2    &= \frac{13}{3}                                     \AddNode[2]\\
  \sqrt{x^2}  &=\sqrt{\frac{13}{3}}                             \AddNode[2]\\
       |x|   &=\sqrt{\frac{13}{3}}                                       \\
      x      &=\pm\sqrt{\frac{13}{3}}
  \end{aligned}
 \end{displaymath}
 \LinkNodes{$\div 3$}%
 \LinkNodes{$\sqrt{\ldots}$}
\end{NodesList}
```

6.4 Two groups on the same line

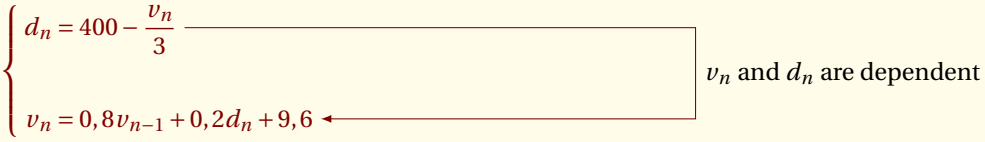
We can also do that.




```
\begin{NodesList}[margin=3cm]
 \begin{displaymath}\displaywidth=.4\linewidth
   \begin{aligned}
      x^2-4       & = 0                              \AddNode \AddNode[2]\\
      (x-2)(x+2)  & = 0                                                  \\
     \left.\begin{aligned}
               x-2 & = 0                                        \AddNode\\
               x   & = 2                                                \\
                   &                                                    \\
               x+2 & = 0                                    \AddNode[2]\\
               x   & = -2                                               \\
           \end{aligned}\right\}                                        \\
     \end{aligned}
 \end{displaymath}
  {\tikzset{LabelStyle/.style = {left=5cm,pos=.5,above,text=red}}
  \LinkNodes[margin=5cm]{ first factor is null}%
   \LinkNodes{Or  second factor is null}%
  }
\end{NodesList}
```

6.5 Empty line

You can try this example without **\hfill** at line 5.




```
 \begin{minipage}{10cm}
 \begin{NodesList}[margin=-2cm]
     \[\left\{
    \begin{aligned}
      d_n & =  \displaystyle {400-\frac{v_n}{3}}              \AddNode\hfill\\
          &                                                          \\
      v_n & =   0,8v_{n-1}+0,2d_n+9,6                      \AddNode\\
      \end{aligned}
     \right.\]
   \LinkNodes{$v_n$ and $d_n$  are dependent}
\end{NodesList}
 \end{minipage}
```

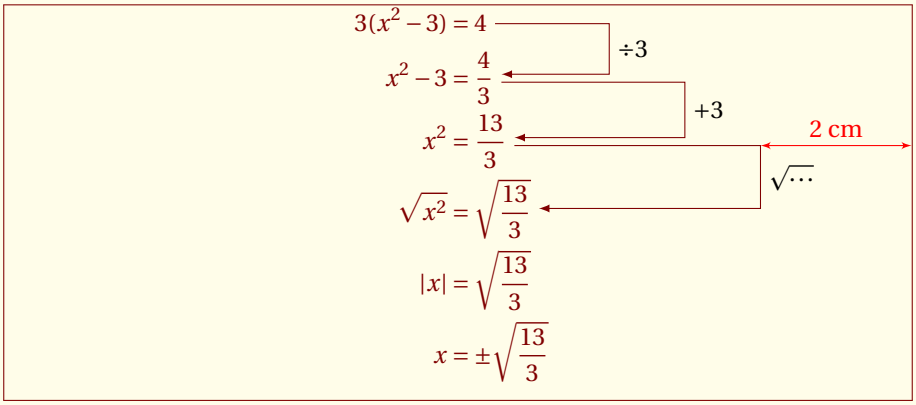
SECTION 7

Options with effects on the presentation

These options are among two, **margin** and **dy**. They are useful globally at the level of the environment **NodesList** either locally at the level of the macro **\LinkNodes**.

7.1 Option margin

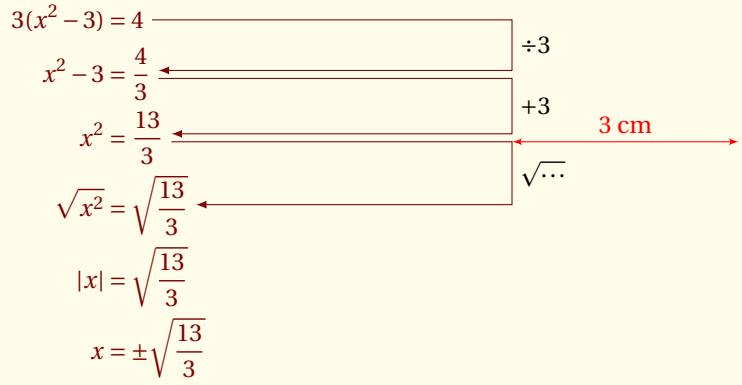
First of all, let us remind that the default margin is 2 cm. It is represented by the red arrow on the following figure. The margin is defined from the right edge of the box which begins the environment.



It is necessary to notice that the box of the introduction is slightly different from this one. Indeed, the macro **\fbox** adds a space around its equal contents in **\fboxsep**. This one was put in zero for the occasion.

7.2 Equal margins

I suppose that you understood that the option **margin** of the macro **\LinkNodes** plays the same role as that of the environment. So having deleted them, I choose a margin of 3 cm as everybody. This time with regard to the edge of the text field of the page.




