pstricks-add
additionals Macros for pstricks

v.2.78

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Abstract

This version of pstricks-add needs pstricks.tex version >1.04 from June 2004, otherwise the additional macros may not work as espected. The ellipsis material and the option asolid (renamed to eofill) are now part of the new pstricks.tex package, available at CTAN or at http://perce.de/LaTeX/. pstricks-add will for ever be an experimental and dynamical package, try it at your own risk.

- It is important to load pstricks-add as **last** PSTricks related package, otherwise a lot of the macros won't work in the expected way.
- pstricks-add uses the extended version of the keyval package. So be sure, that you have installed pst-xkey which is part of the xkeyval-package and that all packages, that uses the old keyval interface are loaded **before** the xkeyval.[1]
- the option tickstyle from pst-plot is no more supported, use ticksize instead.
- the option xyLabel is no more supported, use the option labelFontSize instead.

Contents

Part I

pstricks

1 Numeric functions

All macronames contain a @ in their name, because they are only for internal use, but it is no problem to use it as the other macros. One can define another name without a @:

```
\makeatletter
\let\pstdivide\pst@divide
\makeatother
```

or put the macro inside of the \makeatletter – \makeatother sequence.

1.1 \pst@divide

pstricks itself has its own divide macro, called \pst@divide which can divide two lengthes and saves the quotient as a floating point number:

```
\pst@divide{<dividend>}{<divisor>}{<result as a macro>}
```

5.66666
-0.17647

```
\makeatletter
\pst@divide{34pt}{6pt}\quotient \quotient\\
\pst@divide{-6pt}{34pt}\quotient \quotient
\makeatother
```

this gives the output 5.66666. The result is not a length!

1.2 \pst@mod

pstricks-add defines an additional numeric function for the modulus:

```
\pst@mod{<integer>}{<integer>}{<result as a macro>}
```

4
1

```
\makeatletter
\pst@mod{34}{6}\modulo \modulo\\
\pst@mod{25}{-6}\modulo \modulo
\makeatother
```

this gives the output 4. Using this internal numeric functions in documents requires a setting inside the makeatletter and makeatother environment. It makes some sense to define a new macroname in the preamble to use it throughou, e.g. \let\modulo\pst@mod.

1.3 \pst@max

```
\pst@max{<integer>}{<integer>}{<result as count register>}
```

-6
11

```
\newcount\maxNo
\makeatletter
\pst@max{-34}{-6}\maxNo \the\maxNo\\
\pst@max{0}{11}\maxNo \the\maxNo
\makeatother
```

1.4 \pst@maxdim

```
\pst@maxdim{<dimension>}{<dimension>}{<result as dimension register>}
```

1234.0pt
967.39369pt

```
\newdimen\maxDim
\makeatletter
\pst@maxdim{34cm}{1234pt}\maxDim \the\maxDim\\
\pst@maxdim{34cm}{123pt}\maxDim \the\maxDim
\makeatother
```

1.5 \pst@abs

```
\pst@abs{<integer>}{<result as a count register>}
```

34
4

```
\newcount\absNo
\makeatletter
\pst@abs{-34}\absNo \the\absNo\\
\pst@abs{4}\absNo \the\absNo
\makeatother
```

1.6 \pst@absdim

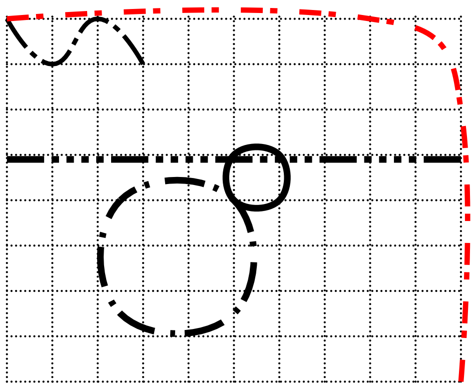
```
\pst@absdim{<dimension>}{<result as a dimension register>}
```

967.39369pt
0.00006pt

```
\newdimen\absDim
\makeatletter
\pst@absdim{-34cm}\absDim \the\absDim\\
\pst@absdim{4sp}\absDim \the\absDim
\makeatother
```

2 Dashed Lines

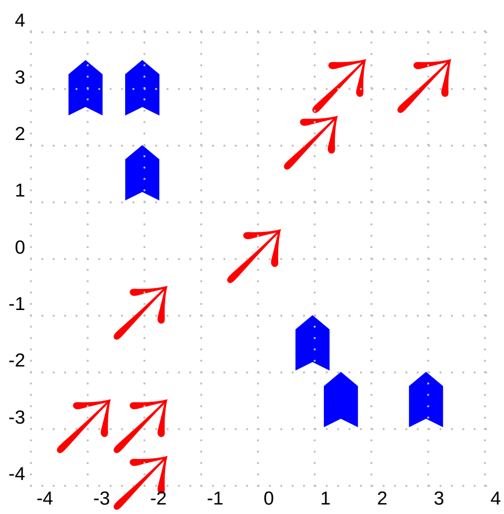
Tobias Nähring implemented an enhanced feature for dashed lines. The number of arguments is no more limited.
`dash=value1[unit] value2[unit] ...`



```
\psset{linewidth=2.5pt,unit=0.6}
\begin{pspicture}(-5,-4)(5,4)
 \psgrid[subgriddiv=0,griddots=10,gridlabels=0pt]
  \psset{linestyle=dashed}
  \pscurve[dash=5mm 1mm 1mm 1mm,linewidth=0.1](-5,4)(-4,3)(-3,4)(-2,3)
  \psline[dash=5mm 1mm 1mm 1mm 1mm 1mm 1mm 1mm 1mm 1mm](-5,0.9)(5,0.9)
  \psccurve[linestyle=solid](0,0)(1,0)(1,1)(0,1)
  \psccurve[linestyle=dashed,dash=5mm 2mm 0.1 0.2,linetype=0](0,0)(-2.5,0)(-2.5,-2.5)(0,-2.5)
  \pscurve[dash=3mm 3mm 1mm 1mm,linecolor=red,linewidth=2pt](5,-4)(5,2)(4.5,3.5)(3,4)(-5,4)
\end{pspicture}
```

3 \rmultiput: a multiple \rput

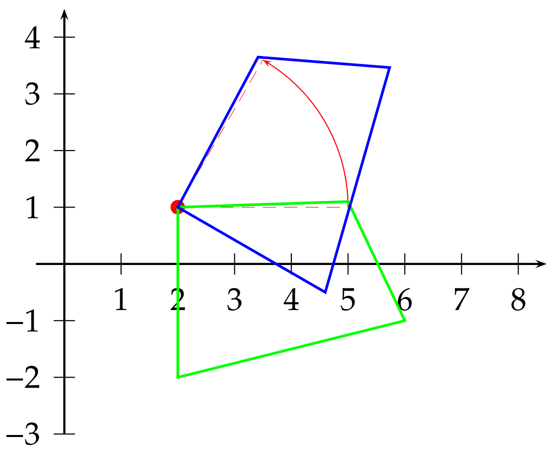
`PSTricks` already knows a `multirput`, which puts a box n times with a difference of *dx* and *dy* relativ to each other. It is not possible to put it with a different distance from one point to the next one. This is possible with `rmultiput`:
`\rmultiput[<options>]{<any material>}(x1,y1)(x2,y2) ... (xn,yn)`
`\rmultiput*[<options>]{<any material>}(x1,y1)(x2,y2) ... (xn,yn)`




```
\psset{unit=0.75}
\begin{pspicture}(-4,-4)(4,4)
\rmultiput[rot=45]{\red\psscalebox{3}{\ding{250}}}%
   (-2,-4)(-2,-3)(-3,-3)(-2,-1)(0,0)(1,2)(1.5,3)(3,3)
\rmultiput[rot=90,ref=lC]{\blue\psscalebox{2}{\ding{253}}}%
   (-2,2.5)(-2,2.5)(-3,2.5)(-2,1)(1,-2)(1.5,-3)(3,-3)
\psgrid[subgriddiv=0,gridcolor=lightgray]
\end{pspicture}
```

4 \psrotate: Rotating objects

\rput also has an optional argument for rotating objects, but always depending to the \rput coordinates. With \psrotate the rotating center can be placed anywhere. The rotation is done with \pscustom, all optional arguments are only valid if they are part of the \pscustom macro.
\psrotate[options](x,y){rot angle}{<object>}

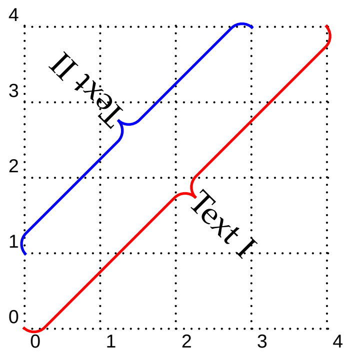



```
\psset{unit=0.75}
\begin{pspicture}(-0.5,-3.5)(8.5,4.5)
  \psaxes{->}(0,0)(-0.5,-3)(8.5,4.5)
  \psdots[linecolor=red,dotscale=1.5](2,1)
  \psarc[linecolor=red,linewidth=0.4pt,
    showpoints=true]
       {->}(2,1){3}{0}{60}
  \pspolygon[linecolor=green,linewidth=1pt
    ](2,1)(5,1.1)(6,-1)(2,-2)
  \psrotate[linecolor=blue,linewidth=1pt](2,1)
    {60}{
    \pspolygon(2,1)(5,1.1)(6,-1)(2,-2)}
\end{pspicture}
```

5 \psbrace

5.1 Syntax

```
\psbrace[<options>](<A>)(<B>){<text>}
```




```
\begin{pspicture}(4,4)
\psgrid[subgriddiv=0,griddots=10]
\pnode(0,0){A}
\pnode(4,4){B}
\psbrace[linecolor=red,ref=lC](A)(B){Text I}
\psbrace[linecolor=blue,ref=lC](3,4)(0,1){Text II}
\end{pspicture}
```

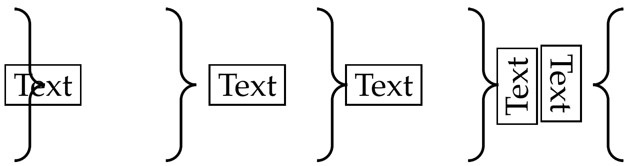
The option `\specialCoor` is enabled, so that all types of coordinates are possible, (nodename), (x, y), $(nodeA|nodeB)$, ...

5.2 Options

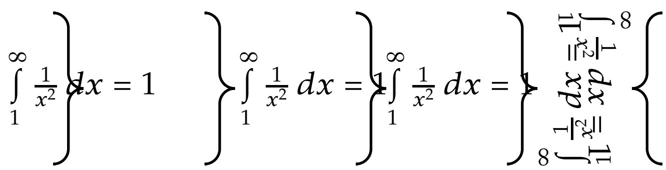
Additional to all other available options from `pstricks` or the other related packages, there are two new option, named `braceWidth` and `bracePos`. All important ones are shown in the following table.

name	meaning
`braceWidth`	default is 0.35
`bracePos`	relative position (default is 0.5)
`linearc`	absolute value for the arcs (default is 2mm)
`nodesepA`	x-separation (default is $0pt$)
`nodesepB`	y-separation (default is $0pt$)
`rot`	additional rotating for the text (default is 0)
`ref`	reference point for the text (default is c)

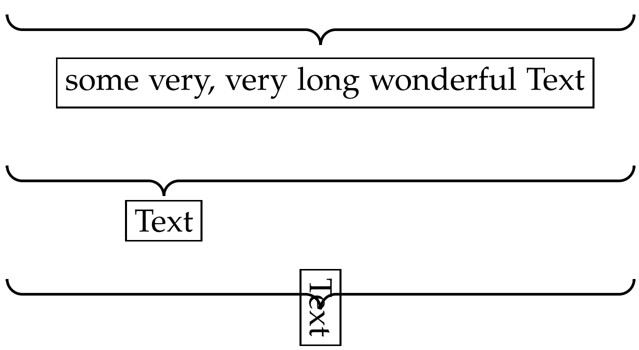
By default the text is written perpedicular to the brace line and can be changed with the `pstricks` option `rot=...`. The text parameter can take any object and may also be empty. The reference point can be any value of the combination of `l` (left) or `r` (right) and `b` (bottom) or `B` (Baseline) or `C` (center) or `t` (top), where the default is `c`, the center of the object.



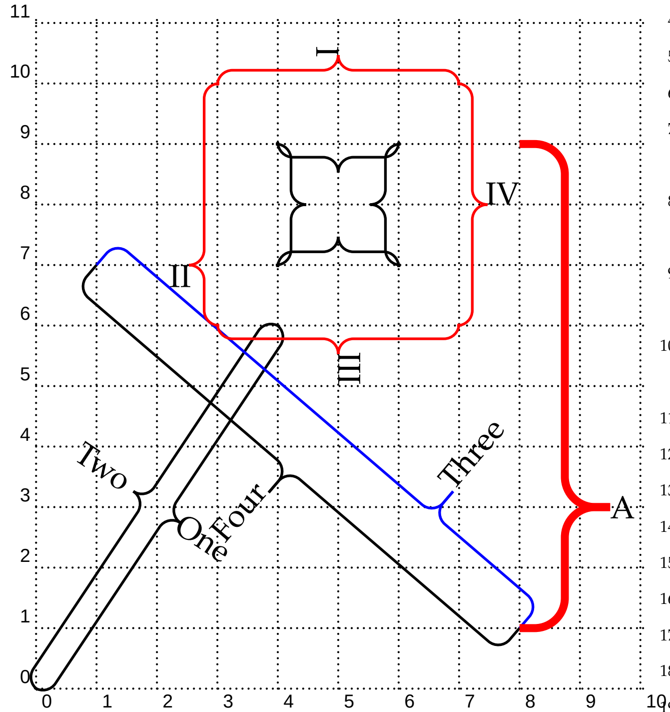

```
\begin{pspicture}(8,2.5)
\psbrace(0,0)(0,2){\fbox{Text}}%
\psbrace[nodesepA=20pt](2,0)(2,2){\fbox{Text}}
\psbrace[ref=lC](4,0)(4,2){\fbox{Text}}
\psbrace[ref=lt,rot=90,nodesepB=-15pt](6,0)(6,2){\fbox{Text}}
\psbrace[ref=lt,rot=90,nodesepA=-5pt,nodesepB=15pt](8,2)(8,0){\fbox{Text}}
\end{pspicture}
```



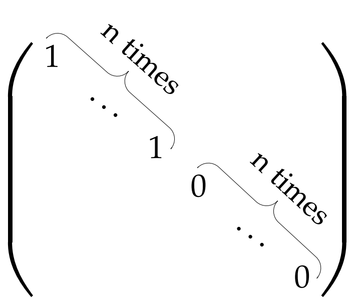
```
\def\someMath{$\int\limits_1^{\infty}\frac{1}{x^2}\,dx=1$}
\begin{pspicture}(8,2.5)
\psbrace(0,0)(0,2){\someMath}%
\psbrace[nodesepA=30pt](2,0)(2,2){\someMath}
\psbrace[ref=lC](4,0)(4,2){\someMath}
\psbrace[ref=lt,rot=90,nodesepB=-30pt](6,0)(6,2){\someMath}
\psbrace[ref=lt,rot=90,nodesepB=30pt](8,2)(8,0){\someMath}
\end{pspicture}
```




```
\begin{pspicture}(\linewidth,5)
\psbrace(0,0.5)(\linewidth,0.5){\fbox{Text}}%
\psbrace[bracePos=0.25,nodesepB=-10pt,rot=90](0,2)(\linewidth,2){\fbox{Text}}
\psbrace[ref=lC,nodesepA=-3.5cm,nodesepB=-15pt,rot=90](0,4)(\linewidth,4){%
  \fbox{some very, very long wonderful Text}}
\end{pspicture}
```




```
\psset{unit=0.8}
\begin{pspicture}(10,11)
\psgrid[subgriddiv=0,griddots=10]
\pnode(0,0){A}
\pnode(4,6){B}
\psbrace[ref=lC](A)(B){One}
\psbrace[rot=180,nodesepA=-5pt,ref=rb](B)(A){Two
  }
\psbrace[linecolor=blue,bracePos=0.25,braceWidth
  =1,ref=lB](8,1)(1,7){Three}
\psbrace[braceWidth=-1,rot=180,ref=rB](8,1)(1,7)
  {Four}
\psbrace[linearc=0.5,linecolor=red,linewidth=3pt
  ,braceWidth=1.5,%
  bracePos=0.25,ref=lC](8,1)(8,9){A}
\psbrace(4,9)(6,9){}
\psbrace(6,9)(6,7){}
\psbrace(6,7)(4,7){}
\psbrace(4,7)(4,9){}
\psset{linecolor=red}
\psbrace[ref=lb](7,10)(3,10){I}
\psbrace[ref=lb,bracePos=0.75](3,10)(3,6){II}
\psbrace[ref=lb](3,6)(7,6){III}
\psbrace[ref=lb](7,6)(7,10){IV}
\end{pspicture}
```




```
\[
\begin{pmatrix}
   \Rnode[vref=2ex]{A}{~1} \\
   & \ddots \\
   && \Rnode[href=2]{B}{1} \\
   &&& \Rnode[vref=2ex]{C}{0} \\
   &&&& \ddots \\
   &&&&& \Rnode[href=2]{D}{0}~ \\
\end{pmatrix}
\]
\psbrace[linewidth=0.1pt,rot=-90,nodesep=0.2](B)(A){\small n
  times}
\psbrace[linewidth=0.1pt,rot=-90,nodesep=0.2](D)(C){\small n
  times}
```

It is also possible to put a vertical brace around a default paragraph. This works with setting two invisible nodes at the beginning and the end of the paragraph. Inentation is possible with a minipage.

Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense.

Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense.

Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense.

Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense. Some nonsense text, which is nothing more than nonsense.

```
\begin{framed}
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.

\noindent\rnode{A}{}

\vspace*{-1ex}
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.

\vspace*{-2ex}
\noindent\rnode{B}{}\psbrace[linecolor=red](A)(B){}

Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.

\medskip
\hfill\begin{minipage}{0.95\linewidth}
\noindent\rnode{A}{}
```

```
\vspace*{-1ex}
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.
Some nonsense text, which is nothing more than nonsense.

\vspace*{-2ex}
\noindent\rnode{B}{}\psbrace[linecolor=red](A)(B){}
\end{minipage}
\end{framed}
```

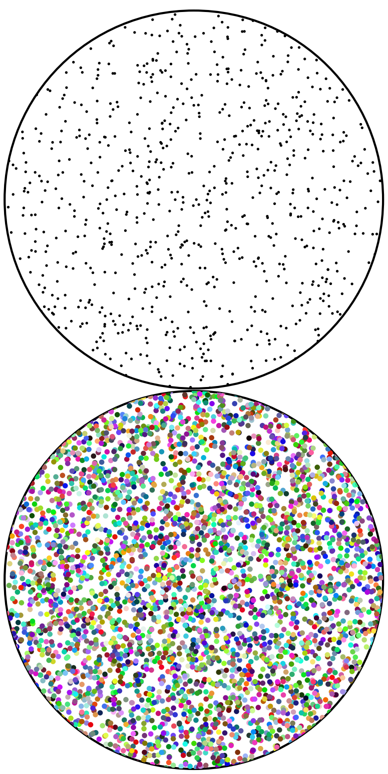
6 Random dots

The syntax of the new macro `\psRandom` is:

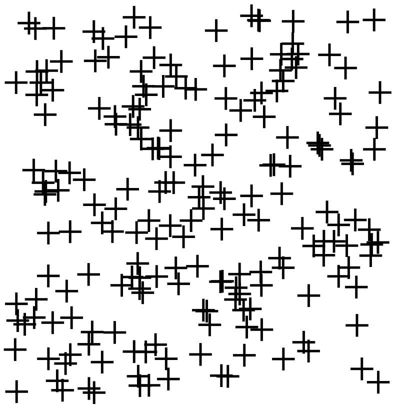
```
\psRandom[<option>]{}
\psRandom[<option>]{<clip path>}
\psRandom[<option>](<xMax,yMax>){<clip path>}
\psRandom[<option>](<xMin,yMin>)(<xMax,yMax>){<clip path>}
```

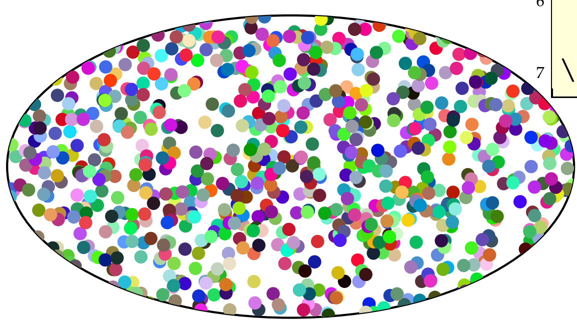
If there is no area for the dots defined, then `(0,0)(1,1)` in the actual scale is used for placing the dots. This area should be greater than the clipping path to be sure that the dots are placed over the full area. The clipping path can be everything. If no clipping path is given, then the frame `(0,0)(1,1)` in user coordinates is used. The new options are:

name	default	
randomPoints	1000	number of random dots
color	false	random color

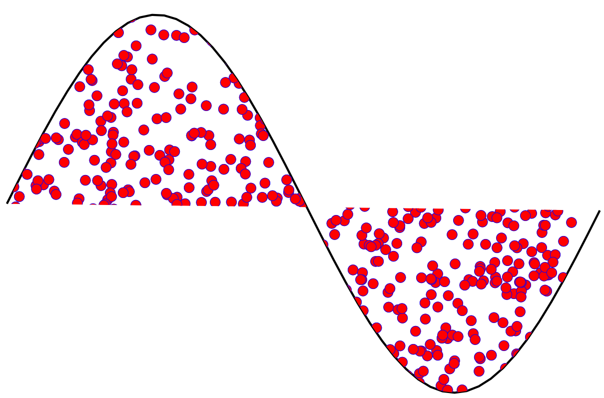


```
\psset{unit=5cm}
\begin{pspicture}(1,1)
  \psRandom[dotsize=1pt,fillstyle=solid](1,1){\pscircle(0.5,0.5){0.5}}
\end{pspicture}
\begin{pspicture}(1,1)
  \psRandom[dotsize=2pt,randomPoints=5000,color,%
     fillstyle=solid](1,1){\pscircle(0.5,0.5){0.5}}
\end{pspicture}
```





```
\psset{unit=5cm}
\begin{pspicture}(1,1)
  \psRandom[randomPoints=200,dotsize=8pt,
    dotstyle=+]{}
\end{pspicture}
\begin{pspicture}(1.5,1)
  \psRandom[dotsize=5pt,color](0,0)(1.5,0.8){\
    psellipse(0.75,0.4)(0.75,0.4)}
\end{pspicture}
```

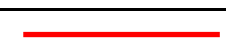


```
\psset{unit=2.5cm}
\begin{pspicture}(0,-1)(3,1)
  \psRandom[dotsize=4pt,dotstyle=o,
    linecolor=blue,fillcolor=red,%
     fillstyle=solid,randomPoints
       =1000]%
      (0,-1)(3,1){\psplot{0}{3.14}{ x
        114 mul sin }}
\end{pspicture}
```

7 Arrows

7.1 Definition

pstricks-add defines the following "arrows":

Value	Example	Name
-		None
<->		Arrowheads.
>-<		Reverse arrowheads.
<<->>		Double arrowheads.
>>-<<		Double reverse arrowheads.
|-|		T-bars, flush to endpoints.
|*-|*		T-bars, centered on endpoints.
[-]		Square brackets.
]-[		Reversed square brackets.
(-)		Rounded brackets.
)-(		Reversed rounded brackets.
o-o		Circles, centered on endpoints.
-		Disks, centered on endpoints.
oo-oo		Circles, flush to endpoints.
-		Disks, flush to endpoints.
|<->|		T-bars and arrows.
|>-<|		T-bars and reverse arrows.
h-h|		left/right hook arrows.
H-H|		left/right hook arrows.

You can also mix and match, e.g., ->, *-) and [-> are all valid values of the arrows parameter. The parameter can be set with

```
\psset{arrows=<type>}
```

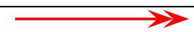
or for some macros with a special option, like

```
\psline[<general options>]{<arrow type>}(A)(B)
\psline[linecolor=red,linewidth=2pt]{|->}(0,0)(0,2)
```

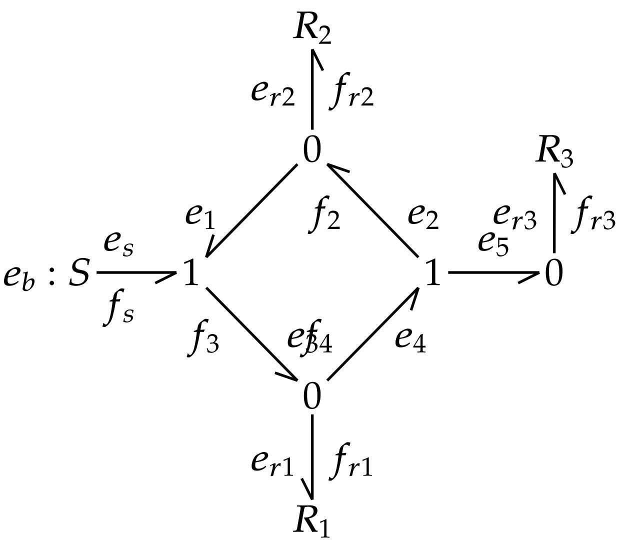
7.2 Multiple arrows

There are two new options which are only valid for the arrow type << or >>. nArrow sets both, the nArrowA and the nArrowB parameter. The meaning is declared in the following tables. Without setting one of these parameters the behaviour is like the one described in the old PSTricks manual.

Value	Meaning
`->>`	-A
`<<->>`	A-A
`<<-`	A-
`>>-`	B-
`-<<`	-B
`>>-<<`	B-B
`>>->>`	B-A
`<<-<<`	A-B

Value	Example
`\psline{->>}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3]{->>}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=5]{->>}(0,1ex)(2.3,1ex)`	
`\psline{<<-}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3]{<<-}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=5]{<<-}(0,1ex)(2.3,1ex)`	
`\psline{<<->>}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3]{<<->>}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=5]{<<->>}(0,1ex)(2.3,1ex)`	
`\psline{<<-|}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3]{<<-<<}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=5]{<<-o}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3,nArrowsB=4]{<<-<<}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=3,nArrowsB=4]{>>->>}(0,1ex)(2.3,1ex)`	
`\psline[nArrowsA=1,nArrowsB=4]{>>->>}(0,1ex)(2.3,1ex)`	

7.3 hookarrow

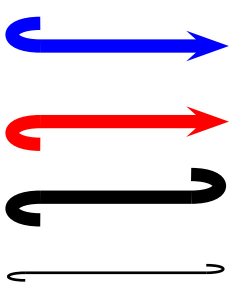



```
\psset{arrowsize=8pt,arrowlength=1,linewidth=1pt,nodesep=2pt,shortput=tablr}
\large
\begin{psmatrix}[colsep=12mm,rowsep=10mm]
      &  & $R_2$        \\
      &  &  0  &  & $R_3$\\
$e_b:S$ & 1 &  & 1 & 0 \\
      &  &  0          \\
      &  &  $R_1$      \\
\end{psmatrix}
\ncline{h-}{1,3}{2,3}<{$e_{r2}$}>{$f_{r2}$}
\ncline{-h}{2,3}{3,2}<{$e_1$}
\ncline{-h}{3,1}{3,2}^{$e_s$}_{$f_{s}$}
\ncline{-h}{3,2}{4,3}>{$e_3$}<{$f_3$}
\ncline{-h}{4,3}{3,4}>{$e_4$}<{$f_4$}
\ncline{-h}{3,4}{2,3}>{$e_2$}<{$f_2$}
\ncline{-h}{3,4}{3,5}^{$e_5$}
\ncline{-h}{3,5}{2,5}<{$e_{r3}$}>{$f_{r3}$}
\ncline{-h}{4,3}{5,3}<{$e_{r1}$}>{$f_{r1}$}
```

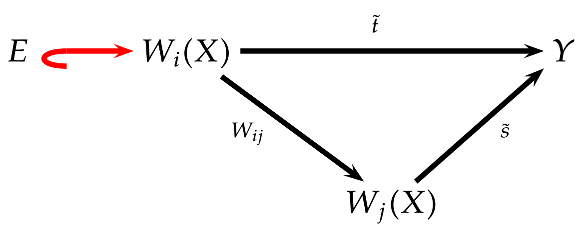
7.4 hookrightarrow and hookleftarrow

This is another type of an arrow and abbreviated with `H`. The length and width of the hook is set by the new options `hooklength` and `hookwidth`, which are by default set to `\psset{hooklength=3mm,hookwidth=1mm}`

If the line begins with a right hook then the line ends with a left hook and vice versa:



```
\begin{pspicture}(3,4)
\psline[linewidth=5pt,linecolor=blue,hooklength=5mm,hookwidth=-3mm]{H->}(0,3.5)(3,3.5)
\psline[linewidth=5pt,linecolor=red,hooklength=5mm,hookwidth=3mm]{H->}(0,2.5)(3,2.5)
\psline[linewidth=5pt,hooklength=5mm,hookwidth=3mm]{H-H}(0,1.5)(3,1.5)
\psline[linewidth=1pt]{H-H}(0,0.5)(3,0.5)
\end{pspicture}
```




```
$\begin{psmatrix}
E&W_i(X)&&Y\\
&&W_j(X)
\psset{arrows=->,nodesep=3pt,linewidth=2pt}
\everypsbox{\scriptstyle}
\ncline[linecolor=red,arrows=H->,%
  hooklength=4mm,hookwidth=2mm]{1,1}{1,2}
\ncline{1,2}{1,4}^{\tilde{t}}
\ncline{1,2}{2,3}<{W_{ij}}
\ncline{2,3}{1,4}>{\tilde{s}}
\end{psmatrix}$
```

7.5 ArrowInside Option

It is now possible to have arrows inside the lines and not only at the beginning or the end. The new defined options

Name	Example	Output
ArrowInside	\psline[ArrowInside=->](0,0)(2,0)	
ArrowInsidePos	\psline[ArrowInside=->,% ArrowInsidePos=0.25](0,0)(2,0)	
ArrowInsidePos	\psline[ArrowInside=->,% ArrowInsidePos=10](0,0)(2,0)	
ArrowInsideNo	\psline[ArrowInside=->,% ArrowInsideNo=2](0,0)(2,0)	
ArrowInsideOffset	\psline[ArrowInside=->,% ArrowInsideNo=2,% ArrowInsideOffset=0.1](0,0)(2,0)	
ArrowInside	\psline[ArrowInside=->]{->}(0,0)(2,0)	
ArrowInsidePos	\psline[ArrowInside=->,% ArrowInsidePos=0.25]{->}(0,0)(2,0)	
ArrowInsidePos	\psline[ArrowInside=->,% ArrowInsidePos=10]{->}(0,0)(2,0)	
ArrowInsideNo	\psline[ArrowInside=->,% ArrowInsideNo=2]{->}(0,0)(2,0)	
ArrowInsideOffset	\psline[ArrowInside=->,% ArrowInsideNo=2,% ArrowInsideOffset=0.1]{->}(0,0)(2,0)	
ArrowFill	\psline[ArrowFill=false,% arrowinset=0]{->}(0,0)(2,0)	
ArrowFill	\psline[ArrowFill=false,% arrowinset=0]{«-»}(0,0)(2,0)	

Name	Example	Output
ArrowFill	\psline[ArrowInside=->,% arrowinset=0,% ArrowFill=false,% ArrowInsideNo=2,% ArrowInsideOffset=0.1]{->}(0,0)(2,0)	

Without the default arrow definition there is only the one inside the line, defined by the type and the position. The position is relative to the length of the whole line. 0.25 means at 25% of the line length. The peak of the arrow gets the coordinates which are calculated by the macro. If you want arrows with an abolute position difference, then choose a value greater than 1, e.g. 10 which places an arrow every 10 pt. The default unit pt cannot be changed.

The ArrowInside takes only arrow definitions like -> into account. Arrows from right to left (<-) are not possible and ignored. If you need such arrows, change the order of the pairs of coordinates for the line or curve macro.

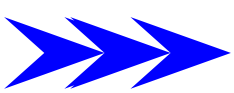
7.6 ArrowFill Option

By default all arrows are filled polygons. With the option ArrowFill=false there are "white" arrows. Only for the beginning/end arrows they are empty, the inside arrows are overpainted with the line.

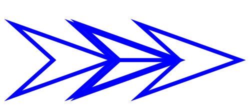
```
\psset{arrowscale=3}
\psline[linecolor=red,arrowinset=0]{<->}(0,0)(3,0)
```

```
\psset{arrowscale=3}
\psline[linecolor=red,arrowinset=0,ArrowFill=false]{<->}(0,0)
  (3,0)
```

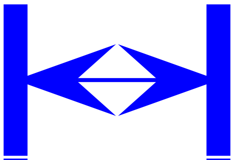
```
\psset{arrowscale=3}
\psline[linecolor=red,arrowinset=0,arrowsize=0.2,ArrowFill=
  false]{<->}(0,0)(3,0)
```



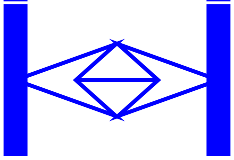
```
\psset{arrowscale=3}
\psline[linecolor=blue,arrowscale=6,ArrowFill=true
  ]{>>->>}(0,0)(3,0)
```



```
\psset{arrowscale=3}
\psline[linecolor=blue,arrowscale=6,ArrowFill=false
  ]{>>->>}(0,0)(3,0)
\rule{3cm}{0pt}\\[30pt]
```



```
\psset{arrowscale=3}
\psline[linecolor=blue,arrowscale=6,ArrowFill=true
  ]{>|->|}(0,0)(3,0)
```

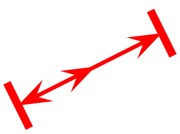


```
\psset{arrowscale=3}
\psline[linecolor=blue,arrowscale=6,ArrowFill=false
  ]{>|->|}(0,0)(3,0)%
```

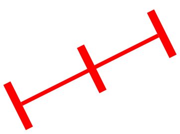
7.7 Examples

All examples are printed with `\psset{arrowscale=2,linecolor=red}`.

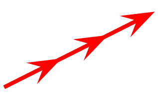
7.7.1 \psline



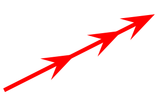
```
\begin{pspicture}(2,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=->]{|<->|}(2,1)
\end{pspicture}
```



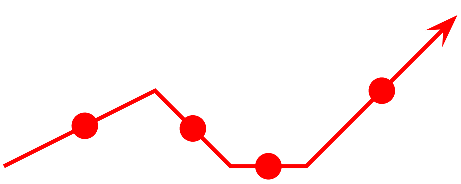
```
\begin{pspicture}(2,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-|]{|-|}(2,1)
\end{pspicture}
```



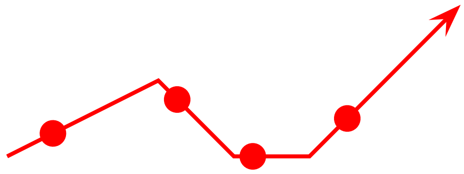
```
\begin{pspicture}(2,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=->,ArrowInsideNo=2]{->}(2,1)
\end{pspicture}
```



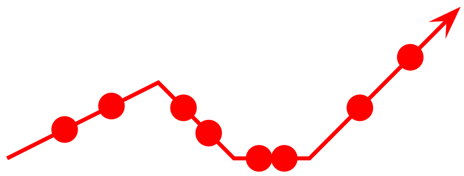
```
\begin{pspicture}(2,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=->,ArrowInsideNo=2,ArrowInsideOffset
  =0.1]{->}(2,1)
\end{pspicture}
```



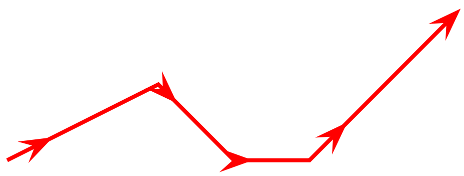
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-*]{->}(0,0)(2,1)(3,0)
  (4,0)(6,2)
\end{pspicture}
```



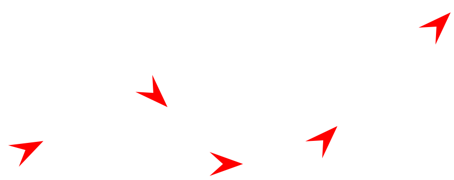
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-*,ArrowInsidePos
  =0.25]{->}(0,0)(2,1)(3,0)(4,0)(6,2)
\end{pspicture}
```



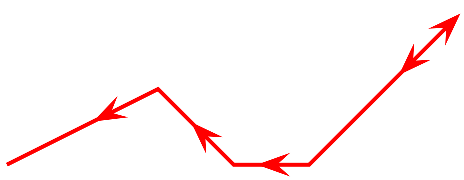
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-*,ArrowInsidePos=0.25,
  ArrowInsideNo=2]{->}%
   (0,0)(2,1)(3,0)(4,0)(6,2)
\end{pspicture}
```



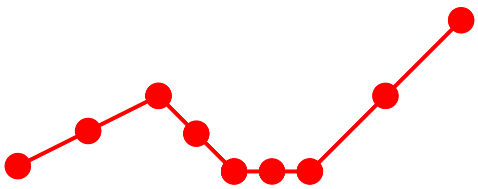
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=->, ArrowInsidePos
  =0.25]{->}%
        (0,0)(2,1)(3,0)(4,0)(6,2)
\end{pspicture}
```



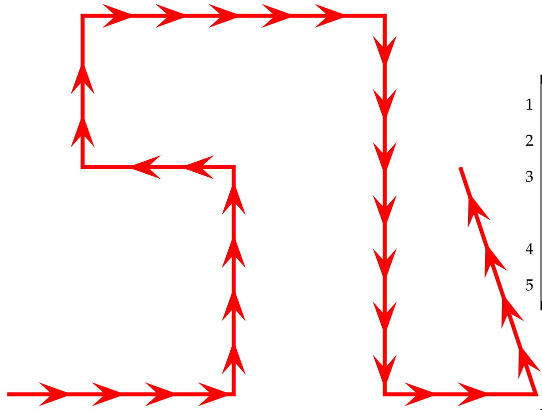
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[linestyle=none,ArrowInside=->,
  ArrowInsidePos=0.25]{->}%
        (0,0)(2,1)(3,0)(4,0)(6,2)
\end{pspicture}
```



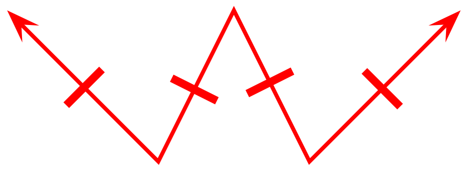
```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-<, ArrowInsidePos
  =0.75]{->}%
     (0,0)(2,1)(3,0)(4,0)(6,2)
\end{pspicture}
```



```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true,ArrowInside
  =-*}
\psline(0,0)(2,1)(3,0)(4,0)(6,2)
\psset{linestyle=none}
\psline[ArrowInsidePos=0](0,0)(2,1)(3,0)(4,0)
  (6,2)
\psline[ArrowInsidePos=1](0,0)(2,1)(3,0)(4,0)
  (6,2)
\end{pspicture}
```

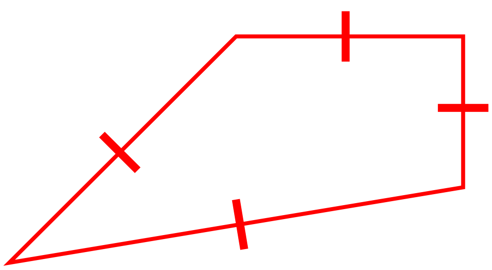


```
\begin{pspicture}(6,5)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=->,ArrowInsidePos=20](0,0)
  (3,0)%
      (3,3)(1,3)(1,5)(5,5)(5,0)(7,0)(6,3)
\end{pspicture}
```

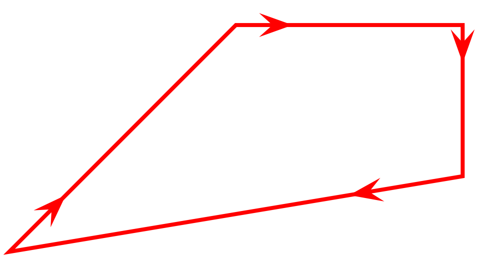