```
\begin{NodesList}[margin=3cm]% By default, margin = 2cm.
 \begin{displaymath}
  \begin{aligned}
   3(x^2-3)   &= 4                                          \AddNode\\
     x^2-3    &= \frac{4}{3}                              \AddNode\\
     x^2      &= \frac{13}{3}                             \AddNode\\
```

```
\sqrt{x^2}    &=\sqrt{\frac{13}{3}}                                  \AddNode\\
      |x|     &=\sqrt{\frac{13}{3}}                                  \AddNode\\
     x        &=\pm\sqrt{\frac{13}{3}}                               \AddNode
  \end{aligned}%
 \end{displaymath}%
 \LinkNodes{$\div 3$}%
 \LinkNodes{$+3$}%
 \LinkNodes{$\sqrt{\ldots}$}%
\end{NodesList}
```

7.3 Negative margins

Yes we can! The example is from **MathMode.pdf** In this example, I use **\displaywidth**

$$y = 2x^2 - 3x + 5$$

$$= 2\left(\overbrace{x^2 - \frac{3}{2}x + \left(\frac{3}{4}\right)^2}^{=0} - \left(\frac{3}{4}\right)^2 + \frac{5}{2}\right)$$

$$= 2\left(\left(x - \frac{3}{4}\right)^2 + \frac{31}{16}\right)$$

$$y = 2\left(x - \frac{3}{4}\right)^2 + \frac{31}{8}$$

$2x^2 - 3x$ is the beginning of an algebraic identity (binomial formula)

$(a-b)^2 = a^2 - 2ab + b^2$

after simplication, the result is

```
\begin{NodesList}[margin=-1cm]
  \begin{displaymath}\displaywidth=.4\linewidth
\begin{aligned}
y &= 2x^2 -3x +5                          \AddNode\\
  & \hphantom{= \ 2\left(x^2-\frac{3}{2}\,x\right. }%
      \textcolor{blue}{%
        \overbrace{\hphantom{+\left(\frac{3}{4}\right)^2- %
          \left(\frac{3}{4}\right)^2}}^{=0}}   \\
  &= 2\left(\textcolor{red}{%
       \underbrace{%
          x^2-\frac{3}{2}\,x + \left(\frac{3}{4}\right)^2}%
   }%
   \underbrace{%
        - \left(\frac{3}{4}\right)^2 + \frac{5}{2}}%
   \right)                                    \AddNode\\
   &= 2\left(\qquad\textcolor{red}{\left(x-\frac{3}{4}\right)^2}
   \qquad + \ \frac{31}{16}\qquad\right)  \AddNode\\
y
   &= 2\left(x\textcolor{cyan}{-\frac{3}{4}}\right)^2\textcolor{blue}{+\frac{31}{8}}\AddNode
\end{aligned}
       \end{displaymath}
{         \tikzset{LabelStyle/.append style = {left,text=red}}
    \LinkNodes{%
    \begin{minipage}{5cm}
      $2x^2 -3x$ is the beginning of an algebraic identity %
       (binomial formula)
      \end{minipage}}
       \LinkNodes{$(a-b)^2=a^2-2ab+b^2$}
       \LinkNodes{after simplication, the result is}}
\end{NodesList}
```

7.4 The general option dy

Here, it is a question of adjusting the distance between two arrows. The distance is equal in 2 × dy

$$
\begin{aligned}
3(x^2-3) &= 4 && \text{÷3}\\
x^2-3 &= \frac{4}{3} && \text{+3}\\
x^2 &= \frac{13}{3} && \sqrt{\cdots}\\
\sqrt{x^2} &= \sqrt{\frac{13}{3}}\\
|x| &= \sqrt{\frac{13}{3}}\\
x &= \pm\sqrt{\frac{13}{3}}
\end{aligned}
$$

```
\begin{NodesList}[margin=3cm,dy=3pt]%
 \begin{displaymath}
  \begin{aligned}
   3(x^2-3)   &= 4                                          \AddNode\\
     x^2-3    &= \frac{4}{3}                              \AddNode\\
     x^2      &= \frac{13}{3}                             \AddNode\\
\sqrt{x^2}    &=\sqrt{\frac{13}{3}}                       \AddNode\\
       |x|    &=\sqrt{\frac{13}{3}}                       \AddNode\\
      x       &=\pm\sqrt{\frac{13}{3}}                    \AddNode
  \end{aligned}
 \end{displaymath}
 \LinkNodes{$\div 3$}%
 \LinkNodes{$+3$}%
 \LinkNodes{$\sqrt{\ldots}$}
\end{NodesList}
```

SECTION 8

Modification of the style

It is enough for it to modify either **{ArrowStyle}**, or **{LabelStyle}**. By default, the values are the following ones

8.1 Adding some style

At first, the shape of the arrow is modified as well as its color. For other forms of arrow, see the documention on the **pgfmanual**.

Then the place of the label is modified with `pos=0.75` . `pos=0` corresponds to the superior corner, `pos=0.25` in the middle of the vertical line. We can then adjust the position of the node, here **above** is used. For other adjustments, see **pgfmanual** or the following examples.

$$
\begin{aligned}
2x &= 8 && \text{÷2}\\
x &= 4
\end{aligned}
$$

```
  \begin{NodesList}
 \[
   \begin{aligned}
       2x     &= 8                                                  \AddNode\\
       x      &= 4                                                  \AddNode
   \end{aligned}
 \]
  {\tikzset{ArrowStyle/.style={>=stealth',->,cyan}}
   \tikzset{LabelStyle/.style={pos=0.75,above,text=red}}
   \LinkNodes{$\div 2$}}
\end{NodesList}
```

8.2 Modification of the text color

Since styles are just special cases of pgfkeys's general style facility, you can actually do quite a bit more. Let us start with adding options to an already existing style. This is done using /.append style instead of /.style:

`.append style` allows to take back the values of the style **`LabelStyle`** by adding the color[4] **`red`** in the text which replaces the old color. Note that two colors are set, so the last one will "win."


```
  \begin{NodesList}
 \[
   \begin{aligned}
       2x     &= 8                                                  \AddNode\\
       x      &= 4                                                  \AddNode
   \end{aligned}
 \]
  {\tikzset{LabelStyle/.append style = {text=red}}
   \LinkNodes{$\div 2$}}
\end{NodesList}
```

8.3 Modification of the text position

You need to read the paragraph of **`pgfmanual`** "Basic Placement Options". You can use **`left`**, **`right`**, **`above`** and **`below`** but also something like **`above right`** or **`left = 2 cm`**.


```
\begin{NodesList}
 \[
   \begin{aligned}
       2x     &= 8                                                  \AddNode\\
       x      &= 4                                                  \AddNode
   \end{aligned}
 \]
  {\tikzset{LabelStyle/.append style = {text=red,left}}
   \LinkNodes{$\div 2$}}
\end{NodesList}
```

4 Another possibility is **`\LinkNodes\textcolor{orange}{$\div 2$}`**

8.4 Boxed text

A little more sophisticated: **draw** allows to frame, **right=10pt** allows to move away a little the label, **green** defines the color of the line, **fill=green!30** defines the color of filling and finally the color of the text is red.

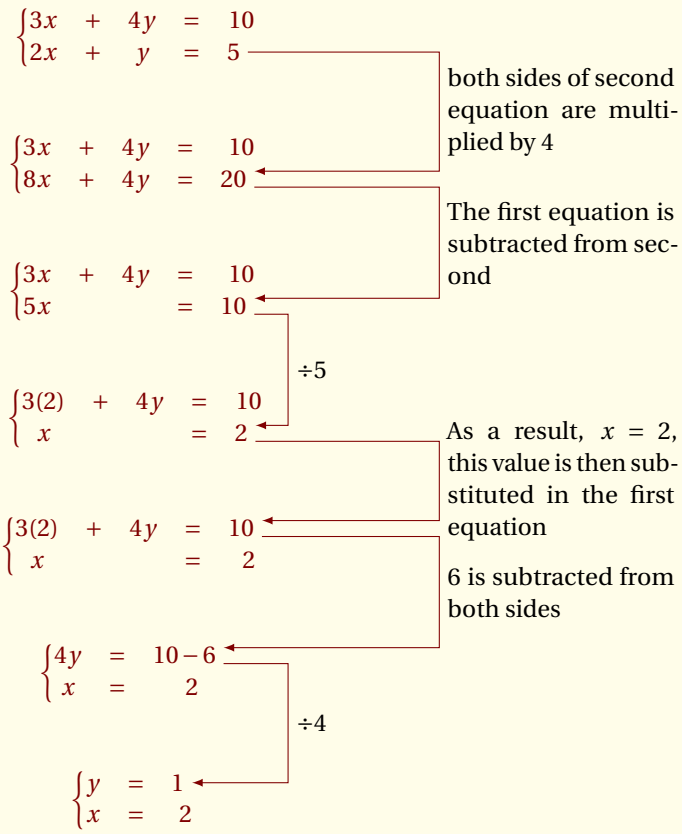

```
\begin{NodesList}
 \[
   \begin{aligned}
       2x     &= 8                                                \AddNode\\
       x      &= 4                                                \AddNode
   \end{aligned}
 \]
{\tikzset{LabelStyle/.style = {draw,right=10pt,red,fill=green!30,text=red}}
   \LinkNodes{$\div 2$}}
\end{NodesList}
```

SECTION 9

Some more complex examples

9.1 Solution of two simultaneous equations.

Solution of two simultaneous equations. The problem is to find the set of all solutions that satisfies both equations. These are called simultaneous equations.



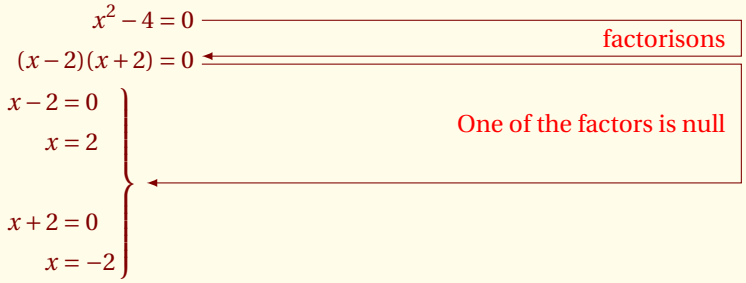
The solution is $\{(x = 2\,;\ y = 1)\}$

```
 \begin{minipage}{12cm}
 \begin{NodesList}[dy=3pt]
 \[ \left\{\begin{matrix}
 3x  &+& 4y   &=& 10\\
 2x &+&  y &=& 5  \AddNode\\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 3x  &+& 4y   &=& 10\\
 8x &+&  4y &=& 20  \AddNode\\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 3x  &+& 4y   &=& 10  \\
 5x &&    &=& 10  \AddNode\\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 3(2)  &+& 4y   &=& 10\\
 x &&    &=& 2  \AddNode\\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 3(2)  &+& 4y   &=& 10\AddNode\\
 x &&    &=& 2  \\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 4y   &=& 10-6\AddNode\\
 x   &=& 2  \\
 \end{matrix}\right. \]
\vspace{0.5cm}
 \[ \left\{\begin{matrix}
 y   &=& 1 \AddNode\\
 x   &=& 2  \\
 \end{matrix}\right. \]
\LinkNodes{\begin{minipage}{3cm}
   both sides of second equation  are multiplied by 4\end{minipage}}
\LinkNodes{\begin{minipage}{3cm}
  The first equation  is subtracted from  second \end{minipage}}
\LinkNodes[margin=4 cm]{$\div 5$}
\LinkNodes{\begin{minipage}{3cm}
  As a result, $x = 2$, this value is then substituted in the first equation
\end{minipage}}
\LinkNodes{%
\begin{minipage}{3cm}
      $6$ is subtracted from both sides\end{minipage}}
         \LinkNodes[margin=4 cm]{$\div 4$}
\end{NodesList}

The solution is $\{(x=2~;~y=1)\}$
 \end{minipage}
```

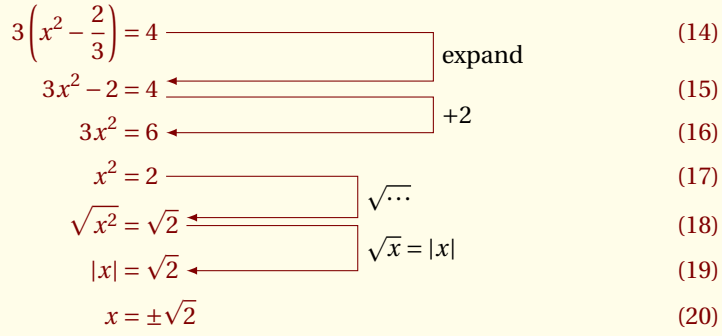
9.2 Nested Environments aligned

This example is more complex because the environments are nested.



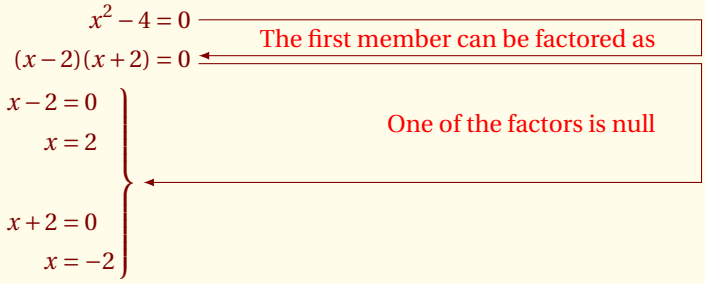