```
\begin{pspicture}(6,2)
\psset{arrowscale=2,ArrowFill=true}
\psline[ArrowInside=-|]{<->}(0,2)(2,0)(3,2)
  (4,0)(6,2)
\end{pspicture}
```

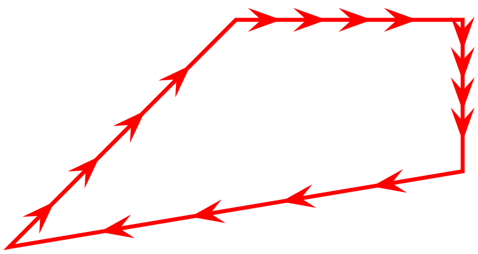
7.7.2 \pspolygon



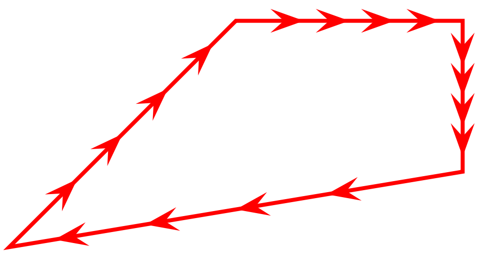
```
\begin{pspicture}(6,3)
\psset{arrowscale=2}
\pspolygon[ArrowInside=-|](0,0)(3,3)(6,3)(6,1)
\end{pspicture}
```



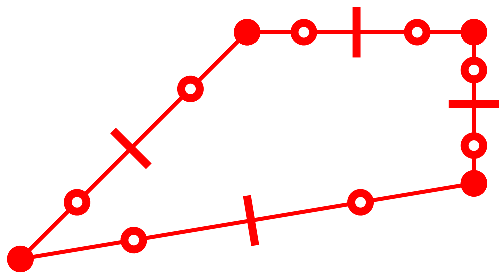
```
\begin{pspicture}(6,3)
\psset{arrowscale=2}
\pspolygon[ArrowInside=->,ArrowInsidePos
  =0.25]%
     (0,0)(3,3)(6,3)(6,1)
\end{pspicture}
```



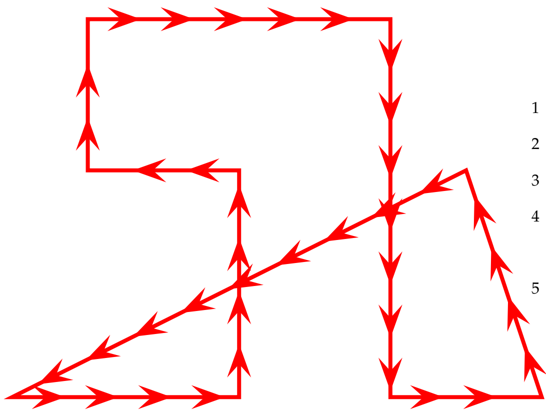
```
\begin{pspicture}(6,3)
\psset{arrowscale=2}
\pspolygon[ArrowInside=->,ArrowInsideNo=4]%
      (0,0)(3,3)(6,3)(6,1)
\end{pspicture}
```



```
\begin{pspicture}(6,3)
\psset{arrowscale=2}
\pspolygon[ArrowInside=->,ArrowInsideNo=4,%
  ArrowInsideOffset=0.1](0,0)(3,3)(6,3)(6,1)
\end{pspicture}
```

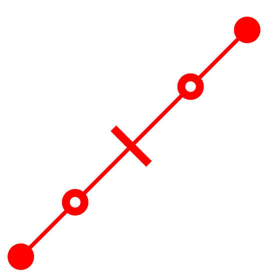


```
\begin{pspicture}(6,3)
\psset{arrowscale=2}
 \pspolygon[ArrowInside=-|](0,0)(3,3)(6,3)(6,1)
 \psset{linestyle=none,ArrowInside=-*}
 \pspolygon[ArrowInsidePos=0](0,0)(3,3)(6,3)
   (6,1)
 \pspolygon[ArrowInsidePos=1](0,0)(3,3)(6,3)
   (6,1)
 \psset{ArrowInside=-o}
 \pspolygon[ArrowInsidePos=0.25](0,0)(3,3)(6,3)
   (6,1)
 \pspolygon[ArrowInsidePos=0.75](0,0)(3,3)(6,3)
   (6,1)
\end{pspicture}
```

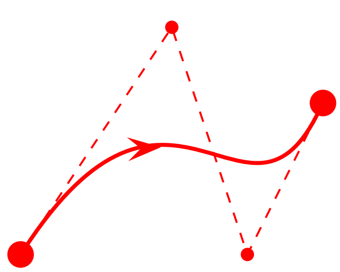


```
\begin{pspicture}(6,5)
\psset{arrowscale=2}
  \pspolygon[ArrowInside=->,ArrowInsidePos=20]%
    (0,0)(3,0)(3,3)(1,3)(1,5)(5,5)(5,0)(7,0)
      (6,3)
\end{pspicture}
```

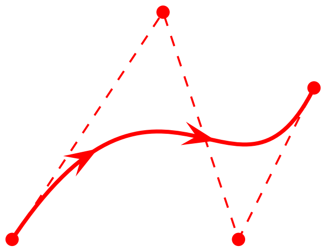
7.7.3 \psbezier



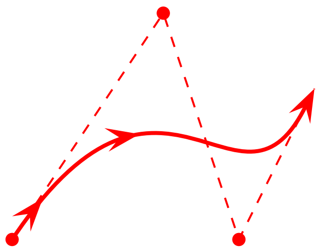
```
\begin{pspicture}(3,3)
\psset{arrowscale=2}
  \psbezier[ArrowInside=-|](1,1)(2,2)(3,3)
  \psset{linestyle=none,ArrowInside=-o}
  \psbezier[ArrowInsidePos=0.25](1,1)(2,2)(3,3)
  \psbezier[ArrowInsidePos=0.75](1,1)(2,2)(3,3)
  \psset{linestyle=none,ArrowInside=-*}
  \psbezier[ArrowInsidePos=0](1,1)(2,2)(3,3)
  \psbezier[ArrowInsidePos=1](1,1)(2,2)(3,3)
\end{pspicture}
```



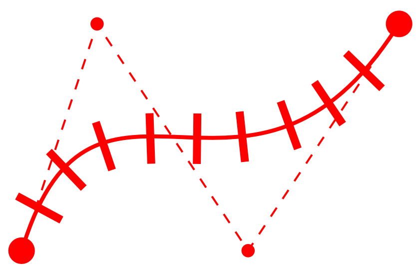
```
\begin{pspicture}(4,3)
\psset{arrowscale=2}
  \psbezier[ArrowInside=->,showpoints=true]%
     {*-*}(2,3)(3,0)(4,2)
\end{pspicture}
```



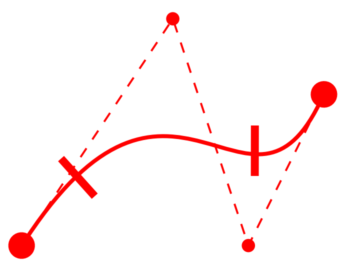
```
\begin{pspicture}(4,3)
\psset{arrowscale=2}
  \psbezier[ArrowInside=->,showpoints=true,%
      ArrowInsideNo=2](2,3)(3,0)(4,2)
\end{pspicture}
```



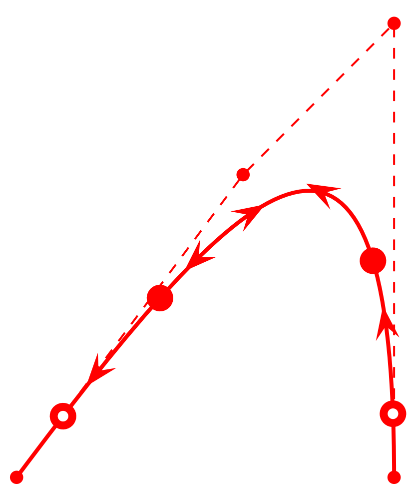
```
\begin{pspicture}(4,3)
\psset{arrowscale=2}
  \psbezier[ArrowInside=->,showpoints=true,%
      ArrowInsideNo=2,ArrowInsideOffset=-0.2]{->}(2,3)
        (3,0)(4,2)
\end{pspicture}
```



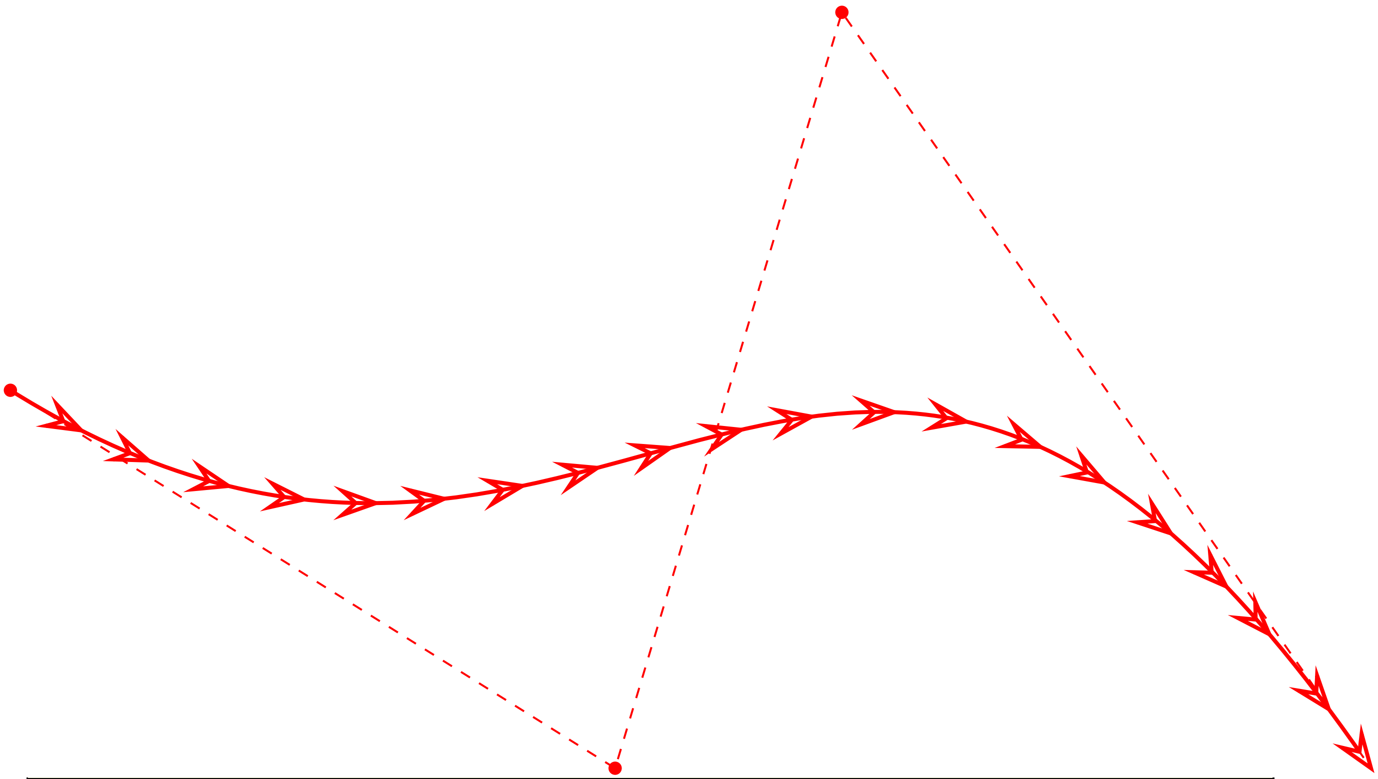
```
\begin{pspicture}(5,3)
\psset{arrowscale=2}
  \psbezier[ArrowInsideNo=9,ArrowInside=-|,%
    showpoints=true]{*-*}(1,3)(3,0)(5,3)
\end{pspicture}
```



```
\begin{pspicture}(4,3)
\psset{arrowscale=2}
  \psset{ArrowInside=-|}
  \psbezier[ArrowInsidePos=0.25,showpoints=true
    ]{*-*}(2,3)(3,0)(4,2)
  \psset{linestyle=none}
  \psbezier[ArrowInsidePos=0.75](2,3)(3,0)(4,2)
\end{pspicture}
```



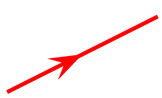
```
\begin{pspicture}(5,6)
\psset{arrowscale=2}
  \pnode(3,4){A}\pnode(5,6){B}\pnode(5,0){C}
  \psbezier[ArrowInside=->,%
     showpoints=true](A)(B)(C)
  \psset{linestyle=none,ArrowInside=-<}
  \psbezier[ArrowInsideNo=4](A)(B)(C)
  \psset{ArrowInside=-o}
  \psbezier[ArrowInsidePos=0.1](A)(B)(C)
  \psbezier[ArrowInsidePos=0.9](A)(B)(C)
  \psset{ArrowInside=-*}
  \psbezier[ArrowInsidePos=0.3](A)(B)(C)
  \psbezier[ArrowInsidePos=0.7](A)(B)(C)
\end{pspicture}
```



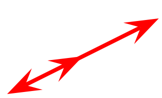
```
\begin{pspicture}(-3,-5)(15,5)
  \psbezier[ArrowInsideNo=19,%
      ArrowInside=->,ArrowFill=false,%
      showpoints=true]{->}(-3,0)(5,-5)(8,5)(15,-5)
\end{pspicture}
```

7.7.4 \pcline

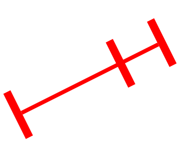
These examples need the package pst-node.



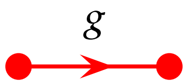
```
\begin{pspicture}(2,1)
\psset{arrowscale=2}
\pcline[ArrowInside=->](0,0)(2,1)
\end{pspicture}
```



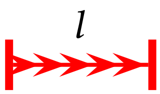
```
\begin{pspicture}(2,1)
\psset{arrowscale=2}
\pcline[ArrowInside=->]{<->}(0,0)(2,1)
\end{pspicture}
```



```
\begin{pspicture}(2,1)
\psset{arrowscale=2}
\pcline[ArrowInside=-|,ArrowInsidePos=0.75]{|-|}(0,0)(2,1)
\end{pspicture}
```



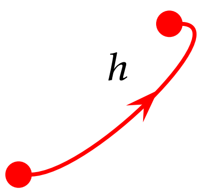

```
\psset{arrowscale=2}
\pcline[ArrowInside=->,ArrowInsidePos=0.65]{*-*}(0,0)(2,0)
\naput[labelsep=0.3]{\large$g$}
```



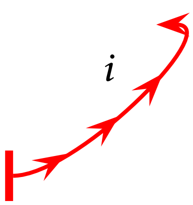

```
\psset{arrowscale=2}
\pcline[ArrowInside=->,ArrowInsidePos=10]{|-|}(0,0)(2,0)
\naput[labelsep=0.3]{\large$l$}
```

7.7.5 \pccurve

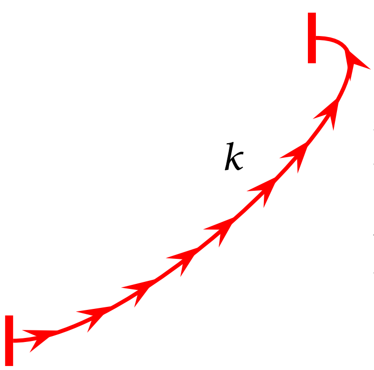
These examples also need the package pst-node.




```
\begin{pspicture}(2,2)
\psset{arrowscale=2}
\pccurve[ArrowInside=->,ArrowInsidePos=0.65,showpoints=true
  ]{*-*}(0,0)(2,2)
\naput[labelsep=0.3]{\large$h$}
\end{pspicture}
```




```
\begin{pspicture}(2,2)
\psset{arrowscale=2}
\pccurve[ArrowInside=->,ArrowInsideNo=3,showpoints=true]{|->}(0,0)
  (2,2)
\naput[labelsep=0.3]{\large$i$}
\end{pspicture}
```




```
\begin{pspicture}(4,4)
\psset{arrowscale=2}
\pccurve[ArrowInside=->,ArrowInsidePos=20]{|-|}(0,0)
  (4,4)
\naput[labelsep=0.3]{\large$k$}
\end{pspicture}
```

8 \psFormatInt

There exist some packages and a lot of code to format an integer like 1 000 000 or 1,234,567 (in Europe 1.234.567). But all packages expect a real number as argument and cannot handle macros as an argument. For this case `pstricks-add` has a macro `psFormatInt` which can handle both:

1,234,567
1,234,567
1.234.567
1·234·567
965,432

```
\psFormatInt{1234567}\\
\psFormatInt[intSeparator={,}]{1234567}\\
\psFormatInt[intSeparator=.]{1234567}\\
\psFormatInt[intSeparator=$\cdot$]{1234567}\\
\def\temp{965432}
\psFormatInt{\temp}
```

With the option `intSeparator` the symbol can be changed to any any non-number character.

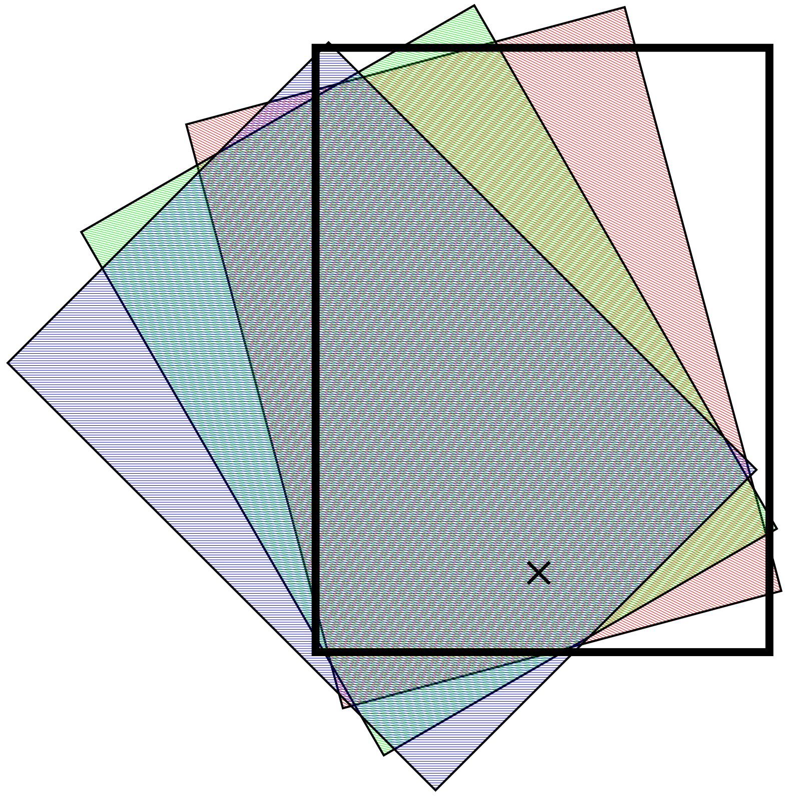
9 Color

9.1 „Transparent colors"

`pstricks-add` simulates transparency with hatch lines:

```
\def\defineTColor{\@ifnextchar[{\defineTColor@i}{\defineTColor@i[]}}
\def\defineTColor@i[#1]#2#3{%     transparency "Colors"
  \newpsstyle{#2}{%
     fillstyle=vlines,hatchwidth=0.1\pslinewidth,
     hatchsep=1\pslinewidth,hatchcolor=#3,#1%
  }%
}
\defineTColor{TRed}{red}
\defineTColor{TGreen}{green}
\defineTColor{TBlue}{blue}
```

There are three predefined "'transparent"' colors `TRed`, `TGreen`, `TBlue`. They are used as `PSTricks`styles and not as colors:



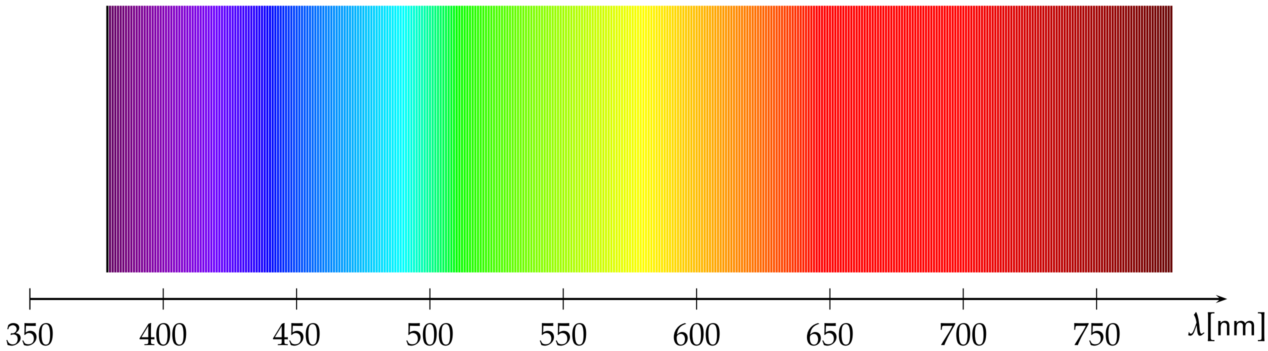
```
\begin{pspicture}(-3,-5)(5,5)
\psframe(-1,-3)(5,5) % objet de base
\psrotate(2,-2){15}{%
  \psframe[style=TRed](-1,-3)(5,5)}
\psrotate(2,-2){30}{%
  \psframe[style=TGreen](-1,-3)(5,5)}
\psrotate(2,-2){45}{%
  \psframe[style=TBlue](-1,-3)(5,5)}
\psframe[linewidth=3pt](-1,-3)(5,5)
\psdots[dotstyle=+,dotangle=45,dotscale=3](2,-2) % centre de la rotation
\end{pspicture}
```

9.2 Calculated colors

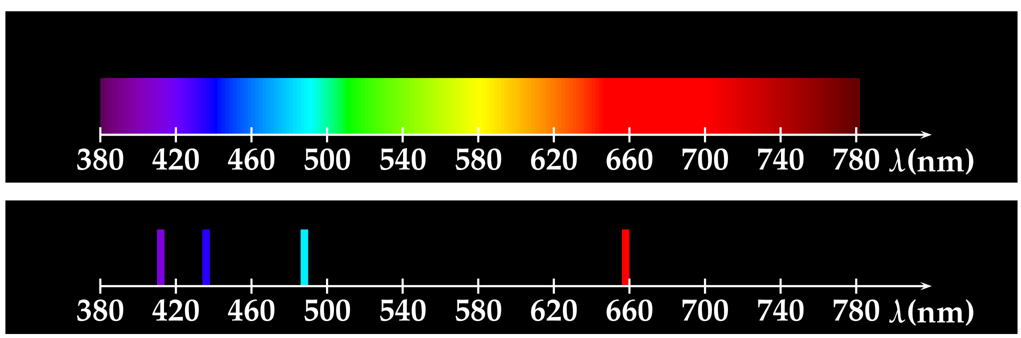
The xcolor package (version 2.6) has a new feature for defining colors:

```
\definecolor[ps]{<name>}{<model>}{< PS code >}
```

model can be one of the color models, which PostScript will understand, e.g. rgb. With this definition the color is calculated on PostScript side.




```
\definecolor[ps]{bl}{rgb}{tx@addDict begin Red Green Blue end}%
\psset{unit=1bp}
\begin{pspicture}(0,-30)(400,100)
\multido{\iLAMBDA=0+1}{400}{%
  \pstVerb{
    \iLAMBDA\space 379 add dup /lambda exch def
    tx@addDict begin wavelengthToRGB end
  }%
  \psline[linecolor=bl](\iLAMBDA,0)(\iLAMBDA,100)%
}
\psaxes[yAxis=false,Ox=350,dx=50bp,Dx=50]{->}(-29,-10)(420,100)
\uput[-90](420,-10){$\lambda$[\textsf{nm}]}
\end{pspicture}
```



Spectrum of hydrogen emission (Manuel Luque)

```
\newcommand{\Touch}{%
\psframe[linestyle=none,fillstyle=solid,fillcolor=bl,dimen=middle](0.1,0.75)}
\definecolor[ps]{bl}{rgb}{tx@addDict begin Red Green Blue end}%
% Echelle 1cm <-> 40 nm
%         1 nm <-> 0.025 cm
\psframebox[fillstyle=solid,fillcolor=black]{%
\begin{pspicture}(-1,-0.5)(12,1.5)
\multido{\iLAMBDA=380+2}{200}{%
  \pstVerb{
    /lambda \iLAMBDA\space def
    lambda
    tx@addDict begin  wavelengthToRGB end
```

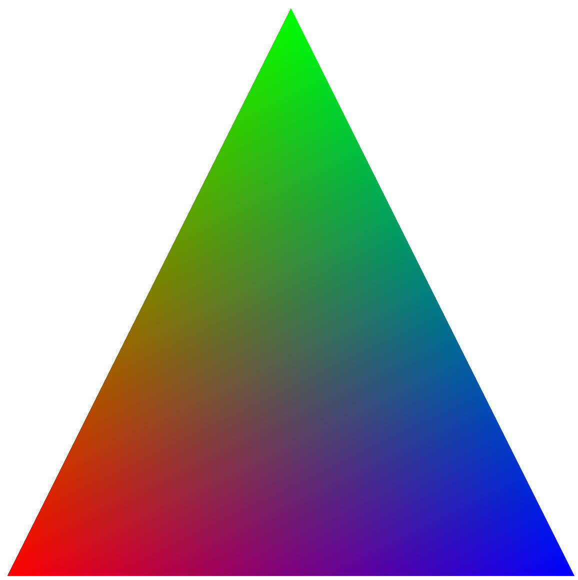
```
  }%
 \rput(! lambda 0.025 mul 9.5 sub 0){\Touch}
}
\multido{\n=0+1,\iDiv=380+40}{11}{%
    \psline[linecolor=white](\n,0.1)(\n,-0.1)
    \uput[270](\n,0){\textbf{\white\iDiv}}}
    \psline[linecolor=white]{->}(11,0)
    \uput[270](11,0){\textbf{\white$\lambda$(nm)}}
\end{pspicture}}

\psframebox[fillstyle=solid,fillcolor=black]{%
\begin{pspicture}(-1,-0.5)(12,1)
  \pstVerb{
    /lambda 656 def
    lambda
    tx@addDict begin  wavelengthToRGB end
  }%
 \rput(! 656 0.025 mul 9.5 sub 0){\Touch}
  \pstVerb{
    /lambda 486 def
    lambda
    tx@addDict begin  wavelengthToRGB end
  }%
 \rput(! 486 0.025 mul 9.5 sub 0){\Touch}
   \pstVerb{
    /lambda 434 def
    lambda
    tx@addDict begin  wavelengthToRGB end
  }%
 \rput(! 434 0.025 mul 9.5 sub 0){\Touch}
  \pstVerb{
    /lambda 410 def
    lambda
    tx@addDict begin  wavelengthToRGB end
  }%
 \rput(! 410 0.025 mul 9.5 sub 0){\Touch}
\multido{\n=0+1,\iDiv=380+40}{11}{%
    \psline[linecolor=white](\n,0.1)(\n,-0.1)
    \uput[270](\n,0){\textbf{\white\iDiv}}}
    \psline[linecolor=white]{->}(11,0)
    \uput[270](11,0){\textbf{\white$\lambda$(nm)}}
\end{pspicture}}

Spectrum of hydrogen emission (Manuel Luque)
```

9.3 Gouraud shading

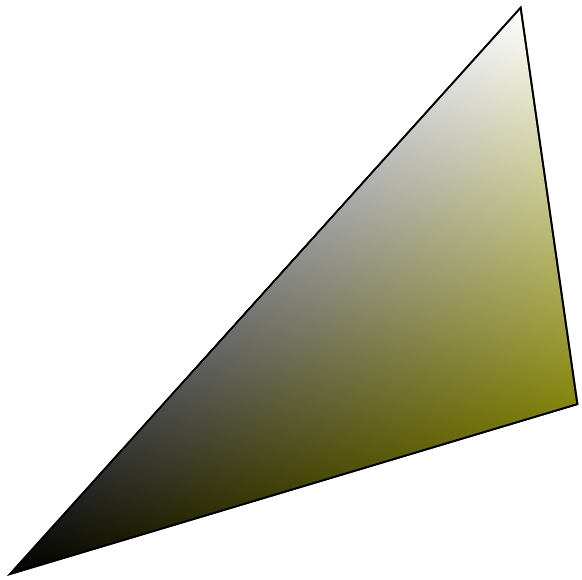
> Gouraud shading is a method used in computer graphics to simulate the differing effects of light and colour across the surface of an object. In practice, Gouraud shading is used to achieve smooth lighting on low-polygon surfaces without the heavy computational requirements of calculating lighting for each pixel. The technique was first presented by Henri Gouraud in 1971.
> http://www.wikipedia.org

PostScript level 3 supports this kind of shading and it could only be seen with Acroread 7 or younger. Die Syntax is easy:

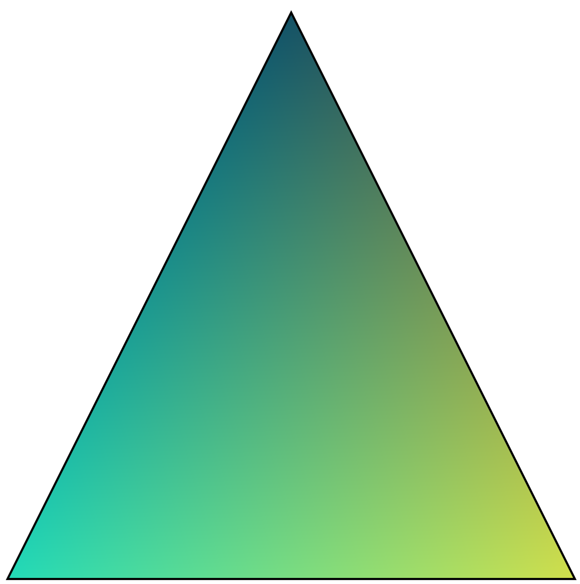
```
\psGTriangle(x1,y1)(x2,y2)(x3,y3){color1}{color2}{color3}
```



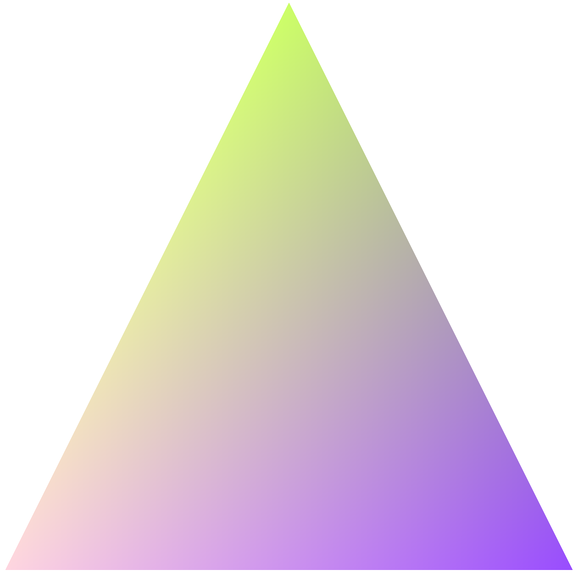
```
\begin{pspicture}(0,-.25)(10,10)
  \psGTriangle(0,0)(5,10)(10,0){red}{green}{blue}
\end{pspicture}
```



```
\begin{pspicture}(0,-.25)(10,10)
  \psGTriangle*(0,0)(9,10)(10,3){black}{white!50}{red!50!green!95}
\end{pspicture}
```



```
\begin{pspicture}(0,-.25)(10,10)
  \psGTriangle*(0,0)(5,10)(10,0){-red!100!green!84!blue!86}
                               {-red!80!green!100!blue!40}
                               {-red!60!green!30!blue!100}
\end{pspicture}
```



```
\definecolor{rose}{rgb}{1.00, 0.84, 0.88}
\definecolor{vertpommepasmure}{rgb}{0.80, 1.0, 0.40}
\definecolor{fushia}{rgb}{0.60, 0.30, 1.0}
\begin{pspicture}(0,-.25)(10,10)
  \psGTriangle(0,0)(5,10)(10,0){rose}{vertpommepasmure}{fushia}
\end{pspicture}
```

Part II

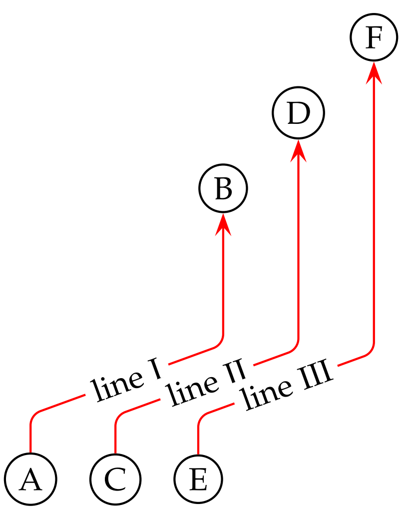
pst-node

10 \ncdiag and \pcdiag

With the new option `lineAngle` the lines drawn by the `ncdiag` macro can now have a specified gradient. Without this option one has to define the two arms (which maybe zero) and PSTricks draws the connection between them. Now there is only a static `armA`, the second one `armB` is calculated when an angle `lineAngle` is defined. This angle is the gradient of the intermediate line between the two arms. The syntax of `ncdiag` is

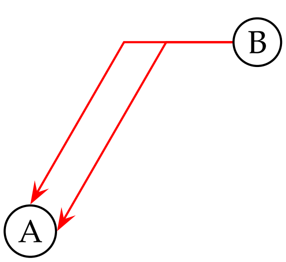
```
\ncdiag[<options>]{<Node A>}{<Node B>}
\pcdiag[<options>](<Node A>)(<Node B>)
```

name	meaning
`lineAngle`	angle of the intermediate line segment. Default is 0, which is the same than using `ncdiag` without the `lineAngle` option.

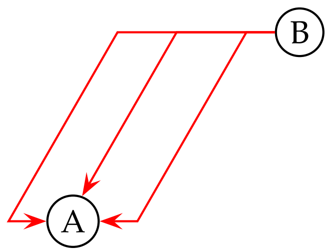



```
\begin{pspicture}(5,6)
  \circlenode{A}{A}\quad\circlenode{C}{C}%
    \quad\circlenode{E}{E}
  \rput(0,4){\circlenode{B}{B}}
  \rput(1,5){\circlenode{D}{D}}
  \rput(2,6){\circlenode{F}{F}}
  \psset{arrowscale=2,linearc=0.2,%
    linecolor=red,armA=0.5, angleA=90,angleB=-90}
  \ncdiag[lineAngle=20]{->}{A}{B}
  \ncput*[nrot=:U]{line I}
  \ncdiag[lineAngle=20]{->}{C}{D}
  \ncput*[nrot=:U]{line II}
  \ncdiag[lineAngle=20]{->}{E}{F}
  \ncput*[nrot=:U]{line III}
\end{pspicture}
```

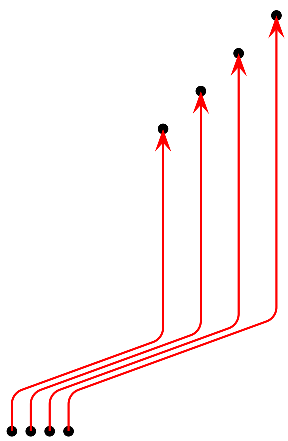
The `ncdiag` macro sets the `armB` dynamically to the calculated value. Any user setting of `armB` is overwritten by the macro. The `armA` could be set to a zero length:




```
\begin{pspicture}(4,3)
  \rput(0.5,0.5){\circlenode{A}{A}}
  \rput(3.5,3){\circlenode{B}{B}}
  {\psset{linecolor=red,arrows=<-,arrowscale=2}
  \ncdiag[lineAngle=60,%
      armA=0,angleA=0,angleB=180]{A}{B}
  \ncdiag[lineAngle=60,%
      armA=0,angleA=90,angleB=180]{A}{B}}
\end{pspicture}
```




```
\begin{pspicture}(4,3)
  \rput(1,0.5){\circlenode{A}{A}}
  \rput(4,3){\circlenode{B}{B}}
  {\psset{linecolor=red,arrows=<-,arrowscale=2}
  \ncdiag[lineAngle=60,%
      armA=0.5,angleA=0,angleB=180]{A}{B}
  \ncdiag[lineAngle=60,%
      armA=0,angleA=70,angleB=180]{A}{B}
  \ncdiag[lineAngle=60,%
      armA=0.5,angleA=180,angleB=180]{A}{B}}
\end{pspicture}
```

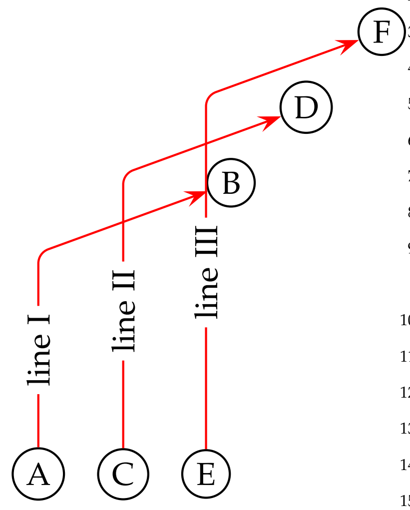


```
\begin{pspicture}(4,5.5)
  \cnode*(0,0){2pt}{A}%
  \cnode*(0.25,0){2pt}{C}%
  \cnode*(0.5,0){2pt}{E}%
  \cnode*(0.75,0){2pt}{G}%
  \cnode*(2,4){2pt}{B}%
  \cnode*(2.5,4.5){2pt}{D}%
  \cnode*(3,5){2pt}{F}%
  \cnode*(3.5,5.5){2pt}{H}%
  {\psset{arrowscale=2,linearc=0.2,%
   linecolor=red,armA=0.5, angleA=90,angleB=-90}
  \pcdiag[lineAngle=20]{->}(A)(B)
  \pcdiag[lineAngle=20]{->}(C)(D)
  \pcdiag[lineAngle=20]{->}(E)(F)
  \pcdiag[lineAngle=20]{->}(G)(H)}
\end{pspicture}
```

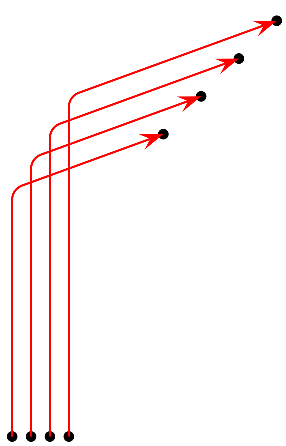
11 \ncdiagg and \pcdiagg

This is nearly the same than `\ncdiag` except that `armB=0` and the `angleB` value is computed by the macro, so that the line ends at the node with an angle like a `\pcdiagg` line. The syntax of `ncdiagg`/`pcdiagg` is

```
\ncdiag[<options>]{<Node A>}{<Node B>}
\pcdiag[<options>](<Node A>)(<Node B>)
```

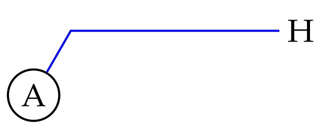



```
\begin{pspicture}(4,6)
  \psset{linecolor=black}
  \circlenode{A}{A}%
  \quad\circlenode{C}{C}%
  \quad\circlenode{E}{E}
  \rput(0,4){\circlenode{B}{B}}
  \rput(1,5){\circlenode{D}{D}}
  \rput(2,6){\circlenode{F}{F}}
  {\psset{arrowscale=2,linearc=0.2,linecolor=red,armA
    =0.5, angleA=90}
  \ncdiagg[lineAngle=-160]{->}{A}{B}
  \ncput*[nrot=:U]{line I}
  \ncdiagg[lineAngle=-160]{->}{C}{D}
  \ncput*[nrot=:U]{line II}
  \ncdiagg[lineAngle=-160]{->}{E}{F}
  \ncput*[nrot=:U]{line III}}
\end{pspicture}
```



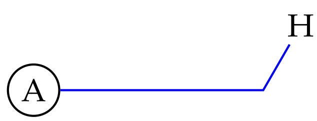
```
\begin{pspicture}(4,6)
  \psset{linecolor=black}
  \cnode*(0,0){2pt}{A}%
  \cnode*(0.25,0){2pt}{C}%
  \cnode*(0.5,0){2pt}{E}%
  \cnode*(0.75,0){2pt}{G}%
  \cnode*(2,4){2pt}{B}%
  \cnode*(2.5,4.5){2pt}{D}%
  \cnode*(3,5){2pt}{F}%
  \cnode*(3.5,5.5){2pt}{H}%
  {\psset{arrowscale=2,linearc=0.2,linecolor=red,armA
    =0.5, angleA=90}
  \pcdiagg[lineAngle=20]{->}(A)(B)
  \pcdiagg[lineAngle=20]{->}(C)(D)
  \pcdiagg[lineAngle=20]{->}(E)(F)
  \pcdiagg[lineAngle=20]{->}(G)(H)}
\end{pspicture}
```

The only catch for `\ncdiagg` is, that you need the right value for `lineAngle`. If the node connection is on the wrong side of the second node, then choose the corresponding angle, e.g.: if 20 is wrong then take −160, the corresponding to 180.