```
\begin{NodesList}[margin=0cm]
 \begin{displaymath}
   \begin{aligned}
      x^2-4       & = 0                                          \AddNode\\
      (x-2)(x+2)  & = 0                                          \AddNode\\
     \left.\begin{aligned}
               x-2 & = 0                                                 \\
               x   & = 2                                                 \\
                   &                                                     \\
               x+2 & = 0                                                 \\
               x   & = -2                                                \\
           \end{aligned}\right\}                                  \AddNode\\
     \end{aligned}
 \end{displaymath}
  {\tikzset{LabelStyle/.style = {left=0.1cm,pos=.25,text=red}}
  \LinkNodes[]{factorisons}%
   \LinkNodes{One of the factors is null}%
  }
\end{NodesList}
```

9.3 One environment and two groups



```
   \begin{NodesList}[margin=4 cm,dy=3pt]
      \begin{align}
    3\left(x^2-\frac{2}{3}\right) &= 4                                  \AddNode\\
      3x^2-2  &= 4                                                      \AddNode\\
      3x^2    &= 6                                                      \AddNode\\
       x^2    &= 2                                                      \AddNode[2]\\
\sqrt{x^2}    &= \sqrt{2}                                              \AddNode[2]\\
     |x|      &= \sqrt{2}                                              \AddNode[2]\\
      x       &= \pm\sqrt{2}
        \end{align}
\LinkNodes{expand}%
\LinkNodes{$+2$}%
\LinkNodes[margin=5 cm]{$\sqrt{\ldots}$}
\LinkNodes[margin=5 cm]{$\sqrt{x}=|x|$}
   \end{NodesList}
```

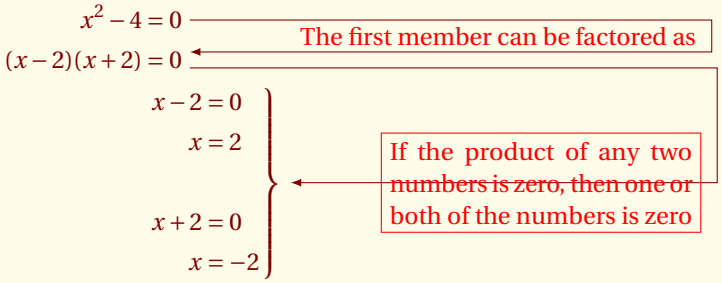
9.4 Two environments and a group




```
\begin{NodesList}[margin=0.5cm]
 \begin{displaymath}
   \begin{aligned}
      x^2-4       &= 0                                          \AddNode\\
      (x-2)(x+2)  &= 0                                          \AddNode\\
      {\left.
         \begin{aligned}
             x-2 &= 0                                                  \\
             x   &= 2                                                  \\
                 &                                                    \\
             x+2 &= 0                                                  \\
             x   &= -2                                                 \\
         \end{aligned}
       \right\}%
      }                                                          \AddNode\\
     \end{aligned}
 \end{displaymath}
{\tikzset{LabelStyle/.style = {left=0.5cm,pos=.25,text=red}}
 \LinkNodes[]{The first member can be factored as}%
 \LinkNodes{One of the factors is null}%
}
\end{NodesList}
```

9.5 Label with `minipage`

You can see in this example how to define a style if you want to place correctly a "minipage".

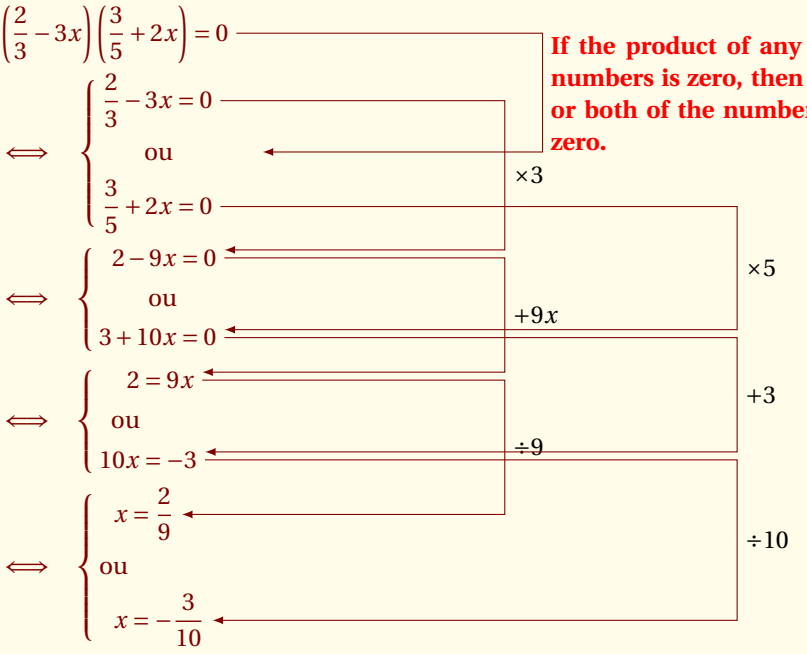



```
\begin{NodesList}[margin=1cm,dy=3pt]
  \begin{displaymath}
    \begin{aligned}
        x^2-4       &= 0                                          \AddNode\\
        (x-2)(x+2)  &= 0                                          \AddNode\\
                    &\left.%
                     \begin{aligned}
                            x-2 &= 0                                    \\
                            x   &= 2                                    \\
                                &                                       \\
                            x+2 &= 0                                    \\
                            x   &= -2
                     \end{aligned}%
                     \right\}\AddNode%
    \end{aligned}%
  \end{displaymath}
  {\tikzset{LabelStyle/.style = {left=0.1cm,pos=.25,text=red}}
  \LinkNodes{The first member can be factored as}%
  \tikzset{LabelStyle/.append style = {pos=.5,sloped}}
  \LinkNodes{%
\fbox{\begin{minipage}{4cm}
     If the product of any two numbers is zero, %
      then one or both of the numbers is zero
  \end{minipage}%
}
  }%
  }%
\end{NodesList}
```

9.6 Three groups and few environments aligned

It is interesting to notice the use of **\displaywidth** which allows in display mathematical mode to modify the placement with regard to the left margin.

Solve in **R** : $\left(\frac{2}{3}-3x\right)\left(\frac{3}{5}+2x\right)=0$



On the next page, the code looks like:

```
\begin{NodesList}[dy=3]
  \begin{displaymath}\displaywidth=.8\linewidth
    \begin{aligned}
      &\left(\frac{2}{3}-3x\right)\left(\frac{3}{5}+2x\right)=0    \AddNode\\
      &{\begin{aligned}
          &\Longleftrightarrow&&%
          \left\{{%
            \begin{aligned}
              \frac{2}{3}-3x&=0
                                                          \AddNode[2]&\\
              \textrm{ou}&&                                 \AddNode    \\
              \frac{3}{5}+2x&=0                           \AddNode[3]&\\
            \end{aligned}}%
          \right.                                                    \\
        &\Longleftrightarrow&&%
        {%
          \left\{%
          \begin{aligned}
            2-9x&=0                                        \AddNode[2]\\
            \textrm{ou}&                                              \\
            3+10x&=0                                       \AddNode[3]\\
          \end{aligned}\right.}                                      \\
        &\Longleftrightarrow&&%
        {%
          \left\{%
          \begin{aligned}
             2&=9x                                         \AddNode[2]\\
                    \textrm{ou}&                                      \\
            10x&=-3                                        \AddNode[3]\\
          \end{aligned}\right.}                                      \\
         &\Longleftrightarrow&&%
        {%
          \left\{%
          \begin{aligned}
            x&=\frac{2}{9}                                 \AddNode[2]\\
            \textrm{ou}&                                              \\
            x&=-\frac{3}{10}                               \AddNode[3]\\
          \end{aligned}\right.}                                      \\
       \end{aligned}}
    \end{aligned}
  \end{displaymath}
 \LinkNodes[margin=4.5cm]{%
\begin{minipage}{4cm}
   \textcolor{red}{\textbf{If the product of any two numbers is zero, then %
      one or both of the numbers is zero.}}
\end{minipage}}%
{\LinkNodes[margin=5cm]{$\times{}3$}%
 \LinkNodes[margin=5cm]{$+9x$}
 \LinkNodes[margin=5cm]{$\div(9)$}}
 \LinkNodes{$\times{}5$}%
 \LinkNodes{$+3$}
 \LinkNodes{$\div(10)$}
\end{NodesList}
```

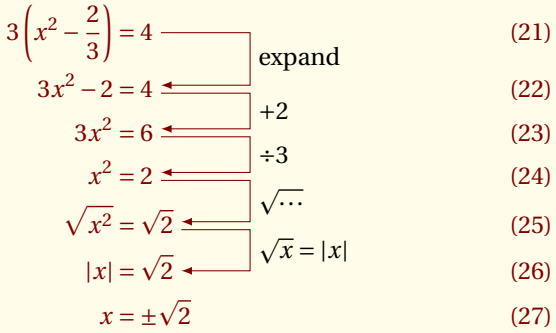
SECTION 10

How to use tkz-linknodes.sty with align

10.1 With align et minipage

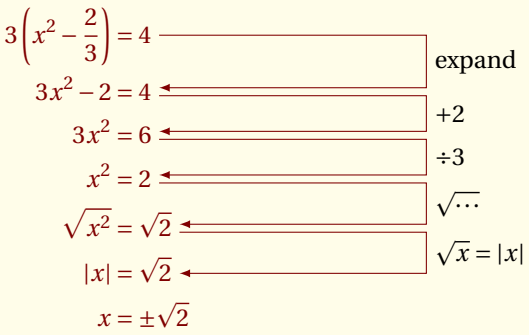
With this environment, we are directly in the display math mode and the lines are numbered.

This environment is very useful and I recommend you to see the examples in MathMode.tex of Herbert Voß.



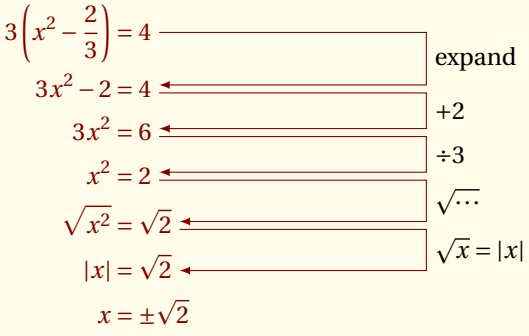

```
 \begin{minipage}{12cm}
   \begin{NodesList}[margin=4 cm]
      \begin{align}
    3\left(x^2-\frac{2}{3}\right) &= 4                                  \AddNode\\
      3x^2-2  &= 4                                                      \AddNode\\
      3x^2    &= 6                                                      \AddNode\\
       x^2    &= 2                                                      \AddNode\\
\sqrt{x^2}    &= \sqrt{2}                                              \AddNode\\
     |x|      &= \sqrt{2}                                              \AddNode\\
      x       &= \pm\sqrt{2}
        \end{align}
\LinkNodes{expand}%
\LinkNodes{$+2$}%
\LinkNodes{$\div 3$}
\LinkNodes{$\sqrt{\ldots}$}
\LinkNodes{$\sqrt{x}=|x|$}
   \end{NodesList}
 \end{minipage}
```

10.2 With `align*`




```
\begin{NodesList}[margin=4 cm]
\begin{align*}
     3\left(x^2-\frac{2}{3}\right) &= 4                    \AddNode\\
       3x^2-2  &= 4                                       \AddNode\\
       3x^2    &= 6                                       \AddNode\\
        x^2    &= 2                                       \AddNode\\
 \sqrt{x^2}    &= \sqrt{2}                                \AddNode\\
      |x|      &= \sqrt{2}                                \AddNode\\
       x       &= \pm\sqrt{2}
    \end{align*}
 \LinkNodes{expand}%
 \LinkNodes{$+2$}%
 \LinkNodes{$\div 3$}
 \LinkNodes{$\sqrt{\ldots}$}
 \LinkNodes{$\sqrt{x}=|x|$}
\end{NodesList}
```

10.3 With `align` and `nonumber`



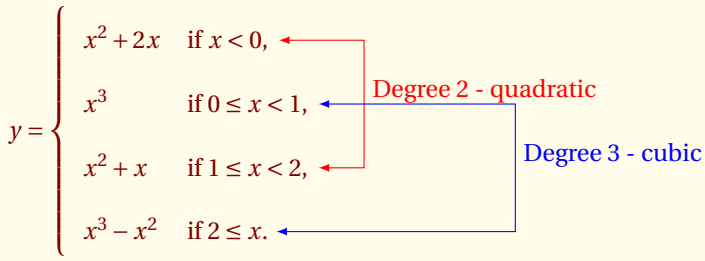
(28) (29) (30) (31) (32)