```
\begin{pspicture}(4,1.5)
  \circlenode{a}{A}
  \rput[l](3,1){\rnode{b}{H}}
  \ncdiagg[lineAngle=60,angleA=180,armA=.5,nodesepA=3pt,
    linecolor=blue]{b}{a}
\end{pspicture}
```

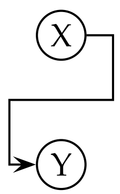

```
\begin{pspicture}(4,1.5)
  \circlenode{a}{A}
  \rput[l](3,1){\rnode{b}{H}}
  \ncdiagg[lineAngle=60,armA=.5,nodesepB=3pt,linecolor=blue]{a}{b}
\end{pspicture}
```



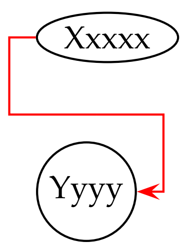

```
\begin{pspicture}(4,1.5)
  \circlenode{a}{A}
  \rput[l](3,1){\rnode{b}{H}}
  \ncdiagg[lineAngle=-120,armA=.5,nodesepB=3pt,linecolor=blue]{a}{b}
\end{pspicture}
```

12 \ncbarr

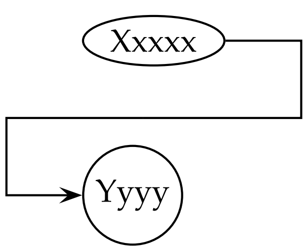
This has the same behaviour as `ncbar`, but has 5 segments and all are horizontal ones. This is the reason why `angleA` must be 0 or alternative 180. All other values are set to 0 by the macro. The intermediate horizontal line is symmetrical to the distance of the two nodes.




```
\psset{arrowscale=2}%
\circlenode{X}{X}\\[1cm]
\circlenode{Y}{Y}
\ncbarr[angleA=0,arrows=->,arrowscale=2]{X}{Y}
```




```
\psset{arrowscale=2}%
\ovalnode{X}{Xxxxx}\\[1cm]
\circlenode{Y}{Yyyy}
\ncbarr[angleA=180,arrows=->,arrowscale=2,linecolor=red]{X}{Y}
```




```
\psset{arrowscale=2}%
\ovalnode{X}{Xxxxx}\\[1cm]
\circlenode{Y}{Yyyy}
\ncbarr[angleA=20,arm=1cm,arrows=->,arrowscale=2]{X}{Y}
```

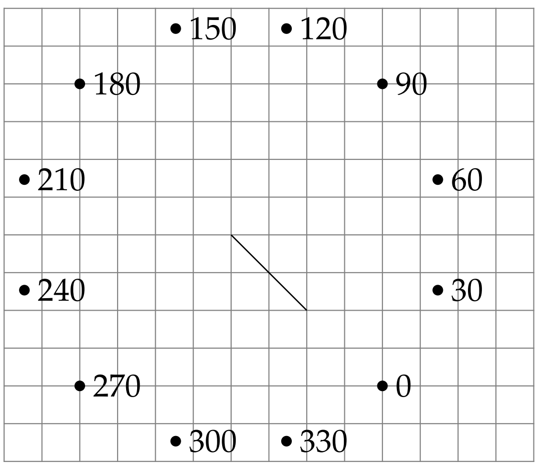
13 \psRelNode

With this macro it is possible to put a node relative to a given line. Parameter are the angle and the length factor:

```
\psRelNode(<P0>)(<P1>){<length factor>}{<end node name>}
\psRelLine[<options>](<P0>)(<P1>){<length factor>}{<end node name>}
```

The length factor depends to the distance of $\overline{P_0P_1}$ and the end node name must be a valid nodename and shouldn't contain any of the special PostScript characters. There are two valid options:

name	default	meaning
`angle`	0	angle between the given line $\overline{P_0P_1}$ and the new one $\overline{P_0P_{endNode}}$
`trueAngle`	false	defines whether the angle depends to the seen line or to the mathematical one, which respect the scaling factors `xunit` and `yunit`.




```
\begin{pspicture}(7,6)
  \psgrid[gridwidth=0pt,gridcolor=gray,
    gridlabels=0pt,subgriddiv=2]
  \pnode(3,3){A}\pnode(4,2){B}
  \psline[nodesep=-3,linewidth=0.5pt](A)(B)
  \multido{\iA=0+30}{12}{%
    \psRelNode[angle=\iA](A)(B){2}{C}%
    \qdisk(C){2pt}
    \uput[0](C){\iA}}
\end{pspicture}
```

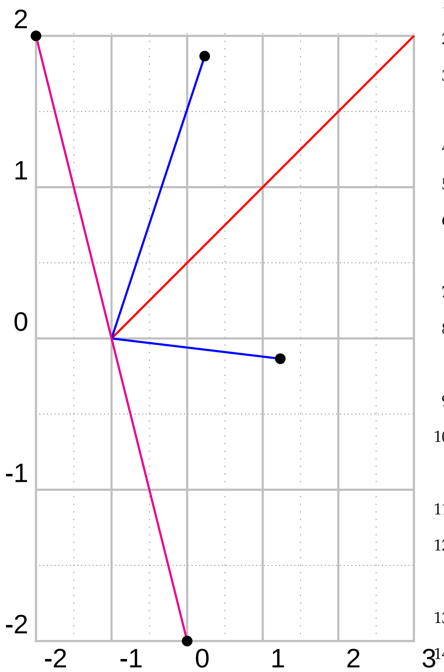
14 \psRelLine

With this macro it is possible to plot lines relative to a given one. Parameter are the angle and the length factor:

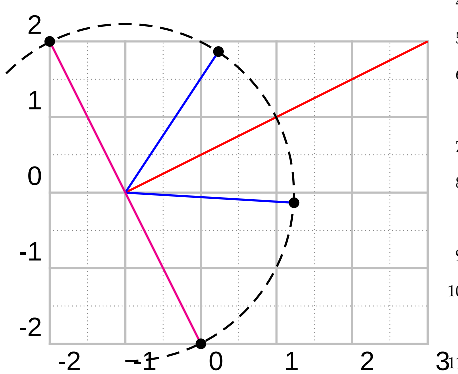
```
\psRelLine(<P0>)(<P1>){<length factor>}{<end node name>}
\psRelLine{<arrows>}(<P0>)(<P1>){<length factor>}{<end node name>}
\psRelLine[<options>](<P0>)(<P1>){<length factor>}{<end node name>}
\psRelLine[<options>]{<arrows>}(<P0>)(<P1>){<length factor>}{<end node name>}
```

The length factor depends to the distance of $\overline{P_0P_1}$ and the end node name must be a valid nodename and shouldn't contain any of the special PostScript characters. There are two valid options which are described in the forgoing section for `\psRelNode`.

The following two figures show the same, the first one with a scaling different to 1 : 1, this is the reason why the end points are on an ellipse and not on a circle like in the second figure.

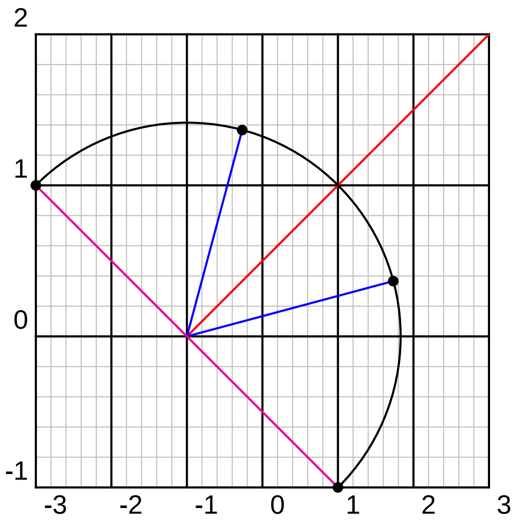



```
\psset{yunit=2,xunit=1}
\begin{pspicture}(-2,-2)(3,2)
\psgrid[subgriddiv=2,subgriddots=10,gridcolor=
  lightgray]
\pnode(-1,0){A}\pnode(3,2){B}
\psline[linecolor=red](A)(B)
\psRelLine[linecolor=blue,angle=30](-1,0)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=blue,angle=-30](A)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=90](-1,0)(3,2)
  {0.5}{EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=-90](A)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\end{pspicture}
```



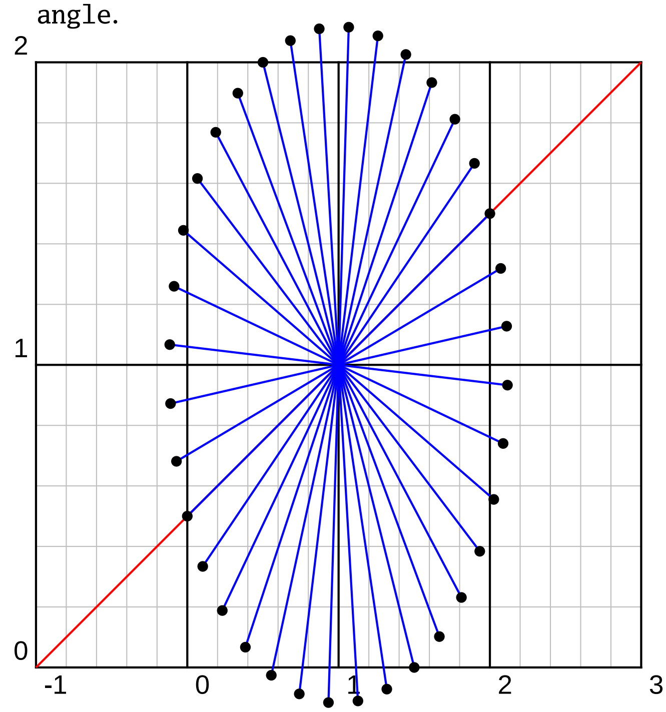

```
\begin{pspicture}(-2,-2)(3,2)
\psgrid[subgriddiv=2,subgriddots=10,gridcolor=
  lightgray]
\pnode(-1,0){A}\pnode(3,2){B}
\psline[linecolor=red](A)(B)
\psarc[linestyle=dashed](A){2.23}{-90}{135}
\psRelLine[linecolor=blue,angle=30](-1,0)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=blue,angle=-30](A)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=90](-1,0)(3,2)
  {0.5}{EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=-90](A)(B){0.5}{
  EndNode}
\qdisk(EndNode){2pt}
\end{pspicture}
```

The following figure has also a different scaling, but has set the option `trueAngle`, all angles depends to what "you see".

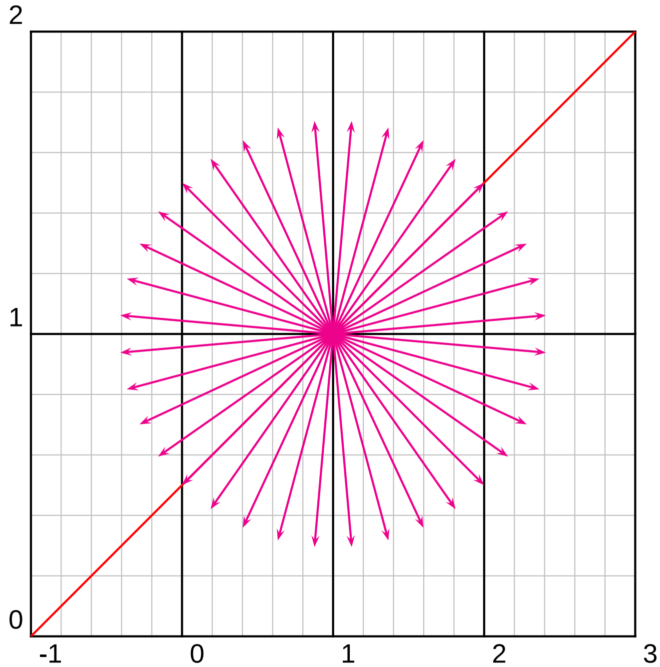



```
\psset{yunit=2,xunit=1}
\begin{pspicture}(-3,-1)(3,2)\psgrid[subgridcolor=lightgray]
\pnode(-1,0){A}\pnode(3,2){B}
\psline[linecolor=red](A)(B)
\psarc(A){2.83}{-45}{135}
\psRelLine[linecolor=blue,angle=30,trueAngle](A)(B){0.5}{EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=blue,angle=-30,trueAngle](A)(B){0.5}{EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=90,trueAngle](A)(B){0.5}{EndNode}
\qdisk(EndNode){2pt}
\psRelLine[linecolor=magenta,angle=-90,trueAngle](A)(B){0.5}{EndNode}
\qdisk(EndNode){2pt}
\end{pspicture}
```

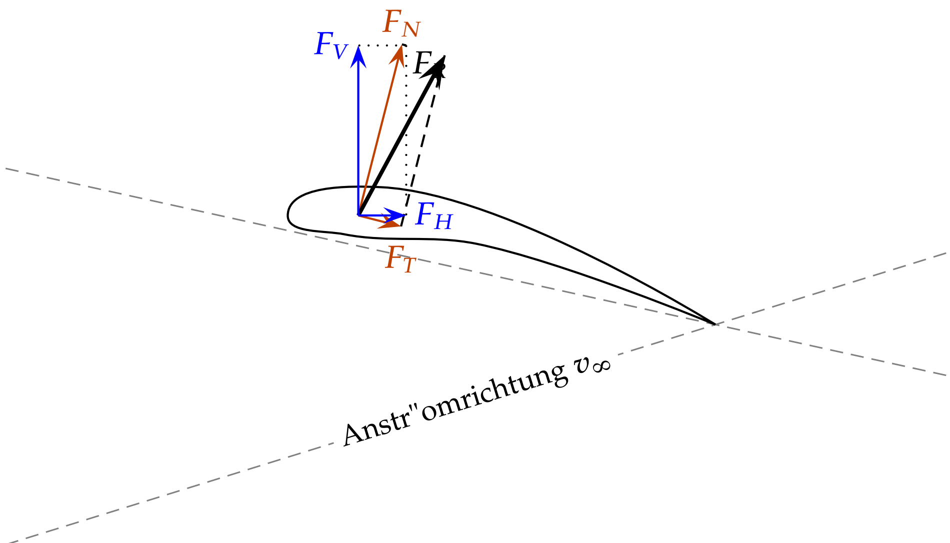
Two examples with using `\multido` to show the behaviour of the options `trueAngle` and `angle`.




```
\psset{yunit=4,xunit=2}
\begin{pspicture}(-1,0)(3,2)\psgrid[subgridcolor=lightgray]
\pnode(-1,0){A}\pnode(1,1){B}
\psline[linecolor=red](A)(3,2)
\multido{\iA=0+10}{36}{%
  \psRelLine[linecolor=blue,angle=\iA](B)(A){-0.5}{EndNode}
  \qdisk(EndNode){2pt}
}
\end{pspicture}
```




```
\psset{yunit=4,xunit=2}
\begin{pspicture}(-1,0)(3,2)\psgrid[
  subgridcolor=lightgray]
\pnode(-1,0){A}\pnode(1,1){B}
\psline[linecolor=red](A)(3,2)
\multido{\iA=0+10}{36}{%
  \psRelLine[linecolor=magenta,angle=\
    iA,trueAngle]{->}(B)(A){-0.5}{
    EndNode}
}
\end{pspicture}
```




```
\psset{xunit=0.75\linewidth,yunit=0.75\linewidth,trueAngle}%
\end{center}
\begin{pspicture}(1,0.6)%\psgrid
  \pnode(.3,.35){Vk} \pnode(.375,.35){D} \pnode(0,.4){DST1} \pnode(1,.18){DST2}
  \pnode(0,.1){A1}   \pnode(1,.31){A1}
  { \psset{linewidth=.02,linestyle=dashed,linecolor=gray}%
    \pcline(DST1)(DST2) % <- Druckseitentangente
    \pcline(A2)(A1) % <- Anstr"omrichtung
    \lput*{:U}{\small Anstr"omrichtung $v_{\infty}$} }%
  \psIntersectionPoint(A1)(A2)(DST1)(DST2){Hk}
  \pscurve(Hk)(.4,.38)(Vk)(.36,.33)(.5,.32)(Hk)
  \psParallelLine[linecolor=red!75!green,arrows=->,arrowscale=2](Vk)(Hk)(D){.1}{
    FtE}
```

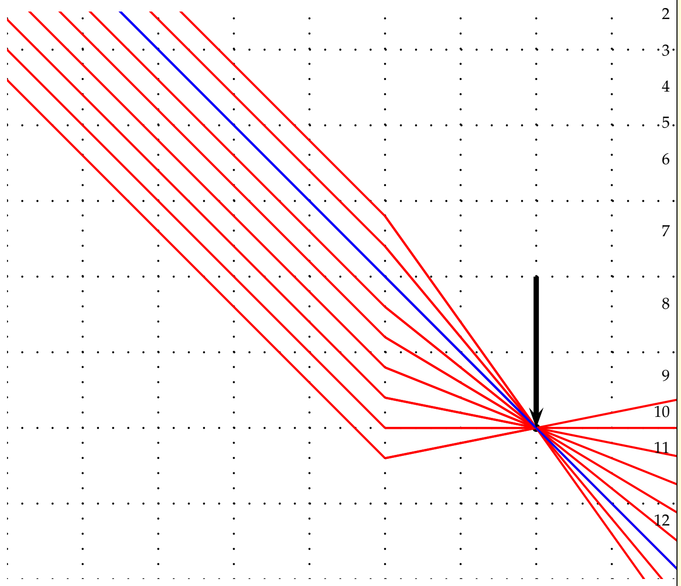
```
  \psRelLine[linecolor=red!75!green,arrows=->,arrowscale=2,angle=90](D)(FtE){4}{
    Fn}% why "4"?
  \psParallelLine[linestyle=dashed](D)(FtE)(Fn){.1}{Fnr1}
  \psRelLine[linestyle=dashed,angle=90](FtE)(D){-4}{Fnr2} % why "-4"?
  \psline[linewidth=1.5pt,arrows=->,arrowscale=2](D)(Fnr2)
  \psIntersectionPoint(D)([nodesep=2]D)(Fnr1)([offset=-4]Fnr1){Fh}
  \psIntersectionPoint(D)([offset=2]D)(Fnr1)([nodesep=4]Fnr1){Fv}
  \psline[linecolor=blue,arrows=->,arrowscale=2](D)(Fh)
  \psline[linecolor=blue,arrows=->,arrowscale=2](D)(Fv)
  \psline[linestyle=dotted](Fh)(Fnr1)  \psline[linestyle=dotted](Fv)(Fnr1)
  \uput{.1}[0](Fh){\blue $F_{H}$}   \uput{.1}[180](Fv){\blue $F_{V}$}
  \uput{.1}[-45](Fnr1){$F_{R}$}     \uput{.1}[90](Fn){\color{red!75!green}$F_{N}
    $}
  \uput{.25}[-90](FtE){\color{red!75!green}$F_{T}$}
\end{pspicture}
```

15 \psParallelLine

With this macro it is possible to plot lines relative to a given one, which is parallel. There is no special parameter here.

```
\psParallelLine(<P0>)(<P1>)(<P2>){<length>}{<end node name>}
\psParallelLine{<arrows>}(<P0>)(<P1>)(<P2>){<length>}{<end node name>}
\psParallelLine[<options>](<P0>)(<P1>)(<P2>){<length>}{<end node name>}
\psParallelLine[<options>]{<arrows>}(<P0>)(<P1>)(<P2>){<length>}{<end node name>}
```

The line starts at P_2, is parallel to $\overline{P_0P_1}$ and the length of this parallel line depends to the length factor. The end node name must be a valid nodename and shouldn't contain any of the special PostScript characters.

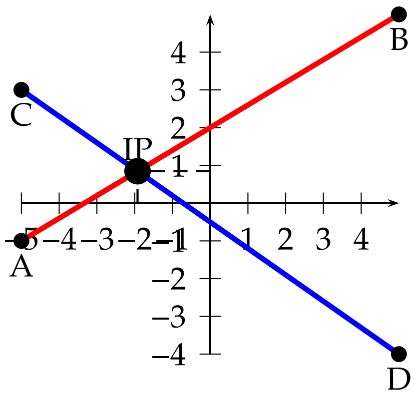


```
\begin{pspicture*}(-5,-4)(5,3.5)
  \psgrid[subgriddiv=0,griddots=5]
  \pnode(2,-2){FF}\qdisk(FF){1.5pt}
  \pnode(-5,5){A}\pnode(0,0){O}
  \multido{\nCountA=-2.4+0.4}{9}{%
    \psParallelLine[linecolor=red](O)(A)(0,\nCountA){9}{P1}
    \psline[linecolor=red](0,\nCountA)(FF)
    \psRelLine[linecolor=red](0,\nCountA)(FF){9}{P2}
  }
  \psline[linecolor=blue](A)(FF)
  \psRelLine[linecolor=blue](A)(FF){5}{END1}
  \psline[linewidth=2pt,arrows=->](2,0)(FF)
\end{pspicture*}
```

16 \psIntersectionPoint

This macro calculates the intersection point of two lines, given by the four coordinates. There is no special parameter here.

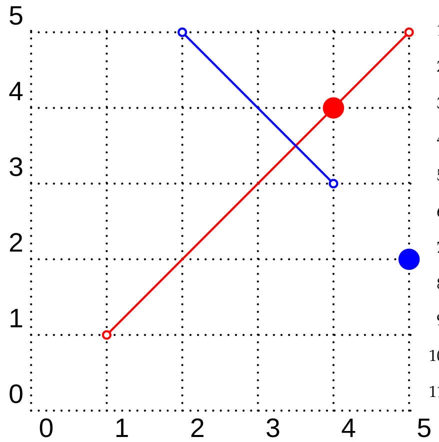
`\psIntersectionPoint(<P0>)(<P1>)(<P2>)(<P3>){<node name>}`




```
\psset{unit=0.5cm}
\begin{pspicture}(-5,-4)(5,5)
  \psaxes{->}(0,0)(-5,-4)(5,5)
  \psline[linecolor=red,linewidth=2pt](-5,-1)(5,5)
  \psline[linecolor=blue,linewidth=2pt](-5,3)(5,-4)
  \qdisk(-5,-1){3pt}\uput[-90](-5,-1){A}
  \qdisk(5,5){3pt}\uput[-90](5,5){B}
  \qdisk(-5,3){3pt}\uput[-90](-5,3){C}
  \qdisk(5,-4){3pt}\uput[-90](5,-4){D}
  \psIntersectionPoint(-5,-1)(5,5)(-5,3)(5,-4){IP}
  \qdisk(IP){5pt}\uput{0.3}[90](IP){IP}
  \psline[linestyle=dashed](IP|0,0)(IP)(0,0|IP)
\end{pspicture}
```

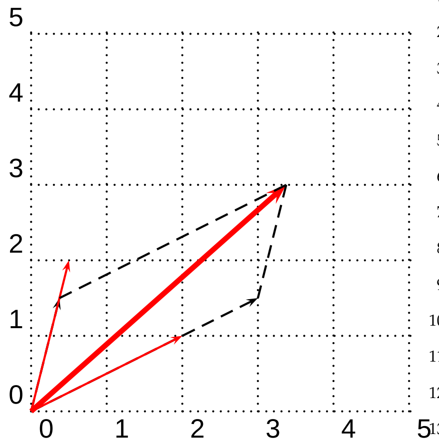
17 \psLNode and \psLCNode

\psLNode interpolates the Line $\overline{AB}$ by the given value and sets a node at this point. The syntax is
`\psLNode(P1)(P2){value}{Node name}`




```
\begin{pspicture}(5,5)
\psgrid[subgriddiv=0,griddots=10]
\psset{linecolor=red}
\psline{o-o}(1,1)(5,5)
\psLNode(1,1)(5,5){0.75}{PI}
\qdisk(PI){4pt}
\psset{linecolor=blue}
\psline{o-o}(4,3)(2,5)
\psLNode(4,3)(2,5){-0.5}{PII}
\qdisk(PII){4pt}
\end{pspicture}
```

The \psLCNode macro builds the linear combination of the two given vectors and stores the end of the new vector as a node. All vectors start at (0,0), so a \rput maybe appropriate. The syntax is
`\psLCNode(P1){value 1}(P2){value 2}{Node name}`




```
\begin{pspicture}(5,5)
\psgrid[subgriddiv=0,griddots=10]
\psset{linecolor=black}
\psline[linestyle=dashed]{->}(3,1.5)
\psline[linestyle=dashed]{->}(0.375,1.5)
\psset{linecolor=red}
\psline{->}(2,1)\psline{->}(0.5,2)
\psLCNode(2,1){1.5}(0.5,2){0.75}{PI}
\psline[linewidth=2pt]{->}(PI)
\psset{linecolor=black}
\psline[linestyle=dashed](3,1.5)(PI)
\psline[linestyle=dashed](0.375,1.5)(PI)
\end{pspicture}
```

18 \nlput and \psLDNode

\ncput allows to set a label relative to the first node of the last node connection. With \nlput this can be done absolute to a given node. The syntax is different to the other node connection makros. It uses internally the macro \psLDNode which places a node absolute to two given points, starting from the first one.

```
\nlput[options](A)(B){distance}{text}
\psLDNode[options](A)(B){distance}{node name}
```


```
\begin{pspicture}(5,2)
\pnode(0,0){A}
\pnode(5,2){B}
\ncline{A}{B}
\psLDNode(A)(B){1.5cm}{KN}\qdisk(KN){2pt}
\nlput[nrot=:U](A)(B){1cm}{Test}
\nlput[nrot=:D](A)(B){2cm}{Test}
\nlput[nrot=:U](A)(B){3cm}{Test}
\nlput(A)(B){4cm}{Test}
\end{pspicture}
```

Part III

pst-plot

19 New options

The option tickstyle=full|top|bottom is no more working in the pstricks-add package, because everything can be set by the ticksize option. When using the comma or trigLabels option, the macros \pshlabel and \psvlabel shouldn't be redefined, because the package does it itself in these cases.

Table 2: All new parameters for pst-plot

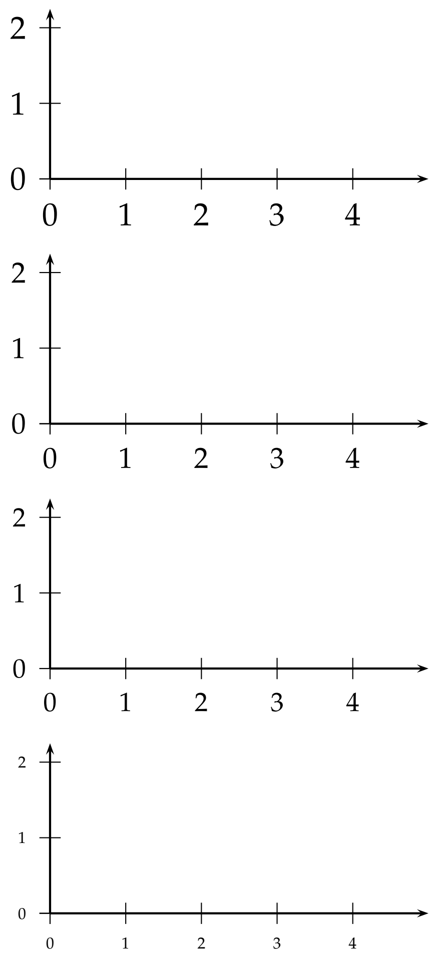
Name	Type	Default
labelFontSize	<fontsize macro>	{}
algebraic	false|true	false
comma	false|true	false
xAxis	false|true	true
yAxis	false|true	true
xyAxes	false|true	true
xDecimals	<number> or empty	{}
yDecimals	<number> or empty	{}
xyDecimals	<number> or empty	{}
ticks	<all|x|y|none>	all
labels	<all|x|y|none>	all
subticks	<number>	0
xsubticks	<number>	0
ysubticks	<number>	0
ticksize	<length [length]>	-4pt 4pt
subticksize	<number>	0.75
tickwidth	<length>	0.5\pslinewidth
subtickwidth	<length>	0.25\pslinewidth
tickcolor	<color>	black
xtickcolor	<color>	black
ytickcolor	<color>	black
subtickcolor	<color>	darkgray
xsubtickcolor	<color>	darkgray
ysubtickcolor	<color>	darkgray
ticklinestyle	solid | dashed | dotted | none	solid
subticklinestyle	solid | dashed | dotted | none	solid
xlabelFactor	<anything>	{\ empty}
ylabelFactor	<anything>	{\ empty}
xlogBase	<number> or empty	{}
ylogBase	<number> or empty	{}

Name	Type	Default
xylogBase	<number> or empty	{}
logLines	<none|x|y|all>	none
ignoreLines	<number>	0
nStep	<number>	1
nStart	<number>	0
nEnd	<number> or empty	{}
xStep	<number>	0
yStep	<number>	0
xStart	<number> or empty	{}
yStart	<number> or empty	{}
xEnd	<number> or empty	{}
yEnd	<number> or empty	{}
plotNo	<number>	1
plotNoMax	<number>	1
xAxisLabel	<anything>	{\ empty}
yAxisLabel	<anything>	{\ empty}
xAxisLabelPos	<(x,y)> or empty	{\ empty}
yAxisLabelPos	<(x,y)> or empty	{\ empty}
llx	<length>	0pt
lly	<length>	0pt
urx	<length>	0pt
ury	<length>	0pt
polarplot	false|true	false
trigLabels	false|true	false
trigLabelBase	<number>	0
ChangeOrder	false|true	false

19.1 Changing the label font size with `labelFontSize`

This option sets the horizontal **and** vertical font size for the labels. It will be overwritten when another package or a user defines

```
\def\pshlabel#1{...}
\def\psvlabel#1{...}
```



```
\begin{pspicture}(-0.25,-0.25)(5,2.25)
\psaxes{->}(5,2.25)
\end{pspicture}\\[20pt]
\begin{pspicture}(-0.25,-0.25)(5,2.25)
\psaxes[labelFontSize=\small]{->}(5,2.25)
\end{pspicture}\\[20pt]
\begin{pspicture}(-0.25,-0.25)(5,2.25)
\psaxes[labelFontSize=\footnotesize]{->}(5,2.25)
\end{pspicture}\\[20pt]
\begin{pspicture}(-0.25,-0.25)(5,2.25)
\psaxes[labelFontSize=\tiny]{->}(5,2.25)
\end{pspicture}%
```

19.2 algebraic[1]

By default the function of \psplot has to be described in Reversed Polish Notation. The option algebraic allows to do this in the common algebraic notation. E.g.:

RPN	algebraic
x ln	ln(x)
x cos 2.71 x neg 10 div exp mul	cos(x)*2.71^(-x/10)
1 x div cos 4 mul	4*cos(1/x)
t cos t sin	cos(t)|sin(t)

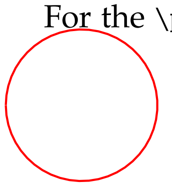
Setting the option algebraic to true, allow the user to describe all expression to be written in the classical algebraic notation (infix notation). The four arithmetic operarions are obviously defined +-*/, and also the exponential operator ^. The natural priorities are used : $3 + 4 \times 5^5 = 3 + (4 \times (5^5))$, and by default the computation is done from left to right. The following functions are defined :

sin, cos, tan, acos, asin	in radians
log, ln	
ceiling, floor, truncate, round	
sqrt	square root
abs	absolute value
fact	for the factorial
Sum	for building sums
IfTE	for an easy case structure

These options can be used with **all** plot macros.

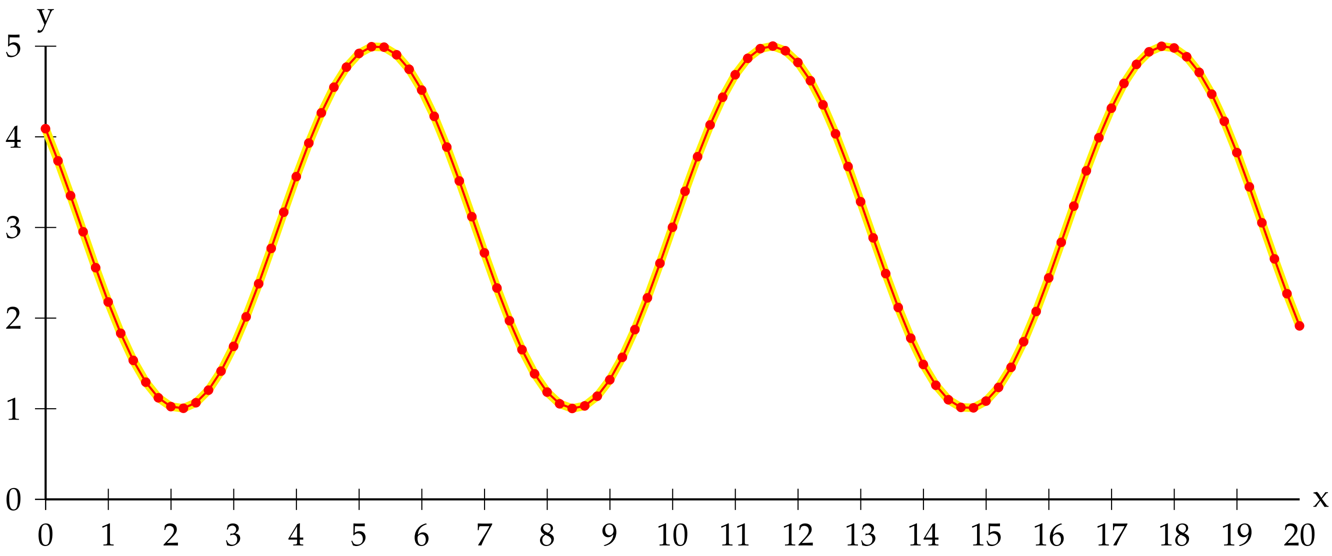
Using the option algebraic **implies that all angles have to be used in the radian unit!**

For the \parametricplot the two parts must be divided by the | character:

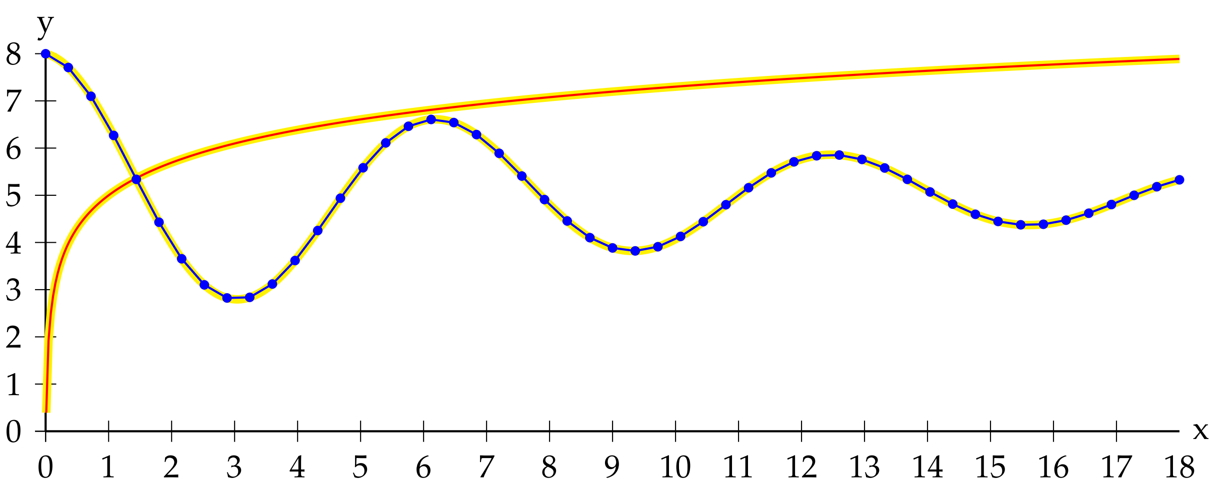


```
\begin{pspicture}(-0.5,-0.5)(0.5,0.5)
\parametricplot[algebraic,linecolor=red]{-3.14}{3.14}{cos(t)|sin(t)}
\end{pspicture}
```

[1]This part is adapted from the package pst-eqdf, written by Dominique Rodriguez.




```
\psset{lly=-0.5cm}
\psgraph(-10,-3)(10,2){\linewidth}{6cm}
  \psset{algebraic=true, plotpoints=101}
  \psplot[linecolor=yellow, linewidth=4\pslinewidth]{-10}{10}{2*sin(x)}%
  \psplot[linecolor=red, showpoints=true]{-10}{10}{2*sin(x)}
\endpsgraph
```

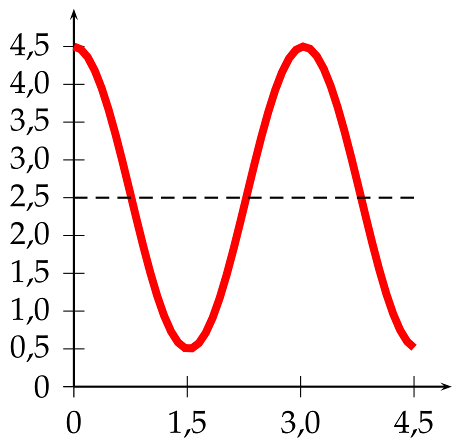



```
\psset{lly=-0.5cm}
\psgraph(0,-5)(18,3){15cm}{5cm}
  \psset{algebraic,plotpoints=501}
  \psplot[linecolor=yellow, linewidth=4\pslinewidth]{0.01}{18}{ln(x)}%
  \psplot[linecolor=red]{0.01}{18}{ln(x)}
  \psplot[linecolor=yellow,linewidth=4\pslinewidth]{0}{18}{3*cos(x)*2.71^(-x/10)
    }
  \psplot[linecolor=blue,showpoints=true,plotpoints=51]{0}{18}{3*cos(x)*2.71^(-x
    /10)}
\endpsgraph
```

19.3 comma

Syntax:
`comma=false|true`

Setting this option to true gives labels with a comma as a decimal separator instead of the dot. `comma` and `comma=true` is the same.

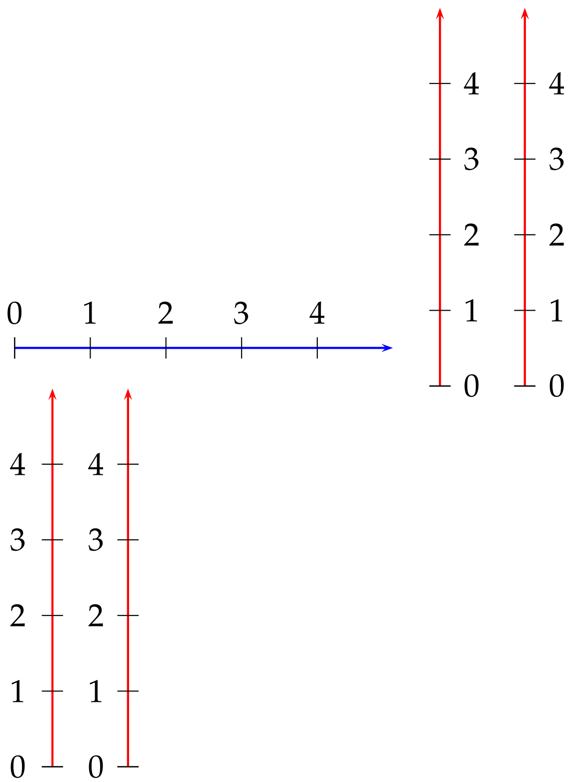



```
\begin{pspicture}(-0.5,-0.5)(5,5.5)
\psaxes[Dx=1.5,Dy=0.5,comma]{->}(5,5)
\psplot[linecolor=red,linewidth=3pt]{0}{4.5}%
  {x 180 mul 1.52 div cos 2 mul 2.5 add}
\psline[linestyle=dashed](0,2.5)(4.5,2.5)
\end{pspicture}
```

19.4 xyAxes, xAxis and yAxis

Syntax:
```
xyAxes=true|false
xAxis=true|false
yAxis=true|false
```

Sometimes there is only a need for one axis with ticks. In this case you can set one of the following options to false. The `xyAxes` makes only sense, when you want to set both, x and y to true with only one command again to the default, because with `xyAxes=false` you get nothing with the `psaxes` macro.