```
\begin{NodesList}[margin=4 cm]
\begin{align}
     3\left(x^2-\frac{2}{3}\right) &= 4                    \nonumber\AddNode\\
       3x^2-2  &= 4                                                \AddNode\\
       3x^2    &= 6                                        \nonumber\AddNode\\
        x^2    &= 2                                                \AddNode\\
 \sqrt{x^2}    &= \sqrt{2}                                         \AddNode\\
      |x|      &= \sqrt{2}                                         \AddNode\\
       x       &= \pm\sqrt{2}
    \end{align}
 \LinkNodes{expand}%
 \LinkNodes{$+2$}%
 \LinkNodes{$\div 3$}
 \LinkNodes{$\sqrt{\ldots}$}
 \LinkNodes{$\sqrt{x}=|x|$}
\end{NodesList}
```

SECTION 11

How to use tkz-linknodes.sty with array

11.1 With array an example from Mathmode.tex




```
\begin{minipage}{11cm}
{\renewcommand{\arraystretch}{2}%
\begin{NodesList}
\[y = \left\{%
   \begin{array}{ll}
     x^2+2x  &\textrm{if }x<0,                                  \AddNode   \\
     x^3     &\textrm{if }0\le x<1,                             \AddNode[2]\\
     x^2+x   &\textrm{if }1\le x<2,                             \AddNode   \\
     x^3-x^2 &\textrm{if }2\le x.                              \AddNode[2]
   \end{array}\right.\]
\tikzset{ArrowStyle/.append style = {<->,red}}
\tikzset{LabelStyle/.append style = {pos=0.20}}
\LinkNodes[margin=3cm]{Degree 2 - quadratic}
{\tikzset{ArrowStyle/.append style = {<->,blue}}
\LinkNodes[margin=1cm]{Degree 3 - cubic}}
\end{NodesList}}
\end{minipage}
```

11.2 An example from Mathmode.tex

In this example, we use an environment **minipage** in the label.

$$
\begin{array}{llrrr}
\text{a)} & y & = & c & (constant) \\
\text{b)} & y & = & cx+d & (linear) \\
\text{c)} & y & = & bx^2+cx+d & (square) \\
\text{d)} & y & = & ax^3+bx^2+cx+d & (cubic)
\end{array}
$$

Here are the various studied cases

```
\begin{NodesList}[margin=0cm]
  \[
  \begin{array}{@{}r@{\quad}ccrr@{}}
   \textrm{a}) & y & = & c & (constant)                          \AddNode \\
   \textrm{b}) & y & = & cx+d & (linear)                                 \\
   \textrm{c}) & y & = & bx^{2}+cx+d & (square)                        \\
   \textrm{d}) & y & = & ax^{3}+bx^{2}+cx+d & (cubic)             \AddNode
  \end{array}
\]
{\tikzset{ArrowStyle/.append style = {-,red}}
 \tikzset{LabelStyle/.append style = {left,text=red}}
 \LinkNodes{%
   \begin{minipage}{4cm}
    Here are the various studied cases
   \end{minipage}}%
 }
\end{NodesList}
```

11.3 An example from Mathmode.tex

$$
\begin{array}{rcll}
y & = & x^2+bx+c & \\
 & = & x^2+2\cdot\dfrac{b}{2}x+c & \\
 & = & \underbrace{x^2+2\cdot\dfrac{b}{2}x+\left(\dfrac{b}{2}\right)^2}_{\left(x+\frac{b}{2}\right)^2}-\left(\dfrac{b}{2}\right)^2+c & \\
 & = & \left(x+\dfrac{b}{2}\right)^2-\left(\dfrac{b}{2}\right)^2+c & \text{we add to each members } \left(\dfrac{b}{2}\right)^2-c \\
y+\left(\dfrac{b}{2}\right)^2-c & = & \left(x+\dfrac{b}{2}\right)^2 & \\
y-y_S & = & (x-x_S)^2 & \\
S(x_S;y_S) & \text{soit} & S\left(-\dfrac{b}{2};\left(\dfrac{b}{2}\right)^2-c\right) &
\end{array}
$$

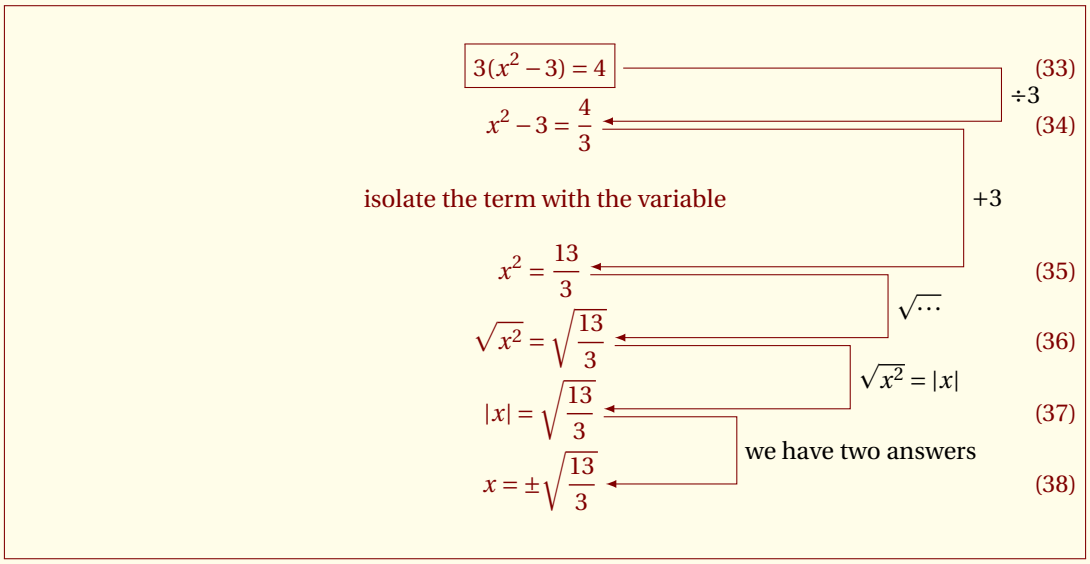
```
\begin{NodesList}
\[
\begin{array}{rcll}
   y & = & x^{2}+bx+c                                                    \\
     & = & x^{2}+2\cdot{\displaystyle\frac{b}{2}x+c}                     \\
     & = & \underbrace{x^{2}+2\cdot\frac{b}{2}x+%
           \left(\frac{b}{2}\right)^{2}}-%
           {\displaystyle\left(\frac{b}{2}\right)^{2}+c}                 \\
     &   & \qquad\left(x+{\displaystyle \frac{b}{2}}\right)^{2}          \\
     & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2}-%
          \left({\displaystyle  \frac{b}{2}}\right)^{2}+c          \AddNode\\
   y+\left({\displaystyle \frac{b}{2}}\right)^{2}-c%
     & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2}          \AddNode\\
   y-y_{S}%
     & = & (x-x_{S})^{2}                                                 \\
   S(x_{S};y_{S})%
     & \,\textrm{soit}\,%
         & S\left(-{\displaystyle%
           \frac{b}{2};\,\left({\displaystyle\frac{b}{2}}\right)^{2}-c}\right)
\end{array}
 \]
 \tikzset{LabelStyle/.append style = {right=0.5cm,pos=0.25,text=red}}
 \LinkNodes[margin=5cm]{%
 \begin{minipage}{3cm}
 we add to each members $\left({\displaystyle \frac{b}{2}}\right)^{2}-c$
   \end{minipage}}%
 \end{NodesList}
```

SECTION 12

Use with diverse environments

12.1 With `gather`

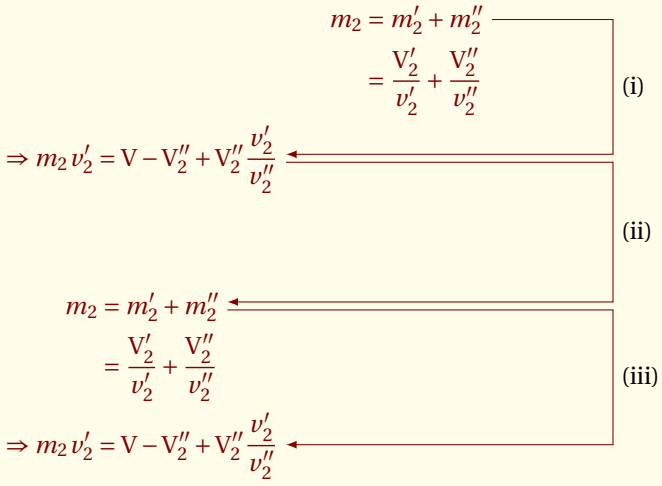
A little modified example from Mathmode.tex




```
\begin{center}
\fbox{%
 \begin{minipage}{14cm}
 \begin{NodesList}
   \begin{gather}
      \boxed{ 3(x^2-3) =4 }                                          \AddNode\\
      x^2-3  =\frac{4}{3}                                            \AddNode\\
      \intertext{\hfil isolate the term with the variable \hfil}
      x^2    =\frac{13}{3}                                           \AddNode\\
      \sqrt{x^2}    =\sqrt{\frac{13}{3}}                            \AddNode\\
       |x|   =\sqrt{\frac{13}{3}}                                    \AddNode\\
      x      =\pm\sqrt{\frac{13}{3}}                                 \AddNode
   \end{gather}
   \LinkNodes[margin=1cm]{$\div 3$}%
   \LinkNodes[margin=1.5cm]{$+3$}%
   \LinkNodes[margin=2.5cm]{$\sqrt{\ldots}$}
   \LinkNodes[margin=3cm]{$\sqrt{x^2}=|x|$}
   \LinkNodes[margin=4.5cm]{we have two answers}
 \end{NodesList}
\end{minipage}%
}
\end{center}
```

12.2 With gather* and align*

An example from Mathmode.tex




```
\begin{minipage}{\linewidth-7pt}
  \begin{NodesList}
    \begin{gather*}
      \begin{align*}
        m_2 &=  m_2' + m_2''                                          \AddNode\\
            &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''}
      \end{align*}                                                          \\
      \Rightarrow m_2 v_2' = V - V_2'' + V_2''\frac{v_2'}{v_2''}     \AddNode\\
    \end{gather*}
    \begin{gather*}
      \begin{align*}
        m_2 &=  m_2' + m_2''                                          \AddNode\\
            &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''} &
      \end{align*}                                                          \\
      \Rightarrow m_2 v_2' = V - V_2'' + V_2''\frac{v_2'}{v_2''}     \AddNode\\
    \end{gather*}
     \LinkNodes{(i)}
     \LinkNodes{(ii)}
     \LinkNodes{(iii)}
  \end{NodesList}
\end{minipage}
```

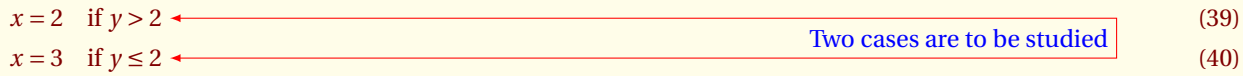
12.3 With enumerate

This example shows that we can use the environment **NodesList** with a list **enumerate**


```
  \begin{NodesList}[margin=7cm]
  \begin{enumerate}
    \item  A                                                \AddNode
    \item  B                                                \AddNode
    \item  C                                                \AddNode
    \item  D                                                \AddNode
  \end{enumerate}
  \LinkNodes{Liberté}%
  \LinkNodes{Égalité}%
  \LinkNodes{Fraternité}
\end{NodesList}
```

12.4 With flalign

Another example from Mathmode.tex