```
\begin{pspicture}(5,1)
\psaxes[yAxis=false,linecolor=blue
  ]{->}(0,0.5)(5,0.5)
\end{pspicture}
\begin{pspicture}(1,5)
\psaxes[xAxis=false,linecolor=red
  ]{->}(0.5,0)(0.5,5)
\end{pspicture}
\begin{pspicture}(1,5)
\psaxes[xAxis=false,linecolor=red
  ]{->}(0.5,0)(0.5,5)
\end{pspicture}\hspace{2em}
\begin{pspicture}(1,5)
\psaxes[xAxis=false,linecolor=red,
  labelsep=-20pt]{->}(0.5,0)(0.5,5)
\end{pspicture}%
\begin{pspicture}(1,5)
\psaxes[xAxis=false,linecolor=red
  ]{->}(0.5,0)(0.501,5)
\end{pspicture}%
```

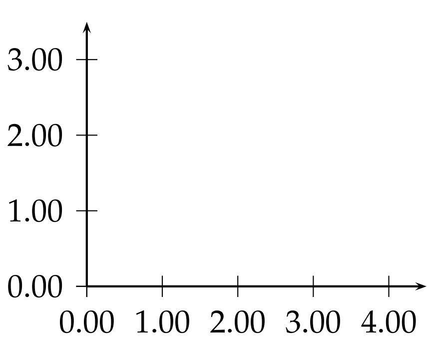
As seen in the example, a single y axis gets the labels on the right side. This can be changed in two ways, first with the option `labelsep` and second with a very short and therefore invisible x-axis (right example).

19.5 xyDecimals, xDecimals and yDecimals

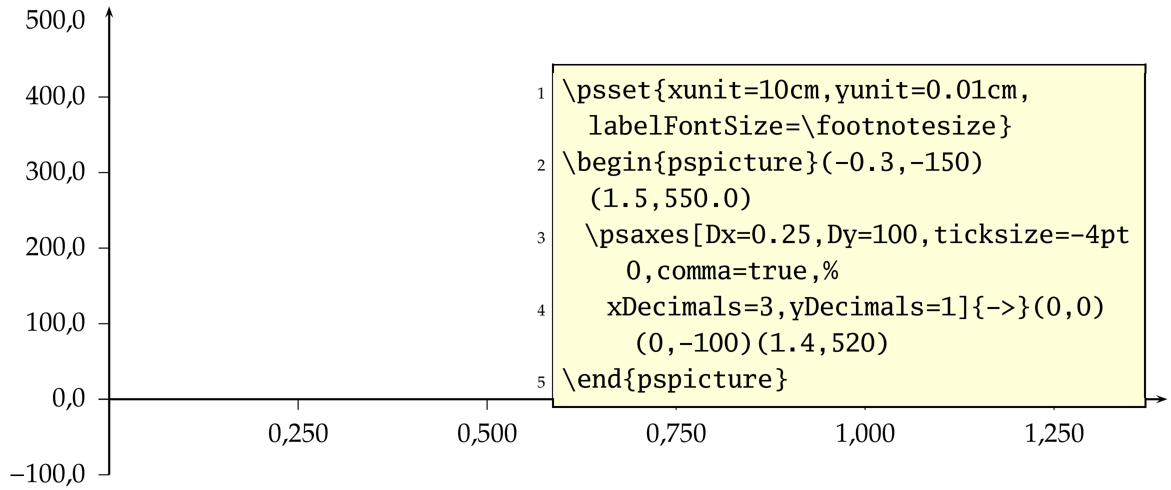
Syntax:

```
xyDecimals=<number>
xDecimals=<any>
yDecimals=<any>
```

By default the labels of the axes get numbers with or without decimals, just depending to the numbers. With these options `??Decimals` it is possible to determine the decimals, where the option `xyDecimals` sets this identical for both axes. The default setting `{}` means, that you'll get the standard behaviour.




```
\begin{pspicture}(-1.5,-0.5)(5,3.75)
  \psaxes[xyDecimals=2]{->}(0,0)(4.5,3.5)
\end{pspicture}
```

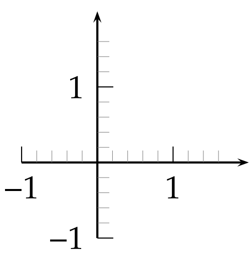



```
\psset{xunit=10cm,yunit=0.01cm,
  labelFontSize=\footnotesize}
\begin{pspicture}(-0.3,-150)
  (1.5,550.0)
  \psaxes[Dx=0.25,Dy=100,ticksize=-4pt
    0,comma=true,%
    xDecimals=3,yDecimals=1]{->}(0,0)
      (0,-100)(1.4,520)
\end{pspicture}
```

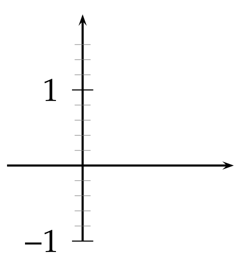
19.6 ticks

Syntax:
`ticks=all|x|y|none`

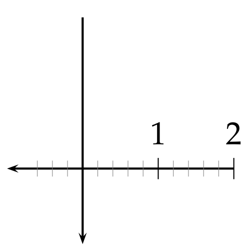
This option is also already in the `pst-plot` package and only mentioned here for some completness.



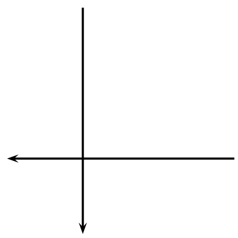

```
\psset{ticksize=6pt}
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=all,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=y,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=x,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```

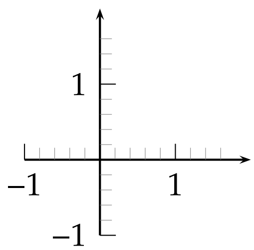


```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=none,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```

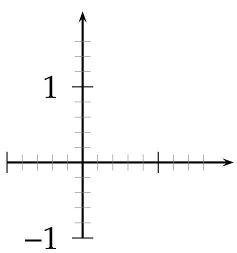
19.7 labels

Syntax:
`labels=all|x|y|none`

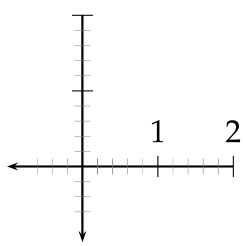
This option is also already in the `pst-plot` package and only mentioned here for some completness.



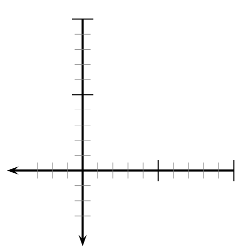

```
\psset{ticksize=6pt}
\begin{pspicture}(-1,-1)(2,2)
\psaxes[labels=all,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[labels=y,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[labels=x,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```



```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[labels=none,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```

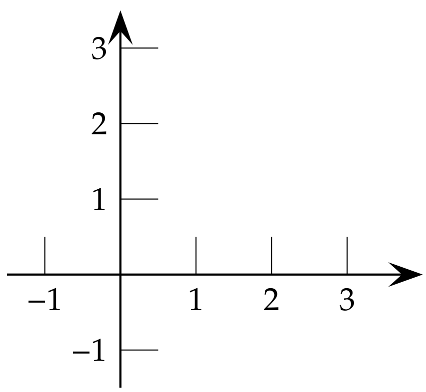
19.8 ticksize, xticksize, yticksize

With this new option the recent `tickstyle` option of `pst-plot` is obsolete and no more supported by `pstricks-add`.

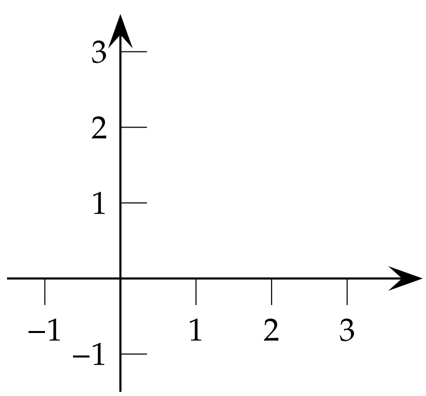
Syntax:

```
ticksize=value[unit]
ticksize=value[unit] value[unit]
xticksize=value[unit]
xticksize=value[unit] value[unit]
yticksize=value[unit]
yticksize=value[unit] value[unit]
```

`ticksize` sets both values. The first one is left/below and the optional second one is right/above of the coordinate axis. The old setting `tickstyle=bottom` is now easy to realize, e.g.: `ticksize=-6pt 0`, or vice versa, if the coordinates are set from positive to negative values.

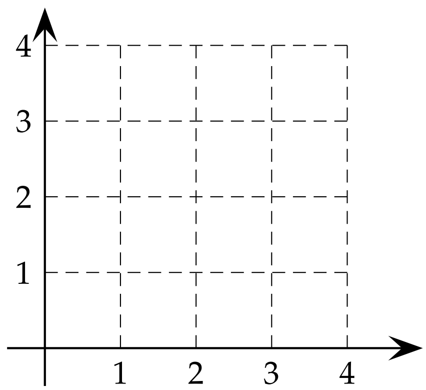



```
\psset{arrowscale=3}
\begin{pspicture}(-1.5,-1.5)(4,3.5)
 \psaxes[ticksize=0.5cm]{->}(0,0)(-1.5,-1.5)(4,3.5)
\end{pspicture}
```




```
\psset{arrowscale=3}
\begin{pspicture}(-1.5,-1.5)(4,3.5)
 \psaxes[xticksize=-10pt 0,yticksize=0 10pt]{->}(0,0)(-1.5,-1.5)(4,3.5)
\end{pspicture}
```

A grid is also possible by setting the values to the max/min coordinates.

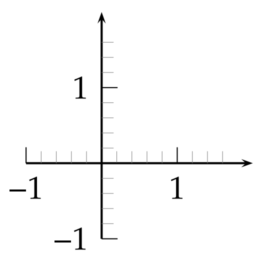



```
\psset{arrowscale=3}
\begin{pspicture}(-.5,-.5)(5,4.5)
  \psaxes[ticklinestyle=dashed,ticksize=0 4cm
    ]{->}(0,0)(-.5,-.5)(5,4.5)
\end{pspicture}
```

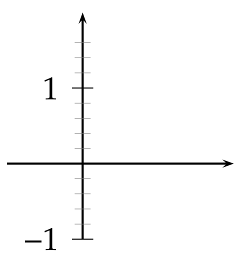
19.9 subticks

Syntax:
`subticks=<number>`

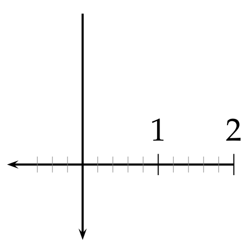
By default subticks cannot have labels.



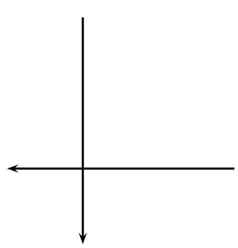

```
\psset{ticksize=6pt}
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=all,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=y,subticks=5]{->}(0,0)(-1,-1)(2,2)
\end{pspicture}
```




```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=x,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```

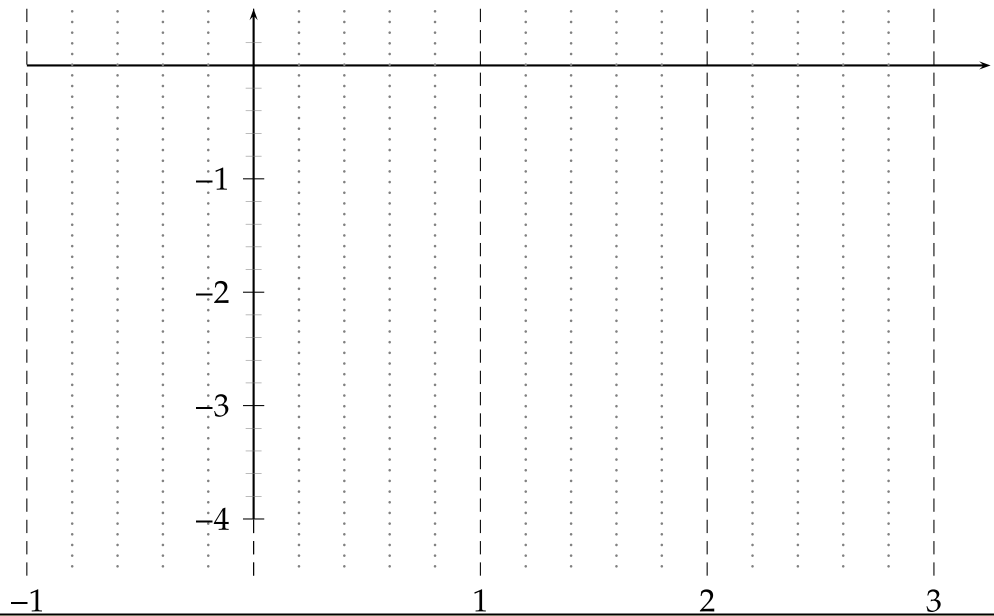


```
\begin{pspicture}(-1,-1)(2,2)
\psaxes[ticks=none,subticks=5]{->}(0,0)(2,2)(-1,-1)
\end{pspicture}
```

19.10 subticksize, xsubticksize, ysubticksize

Syntax:
```
subticksize=value
xsubticksize=value
ysubticksize=value
```

`subticksize` sets both values, which are relative to the ticksize length and can have any number. 1 sets it to the same length as the main ticks.



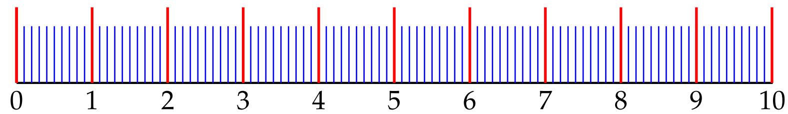

```
\psset{yunit=1.5cm,xunit=3cm}
\begin{pspicture}(-1.25,-4.75)(3.25,.75)
  \psaxes[xticksize=-4.5 0.5,ticklinestyle=dashed,subticks=5,xsubticksize=1,%
    ysubticksize=0.75,xsubticklinestyle=dotted,xsubtickwidth=1pt,
    subtickcolor=gray]{->}(0,0)(-1,-4)(3.25,0.5)
\end{pspicture}
```

19.11 tickcolor, subtickcolor

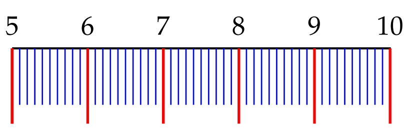
Syntax:

```
tickcolor=<color>
xtickcolor=<color>
ytickcolor=<color>
subtickcolor=<color>
xsubtickcolor=<color>
ysubtickcolor=<color>
```

`tickcolor` and `subtickcolor` set both for the x- and the y-Axis.




```
\begin{pspicture}(0,-0.75)(10,1)
\psaxes[labelsep=2pt,yAxis=false,labelFontSize=\footnotesize,%
  labelsep=-10pt,ticksize=0 10mm,subticks=10,subticksize=0.75,%
  tickcolor=red,subtickcolor=blue,tickwidth=1pt,%
  subtickwidth=0.5pt](10.01,0)
\end{pspicture}
```



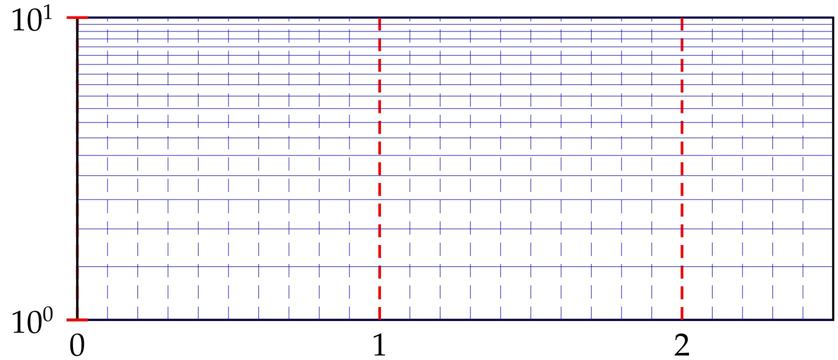

```
\begin{pspicture}(5,-0.75)(10,1)
\psaxes[labelsep=2pt,yAxis=false,labelFontSize=\footnotesize,%
  labelsep=5pt,ticksize=0 -10mm,subticks=10,subticksize=0.75,%
  tickcolor=red,subtickcolor=blue,tickwidth=1pt,%
  subtickwidth=0.5pt,Ox=5](5,0)(5,0)(10.01,0)
\end{pspicture}
```

19.12 ticklinestyle and subticklinestyle

Syntax:

```
ticklinestyle=solid|dashed|dotted|none
xticklinestyle=solid|dashed|dotted|none
yticklinestyle=solid|dashed|dotted|none
subticklinestyle=solid|dashed|dotted|none
xsubticklinestyle=solid|dashed|dotted|none
ysubticklinestyle=solid|dashed|dotted|none
```

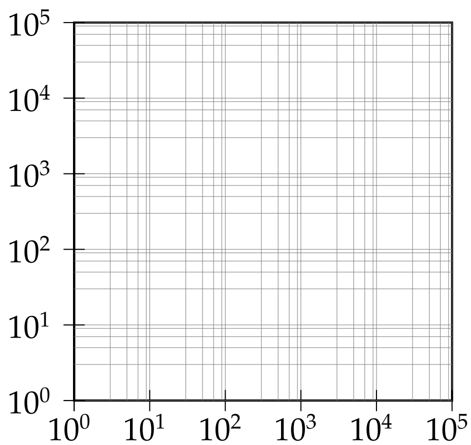
`ticklinestyle` and `subticklinestyle` set both values for the x and y axis. The value `none` doesn't really makes sense, because it is the same to `[sub]ticklines=0`



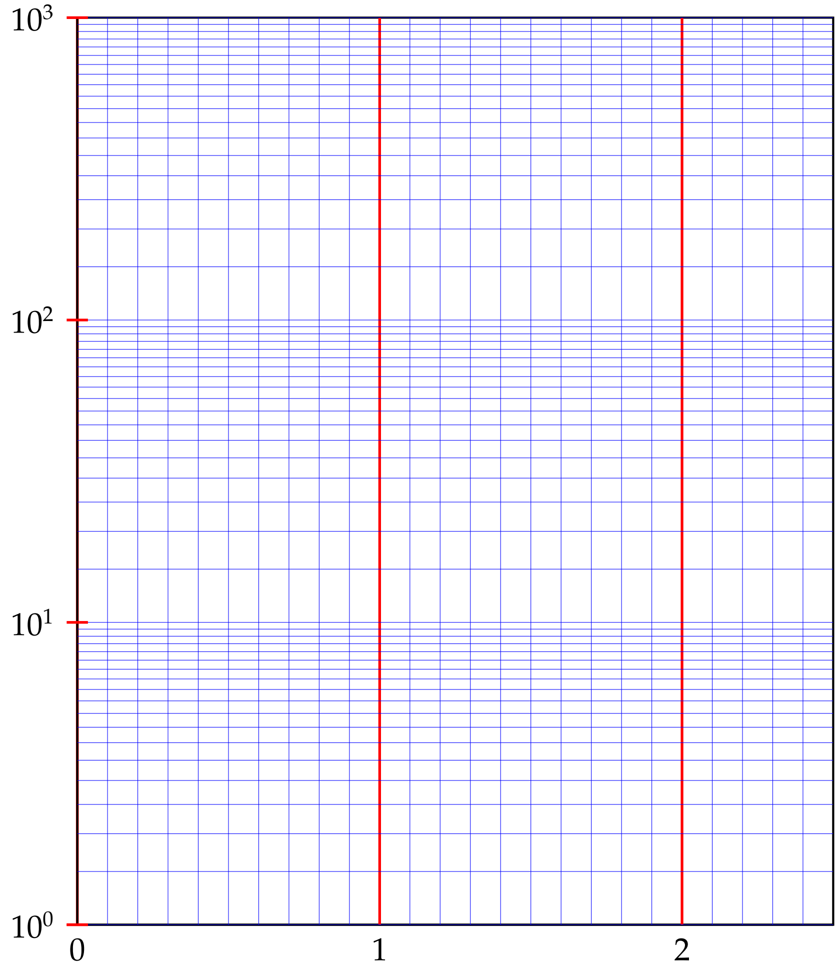

```
\psset{unit=4cm}
\pspicture(-0.15,-0.15)(2.5,1)
  \psaxes[axesstyle=frame,logLines=y,xticksize=0 1,xsubticksize=1,%
    ylogBase=10,tickcolor=red,subtickcolor=blue,tickwidth=1pt,%
    subticks=20,xsubticks=10,xticklinestyle=dashed,%
    xsubticklinestyle=dashed](2.5,1)
\endpspicture
```

19.13 loglines

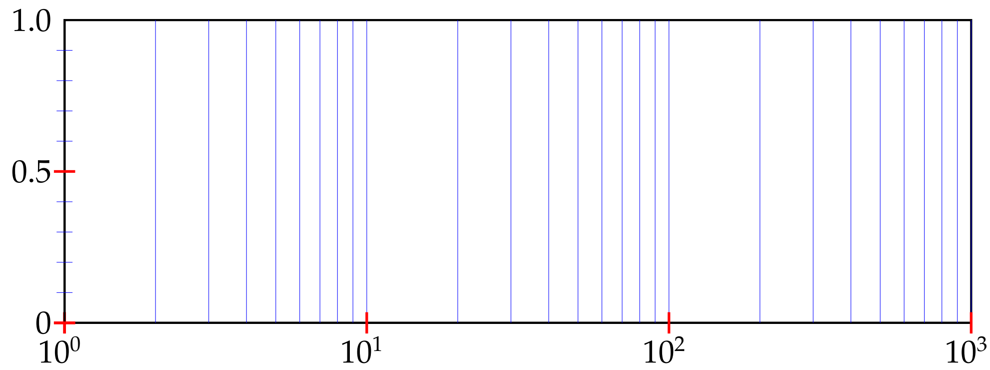
Syntax:
`loglines=all|x|y`




```
\pspicture(0,-1)(5,5)
   \psaxes[subticks=5,axesstyle=frame,xylogBase=10,
     logLines=all](5,5)
\endpspicture
```




```
\psset{unit=4cm}
\pspicture(-0.15,-0.15)(2.5,3)
  \psaxes[axesstyle=frame,logLines=y,xticksize=0 3,xsubticksize=1,%
    ylogBase=10,tickcolor=red,subtickcolor=blue,tickwidth=1pt,%
    subticks=20,xsubticks=10](2.5,3)
\endpspicture
```



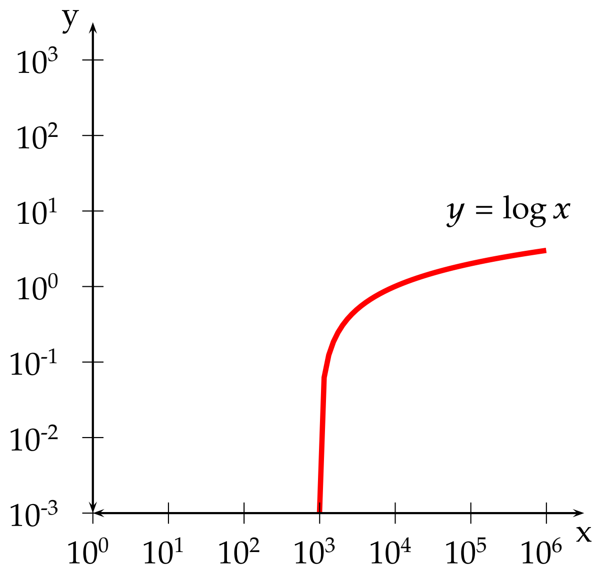

```
\psset{unit=4}
\pspicture(-0.5,-0.3)(3,1.2)
  \psaxes[axesstyle=frame,logLines=x,xlogBase=10,Dy=0.5,%
    tickcolor=red,subtickcolor=blue,tickwidth=1pt,ysubticks=5,xsubticks=10](3,1)
\endpspicture
```

19.14 xylogBase, xlogBase and ylogBase

There are additional options xylogBase xlogBase | ylogBase| to get one or both axes with logarithm labels. For an intervall of $[10^{-3}...10^{2}]$ choose a pstricks intervall of [-3,2]. pstricks takes 0 as the origin of this axes, which is wrong if we want to have a logarithm axes. With the options Oy and Ox we can set the origin to -3, so that the first label gets 10^{-3}. If this is not done by the user then pstricks-add does it by default. An alternative is to set these parameters to empty values Ox={},Oy={}, in this case pstricks-add does nothing.

19.14.1 xylogBase

This mode is in math also called double logarithm. It is a combination of the two forgoing modes and the function is now $y = \log x$ and is shown in the following example.




```
\begin{pspicture}(-3.5,-3.5)(3.5,3.5)
  \psplot[linewidth=2pt,linecolor=red
    ]{0.001}{3}{x log}
  \psaxes[xylogBase=10,Oy=-3]{<->}(-3,-3)
    (3.5,3.5)
  \uput[-90](3.5,-3){x}
  \uput[180](-3,3.5){y}
  \rput(2.5,1){$y=\log x$}
\end{pspicture}
```

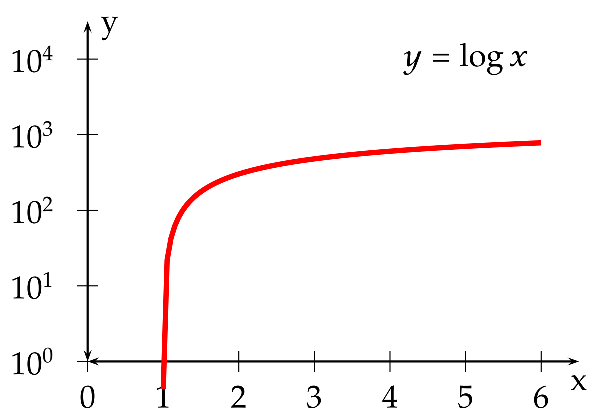
19.14.2 ylogBase

The values for the psaxes y-coordinate are now the exponents to the base 10 and for the right function to the base e: $10^{-3} \ldots 10^{1}$ which corresponds to the given y-intervall $-3 \ldots 1.5$, where only integers as exponents are possible. These logarithm labels have no effect to the internal used units. To draw the logarithm function we have to use the math function

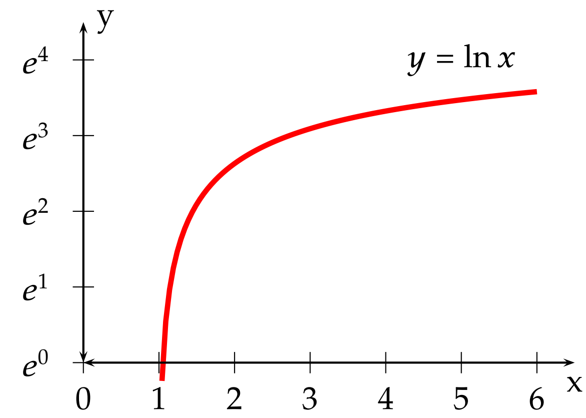
$$y = \log\{\log x\}$$

$$y = \ln\{\ln x\}$$

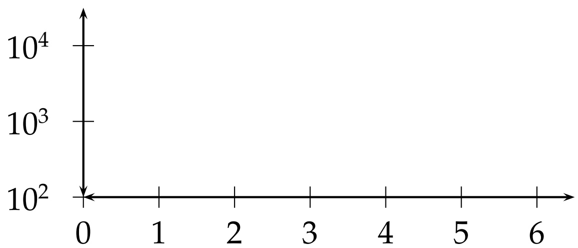
with an drawing intervall of $1.001 \ldots 6$.



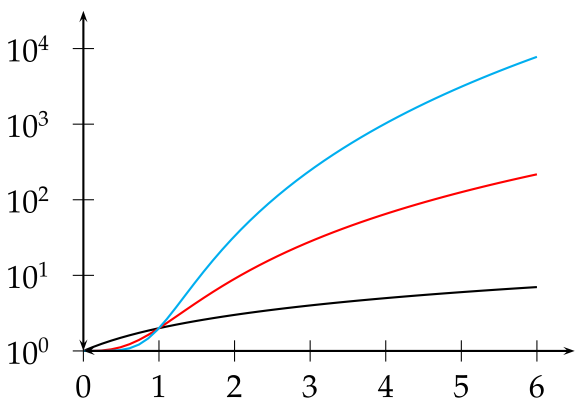

```
\begin{pspicture}(-0.5,-3.5)(6.5,1.5)
  \psaxes[ylogBase=10]{<->}(0,-3)(6.5,1.5)
  \uput[-90](6.5,-3){x}
  \uput[0](0,1.4){y}
  \rput(5,1){$y=\log x$}
  \psplot[linewidth=2pt,%
  plotpoints=100,linecolor=red]{1.001}{6}{x
    log log} % log(x)
\end{pspicture}
```



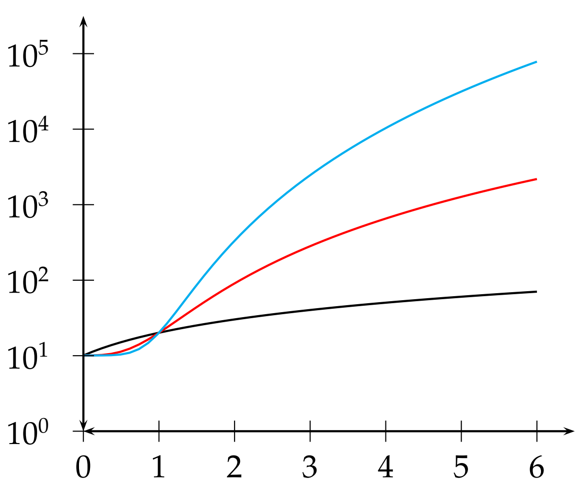

```
\begin{pspicture}(-0.5,-3.5)(6.5,1.5)
  \psplot[linewidth=2pt,plotpoints=100,
    linecolor=red]%
    {1.04}{6}{/ln {log 0.4343 div} def x ln
      ln} % log(x)
  \psaxes[ylogBase=e]{<->}(0,-3)(6.5,1.5)
  \uput[-90](6.5,-3){x}
  \uput[0](0,1.5){y}
  \rput(5,1){$y=\ln x$}
\end{pspicture}
```



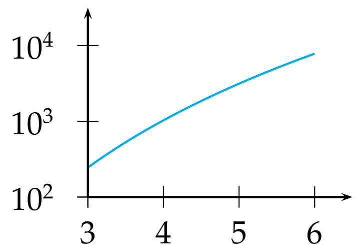

```
  \begin{pspicture}(-0.5,1.75)(6.5,4.5)
    \psaxes[ylogBase=10,Oy=2]{<->}(0,2)(0,2)
      (6.5,4.5)
  \end{pspicture}
```




```
  \begin{pspicture}(-0.5,-0.25)(6.5,4.5)
    \psplot{0}{6}{x x cos add log}          %
       x  + cox(x)
    \psplot[linecolor=red]{0}{6}{x 3 exp x
      cos add log} % x^3 + cos(x)
    \psplot[linecolor=cyan]{0}{6}{x 5 exp x
      cos add log} % x^5 + cos(x)
    \psaxes[ylogBase=10]{<->}(6.5,4.5)
  \end{pspicture}
```



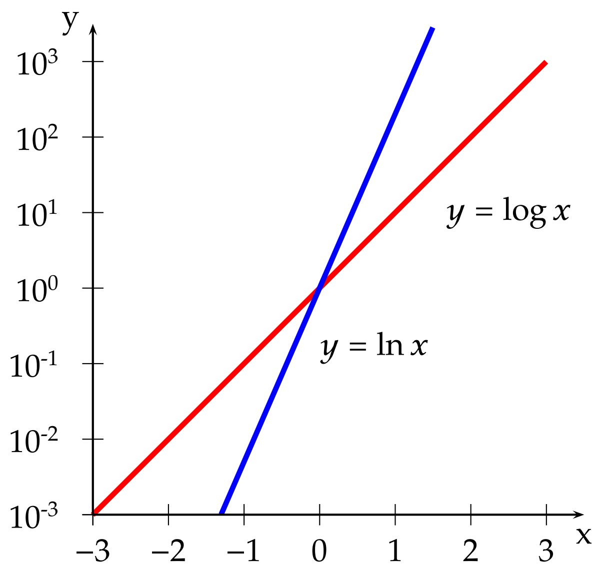

```
\begin{pspicture}(-0.5,-1.25)(6.5,4.5)
  \psplot{0}{6}{x x cos add log}          % x
      + cox(x)
  \psplot[linecolor=red]{0}{6}{x 3 exp x cos
     add log} % x^3 + cos(x)
  \psplot[linecolor=cyan]{0}{6}{x 5 exp x
    cos add log} % x^5 + cos(x)
  \psaxes[ylogBase=10]{<->}(0,-1)(0,-1)
    (6.5,4.5)
\end{pspicture}
```



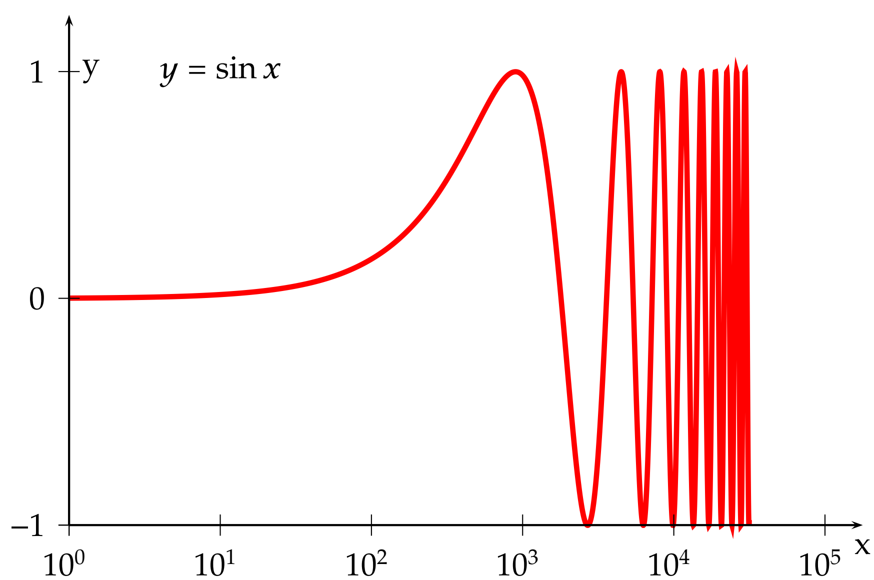

```
\begin{pspicture}(2.5,1.75)(6.5,4.5)
  \psplot[linecolor=cyan]{3}{6}{x 5 exp x cos add log} % x
    ^5 + cos(x)
  \psaxes[ylogBase=10,Ox=3,Oy=2]{->}(3,2)(3,2)(6.5,4.5)
\end{pspicture}
```

19.14.3 xlogBase

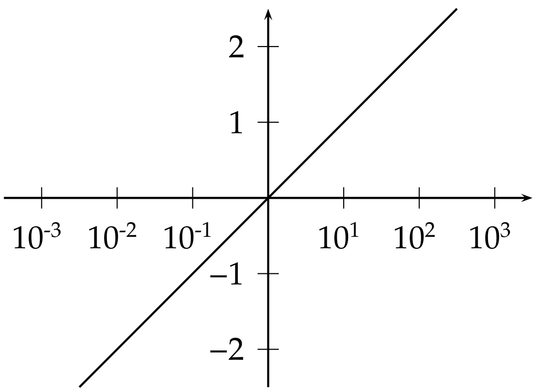
Now we have to use the easy math function $y = x$ because the x axis is still $\log x$.