```
\begin{NodesList}
\begin{flalign}
       x & = 2\quad\textrm{if }y >2\AddNode & \\
       x & = 3\quad\textrm{if }y \le 2 \AddNode&
    \end{flalign}
{\tikzset{ArrowStyle/.append style = {<->,red}}
 \tikzset{LabelStyle/.append style = {left,text=blue}}
 \LinkNodes{Two cases are to be studied}}
\end{NodesList}
```

12.5 With listings

```
void example(FILE *fp)
{
  int c;

  while((c=fgetc(fp)!=EOF)){
    if(c=='X')
      goto done;
    fputc(c,stdout);
  }

done:
  exit(0);
}
```

```
\lstset{escapechar=\§}
\begin{NodesList}
 \begin{lstlisting}
 void example(FILE *fp)
 {
   int c;

   while((c=fgetc(fp)!=EOF)){
     if(c=='X')
       goto done; §\AddNode§
     fputc(c,stdout);
   }

done: §\AddNode§
   exit(0);
 }
 \end{lstlisting}
 \tikzset{ArrowStyle/.append style = {->,red}}

 \LinkNodes{}
\end{NodesList}
```

SECTION 13

Beamer and tkz-linknodes

The next example is from **Guillaume Connan**. The first thing you can notice about this code is the multiple nodes from the first line.

```
\documentclass[xcolor={usenames,pdftex,dvipsnames,table},10pt]{beamer}
\usepackage[utf8]{inputenc}
\usepackage{lmodern}
\usepackage[upright]{fourier}
\usepackage{tikz}

\usepackage{amsmath,calc}
\usepackage{tkz-linknodes}
\usetikzlibrary{arrows,shapes}
\newcommand{\vtab}{\rule[-1.2em]{0pt}{3em}}
\begin{document}
```

```
12
13 \begin{frame}
14 \tiny
15 \begin{NodesList}[margin=1cm]
16 \[
17 \begin{array}{lllllll}
18 \hline
19 \text{ Decimal}&\text{Babylone}&\text{Athenien}&\text{Maya}&%
20 \text{Japonais}&\text{Binaire}&\text{Bibinaire} \\
21 \hline
22 \uncover<2->{\vtab 13&A&B&C&D&1101&DA%
23 \AddNode\AddNode[2]\AddNode[3]\AddNode[4]\AddNode[5]\\}
24 \uncover<4->{\vtab 130&AB&C&D&&10000010&KOHE\AddNode\\}
25 \uncover<6->{\vtab 26&A&B&C&D&11010&HAKE\AddNode[2]\\}
26 \uncover<8->{\vtab 208&A&B&C&D&11010000&DAHO\AddNode[3]\\}
27 \uncover<10->{\vtab 260&A&B&C&D&100000100&HAHOBO \AddNode[4]\\}
28 \uncover<12->{\vtab 780&A&B&C&D&1100001100&HIHODO\AddNode[5]\\
29 \hline}
30 \end{array}
31 \]
32 \tikzstyle{ArrowStyle}+=[<->,blue]
33 \visible<3-4>{\LinkNodes[]{$\times10$}}
34 \visible<5-6>{\LinkNodes[]{$\times2$}}
35 \visible<7-8>{\LinkNodes[]{$\times16$}}
36 \visible<9-10>{\LinkNodes[]{$\times20$}}
37 \visible<11-12>{\LinkNodes[]{$\times60$}}
38 \end{NodesList}
39 \end{frame}
40 \end{document}
```

SECTION 14

tkz-linknodes and ordinary text

The following text is from http://www.sir-lancelot.co.uk/camelot.htm.

"In some versions of the legend, one of Lancelot's first tasks as a knight was to bring Guinevere to Camelot for her wedding to Arthur. During their journey back to Camelot, Guinevere and Lancelot fell in love [1]. In other stories, Guinevere was already Queen when Lancelot arrived, and he became one of the Queen's Knights. Lancelot soon became recognised as the greatest of the knights after successfully completing several quests.
...
Lancelot helped King Arthur put down the rebellion of Galehaut the Haut Prince, who surrendered to Arthur after being influenced by Lancelot's chivalry in battle. Later Galehaut became Lancelot's close friend and acted as a secret go-between [1] Lancelot and Guinevere."

- to feel in love ?
- go-between ?

```
\begin{minipage}{12 cm}
\begin{NodesList}[margin=-1cm]
"In some versions of the legend, one of Lancelot's first tasks as a knight was to%
bring Guinevere to Camelot for her wedding to Arthur. During their journey back to%
 Camelot, Guinevere and Lancelot fell in love.\AddNode In other stories, Guinevere%
 was already Queen when Lancelot arrived, and he became one of the Queen's%
 Knights. Lancelot soon became recognised as the greatest of the knights after%
successfully completing several quests.

\dots

Lancelot helped King Arthur put down the rebellion of Galehaut the Haut Prince, who%
 surrendered to Arthur after being influenced by Lancelot's chivalry in battle. Later%
  Galehaut became Lancelot's close friend and acted as a secret go-between\AddNode%
   Lancelot and Guinevere."

{ \tikzset{ArrowStyle/.append style = {opacity=.5,red,]-[}}
       \LinkNodes{%
     \begin{minipage}{5cm}
          \begin{itemize}
            \item to feel in love ?
             \item go-between  ?
          \end{itemize}

      \end{minipage}
       }}
\end{NodesList}
\end{minipage}
```

SECTION 15

Raise a Node

A better method of solving this problem is obtained by raising box. I use TEX for that but perhaps there is a LATEX method. I remove **\AddNode** and insert

```
\raise -1.2ex\hbox{\AddNode}
```

"In some versions of the legend, one of Lancelot's first tasks as a knight was to bring Guinevere to Camelot for her wedding to Arthur. During their journey back to Camelot, Guinevere and Lancelot fell in love. In other stories, Guinevere was already Queen when Lancelot arrived, and he became one of the Queen's Knights. Lancelot soon became recognised as the greatest of the knights after successfully completing several quests.
...
Lancelot helped King Arthur put down the rebellion of Galehaut the Haut Prince, who surrendered to Arthur after being influenced by Lancelot's chivalry in battle. Later Galehaut became Lancelot's close friend and acted as a secret go-between Lancelot and Guinevere."

- to feel in love ?
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Index