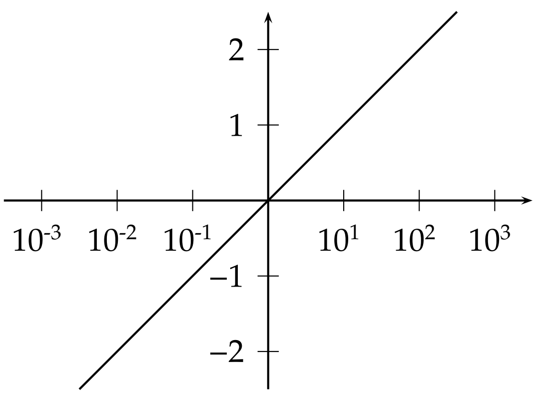

```
\begin{pspicture}(-3.5,-3.5)(3.5,3.5)
  \psplot[linewidth=2pt,linecolor=red
    ]{-3}{3}{x} % log(x)
  \psplot[linewidth=2pt,linecolor=blue
    ]{-1.3}{1.5}{x 0.4343 div} % ln(x)
  \psaxes[ylogBase=10,Oy=-3,Ox
    =-3]{->}(-3,-3)(3.5,3.5)
  \uput[-90](3.5,-3){x}
  \uput[180](-3,3.5){y}
  \rput(2.5,1){$y=\log x$}
  \rput[lb](0,-1){$y=\ln x$}
\end{pspicture}
```



```
\psset{yunit=3cm,xunit=2cm}
\begin{pspicture}(-1.25,-1.25)(4.25,1.5)
  \uput[-90](4.25,-1){x}
  \uput[0](-1,1){y}
  \rput(0,1){$y=\sin x$}
  \psplot[linewidth=2pt,plotpoints=5000,linecolor=red]{-1}{3.5}{10 x exp sin }
  \psaxes[xlogBase=10,Oy=-1]{->}(-1,-1)(4.25,1.25)
\end{pspicture}
```



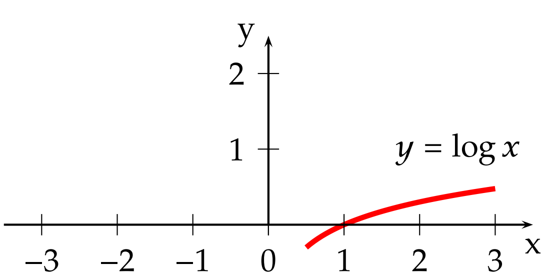

```
\begin{pspicture}(-3.5,-2.5)(3.5,2.5)
  \psaxes[xlogBase=10]{->}(0,0)(-3.5,-2.5)
    (3.5,2.5)
  \psplot{-2.5}{2.5}{10 x exp log}
\end{pspicture}
```




```
\begin{pspicture}(-3.5,-2.5)(3.5,2.5)
  \psaxes[xlogBase=10,Ox={},Oy={}]{->}(0,0)
    (-3.5,-2.5)(3.5,2.5)
  \psplot{-2.5}{2.5}{10 x exp log}
\end{pspicture}
```

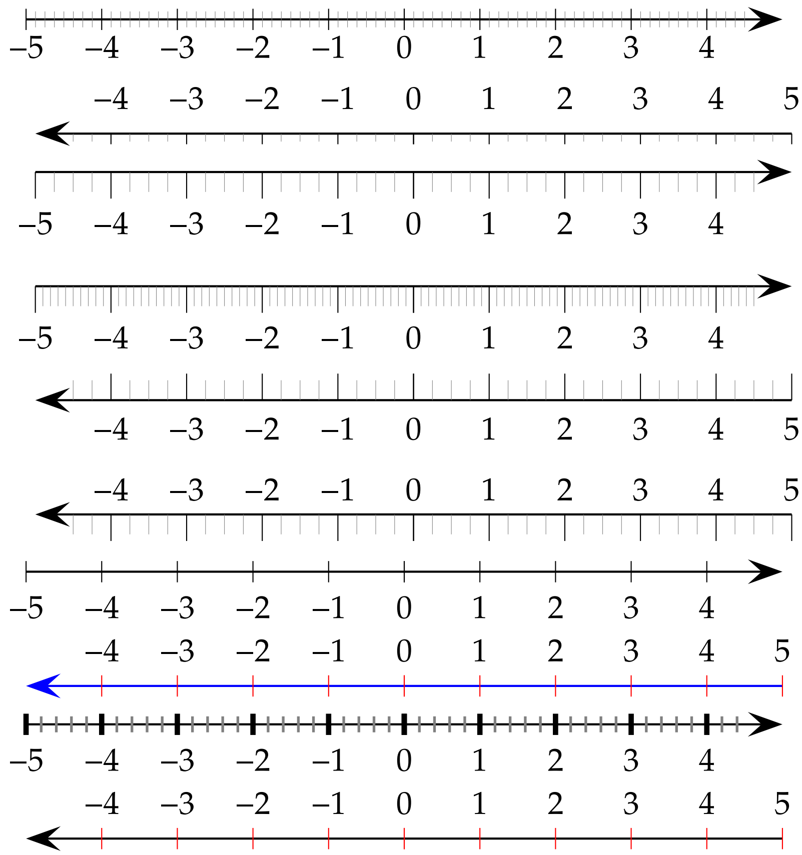
19.14.4 No logstyle (xylogBase={})

This is only a demonstration that the default option `logBase={}` still works ... :-)

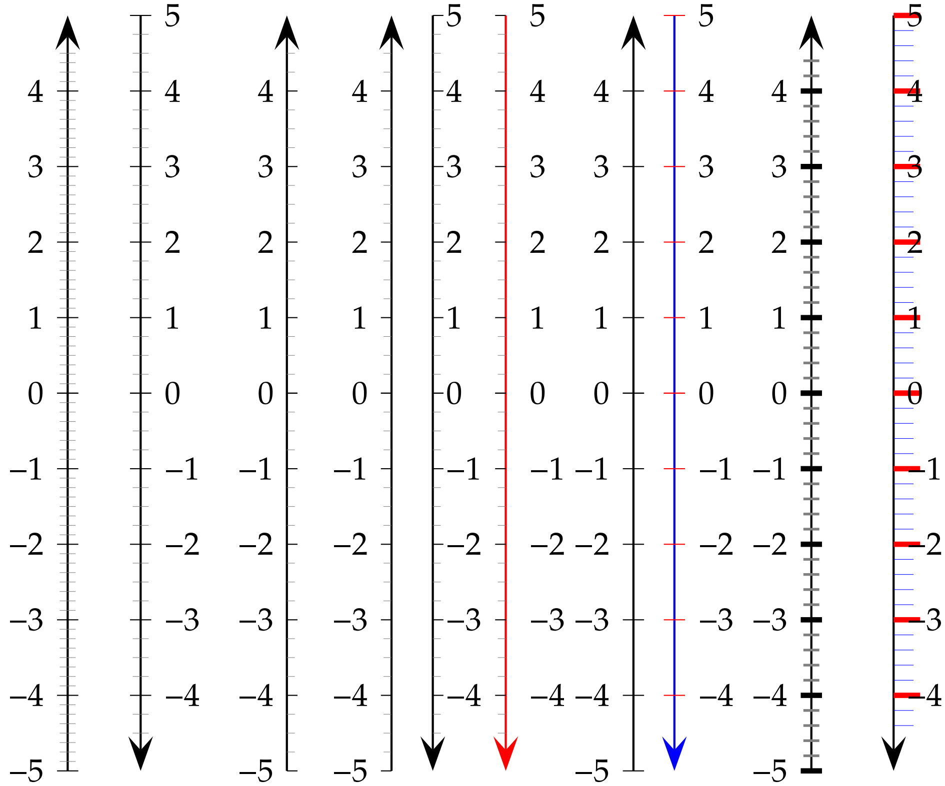



```
\begin{pspicture}(-3.5,-0.5)(3.5,2.5)
  \psplot[linewidth=2pt,linecolor=red,
    xylogBase={}]{0.5}{3}{x log} % log(x)
  \psaxes{->}(0,0)(-3.5,0)(3.5,2.5)
  \uput[-90](3.5,0){x}
  \uput[180](0,2.5){y}
  \rput(2.5,1){$y=\log x$}
\end{pspicture}
```

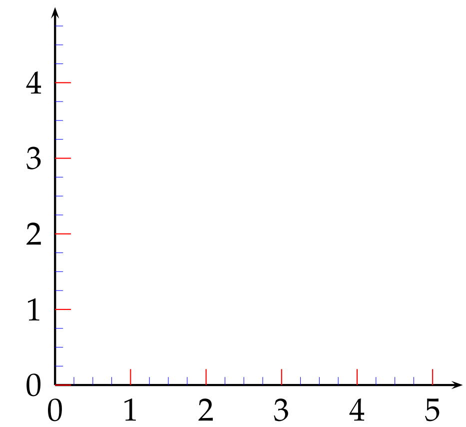
19.15 subticks, tickwidth and subtickwidth



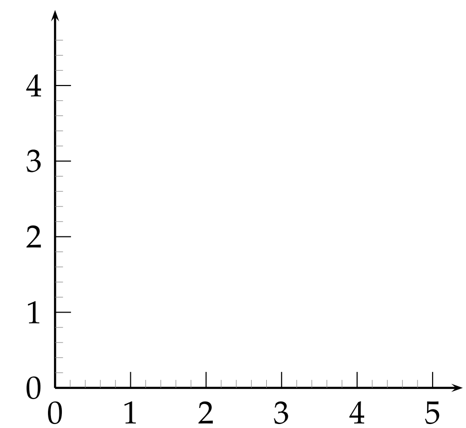

```
\psset{arrowscale=3}
\psaxes[labelsep=2pt,yAxis=false,subticks=8]{->}(0,0)(-5,-1)(5,1)\\[1cm]
\psaxes[yAxis=false,subticks=4,ticksize=-4pt 0]{->}(0,0)(5,1)(-5,-1)\\
\psaxes[yAxis=false,subticks=4,ticksize=-10pt 0]{->}(0,0)(-5,-5)(5,5)\\[1cm]
\psaxes[yAxis=false,subticks=10,ticksize=0 -10pt,labelsep=15pt]{->}(0,0)(-5,-5)(5,5)\\[1cm]
\psaxes[yAxis=false,subticks=4,ticksize=0 10pt,labelsep=-15pt]{->}(0,0)(5,5)(-5,-5)\\[1cm]
\psaxes[yAxis=false,subticks=4,ticksize=0 -10pt]{->}(0,0)(5,5)(-5,-5)\\[0.25cm]
\psaxes[yAxis=false,subticks=0]{->}(0,0)(-5,-5)(5,5)\\[1cm]
\psaxes[yAxis=false,subticks=0,tickcolor=red,linecolor=blue]{->}(0,0)(5,5)(-5,-5)\\
\psaxes[yAxis=false,subticks=5,tickwidth=2pt,subtickwidth=1pt]{->}(0,0)(-5,-5)(5,5)\\[1cm]
\psaxes[yAxis=false,subticks=0,tickcolor=red]{->}(0,0)(5,5)(-5,-5)
```



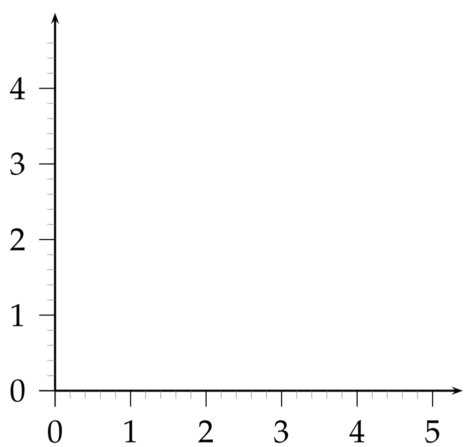
```
\psset{arrowscale=3}
\psaxes[xAxis=false,subticks=8]{->}(0,0)(-5,-5)(5,5)\hspace{2em}
\psaxes[xAxis=false,subticks=4]{->}(0,0)(5,5)(-5,-5)\hspace{4em}
\psaxes[xAxis=false,subticks=4,ticksize=0 4pt]{->}(0,0)(-5,-5)(5,5)\hspace{3em}
\psaxes[xAxis=false,subticks=4,ticksize=-4pt 0]{->}(0,0)(-5,-5)(5,5)\hspace{1em}
\psaxes[xAxis=false,subticks=4,ticksize=0 4pt]{->}(0,0)(5,5)(-5,-5)\hspace{2em}
\psaxes[xAxis=false,subticks=4,ticksize=-4pt 0,linecolor=red]{->}(0,0)(5,5)(-5,-5)\hspace
  {4em}
\psaxes[xAxis=false,subticks=0]{->}(0,0)(-5,-5)(5,5)\hspace{1em}
\psaxes[xAxis=false,subticks=0,tickcolor=red,linecolor=blue]{->}(0,0)(5,5)(-5,-5)\hspace
  {4em}
\psaxes[xAxis=false,subticks=5,tickwidth=2pt,subtickwidth=1pt]{->}(0,0)(-5,-5)(5,5)\
  hspace{2em}
\psaxes[xAxis=false,subticks=5,tickcolor=red,tickwidth=2pt,%
   ticksize=10pt,subtickcolor=blue,subticksize=0.75]{->}(0,0)(5,5)(-5,-5)
```



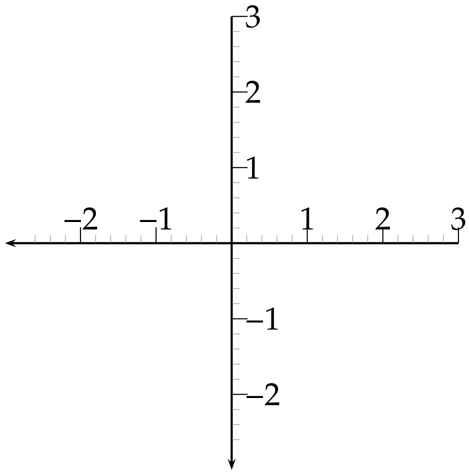

```
\pspicture(5,5.5)
\psaxes[subticks=4,ticksize=6pt,subticksize=0.5,%
  tickcolor=red,subtickcolor=blue]{->}(5.4,5)
\endpspicture
```



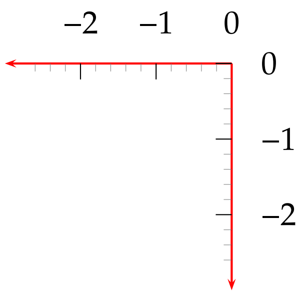

```
\pspicture(5,5.5)
  \psaxes[subticks=5,ticksize=0 6pt,subticksize=0.5]{->}(5.4,5)
\endpspicture
```



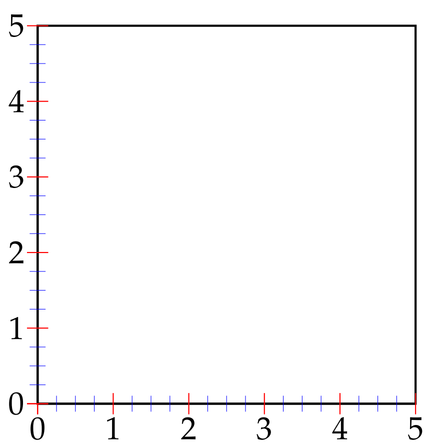

```
\pspicture(5,5.5)
  \psaxes[subticks=5,ticksize=-6pt 0,subticksize=0.5]{->}(5.4,5)
\endpspicture
```



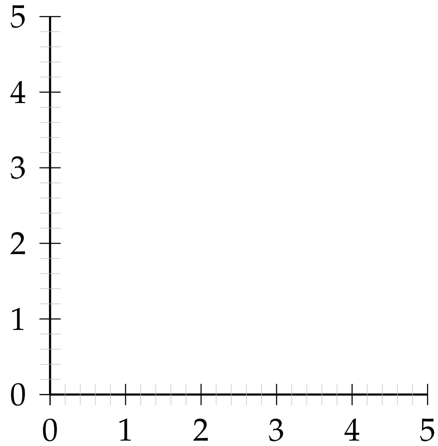

```
\pspicture(-3,-3)(3,3.5)
  \psaxes[subticks=5,ticksize=0 6pt,
    subticksize=0.5]{->}(0,0)(3,3)(-3,-3)
\endpspicture
```



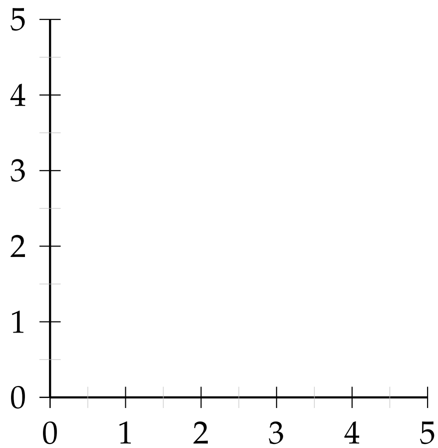

```
\pspicture(0,0.5)(-3,-3)
  \psaxes[subticks=5,ticksize=-6pt 0,
    subticksize=0.5,linecolor=red]{->}(-3,-3)
\endpspicture
```



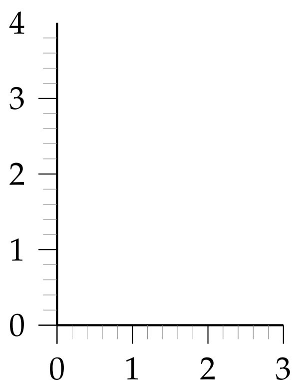

```
\psset{axesstyle=frame}
\pspicture(5,5.5)
  \psaxes[subticks=4,tickcolor=red,subtickcolor=
    blue](5,5)
\endpspicture
```



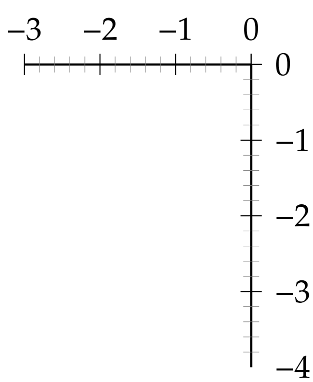

```
\pspicture(5,5.5)
  \psaxes[subticks=5,subticksize=1,subtickcolor=
    lightgray](5,5)
\endpspicture
```



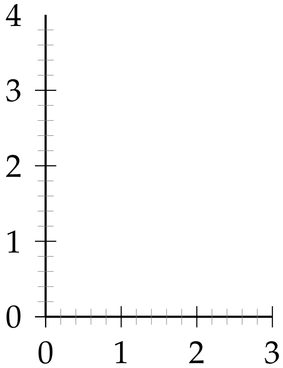

```
\pspicture(5,5.5)
  \psaxes[subticks=2,subticksize=1,subtickcolor=
    lightgray](5,5)
\endpspicture
```



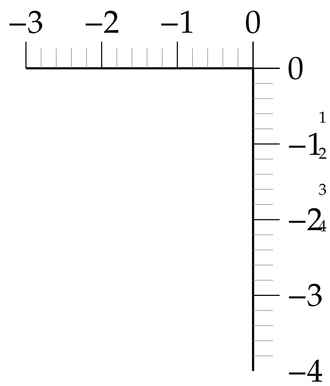

```
\pspicture(3,4.5)
  \psaxes[subticks=5,ticksize=-7pt 0](3,4)
\endpspicture
```




```
\pspicture(0,1)(-3,-4)
  \psaxes[subticks=5](-3,-4)
\endpspicture
```



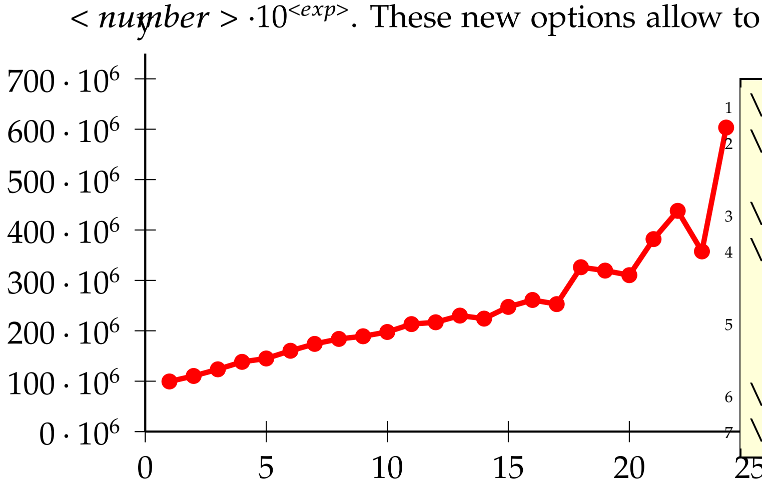

```
\pspicture(3,4.5)
  \psaxes[axesstyle=axes,subticks=5](3,4)
\endpspicture
```




```
\pspicture(0,1)(-3,-4)
 \psaxes[axesstyle=axes,subticks=5,%
   ticksize=0 10pt,labelsep=13pt](-3,-4)
\endpspicture
```

19.16 xlabelFactor and ylabelFactor

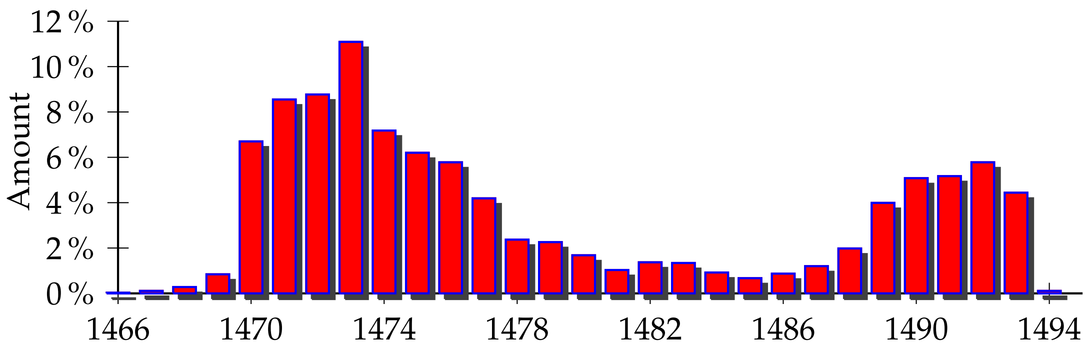
When having big numbers as data records then it makes sense to write the values as $< number > \cdot 10^{<exp>}$. These new options allow to define the additional part of the value.



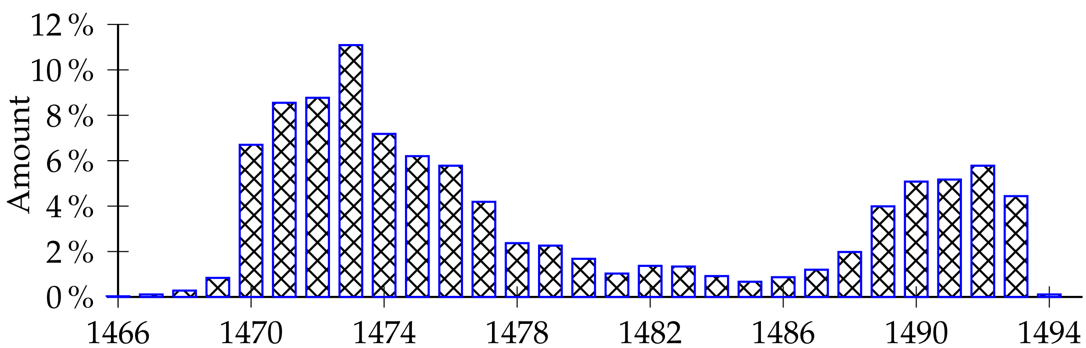

```
\readdata{\data}{demo1.dat}
\pstScalePoints(1,0.000001){}{}% (x,y){additional x operator}{y op}
\psset{llx=-1cm,lly=-1cm}
\psgraph[ylabelFactor={\cdot 10^6},Dx=5,Dy=100](0,0)(25,750){8cm}{5cm}
  \listplot[linecolor=red, linewidth=2pt, showpoints=true]{\data}
\endpsgraph
\pstScalePoints(1,1){}{}% reset
```

19.17 Plot style bar and option barwidth

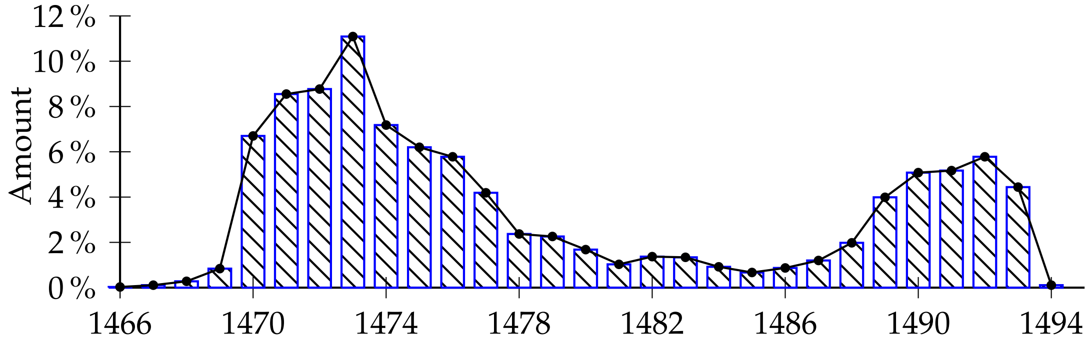
This option allows to draw bars for the data records. The width of the bars is controlled by the option `barwidth`, which is set by default to value of `0.25cm`, which is the total width.




```
\psset{xunit=.44cm,yunit=.3cm}
\begin{pspicture}(-2,-3)(29,13)
  \psaxes[axesstyle=axes,Ox=1466,Oy=0,Dx=4,Dy=2,%
    ylabelFactor={\,\%}]{-}(29,12)
  \listplot[shadow=true,linecolor=blue,plotstyle=bar,barwidth=0.3cm,
    fillcolor=red,fillstyle=solid]{\barData}
  \rput{90}(-3,6.25){Amount}
\end{pspicture}
```




```
\psset{xunit=.44cm,yunit=.3cm}
\begin{pspicture}(-2,-3)(29,13)
  \psaxes[axesstyle=axes,Ox=1466,Oy=0,Dx=4,Dy=2,%
    ylabelFactor={\,\%}]{-}(29,12)
  \listplot[linecolor=blue,plotstyle=bar,barwidth=0.3cm,
    fillcolor=red,fillstyle=crosshatch]{\barData}
  \rput{90}(-3,6.25){Amount}
\end{pspicture}
```




```
\psset{xunit=.44cm,yunit=.3cm}
\begin{pspicture}(-2,-3)(29,13)
  \psaxes[axesstyle=axes,Ox=1466,Oy=0,Dx=4,Dy=2,%
    ylabelFactor={\,\%}]{-}(29,12)
  \listplot[linecolor=blue,plotstyle=bar,barwidth=0.3cm,
    fillcolor=red,fillstyle=vlines]{\barData}
  \listplot[showpoints=true]{\barData}
  \rput{90}(-3,6.25){Amount}
\end{pspicture}
```

19.18 trigLabels and trigLabelBase – axis with trigonmetrical units

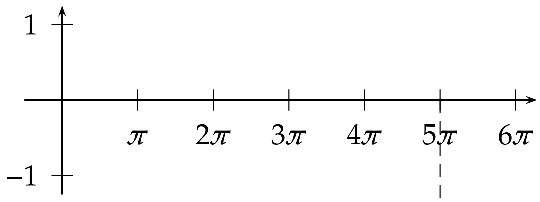
With the option `trigLabels=true` the labels on the x axis are trigonometrical ones. The option `trigLabelBase` set the demoninator of fraction. The default value of 0 is the same as no fraction. The following constants are are defined in the package:

```
\def\psPiFour{12.566371}
\def\psPiTwo{6.283185}
\def\psPi{3.14159265}
\def\psPiH{1.570796327}
\newdimen\pstRadUnit
\newdimen\pstRadUnitInv
\pstRadUnit=1.047198cm % this is pi/3
\pstRadUnitInv=0.95493cm % this is 3/pi
```

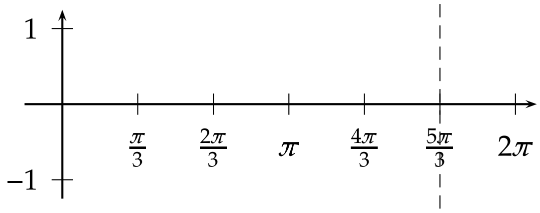
Because it is a bit complicating to set the right values, we show some more examples here.

For **all** following examples in this section we did a global `\psset{trigLabels=true,labelFontSize=\small}`.

Translating the decimal ticks to geometrical makes no real sense, because every 1 xunit (1cm) is a tick and the last one at 6cm.

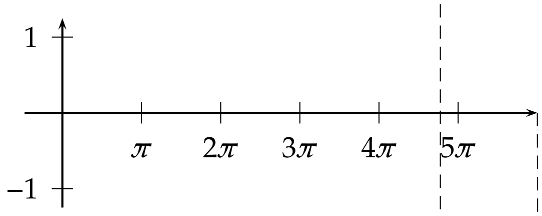



```
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)%
  \pnode(5,0){A}%
  \psaxes{->}(0,0)(-.5,-1.25)(\psPiTwo,1.25)
\end{pspicture}
```

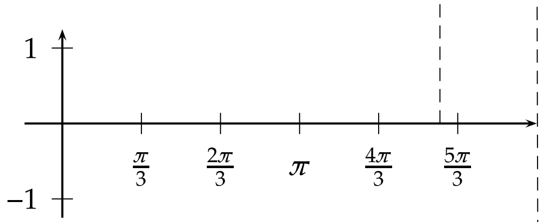



```
\begin{pspicture}(-0.5,-1.25)(10,1.25)%
  \psaxes[trigLabelBase=3]{->}(0,0)(-0.5,-1.25)(\
    psPiTwo,1.25)
\end{pspicture}
```

Modifing the ticks to have the last one exactly at the end is possible with a different dx value ($\frac{\pi}{3} \approx 1.047$):

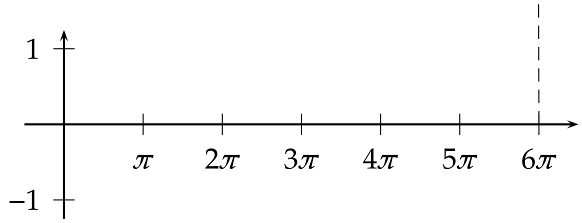



```
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)\pnode(\
 psPiTwo,0){C}%
  \psaxes[dx=\pstRadUnit]{->}(0,0)(-0.5,-1.25)(\
    psPiTwo,1.25)
\end{pspicture}%
```

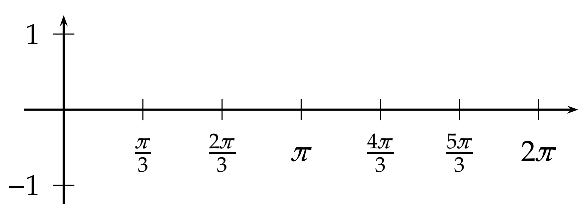



```
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)\pnode(5,0){B
 }%
  \psaxes[dx=\pstRadUnit,trigLabelBase=3] {->}(0,0)
    (-0.5,-1.25)(\psPiTwo,1.25)
\end{pspicture}%
```

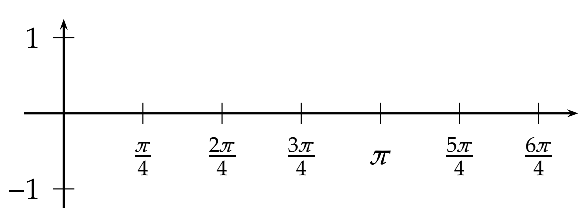
Set globaly everything in radiant unit. Now 6 units on the x-axis are 6π. Using `trigLabelBase=3` reduces this value to 2π, a.s.o.



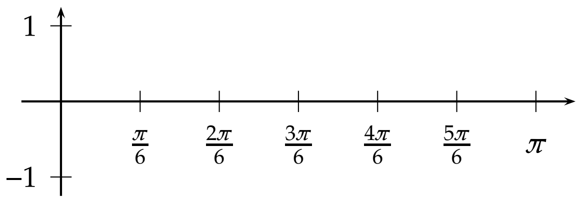

```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)\pnode(6,0){D
 }%
  \psaxes{->}(0,0)(-0.5,-1.25)(6.5,1.25)%
\end{pspicture}%
```




```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[trigLabelBase=3]{->}(0,0)(-0.5,-1.25)
    (6.5,1.25)
\end{pspicture}%
```

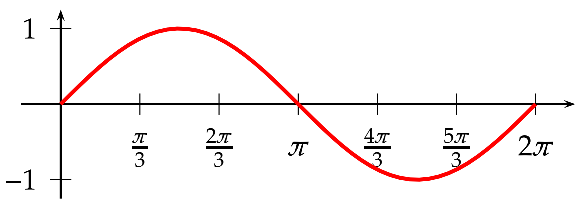



```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[trigLabelBase=4]{->}(0,0)(-0.5,-1.25)
    (6.5,1.25)
\end{pspicture}%
```

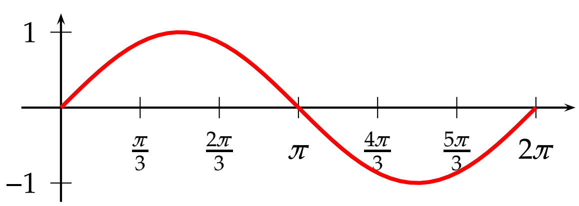



```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[trigLabelBase=6]{->}(0,0)(-0.5,-1.25)
    (6.5,1.25)
\end{pspicture}%
```

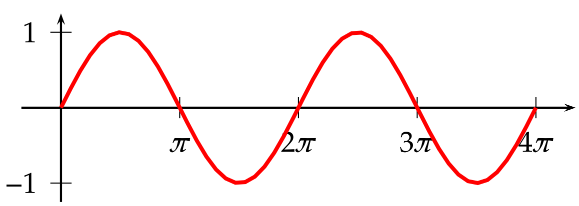
The best way seems to be setting the x-unit to `\pstRadUnit`. Plotting a function doesn't consider the value for `trigLabelBase`, it has to be done by the user. The first example sets the unit locally for the `\psplot` back to 1cm, which is needed, because we use this unit on PostScript side.



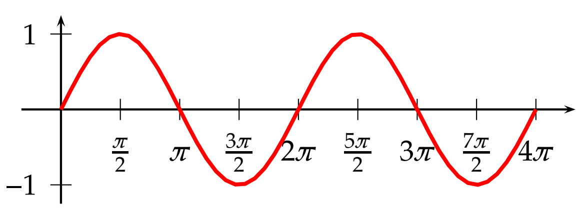

```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[trigLabelBase=3]{->}(0,0)(-0.5,-1.25)
    (6.5,1.25)
  \psplot[xunit=1cm,linecolor=red,linewidth=1.5pt
    ]{0}{\psPiTwo}{x RadtoDeg sin}
\end{pspicture}
```




```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[trigLabelBase=3]{->}(0,0)(-0.5,-1.25)
    (6.5,1.25)
  \psplot[linecolor=red,linewidth=1.5pt]{0}{6}{x Pi 3
    div mul RadtoDeg sin}
\end{pspicture}
```

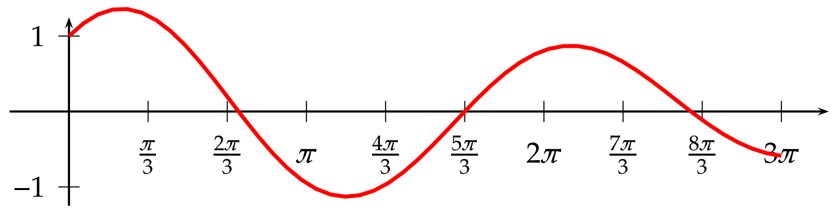



```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[dx=1.5]{->}(0,0)(-0.5,-1.25)(6.5,1.25)
  \psplot[xunit=0.5cm,linecolor=red,linewidth=1.5pt
    ]{0}{\psPiFour}{x RadtoDeg sin}
\end{pspicture}
```

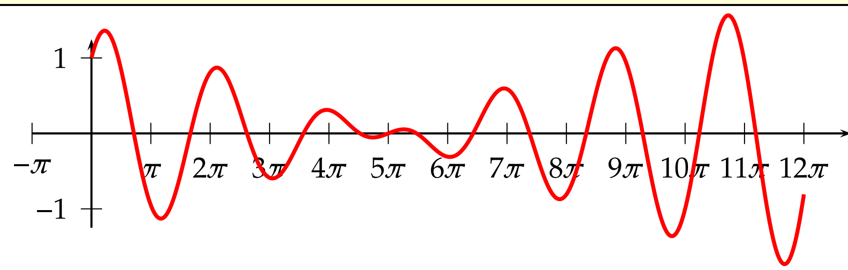



```
\psset{xunit=\pstRadUnit}%
\begin{pspicture}(-0.5,-1.25)(6.5,1.25)
  \psaxes[dx=0.75,trigLabelBase=2]{->}(0,0)
    (-0.5,-1.25)(6.5,1.25)
  \psplot[xunit=0.5cm,linecolor=red,linewidth=1.5pt
    ]{0}{\psPiFour}{x RadtoDeg sin}
\end{pspicture}
```

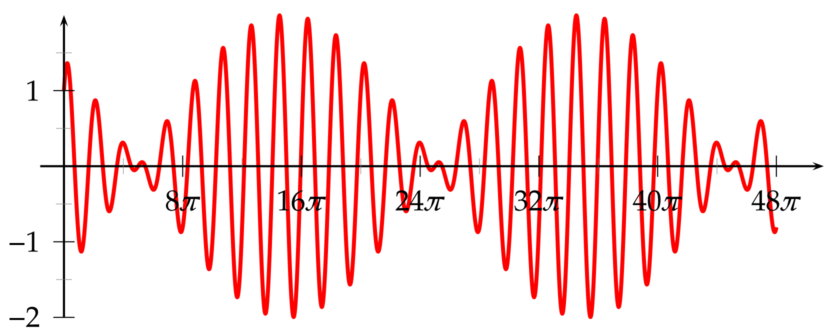
It is also possible to set the x unit and dx value to get the labels right. But this needs some more understanding how it really works. A `xunit=1.570796327` sets the unit to $\pi/2$ and a `dx=0.666667` then puts every $2/3$ of the unit a tick mark and a label. The length of the x-axis is 6.4 units which is $6.4 \cdot 1.570796327cm \approx 10cm$. The function then is plotted from 0 to $3\pi = 9.424777961$.



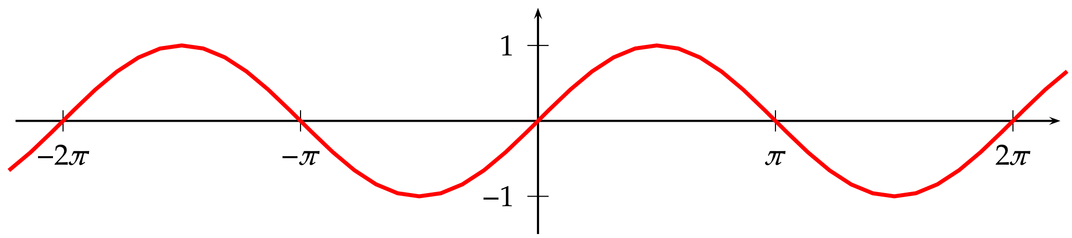

```
\begin{pspicture}(-0.5,-1.25)(10,1.25)
  \psaxes[xunit=1.570796327,trigLabelBase=3,dx=0.666667]{->}(0,0)(-0.5,-1.25)
    (6.4,1.25)
  \psplot[linecolor=red,linewidth=1.5pt]{0}{9.424777961}{%
    x RadtoDeg dup sin exch 1.1 mul cos add}
\end{pspicture}
```



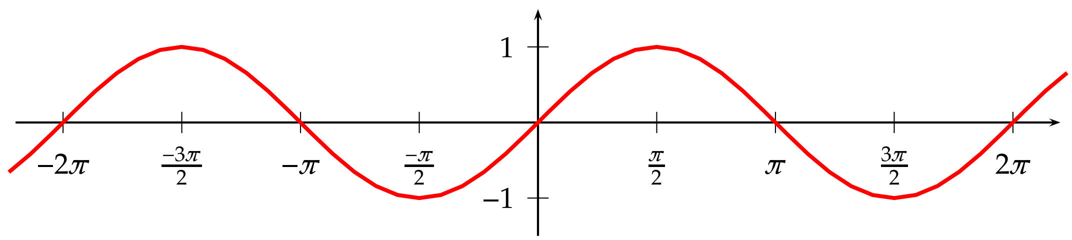

```
\psset{unit=1cm}
  \psplot[xunit=0.25,plotpoints=500,linecolor=red,linewidth=1.5pt]{0}{37.70}{%
    x RadtoDeg dup sin exch 1.1 mul cos add}
\end{pspicture}
```




```
\psset{unit=1cm}
\begin{pspicture}(-0.5,-1.25)(10,1.25)
  \psplot[xunit=0.0625,linecolor=red,linewidth=1.5pt,%
      plotpoints=5000]{0}{150.80}%
    {x RadtoDeg dup sin exch 1.1 mul cos add}
  \psaxes[xunit=\psPi,dx=0.5,Dx=8]{->}(0,0)(-0.25,-1.25)(3.2,1.25)
\end{pspicture}
```




```
\begin{pspicture}(-7,-1.5)(7,1.5)
  \psaxes[trigLabels=true,xunit=\psPi]{->}(0,0)(-2.2,-1.5)(2.2,1.5)
  \psplot[linecolor=red,linewidth=1.5pt]{-7}{7}{x RadtoDeg sin}
\end{pspicture}
```




```
\begin{pspicture}(-7,-1.5)(7,1.5)
  \psaxes[trigLabels=true,
    trigLabelBase=2,dx=\psPiH,xunit=\psPi]{->}(0,0)(-2.2,-1.5)(2.2,1.5)
  \psplot[linecolor=red,linewidth=1.5pt]{-7}{7}{x RadtoDeg sin}
\end{pspicture}
```

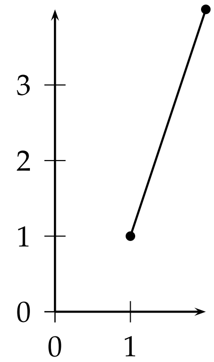
19.19 New options for \readdata

By default the macros `\readdata` reads every data record, which could be annoying when you have some text lines at top of your data files or when there are more than 10000 records to read.

`pstricks-add` defines two additional keys `ignoreLines` and `nStep`, which allows to ignore preceeding lines, e.g. `ignoreLines=2`, or to read only a selected part of the data records, e.g. `nStep=10`, only every 10^{th} records is saved.

```
\readdata[ignoreLines=2]{\dataA}{stressrawdata.dat}
\readdata[nStep=10]{\dataA}{stressrawdata.dat}
```

The default value for `ignoreLines` is 0 and for `nStep` is 1. the following data file has two text lines which shall be ignored by the `\readdata` macro:




```
\begin{filecontents*}{pstricks-add-data9.dat}
some nonsense in this line ï¿½ï¿½ï¿½time forcex forcey
0 0.2
1 1
2 4
\end{filecontents*}
\readdata[ignoreLines=2]{\data}{pstricks-add-data9.dat}
\pspicture(2,4)
  \listplot[showpoints=true]{\data}
  \psaxes{->}(2,4)
\endpspicture
```

19.20 New options for `\listplot`

By default the plot macros `\dataplot`, `\fileplot` and `\listplot` plot every data record. The package `pst-plot-add` defines additional keys `nStep`, `nStart`, `nEnd` and `xStep`, `xStart`, `xEnd`, which allows to plot only a selected part of the data records, e.g. `nStep=10`. These "n" options mark the number of the record to be plot (0, 1, 2, ...) and the "x" ones the x-values of the data records.

Name	Default setting
`nStart`	1
`nEnd`	{}
`nStep`	1
`xStart`	{}
`xEnd`	{}
`yStart`	{}
`yEnd`	{}
`xStep`	0
`plotNo`	1
`plotNoMax`	1
`ChangeOrder`	false

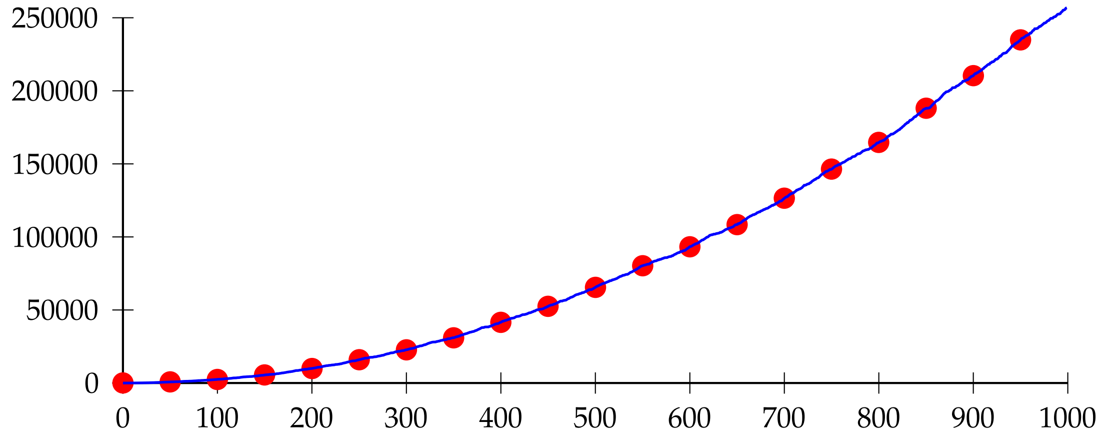
These new options are only available for the `\listplot` macro, which is not a real limitation, because all data records can be read from a file with the `\readdata` macro (see example files or [5]):
`\readdata[nStep=10]{\data}{/home/voss/data/data1.dat}`

The use `nStep` and `xStep` options make only real sense when also using the option `plotstyle=dots`. Otherwise the coordinates are connected by a line as usual. Also the `xStep` option needs increasing x values. Pay attention that `nStep` can be used for `\readdata` and for `\listplot`. If used in both macros than the effect is multiplied, e.g. `\readdata` with `nStep=5` and `\listplot` with `nStep=10` means, that only every 50th data records is read and plotted.

When both, `x/yStart/End` are defined then the values are also compared with both values.

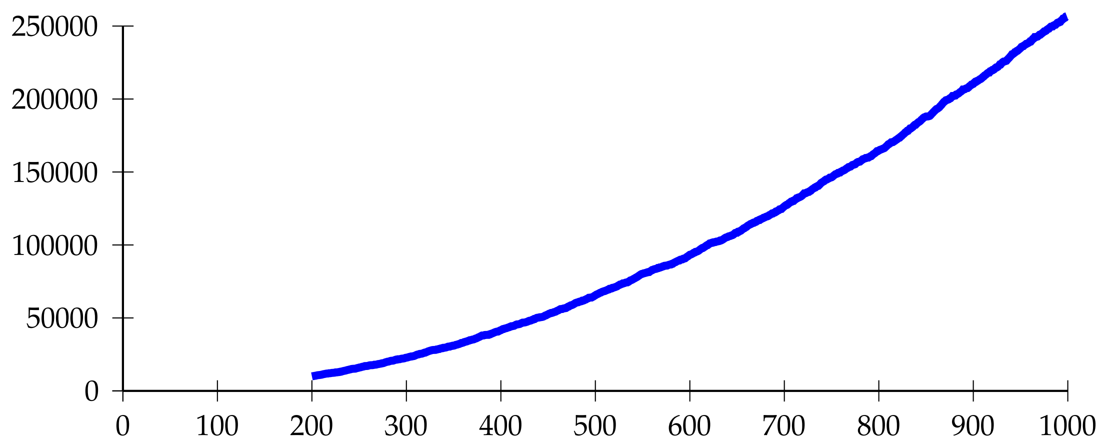
19.20.1 Example for nStep/xStep

The datafile data.dat contains 1000 data records. The thin blue line is the plot of all records with the plotstyle option curve.



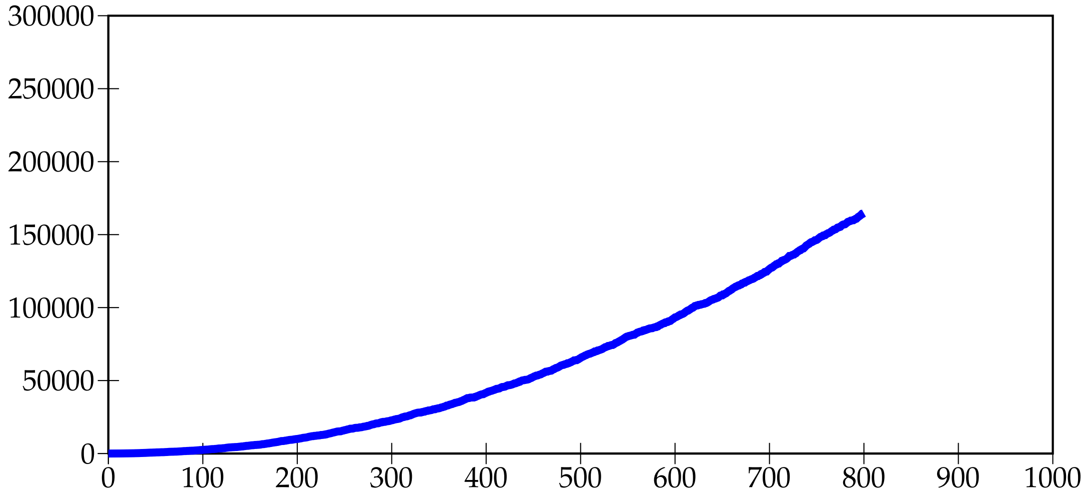

```
\readdata{\data}{examples/data.dat}
\psset{xunit=0.125mm,yunit=0.0002mm}
\begin{pspicture}(-80,-30000)(1000,270000)
\psaxes[Dx=100,dx=100,Dy=50000,dy=50000](1000,250000)
\listplot[nStep=50,linewidth=3pt,linecolor=red,plotstyle=dots]{\data}
\listplot[linewidth=1pt,linecolor=blue]{\data}
\end{pspicture}
```

19.20.2 Example for nStart/xStart



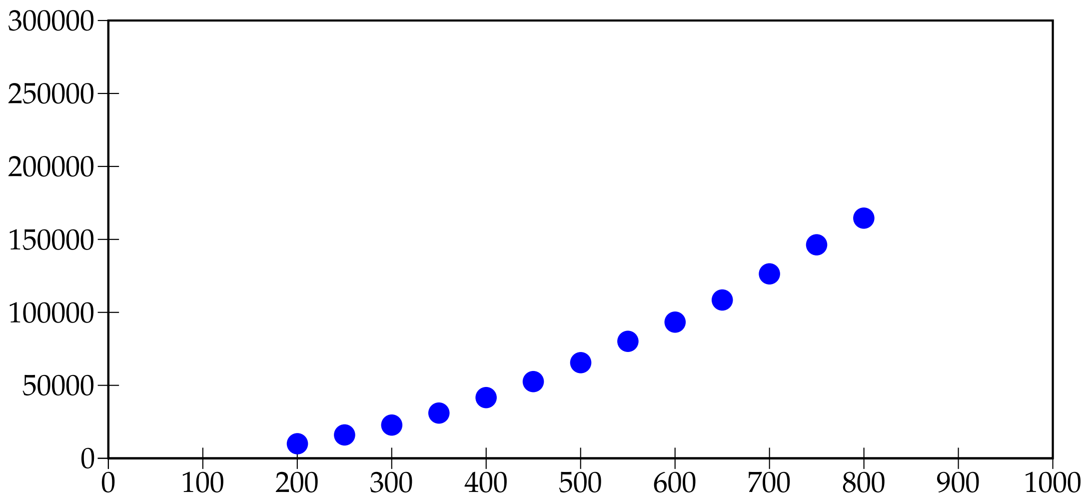

```
\readdata{\data}{examples/data.dat}
\psset{xunit=0.125mm,yunit=0.0002mm}
\begin{pspicture}(-80,-30000)(1000,270000)
\psaxes[Dx=100,dx=100,Dy=50000,dy=50000](1000,250000)
\listplot[nStart=200,linewidth=3pt,linecolor=blue]{\data}
\end{pspicture}
```

19.20.3 Example for nEnd/xEnd




```
\readdata{\data}{examples/data.dat}
\psset{xunit=0.125mm,yunit=0.0002mm}
\begin{pspicture}(-80,-30000)(1000,310000)
\psaxes[axesstyle=frame,Dx=100,dx=100,Dy=50000,dy=50000](1000,300000)
\listplot[nEnd=800,linewidth=3pt,linecolor=blue]{\data}
\end{pspicture}
```

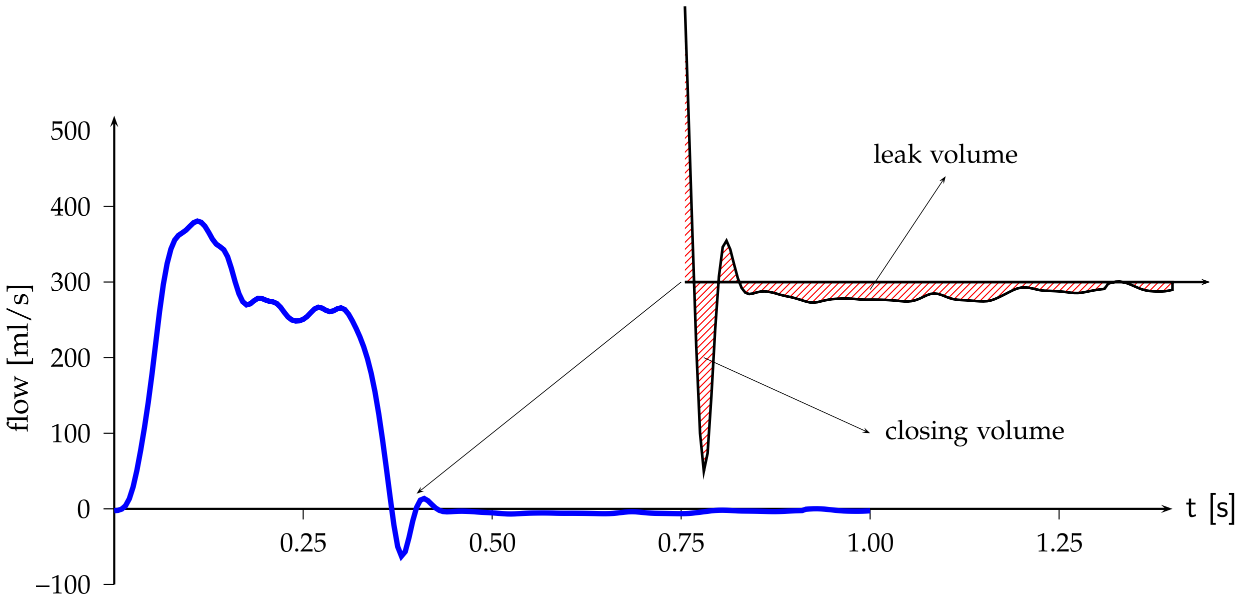
19.20.4 Example for all new options




```
\readdata{\data}{examples/data.dat}
\psset{xunit=0.125mm,yunit=0.0002mm}
\begin{pspicture}(-80,-30000)(1000,310000)
\psaxes[axesstyle=frame,Dx=100,dx=100,Dy=50000,dy=50000](1000,300000)
\listplot[nStart=200, nEnd=800, nStep=50,linewidth=3pt,linecolor=blue,%
   plotstyle=dots]{\data}
\end{pspicture}
```

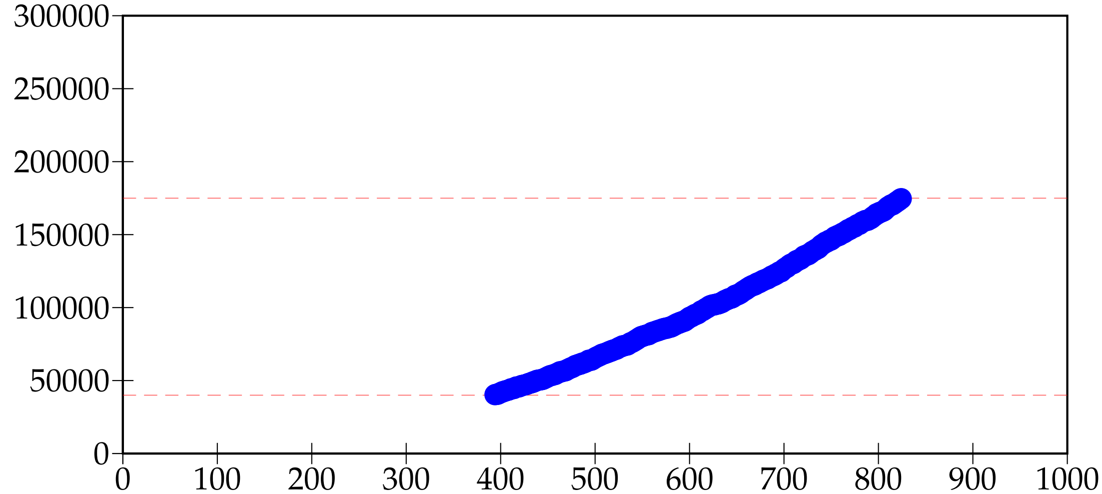
19.20.5 Example for xStart

This example shows the use of the same plot with different units and different `xStart` value. The blue curve is the original plot of the data records. To show the important part of the curve there is another one plotted with a greater `yunit` and a start value of `xStart=0.35`. This makes it possible to have a kind of a zoom to the original graphic.




```
\psset{xunit=10cm, yunit=0.01cm}
\readdata{\data}{examples/data3.dat}
\begin{pspicture}(-0.1,-100)(1.5,700.0)
  \psaxes[Dx=0.25,Dy=100,dy=100\psyunit,ticksize=-4pt 0,%
    labelFontSize={\footnotesize}]{->}(0,0)(0,-100)(1.4,520)
  \uput[0](1.4,0){\textsf{t [s]}}
  \rput(-0.125,200){\psrotateleft{\small flow [ml/s]}}
  \listplot[linewidth=2pt, linecolor=blue]{\data}
  \rput(0.4,300){
    \pscustom[yunit=0.04cm, linewidth=1pt]{%
      \listplot[xStart=0.355]{\data}
      \psline(1,-2.57)(1,0)(0.355,0)
      \fill[fillstyle=hlines,fillcolor=gray,hatchwidth=0.4pt,hatchsep=1.5pt,
        hatchcolor=red]%
      \psline[linewidth=0.5pt]{->}(0.7,0)(1.05,0)
    }%
  }
  \psline[linewidth=.01]{->}(0.75,300)(0.4,20)
  \psline[linewidth=.01]{->}(1,290)(1.1,440)
  \rput(1.1,470){\footnotesize leak volume}
  \psline[linewidth=.01]{->}(0.78,200)(1,100)
  \rput[l](1.02,100){\footnotesize closing volume}
\end{pspicture}
```

19.20.6 Example for yStart/yEnd




```
\readdata{\data}{examples/data.dat}
\psset{xunit=0.125mm,yunit=0.0002mm}
\begin{pspicture}(-80,-30000)(1000,310000)
  \psaxes[axesstyle=frame,Dx=100,dx=100,Dy=50000,dy=50000](1000,300000)
  \psset{linewidth=0.1pt, linestyle=dashed,linecolor=red}
  \psline(0,40000)(1000,40000)
  \psline(0,175000)(1000,175000)
  \listplot[yStart=40000, yEnd=175000,linewidth=3pt,linecolor=blue,plotstyle=dots]{\data}
\end{pspicture}
```

19.20.7 Example for plotNo/plotNoMax

By default the plot macros expect `x|y` data records, but when having data files with multiple values for y, like:

```
x y1 y2 y3 y4 ... yMax
x y1 y2 y3 y4 ... yMax
...
```

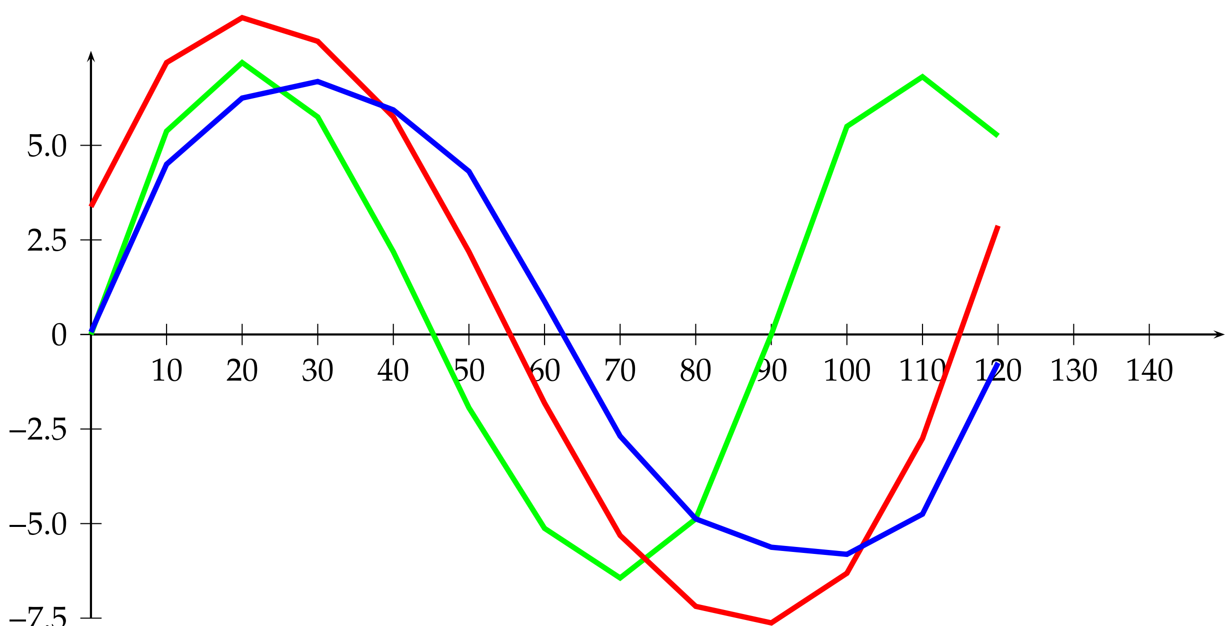
you can select the y value which should be plotted. The option `plotNo` marks the plotted value (default 1) and the option `plotNoMax` tells `pst-plot` how many y values are present. There are no real restrictions in the maximum number for `plotNoMax`.

We have the following data file:

```
[% file examples/data.dat
0     0     3.375     0.0625
10     5.375     7.1875     4.5
20     7.1875     8.375     6.25
30     5.75     7.75     6.6875
40     2.1875     5.75     5.9375
```

```
50    -1.9375    2.1875    4.3125
60    -5.125    -1.8125    0.875
70    -6.4375    -5.3125    -2.6875
80    -4.875    -7.1875    -4.875
90    0    -7.625    -5.625
100    5.5    -6.3125    -5.8125
110    6.8125    -2.75    -4.75
120    5.25    2.875    -0.75
]%
```

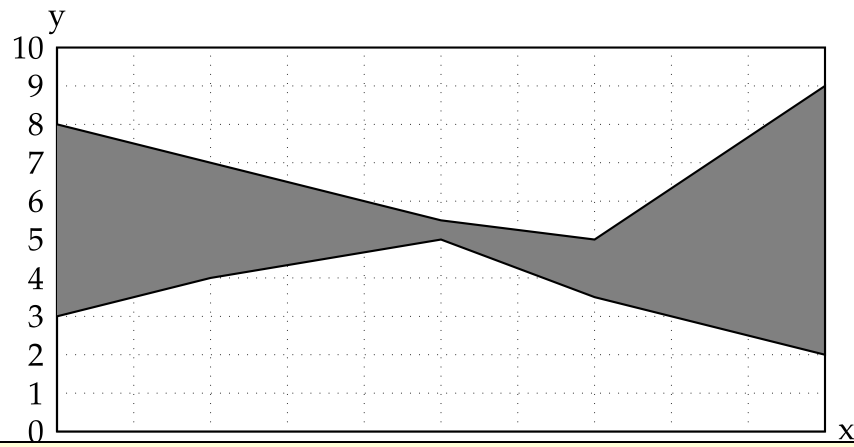
which holds data records for multiple plots (`x y1 y2 y3`). This can be plotted without any modification to the data file:




```
\readdata\Data{examples/dataMul.dat}
\psset{xunit=0.1cm, yunit=0.5cm,lly=-0.5cm}
\begin{pspicture}(0,-7.5)(150,10)
\psaxes[Dx=10,Dy=2.5]{->}(0,0)(0,-7.5)(150,7.5)
\psset{linewidth=2pt,plotstyle=line}
\listplot[linecolor=green,plotNo=1,plotNoMax=3]{\Data}
\listplot[linecolor=red,plotNo=2,plotNoMax=3]{\Data}
\listplot[linecolor=blue,plotNo=3,plotNoMax=3]{\Data}
\end{pspicture}
```

19.20.8 Example for changeOrder

It is only possible to fill the region between two listplots with `\pscustom` if one of both has the values in a reverse order. Otherwise we do not get a closed path. With the option `ChangeOrder` the values are used in a reverse order:




```
\begin{filecontents*}{test.dat}
 0 3 8
 2 4 7
 5 5 5.5
 7 3.5 5
 10 2 9
\end{filecontents*}
\begin{psgraph}[axesstyle=frame,ticklinestyle=dotted,ticksize=0 10](0,0)(10,10)
  {4in}{2in}%
  \readdata{\data}{test.dat}%
  \pscustom[fillstyle=solid,fillcolor=gray]{%
    \listplot[plotNo=2,plotNoMax=2]{\data}%
    \listplot[plotNo=1,plotNoMax=2,ChangeOrder]{\data}}
\end{psgraph}
```

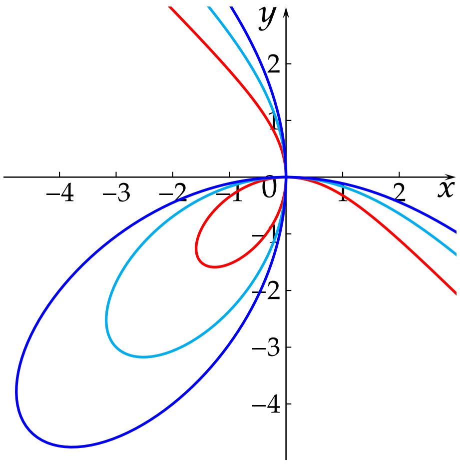
20 Polar plots

With the option `polarplot=false|true` it is possible to use `\psplot` in polar mode:

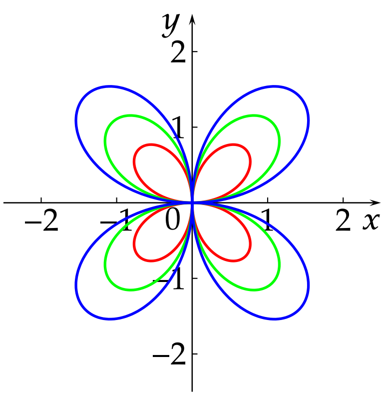
```
\psplot[polarplot=true,...]{<start angle>}{<end angle>}{<r(alpha)>}
```

The equation in PostScript code is interpreted as a function $r = f(\alpha)$, e.g. for the circle with radius 1 as $r = \sqrt{\sin^2 x + \cos^2 x}$:

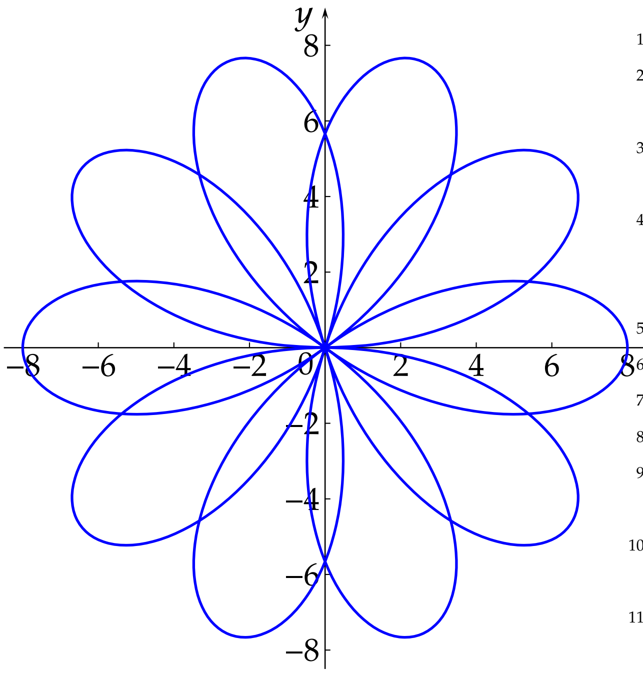
```
x sin dup mul x cos dup mul add sqrt
```




```
\resetOptions
\psset{plotpoints=200,unit=0.75}
\begin{pspicture}*(-5,-5)(3,3)
  \psaxes[labelsep=.75mm,arrowlength=1.75,
    ticksize=2pt,%
    labelFontSize=\footnotesize,%
    linewidth=0.17mm]{->}(0,0)(-4.99,-4.99)(3,3)
  \rput[Br](3,-.35){$x$}
  \rput[tr](-.15,3){$y$}
  \rput[Br](-.15,-.35){$0$}
  \psset{linewidth=.35mm,polarplot=true}
  \psplot[linecolor=red]{140}{310}{3 neg x sin
    mul x cos mul x sin 3 exp x cos 3 exp add div}
  \psplot[linecolor=cyan]{140}{310}{6 neg x sin
    mul x cos mul x sin 3 exp x cos 3 exp add div}
  \psplot[linecolor=blue]{140}{310}{9 neg x sin
    mul x cos mul x sin 3 exp x cos 3 exp add div}
\end{pspicture}
```




```
\resetOptions
\psset{plotpoints=200,unit=1}
\begin{pspicture}(-2.5,-2.5)(2.5,2.5)% Ulrich Dirr
 \psaxes[labelsep=.75mm,arrowlength=1.75,%
    ticksize=2pt,linewidth=0.17mm]{->}(0,0)(-2.5,-2.5)
      (2.5,2.5)
  \rput[Br](2.5,-.35){$x$}
  \rput[tr](-.15,2.5){$y$}
  \rput[Br](-.15,-.35){$0$}
  \psset{linewidth=.35mm,plotstyle=curve,polarplot=
    true}
  \psplot[linecolor=red]{0}{360}{x cos 2 mul x sin mul
    }
  \psplot[linecolor=green]{0}{360}{x cos 3 mul x sin
    mul}
  \psplot[linecolor=blue]{0}{360}{x cos 4 mul x sin
    mul}
\end{pspicture}
```

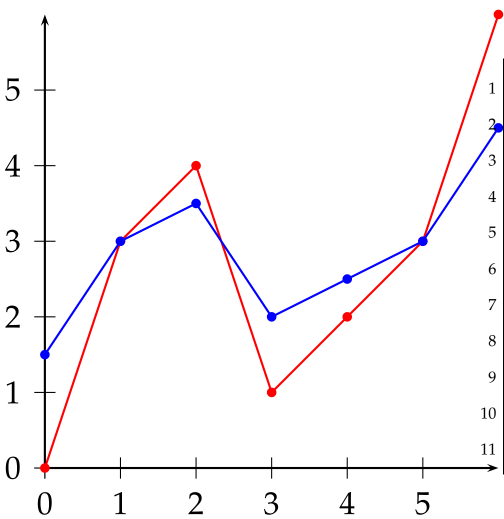



```
\psset{plotpoints=200,unit=0.5}
\begin{pspicture}(-8.5,-8.5)(9,9)%
 Ulrich Dirr
\psaxes[Dx=2,dx=2,Dy=2,dy=2,labelsep
  =.75mm,%
  arrowlength=1.75,ticksize=2pt,
   linewidth=0.17mm]{->}(0,0)
   (-8.5,-8.5)(9,9)
\rput[Br](9,-.7){$x$}
\rput[tr](-.3,9){$y$}
\rput[Br](-.3,-.7){$0$}
%
\psset{linewidth=.35mm,plotstyle=curve,
 polarplot=true}
\psplot[linecolor=blue]{0}{720}{8 2.5 x
  mul sin mul}
\end{pspicture}
```

21 \pstScalePoints

The syntax is
`\pstScalePoints(xScale,xScale){xPS}{yPS}`

`xScale,yScale` are decimal values as scaling factors, the `xPs` and `yPS` are additional PostScript code to the x- and y-values of the data records. This macro is only valid for the `\listplot` macro!




```
\def\data{%
 0 0 1 3 2 4 3 1
 4 2 5 3 6 6 }
\begin{pspicture}(-0.5,-1)(6,6)
 \psaxes{->}(0,0)(6,6)
 \listplot[showpoints=true,%
  linecolor=red]{\data}
 \pstScalePoints(1,0.5){}{3 add}
 \listplot[showpoints=true,%
  linecolor=blue]{\data}
\end{pspicture}
```

`\pstScalePoints(1,0.5){}{3 add}` means that **first** the value 3 is added to the y values and **second** this value is scaled with the factor 0.5. As seen for the blue line for $x = 0$ we get $y(0) = (0 + 3) \cdot 0.5 = 1.5$.

Changes with `\pstScalePoints` are always global to all following `\listplot` macros. This is the reason why it is a good idea to reset the values at the end of the `pspicture` environment.

```
\pstScalePoints(1,1){}{}
```

Part IV

New commands and environments

22 psgraph environment

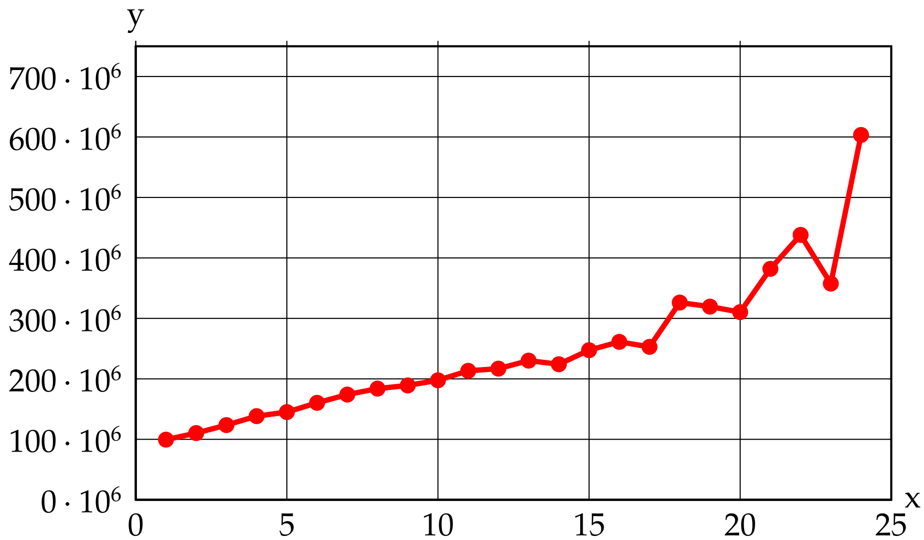
This new environment does the scaling, it expects as parameter the values (without units!) for the coordinate system and the values of the physical width and height (with units!). The syntax is:

```
\psgraph[<axes options>]{<arrows>}%
    (xOrig,yOrig)(xMin,yMin)(xMax,yMax){xLength}{yLength}
...
\endpsgraph

\begin{psgraph}[<axes options>]{<arrows>}%
    (xOrig,yOrig)(xMin,yMin)(xMax,yMax){xLength}{yLength}
...
\end{psgraph}
```

where the options are valid **only** for the the `\psaxes` macro. The first two arguments have the usual `PSTricks` behaviour.

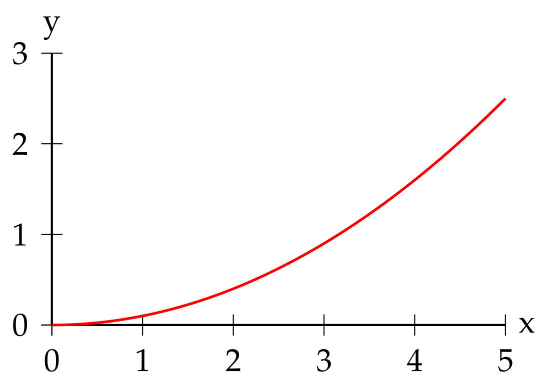
- if `(xOrig,yOrig)` is missing, it is substituted to `(xMin,xMax)`;
- if `(xOrig,yOrig)` **and** `(xMin,yMin)` are missing, they are both substituted to `(0,0)`.

The y-length maybe given as !, then the macro uses the same unit as for the x-axis.

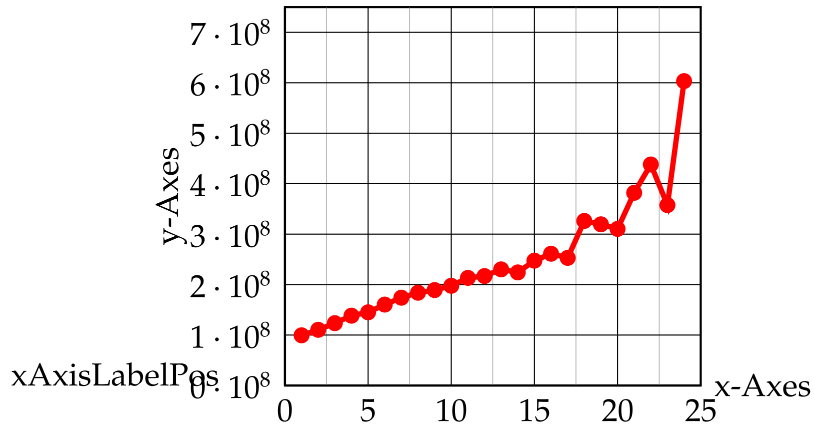



```
\readdata{\data}{demo1.dat}
\pstScalePoints(1,0.000001){}{}% (x,y){additional x operator}{y op}
\psset{llx=-1cm,lly=-1cm}
\begin{psgraph}[axesstyle=frame,xticksize=0 759,yticksize=0 25,%
    subticks=0,ylabelFactor={\cdot 10^6},%
    Dx=5,dy=100\psyunit,Dy=100](0,0)(25,750){10cm}{6cm} % parameters
   \listplot[linecolor=red,linewidth=2pt,showpoints=true]{\data}
\end{psgraph}
```

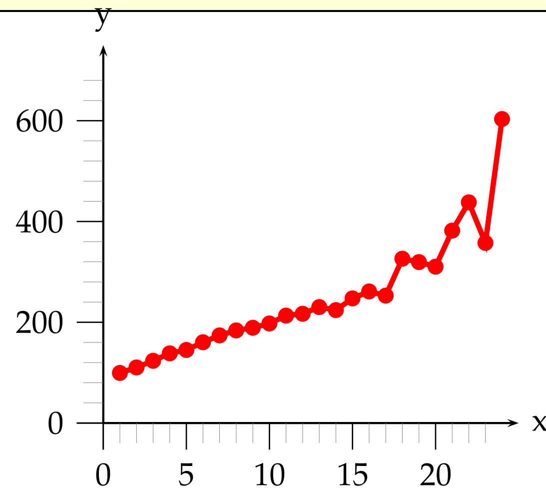
In the following example, the y unit gets the same value as the one for the x-axis.



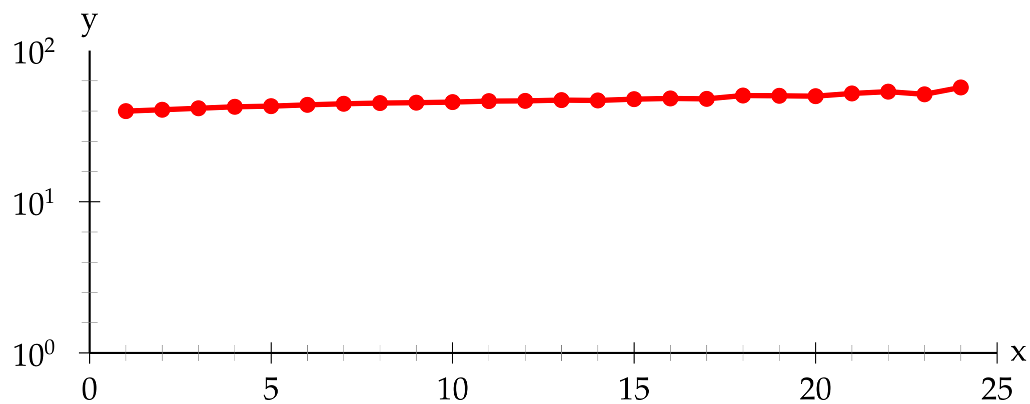

```
\psset{llx=-1cm,lly=-0.5cm,ury=0.5cm}
\begin{psgraph}(0,0)(5,3){6cm}{!} % x-y-axis with same unit
   \psplot[linecolor=red,linewidth=1pt]{0}{5}{x dup mul 10 div}
\end{psgraph}
```



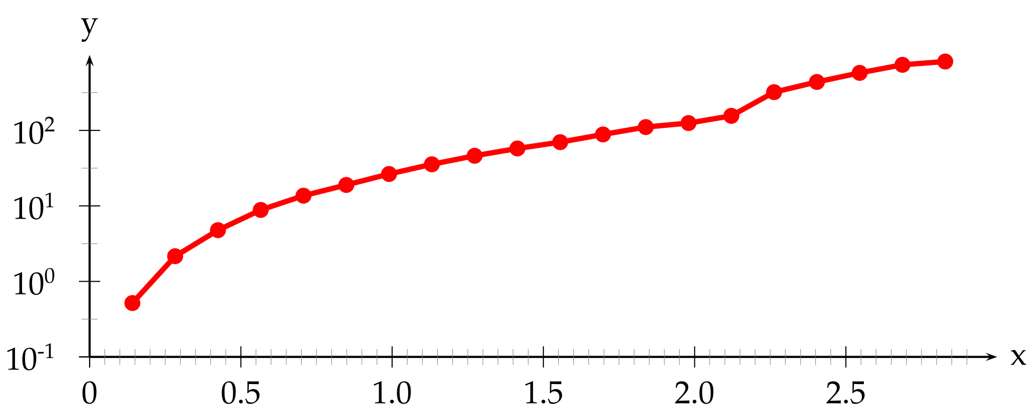

```
\readdata{\data}{demo1.dat}
\psset{xAxisLabel=x-Axes,yAxisLabel=y-Axes,llx=-.5cm,ury=0.5cm%
   xAxisLabelPos={3cm,-1cm},yAxisLabelPos={-1.5cm,2.5cm}}
\pstScalePoints(1,0.00000001){}{}
\begin{psgraph}[axesstyle=frame,xticksize=0 7.5,yticksize=0 25,subticksize=1,%
     ylabelFactor={\cdot 10^8},Dx=5,Dy=1,xsubticks=2](0,0)(25,7.5){5.5cm}{5cm}
  \listplot[linecolor=red, linewidth=2pt, showpoints=true]{\data}
\end{psgraph}
```



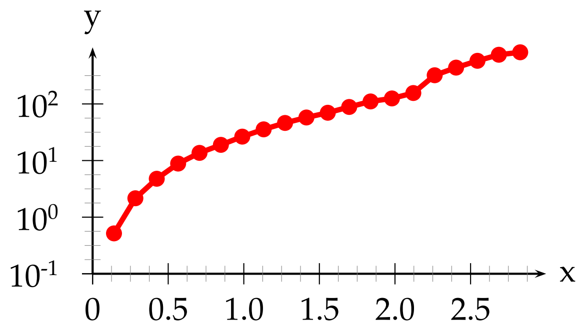

```
\readdata{\data}{demo1.dat}
\psset{llx=-0.5cm,lly=-1cm}
\pstScalePoints(1,0.000001){}{}
\psgraph[arrows=->,Dx=5,dy=200\psyunit,Dy=200,%
   subticks=5,ticksize=-10pt 0,tickwidth=0.5pt,%
   subtickwidth=0.1pt](0,0)(25,750){5.5cm}{5cm}
\listplot[linecolor=red,linewidth=2pt,showpoints=true,]{\data}
\endpsgraph
```



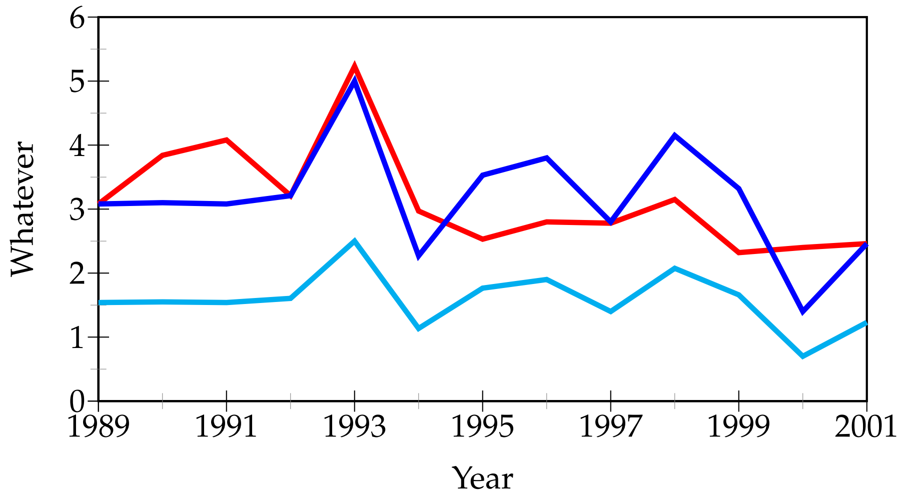

```
\readdata{\data}{demo1.dat}
\pstScalePoints(1,0.2){}{log}
\psset{lly=-0.75cm}
\psgraph[ylogBase=10,Dx=5,Dy=1,subticks=5](0,0)(25,2){12cm}{4cm}
  \listplot[linecolor=red, linewidth=2pt, showpoints=true]{\data}
\endpsgraph
```



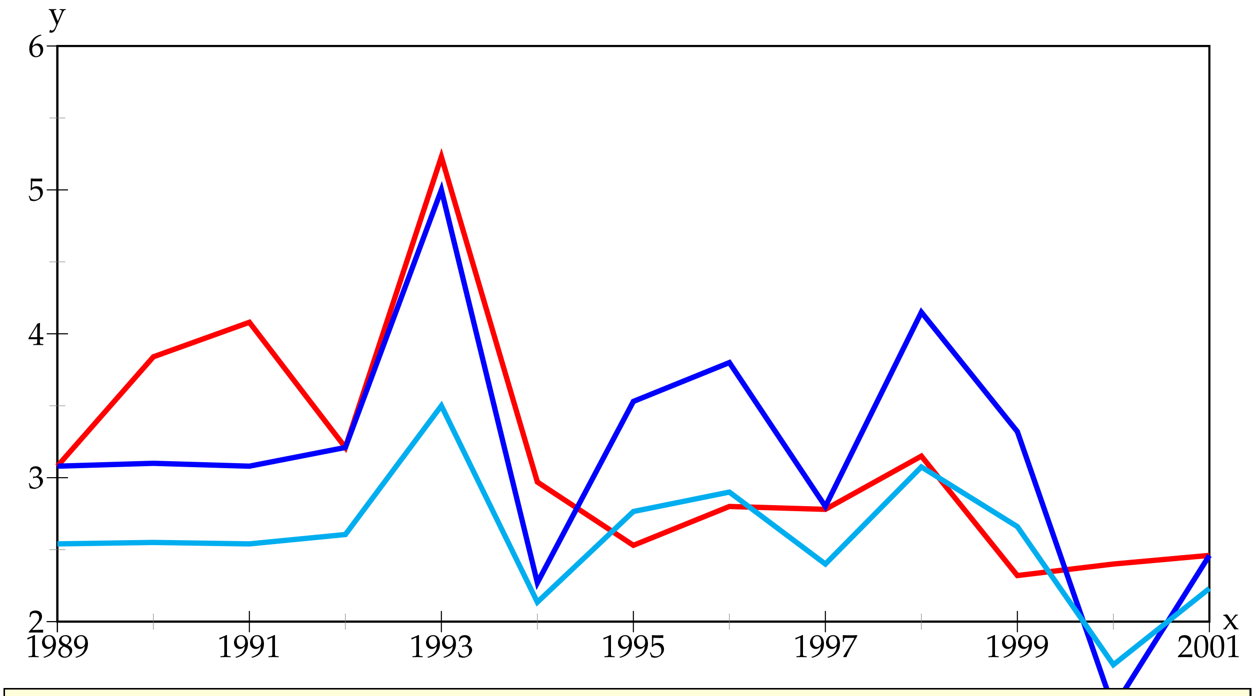

```
\readdata{\data}{demo0.dat}
\psset{lly=-0.75cm,ury=0.5cm}
\pstScalePoints(1,1){}{log}
\begin{psgraph}[arrows=->,Dx=0.5,ylogBase=10,Oy=-1,xsubticks=10,%
    ysubticks=2](0,-3)(3,1){12cm}{4cm}
  \listplot[linecolor=red, linewidth=2pt, showpoints=true]{\data}
\end{psgraph}
```




```
\psset{lly=-0.75cm,ury=0.5cm}
\readdata{\data}{demo0.dat}
\pstScalePoints(1,1){}{log}
\psgraph[arrows=->,Dx=0.5,ylogBase=10,Oy=-1,subticks=4](0,-3)(3,1){6cm}{3cm}
  \listplot[linecolor=red, linewidth=2pt, showpoints=true]{\data}
\endpsgraph
```

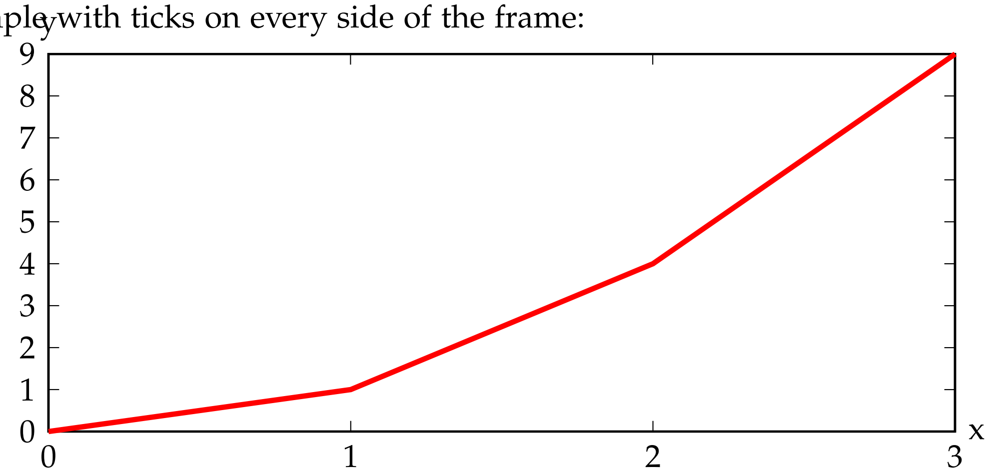



```
\readdata{\data}{demo2.dat}%
\readdata{\dataII}{demo3.dat}%
\pstScalePoints(1,1){1989 sub}{}
\psset{llx=-0.5cm,lly=-1cm, xAxisLabel=Year,yAxisLabel=Whatever,%
     xAxisLabelPos={2in,-0.4in},yAxisLabelPos={-0.4in,1in}}
\psgraph[axesstyle=frame,Dx=2,Ox=1989,subticks=2](0,0)(12,6){4in}{2in}%
   \listplot[linecolor=red,linewidth=2pt]{\data}
   \listplot[linecolor=blue,linewidth=2pt]{\dataII}
   \listplot[linecolor=cyan,linewidth=2pt,yunit=0.5]{\dataII}
\endpsgraph
```




```
\readdata{\data}{demo2.dat}%
\readdata{\dataII}{demo3.dat}%
\psset{llx=-0.5cm,lly=-0.75cm}
\pstScalePoints(1,1){1989 sub}{2 sub}
\begin{psgraph}[axesstyle=frame,Dx=2,Ox=1989,Oy=2,subticks=2](0,0)(12,4){6in}{3
  in}%
  \listplot[linecolor=red,linewidth=2pt]{\data}
  \listplot[linecolor=blue,linewidth=2pt]{\dataII}
  \listplot[linecolor=cyan,linewidth=2pt,yunit=0.5]{\dataII}
\end{psgraph}
```

An example with ticks on every side of the frame:



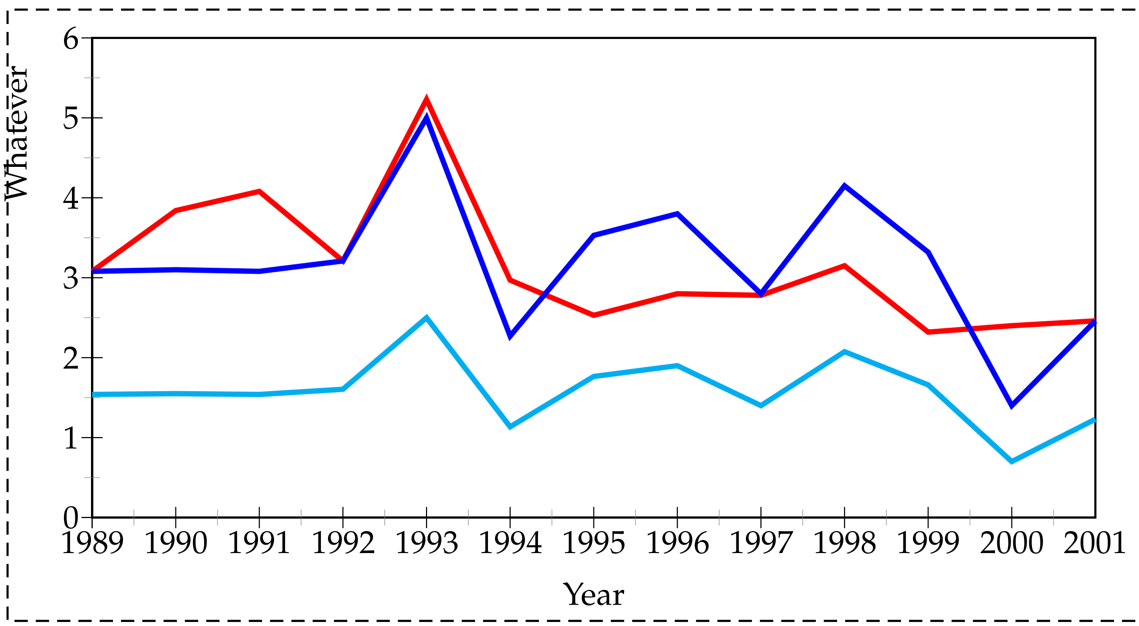

```
\def\data{0 0 1 1 2 4 3 9}
\psset{lly=-0.5cm}
\begin{psgraph}[axesstyle=frame,ticksize=0 4pt](0,0)(3.0,9.0){12cm}{5cm}
  \psaxes[axesstyle=frame,labels=none,ticksize=-4pt 0](3,9)(0,0)(3,9)
```

```
  \listplot[linecolor=red,linewidth=2pt]{\data}
\end{psgraph}
```

22.1 The new options

name	default	meaning
xAxisLabel	x	label for the x-axis
yAxisLabel	y	label for the y-axis
xAxisLabelPos	{}	where to put the x-label
yAxisLabelPos	{}	where to put the y-label
llx	0pt	trim for the lower left x
lly	0pt	trim for the lower left y
urx	0pt	trim for the upper right x
ury	0pt	trim for the upper right y

There is one restriction in using the trim parameters, they must been set **before** `psgraph` is called. They are senseless, when using as parameters of `psgraph` itself.

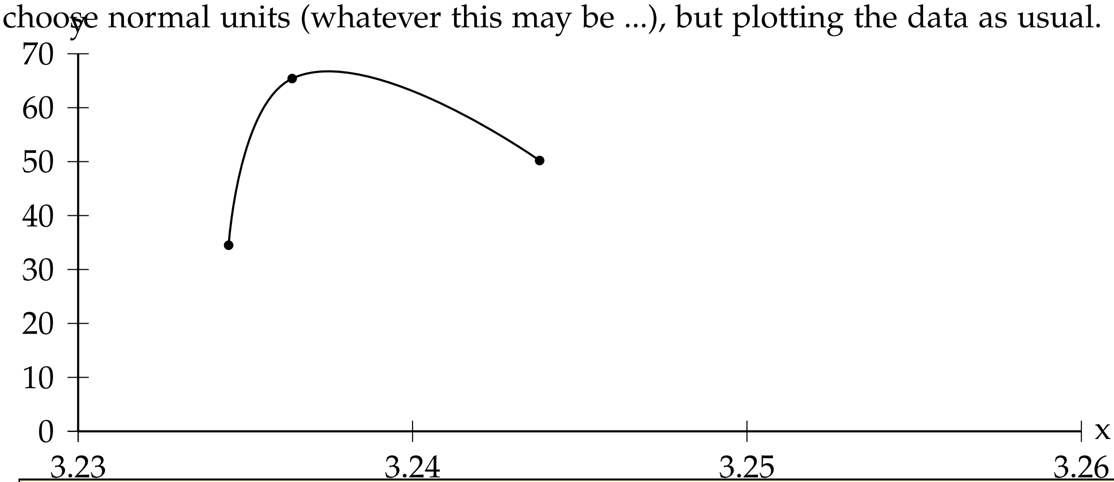



```
\readdata{\data}{demo2.dat}%
\readdata{\dataII}{demo3.dat}%
\psset{llx=-1cm,lly=-1.25cm,urx=0.5cm,ury=0.1in,xAxisLabel=Year,%
   yAxisLabel=Whatever,xAxisLabelPos={.4\linewidth,-0.4in},%
   yAxisLabelPos={-0.4in,2in}}
\pstScalePoints(1,1){1989 sub}{}
\psframebox[linestyle=dashed,boxsep=0pt]{%
\begin{psgraph}[axesstyle=frame,Ox=1989,subticks=2](0,0)(12,6){0.8\linewidth
  }{2.5in}%
```

```
  \listplot[linecolor=red,linewidth=2pt]{\data}%
  \listplot[linecolor=blue,linewidth=2pt]{\dataII}%
  \listplot[linecolor=cyan,linewidth=2pt,yunit=0.5]{\dataII}%
\end{psgraph}%
}
```

22.2 Problems

Floating point operations in TEX are a real mess, which causes a lot of problems when there are very small oder very big units. With the options of `\pst-plot` it is possible to choose normal units (whatever this may be ...), but plotting the data as usual.




```
\begin{filecontents*}{test.dat}
3.2345 34.5
3.2364 65.4
3.2438 50.2
\end{filecontents*}

\psset{lly=-0.5cm,llx=-1cm}
\readdata{\data}{test.dat}
\pstScalePoints(1,1){3.23 sub 100 mul}{}
\begin{psgraph}[Ox=3.23,Dx=0.01,dx=\psxunit,Dy=10](0,0)(3,70){0.8\linewidth}{5cm
  }%
 \listplot[showpoints=true,plotstyle=curve]{\data}
\end{psgraph}
```

This example shows some important facts:

- `3.23 sub 100 mul`: the x values are now 0.45; 0.64; 1.38
- `Ox=3.23`: the origin of the x axis is set to 3.23
- `Dx=0.01`: the increment of the labels
- `dx=\psxunit`: uses the calculated unit value to get every unit a label
- `Dy=10`: increase the y labels by 10

Using the internal \psxunit one can have dynamical x-units, depending to the linewidth od the document.

23 \psStep

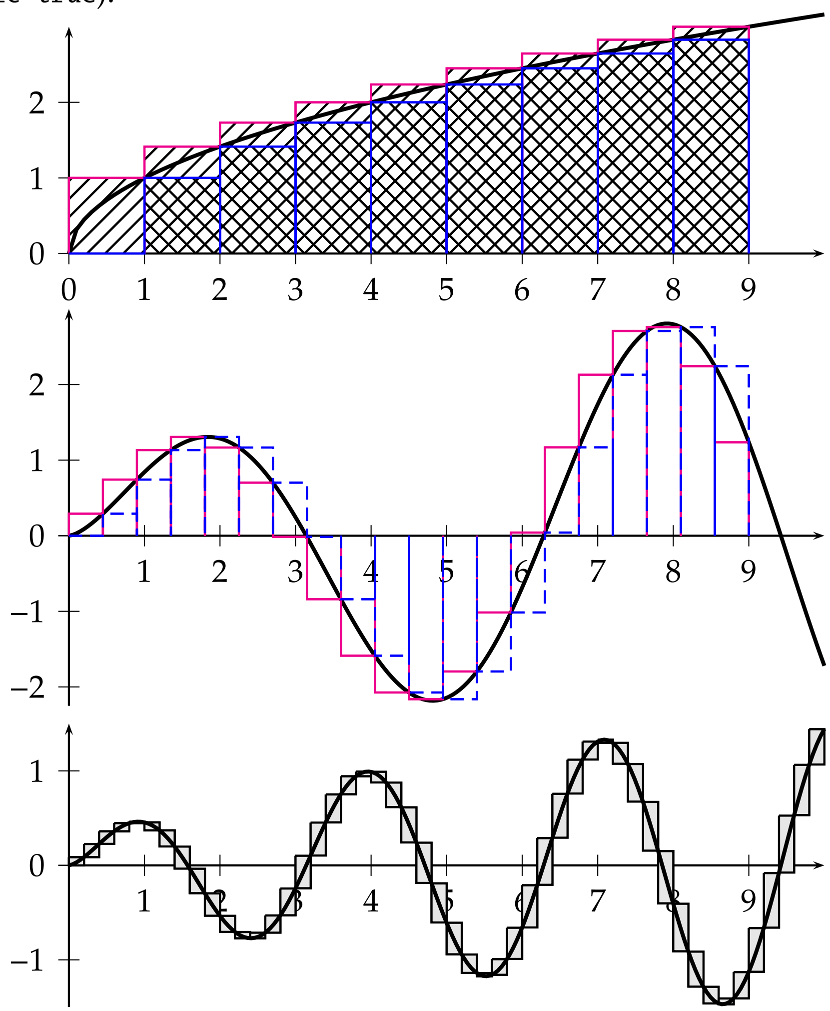
\psStep caclulates a step function for the upper or lower sum or the max/min of the Riemann integral definition of a given function. The available option is

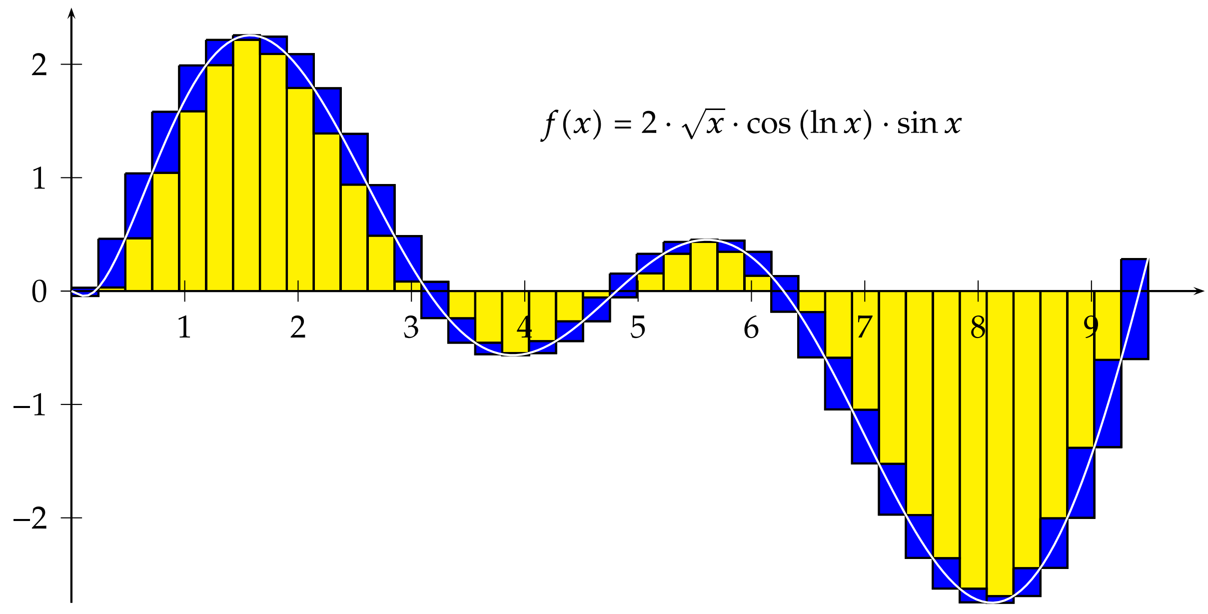
StepType=lower|upper|Riemann

with lower as the default setting. The syntax of the function is

\psStep[options](x1,x2){n}{function}

(x1,x2) is the given Intervall for the step wise caculated function, n is the number of the rectangles and function is the mathematical function in postfix or algebraic notation (with algebraic=true).






```
\begin{pspicture}(-0.5,-0.5)(10,3) \psaxes{->}(10,3)
 \psplot[plotpoints=100,linewidth=1.5pt,algebraic,%
    labelFontSize=\footnotesize]{0}{10}{sqrt(x)}
 \psStep[linecolor=magenta,StepType=upper,fillstyle=hlines](0,9){9}{x sqrt}
 \psStep[linecolor=blue,fillstyle=vlines](0,9){9}{x sqrt }
\end{pspicture}

\psset{plotpoints=200}
\begin{pspicture}(-0.5,-2.25)(10,3)  \psaxes{->}(0,0)(0,-2.25)(10,3)
 \psplot[linewidth=1.5pt,algebraic,labelFontSize=\footnotesize]{0}{10}{sqrt(x)*sin(x)}
 \psStep[algebraic,linecolor=magenta,StepType=upper](0,9){20}{sqrt(x)*sin(x)}
 \psStep[linecolor=blue,linestyle=dashed](0,9){20}{x sqrt x RadtoDeg sin mul}
\end{pspicture}

\psset{yunit=1.25cm}
\begin{pspicture}(-0.5,-1.5)(10,1.5) \psaxes{->}(0,0)(0,-1.5)(10,1.5)
 \psStep[algebraic,StepType=Riemann,fillstyle=solid,fillcolor=black!10](0,10){50}%
    {sqrt(x)*cos(x)*sin(x)}
 \psplot[linewidth=1.5pt,algebraic,labelFontSize=\footnotesize]%
    {0}{10}{sqrt(x)*cos(x)*sin(x)}
\end{pspicture}

\psset{unit=1.5cm}
\begin{pspicture}[plotpoints=200](-0.5,-3)(10,2.5)
  \psStep[algebraic,fillstyle=solid,fillcolor=yellow](0.001,9.5){40}{2*sqrt(x)*cos(ln(x))*sin(x)}
  \psStep[algebraic,StepType=Riemann,fillstyle=solid,fillcolor=blue](0.001,9.5){40}{2*sqrt(x)*cos(ln(x))*sin(x)}
```

```
  \psaxes{->}(0,0)(0,-2.75)(10,2.5)
  \psplot[algebraic,linecolor=white,labelFontSize=\footnotesize]%
    {0.001}{9.75}{2*sqrt(x)*cos(ln(x))*sin(x)}
  \uput[90](6,1.2){$f(x)=2\cdot\sqrt{x}\cdot\cos{(\ln{x})}\cdot\sin{x}$}
\end{pspicture}
```

24 \psplotTangent

There is an additional option, named `Derive` vor an alternative function (see following example) to calculate the slope of the tangent. This will be in general the first derivation, but can also be any other function. If this option is different to to the default value `Derive=default`, then this function is taken to calculate the slope. For the other cases, `pstricks-add` builds a secant with -0.00005<x<0.00005, calculates the slope and takes this for the tangent. This maybe problematic in some cases of special functions or x values, then it may be appropriate to use the Derivate option.

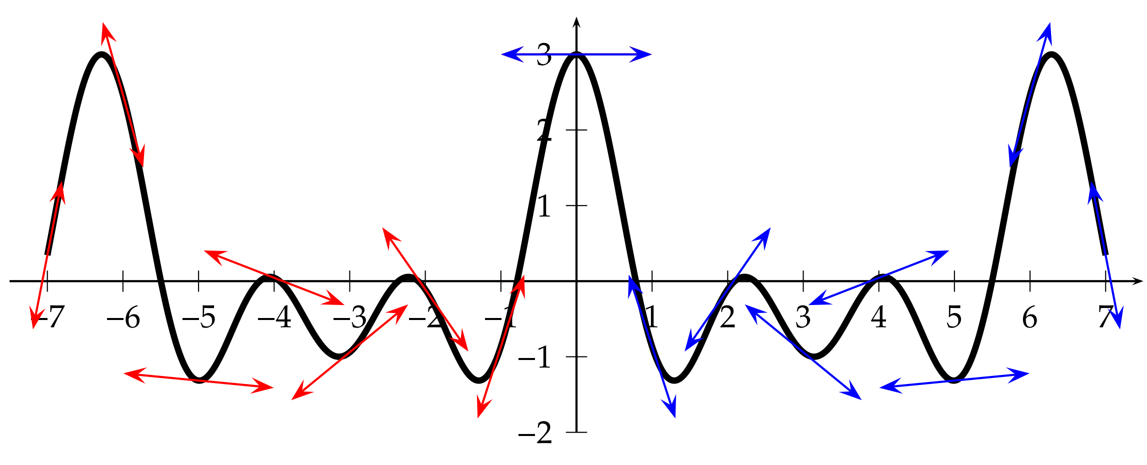
The macro expects three parameters:

x : the x value of the function for which the tangent should be calculated

dx : the dx to both sides of the x value

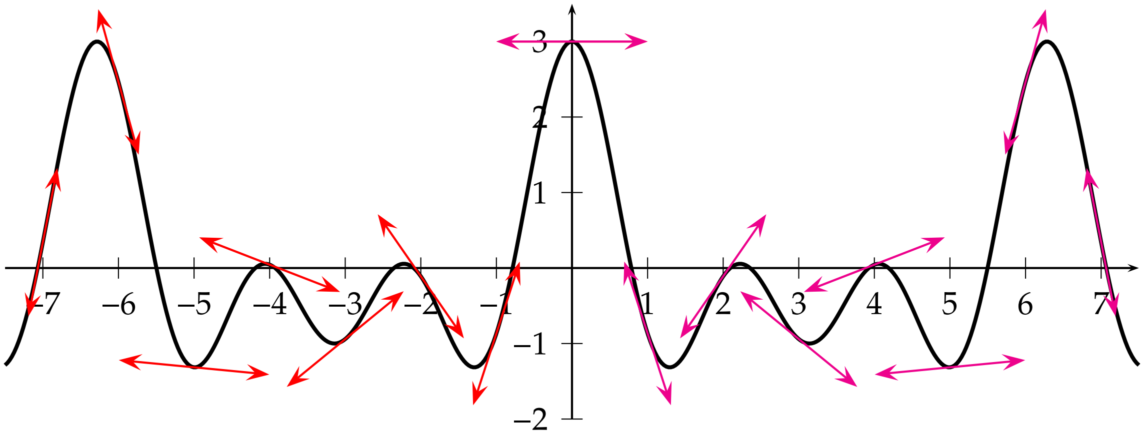
$f(x)$: the function in infix (with option `algebraic`) or the default postfix (PostScript) notation

The following examples show the use of the algebraic option together with the Derive option. Remember that using the `algebraic` option implies that the angles have to be in the radian unit!



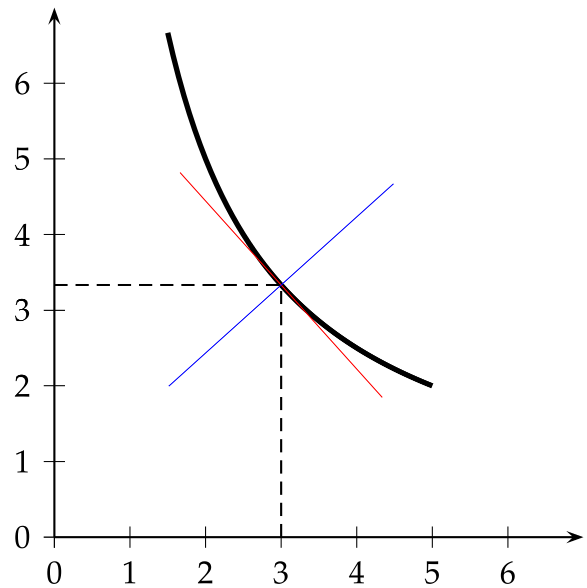

```
\def\F{x RadtoDeg dup dup cos exch 2 mul cos add exch 3 mul cos add}
\def\Fp{x RadtoDeg dup dup sin exch 2 mul sin 2 mul add exch 3 mul sin 3 mul add
   neg}
```

```
\psset{plotpoints=1001}
\begin{pspicture}(-7.5,-2.5)(7.5,4)%X\psgrid
  \psaxes{->}(0,0)(-7.5,-2)(7.5,3.5)
  \psplot[linewidth=3\pslinewidth]{-7}{7}{\F}
  \psset{linecolor=red, arrows=<->, arrowscale=2}
  \multido{\n=-7+1}{8}{\psplotTangent{\n}{1}{\F}}
  \psset{linecolor=magenta, arrows=<->, arrowscale=2}%
  \multido{\n=0+1}{8}{\psplotTangent[linecolor=blue, Derive=\Fp]{\n}{1}{\F}}
\end{pspicture}
```




```
\def\Falg{cos(x)+cos(2*x)+cos(3*x)}   \def\Fpalg{-sin(x)-2*sin(2*x)-3*sin(3*x)}
\begin{pspicture}(-7.5,-2.5)(7.5,4)%\psgrid
  \psaxes{->}(0,0)(-7.5,-2)(7.5,3.5)
  \psplot[linewidth=1.5pt,algebraic,plotpoints=500]{-7.5}{7.5}{\Falg}
  \multido{\n=-7+1}{8}{\psplotTangent[linecolor=red,arrows=<->,arrowscale=2,
    algebraic]{\n}{1}{\Falg}}
  \multido{\n=0+1}{8}{\psplotTangent[linecolor=magenta,%
      arrows=<->,arrowscale=2,algebraic,Derive={\Fpalg}]{\n}{1}{\Falg}}
\end{pspicture}
```

The next example shows the use of `Derive` option to draw the perpendicular line of the tangent.



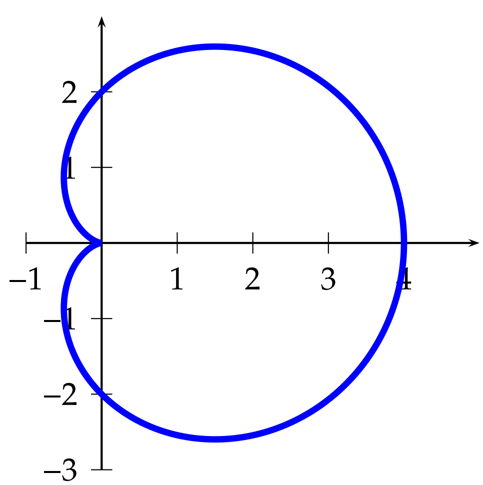

```
\begin{pspicture}(-0.5,-0.5)(7.25,7.25)
 \def\Func{10 x div}
 \psaxes[arrowscale=1.5]{->}(7,7)
 \psplot[linewidth=2pt,algebraic]{1.5}{5}{10/x}
 \psplotTangent[linewidth=.5\pslinewidth,linecolor=red,algebraic]{3}{2}{10/x}
 \psplotTangent[linewidth=.5\pslinewidth,linecolor=blue,algebraic,Derive=(x*x)/10]{3}{2}{10/x}
 \psline[linestyle=dashed](!0 /x 3 def \Func)(!3 /x 3 def \Func)(3,0)
\end{pspicture}
```

24.1 A polarplot example

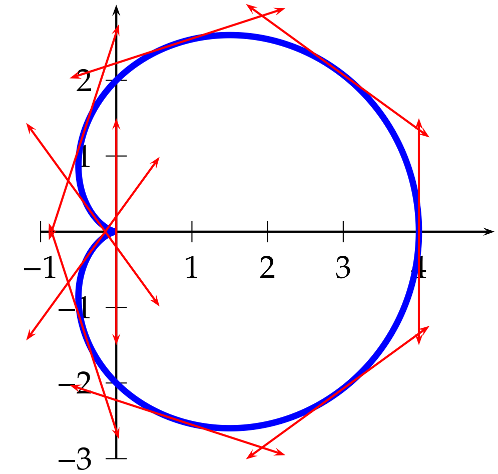
Let's work with the classical cardioid : $\rho = 2(1+\cos(\theta))$ and $\dfrac{d\rho}{d\theta} = -2\sin(\theta)$. The Derive option always expects the $\frac{d\rho}{d\theta}$ value and uses internally the equation for the derivation of implicit defined functions:

$$\frac{dy}{dx} = \frac{\rho\prime \cdot \sin\theta + x}{\rho\prime \cdot \cos\theta - y}$$

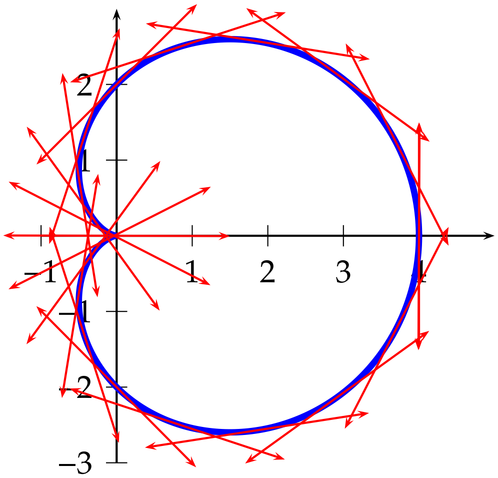
where $x = r\cdot\cos\theta$ and $y = r\cdot\sin\theta$




```
\begin{pspicture}(-1,-3)(5,3)%\psgrid[subgridcolor=lightgray]
 \psaxes{->}(0,0)(-1,-3)(5,3)
 \psplot[polarplot,linewidth=3\pslinewidth,linecolor=blue,%
   plotpoints=500]{0}{360}{1 x cos add 2 mul}
\end{pspicture}
```




```
\begin{pspicture}(-1,-3)(5,3)%\psgrid[subgridcolor=lightgray]
  \psaxes{->}(0,0)(-1,-3)(5,3)
  \psplot[polarplot,linewidth=3\pslinewidth,linecolor=blue,plotpoints=500]{0}{360}{1 x cos add 2 mul}
  \multido{\n=0+36}{10}{%
    \psplotTangent[polarplot,linecolor=red,arrows=<->]{\n}{1.5}{1 x cos add 2 mul} }
\end{pspicture}
```

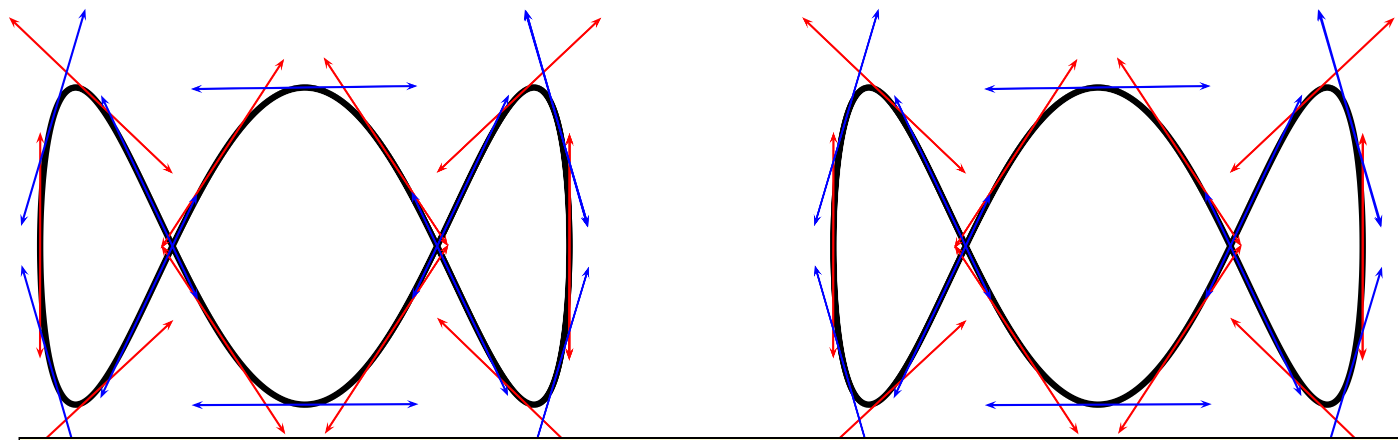



```
\begin{pspicture}(-1,-3)(5,3)%\psgrid[subgridcolor=lightgray]
  \psaxes{->}(0,0)(-1,-3)(5,3)
  \psplot[polarplot,linewidth=3\pslinewidth,linecolor=blue,algebraic,plotpoints=500]{0}{6.289}{2*(1+cos(x))}
  \multido{\r=0.000+0.314}{21}{%
    \psplotTangent[polarplot,Derive=-2*sin(x),algebraic,linecolor=red,arrows=<->]{\r}{1.5}{2*(1+cos(x))} }
\end{pspicture}
```

24.2 A \parametricplot example

Let's work with a Lissajou curve : $\left\{ \begin{array}{l} x = 3.5\cos(2t) \\ y = 3.5\sin(6t) \end{array} \right.$ whose derivative is : $\left\{ \begin{array}{l} x = -7\sin(2t) \\ y = 21\cos(6t) \end{array} \right.$

The parameter must be the letter t instead of x and when using the `algebraic` option divide the two equations by a `|` (see example).



```
\def\Lissa{t dup 2 RadtoDeg mul cos 3.5 mul exch 6 mul RadtoDeg sin 3.5 mul}%
\psset{yunit=0.6}
\begin{pspicture}(-4,-4)(4,6)
  \parametricplot[plotpoints=500,linewidth=3\pslinewidth]{0}{3.141592}{\Lissa}
  \multido{\r=0.000+0.314}{11}{%
    \psplotTangent[linecolor=red,arrows=<->]{\r}{1.5}{\Lissa} }
  \multido{\r=0.157+0.314}{11}{%
    \psplotTangent[linecolor=blue,arrows=<->]{\r}{1.5}{\Lissa} }
\end{pspicture}\hfill%
\def\LissaAlg{3.5*cos(2*t)|3.5*sin(6*t)} \def\LissaAlgDer{-7*sin(2*t)|21*cos(6*t)}%
\begin{pspicture}(-4,-4)(4,6)
  \parametricplot[algebraic,plotpoints=500,linewidth=3\pslinewidth]{0}{3.141592}{\LissaAlg}
  \multido{\r=0.000+0.314}{11}{%
    \psplotTangent[algebraic,linecolor=red,arrows=<->]{\r}{1.5}{\LissaAlg} }
  \multido{\r=0.157+0.314}{11}{%
    \psplotTangent[algebraic,linecolor=blue,arrows=<->,%
       Derive=\LissaAlgDer]{\r}{1.5}{\LissaAlg} }
\end{pspicture}
```

25 Successive derivatives of a function

The new PostScript function `Derive` has been added for plotting the succesive derivatives of a function. It must be used wiht the `algebaic` option. This function has two arguments:

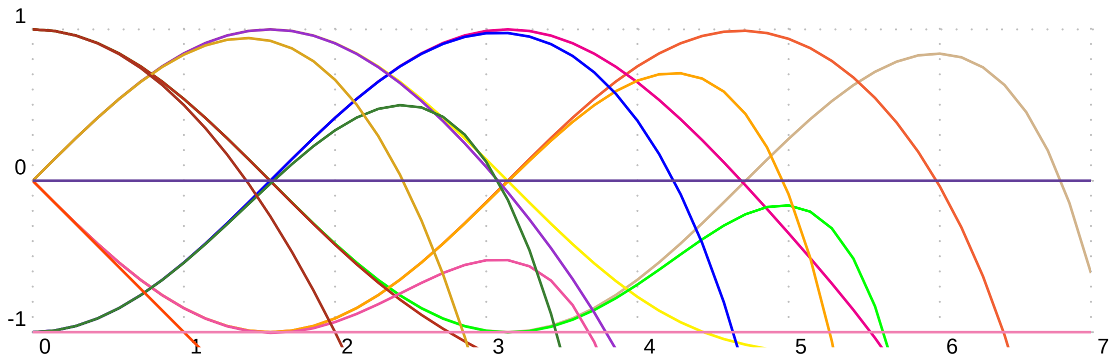
1. a positive integer with define the order of the derivative, obviously 0 means the function itself!
2. a function of variable x which can be any function using the common operators,

Do not think that the derivative is approximated, the internal PostScript engine will compute the real derivative using a formal derivative engine.

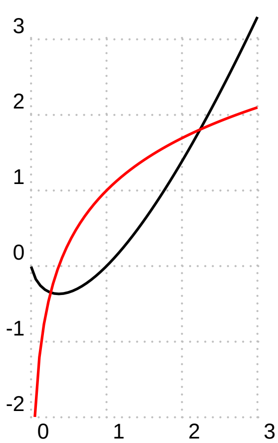
The following diagram contains the plot of the polynomial:

$$f(x) = \sum_{i=0}^{14} \frac{(-1)^i x^{2i}}{i!} = 1 - \frac{x^2}{2} + \frac{x^4}{4!} - \frac{x^6}{6!} + \frac{x^8}{8!} - \frac{x^{10}}{10!} + \frac{x^{12}}{12!} - \frac{x^{14}}{14!}$$

and of its 15 first derivatives. It is the sequence definition of the cosine.




```
\psset{unit=2}
\def\getColor#1{\ifcase#1 Tan\or RedOrange\or magenta\or yellow\or green\or Orange\or blue\or
  DarkOrchid\or BrickRed\or Rhodamine\or OliveGreen\or Goldenrod\or Mahogany\or
  OrangeRed\or CarnationPink\or RoyalPurple\or Lavender\fi}
\begin{pspicture}[showgrid=true](0,-1.2)(7,1.5)
  \psclip{\psframe[linestyle=none](0,-1.1)(7,1.1)}
  \multido{\in=0+1}{16}{%
     \psplot[algebraic=true,linecolor=\getColor{\in},linewidth=1pt]{0}{7}
      {Derive(\in,1-x^2/2+x^4/24-x^6/720+x^8/40320-x^10/3628800+x^12/479001600-x^14/87178291200)}}
  \endpsclip
\end{pspicture}
```




```
\begin{pspicture}[shift=-2.5,showgrid=true,linewidth=1pt](0,-2)(3,3)
  \psplot[algebraic=true]{.001}{3}{x*ln(x)} % f(x)
  \psplot[algebraic=true,linecolor=red]{.05}{3}{Derive(1,x*ln(x))} % f'(x)=1+ln(x)
\end{pspicture}
```

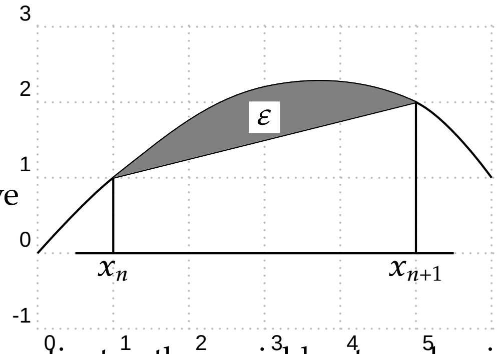
26 Variable step for plotting a curve

26.1 Theory

As you know with the `\psplot` macro, the curve is plotted using a piece wise linear curve. The step is given by the parameter `plotpoints`. For each step between x_i and x_{i+1}, the area defined between the curve and its approximation (a segment) is majored by this formula :

$$|\varepsilon| \leq \frac{M_2(f)(x_{i+1}-x_i)^3}{12}$$

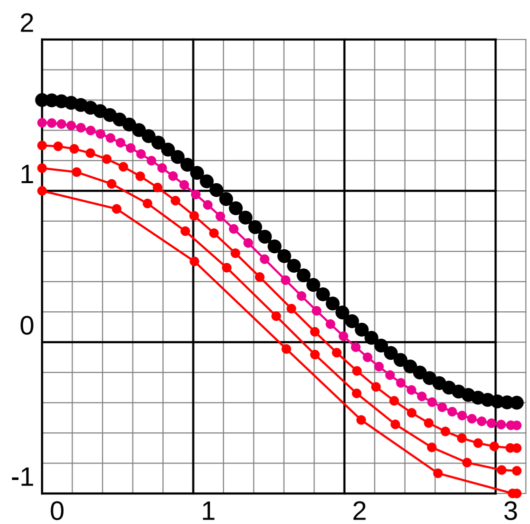
$M_2(f)$ is a majorant of the second derivative of f in the interval $[x_i; x_{i+1}]$.



The parameter `VarStep` (`false` by default) activates the variable step algorithm. It is set to a tolerance defines by the parameter `VarStepEpsilon` (`default` by default, accept real value). If this parameter is not set by the user, then it is automatically computed using the default first step given by the parameter `plotpoints`. Then, for each step, $f''(x_n)$ and $f''(x_{n+1})$ are computed and the smaller is used as $M_2(f)$, and then the step is approximated. This means that the step is constant for a second order polynomials.

26.2 The cosine

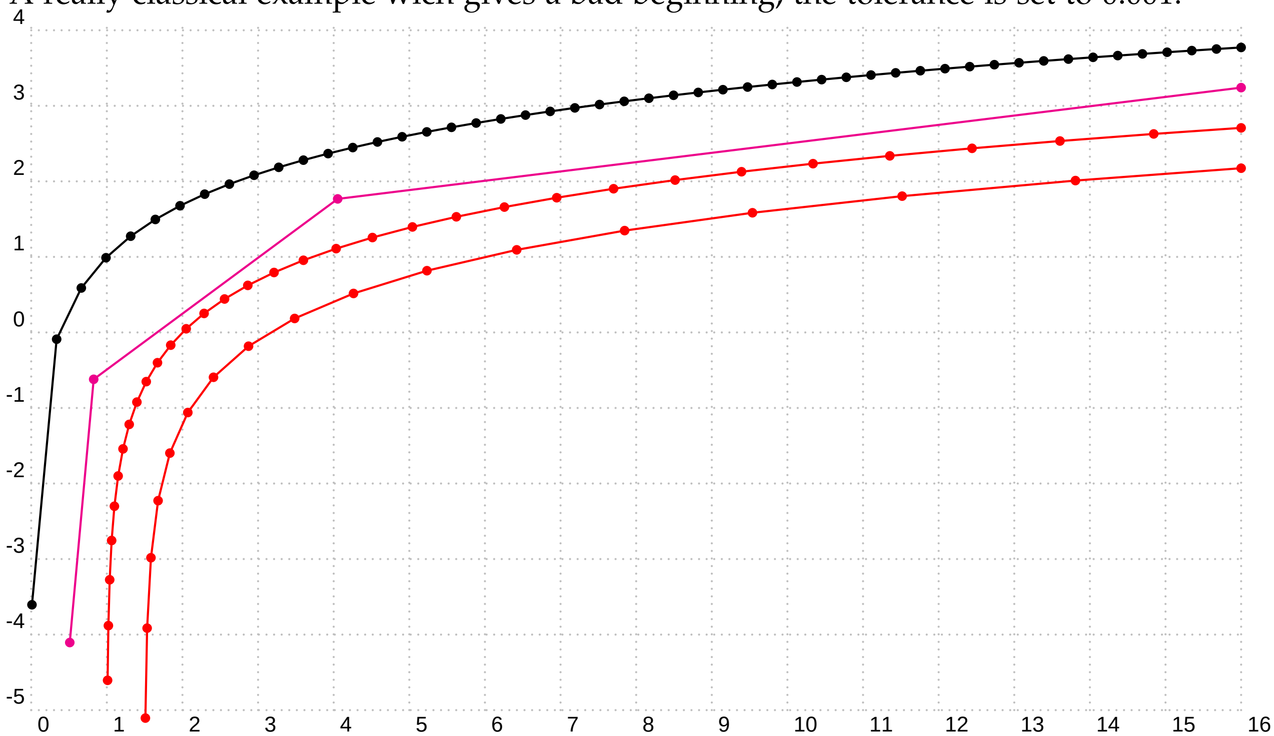
Different value for the tolerance from 0.01 to 0.000 1, a factor 10 between each of them. In black, there is the classical `psplot` behavior, and in magenta the default variable step behavior.



```
\psset{algebraic=true, VarStep=true, unit=2, showpoints=true, linecolor=red}
\begin{pspicture}[showgrid=true](-0,-1)(3.14,2)
  \psplot[VarStepEpsilon=.01]{0}{3.14}{cos(x)}
  \psplot[VarStepEpsilon=.001]{0}{3.14}{cos(x)+.15}
  \psplot[VarStepEpsilon=.0001]{0}{3.14}{cos(x)+.3}
  \psplot[linecolor=magenta]{0}{3.14}{cos(x)+.45}
  \psplot[VarStep=false,linewidth=1pt,linecolor=black]{-0}{3.14}{cos(x)+.6}
\end{pspicture}
```

26.3 The neperian Logarithm

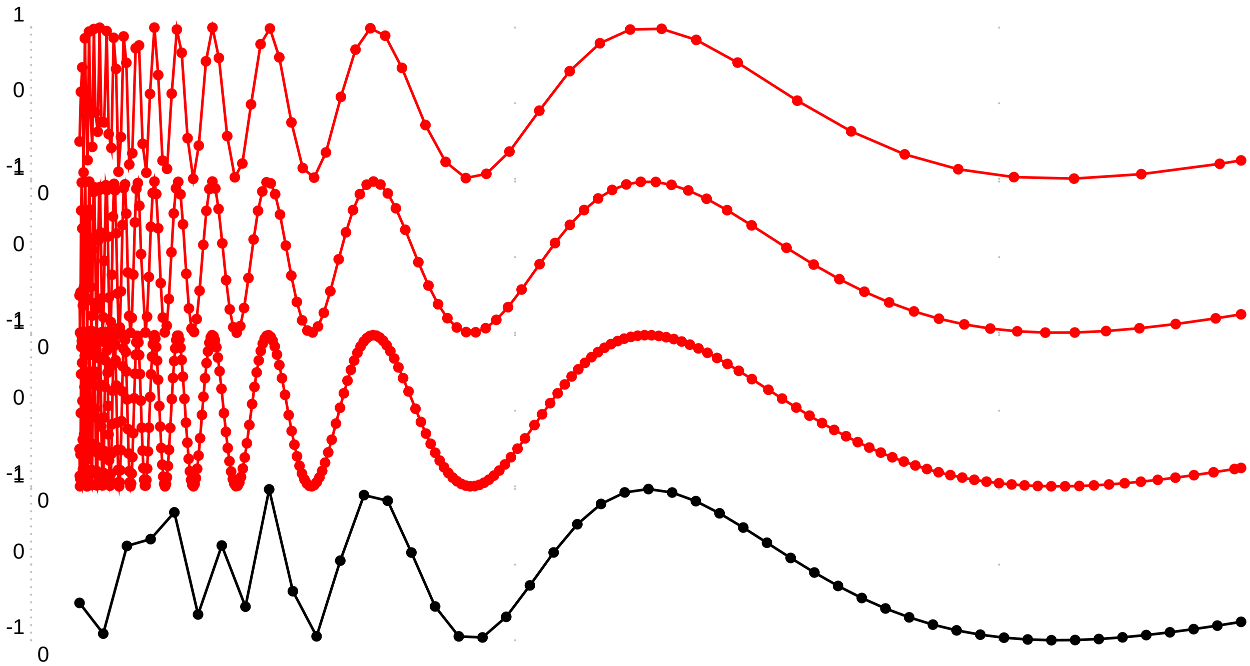
A really classical example wich gives a bad beginning, the tolerance is set to 0.001.




```
\psset{algebraic=true, VarStep=true, linecolor=red, showpoints=true}
\begin{pspicture}[showgrid=true](0,-5)(16,4)
  \psplot[VarStep=false, linecolor=black]{.01}{16}{ln(x)+1}
  \psplot[linecolor=magenta]{.51}{16}{ln(x-1/2)+1/2}
  \psplot[VarStepEpsilon=.001]{1.01}{16}{ln(x-1)}
  \psplot[VarStepEpsilon=.01]{1.51}{16}{ln(x-1.5)-100/200}
\end{pspicture}
```

26.4 Sinus of the inverse of x

Impossible to draw, but let's try!

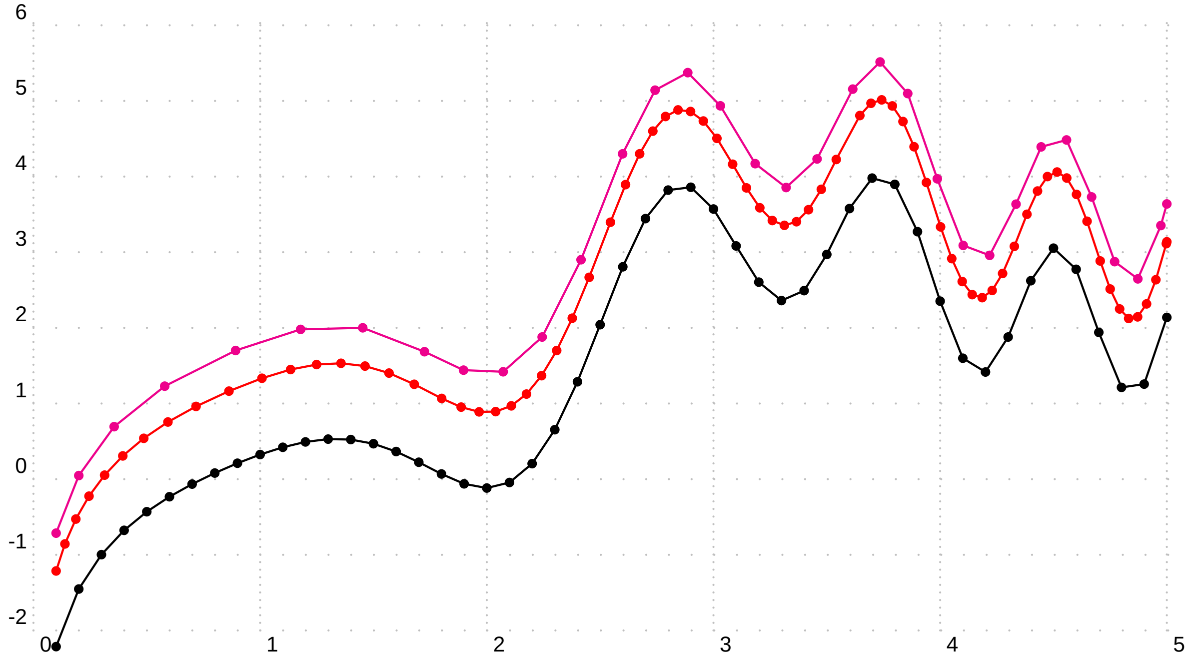



```
\psset{xunit=64,algebraic,VarStep,linecolor=red,showpoints=true,linewidth=1pt}
\begin{pspicture}[showgrid=true](0,-1)(.5,1)
  \psplot[VarStepEpsilon=.0001]{.01}{.25}{sin(1/x)}
\end{pspicture}\\
\begin{pspicture}[showgrid=true](0,-1)(.5,1)
  \psplot[VarStepEpsilon=.00001]{.01}{.25}{sin(1/x)}
\end{pspicture}\\
\begin{pspicture}[showgrid=true](0,-1)(.5,1)
  \psplot[VarStepEpsilon=.000001]{.01}{.25}{sin(1/x)}
\end{pspicture}\\
\begin{pspicture}[showgrid=true](0,-1)(.5,1)
  \psplot[VarStep=false, linecolor=black]{.01}{.25}{sin(1/x)}
\end{pspicture}
```

26.5 A really complex function

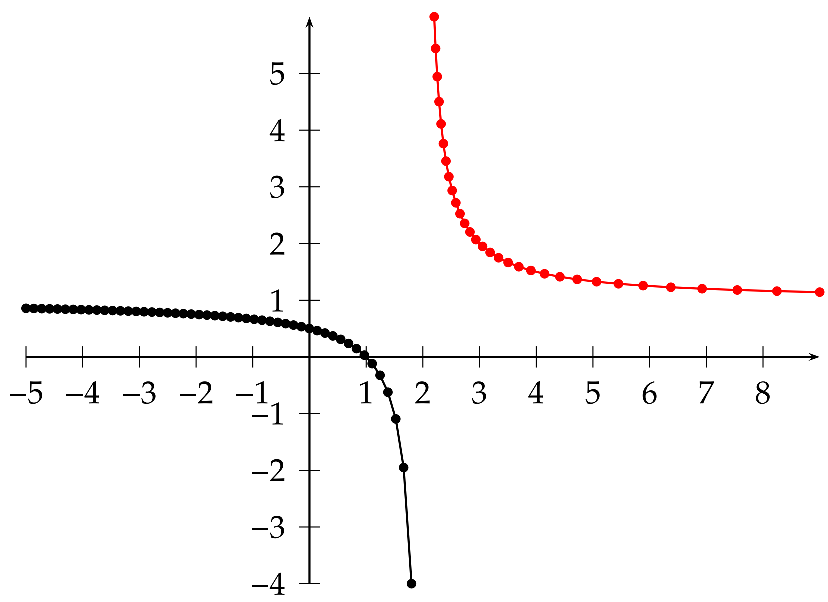
Just appreciate the difference between the normal behavior and the plotting with the varStep option. The function is :

$$f(x) = x - \frac{x^2}{10} + \ln(x) + \cos(2x) + \sin(x^2) - 1$$



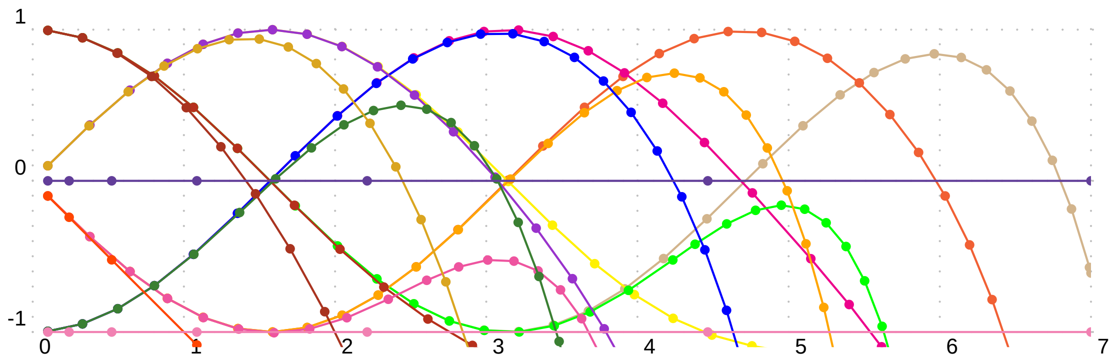

```
\psset{xunit=3, algebraic, VarStep, showpoints=true}
\begin{pspicture}[showgrid=true](0,-2)(5,6)
  \psplot[VarStepEpsilon=.0005, linecolor=red]{.1}{5}{x-x^2/10+ln(x)+cos(2*x)+sin(x^2)}
  \psplot[linecolor=magenta]{.1}{5}{x-x^2/10+ln(x)+cos(2*x)+sin(x^2)+.5}
  \psplot[VarStep=false]{.1}{5}{x-x^2/10+ln(x)+cos(2*x)+sin(x^2)-1}
\end{pspicture}
```

26.6 A hyperbola



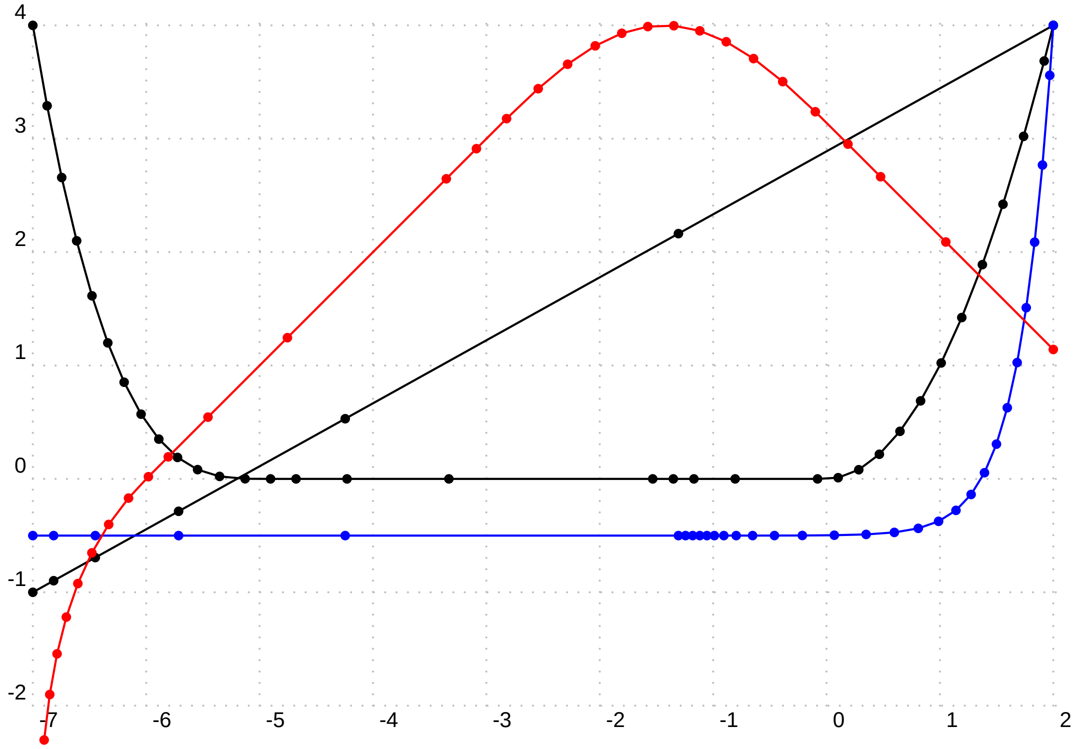
```
\psset{algebraic=true, showpoints=true, unit=0.75}
\begin{pspicture}(-5,-4)(9,6)
  \psplot[linecolor=black]{-5}{1.8}{(x-1)/(x-2)}
  \psplot[VarStep=true, VarStepEpsilon=.001, linecolor=red]{2.2}{9}{(x-1)/(x-2)}
  \psaxes{->}(0,0)(-5,-4)(9,6)
\end{pspicture}
```

26.7 Successive derivatives of a polynom



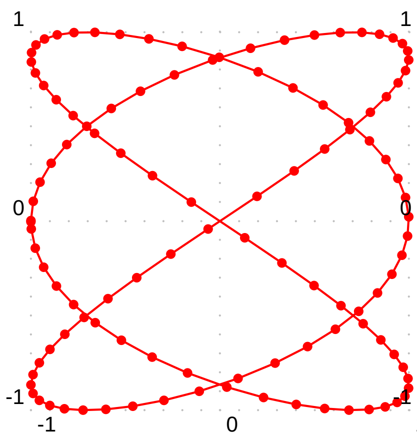

```
\psset{unit=2, algebraic=true, VarStep=true, showpoints=true, VarStepEpsilon=.001}
\def\getColor#1{\ifcase#1 Tan\or RedOrange\or magenta\or yellow\or green\or Orange\or blue\or
  DarkOrchid\or BrickRed\or Rhodamine\or OliveGreen\or Goldenrod\or Mahogany\or
  OrangeRed\or CarnationPink\or RoyalPurple\or Lavender\fi}
\begin{pspicture}[showgrid=true](0,-1.2)(7,1.5)
  \psclip{\psframe[linestyle=none](0,-1.1)(7,1.1)}
  \multido{\in=0+1}{16}{%
    \psplot[algebraic=true, linecolor=\getColor{\in}]{0.1}{7}
    {Derive(\in,Sum(i,0,1,7,(-1)^i*x^(2*i)/Fact(2*i)))}}
  \endpsclip
\end{pspicture}
```

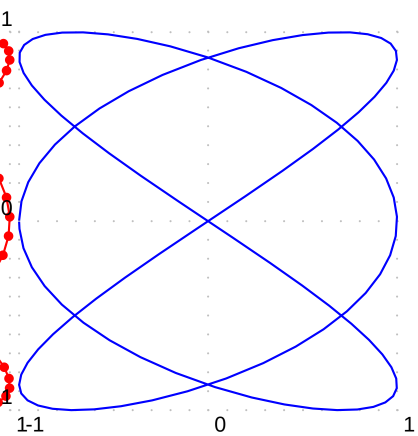
26.8 The variable step algorithm together with the IfTE primitive



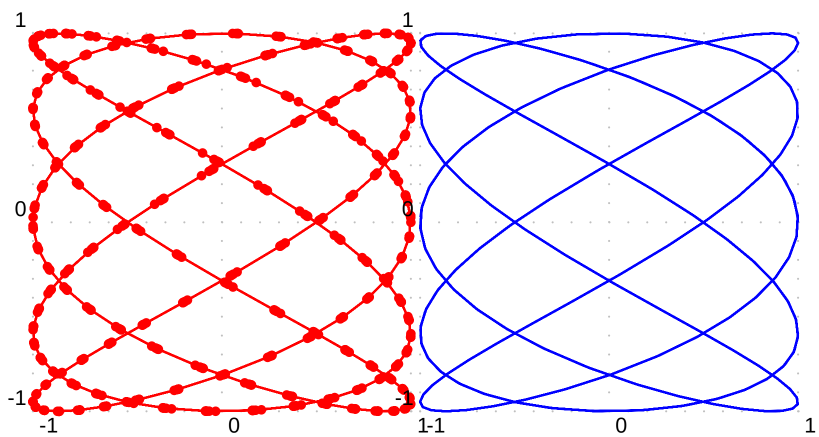

```
\psset{unit=1.5, algebraic, VarStep, showpoints=true, VarStepEpsilon=.001}
\begin{pspicture}[showgrid=true](-7,-2)(2,4)
  \psplot{-7}{2}{IfTE(x<-5,-(x+5)^3/2,IfTE(x<0,0,x^2))}
  \psplot{-7}{2}{5*x/9+26/9}
  \psplot[linecolor=blue]{-7}{2}{(x+7)^30/9^30*4.5-1/2}
  \psplot[linecolor=red]{-6.9}{2}
      {IfTE(x<-6,ln(x+7),IfTE(x<-3,x+6,IfTE(x<0.1415926,sin(x+3)+3,3.1415926-x))
        )}
\end{pspicture}
```

26.9 Using \parametricplot

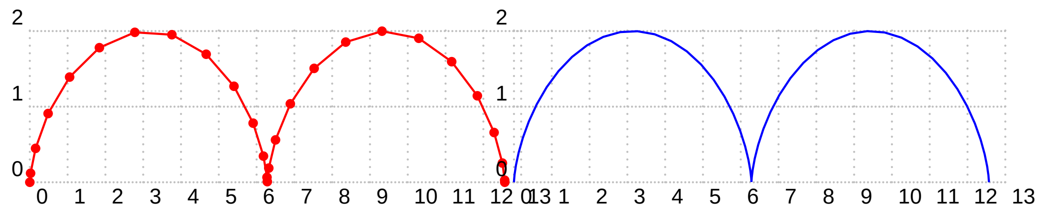




```
\psset{unit=3}
\begin{pspicture}[showgrid=true](-1,-1)(1,1)
\parametricplot[algebraic=true,linecolor=red,VarStep=true, showpoints=true,
                VarStepEpsilon=.0001]
                {-3.14}{3.14}{cos(3*t)|sin(2*t)}
\end{pspicture}
\begin{pspicture}[showgrid=true](-1,-1)(1,1)
\parametricplot[algebraic=true,linecolor=blue,VarStep=true, showpoints=false,
                VarStepEpsilon=.0001]
                {-3.14}{3.14}{cos(3*t)|sin(2*t)}
\end{pspicture}
```




```
\psset{unit=2.5}
\begin{pspicture}[showgrid=true](-1,-1)(1,1)
\parametricplot[algebraic=true,linecolor=red,VarStep=true, showpoints=true,
                VarStepEpsilon=.0001]
                {0}{47.115}{cos(5*t)|sin(3*t)}
\end{pspicture}
\begin{pspicture}[showgrid=true](-1,-1)(1,1)
\parametricplot[algebraic=true,linecolor=blue,VarStep=true, showpoints=false,
                VarStepEpsilon=.0001]
                {0}{47.115}{cos(5*t)|sin(3*t)}
\end{pspicture}
```

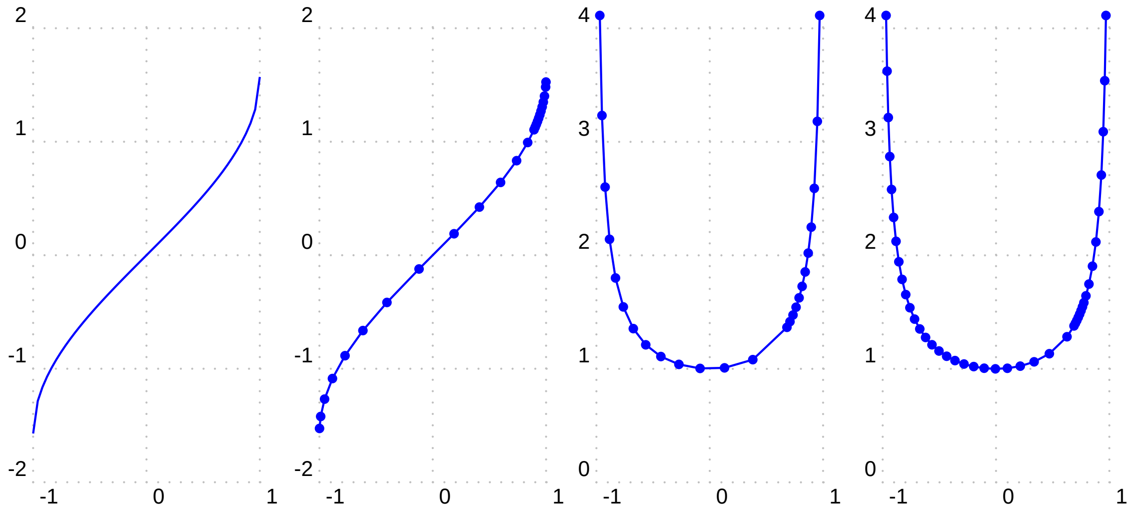



```
\psset{xunit=.5}
\begin{pspicture}[showgrid=true](0,0)(12.566,2)
\parametricplot[algebraic,linecolor=red,VarStep, showpoints=true,
        VarStepEpsilon=.01]{0}{12.566}{t+cos(-t-PI/2)|1+sin(-t-PI/2)}
\end{pspicture}
```

```
%
\begin{pspicture}[showgrid=true](0,0)(12.566,2)
\parametricplot[algebraic,linecolor=blue,VarStep, showpoints=false,
        VarStepEpsilon=.001]{0}{12.566}{t+cos(-t-PI/2)|1+sin(-t-PI/2)}
\end{pspicture}
```

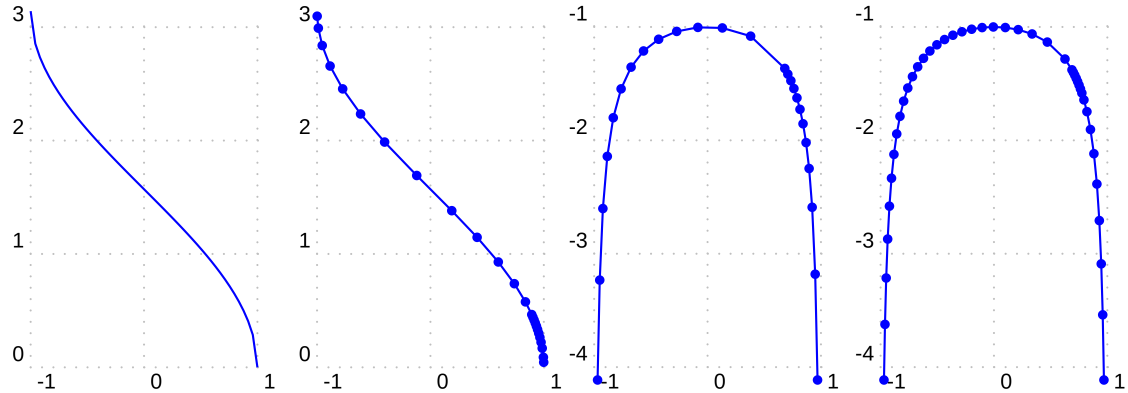
27 New math functions and their derivative

27.1 The inverse sin and its derivative



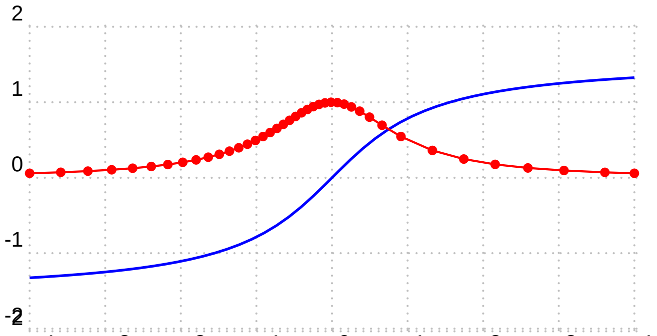

```
\psset{unit=1.5}
\begin{pspicture}[showgrid=true](-1,-2)(1,2)
  \psplot[linecolor=blue,algebraic]{-1}{1}{asin(x)}
\end{pspicture}
\hspace{1em}
\psset{algebraic, VarStep, VarStepEpsilon=.001, showpoints=true}
\begin{pspicture}[showgrid=true](-1,-2)(1,2)
  \psplot[linecolor=blue]{-.999}{.999}{asin(x)}
\end{pspicture}
\hspace{1em}
\begin{pspicture}[showgrid=true](-1,0)(1,4)
  \psplot[linecolor=red]{-.97}{.97}{Derive(1,asin(x))}
\end{pspicture}
\hspace{1em}
\psset{algebraic, VarStep, VarStepEpsilon=.0001, showpoints=true}
\begin{pspicture}[showgrid=true](-1,0)(1,4)
  \psplot[linecolor=red]{-.97}{.97}{Derive(1,asin(x))}
\end{pspicture}
```

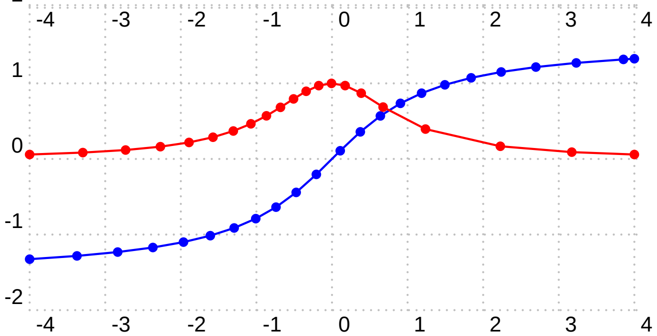
27.2 The inverse cosine and its derivative




```
\psset{unit=1.5}
\begin{pspicture}[showgrid=true](-1,0)(1,3)
  \psplot[linecolor=blue,algebraic]{-1}{1}{acos(x)}
\end{pspicture}
\hspace{1em}
\psset{algebraic, VarStep, VarStepEpsilon=.001, showpoints=true}
\begin{pspicture}[showgrid=true](-1,0)(1,3)
  \psplot[linecolor=blue]{-.999}{.999}{acos(x)}
\end{pspicture}
\hspace{1em}
\begin{pspicture}[showgrid=true](-1,-4)(1,-1)
  \psplot[linecolor=red]{-.97}{.97}{Derive(1,acos(x))}
\end{pspicture}
\hspace{1em}
\psset{algebraic, VarStep, VarStepEpsilon=.0001, showpoints=true}
\begin{pspicture}[showgrid=true](-1,-4)(1,-1)
  \psplot[linecolor=red]{-.97}{.97}{Derive(1,acos(x))}
\end{pspicture}
```

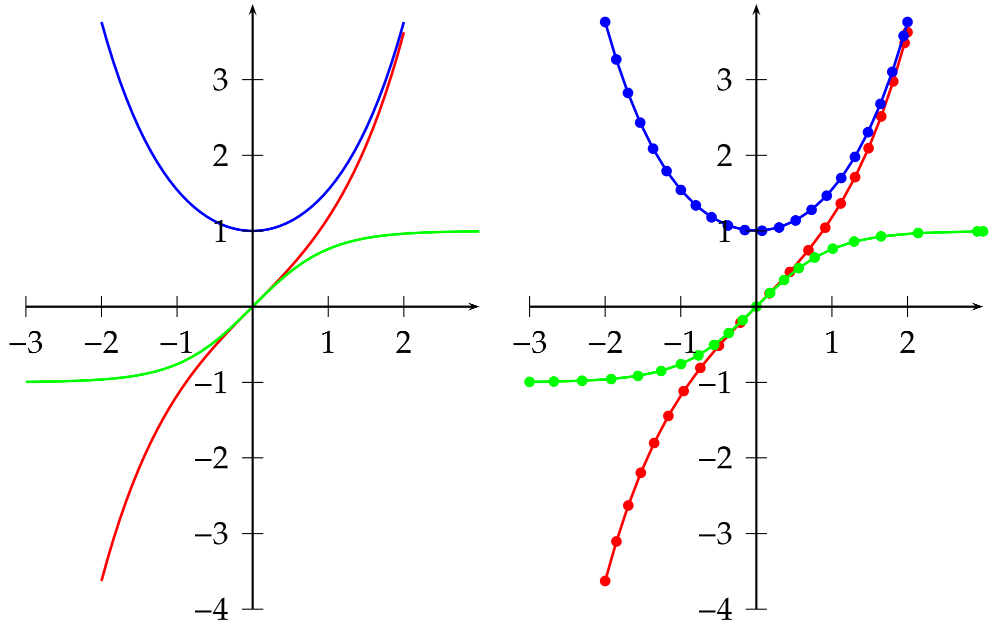
27.3 The inverse tangente and its derivative



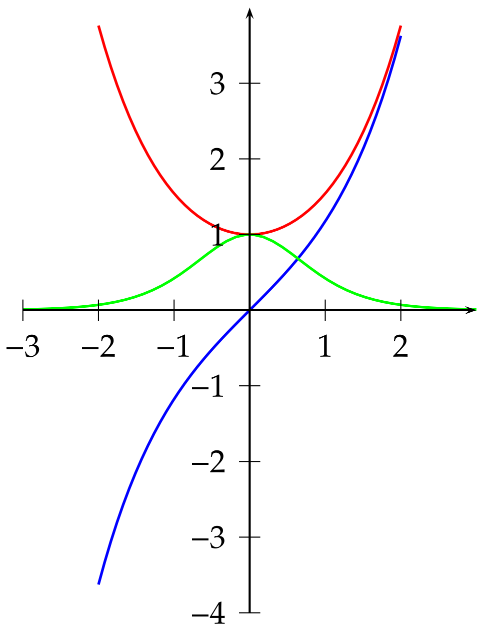


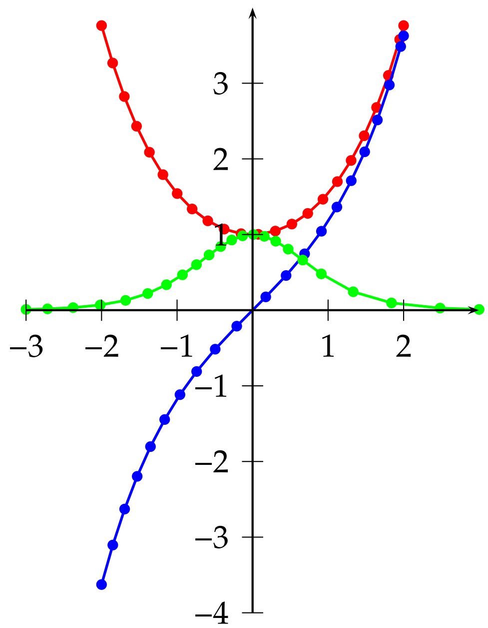

```
\begin{pspicture}[showgrid=true](-4,-2)(4,2)
\psset{algebraic=true}
  \psplot[linecolor=blue,linewidth=1pt]{-4}{4}{atg(x)}
  \psplot[linecolor=red,VarStep, VarStepEpsilon=.0001, showpoints=true]{-4}{4}{
    Derive(1,atg(x))}
\end{pspicture}
\hspace{1em}
\begin{pspicture}[showgrid=true](-4,-2)(4,2)
\psset{algebraic, VarStep, VarStepEpsilon=.001, showpoints=true}
  \psplot[linecolor=blue]{-4}{4}{atg(x)}
  \psplot[linecolor=red]{-4}{4}{Derive(1,atg(x))}
\end{pspicture}
```

27.4 Hyperbolique functions

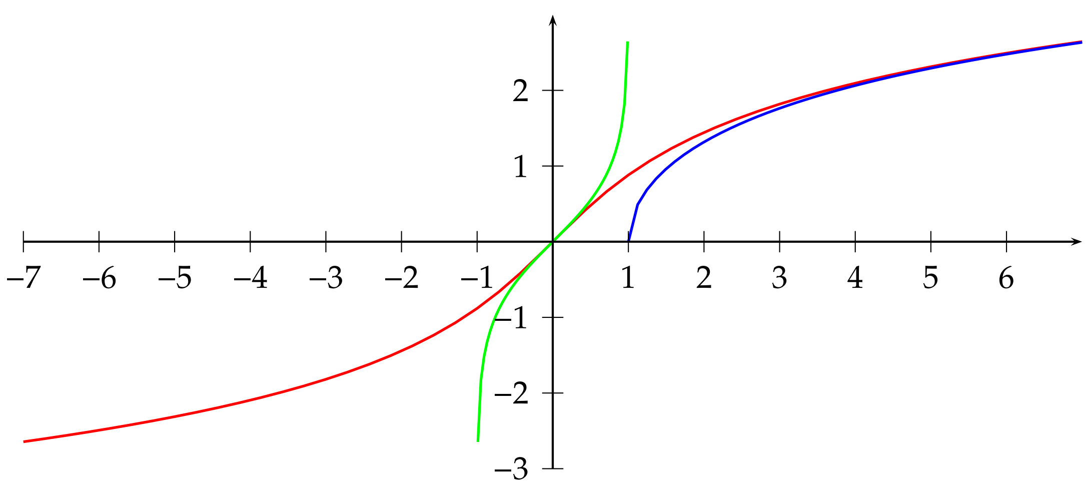


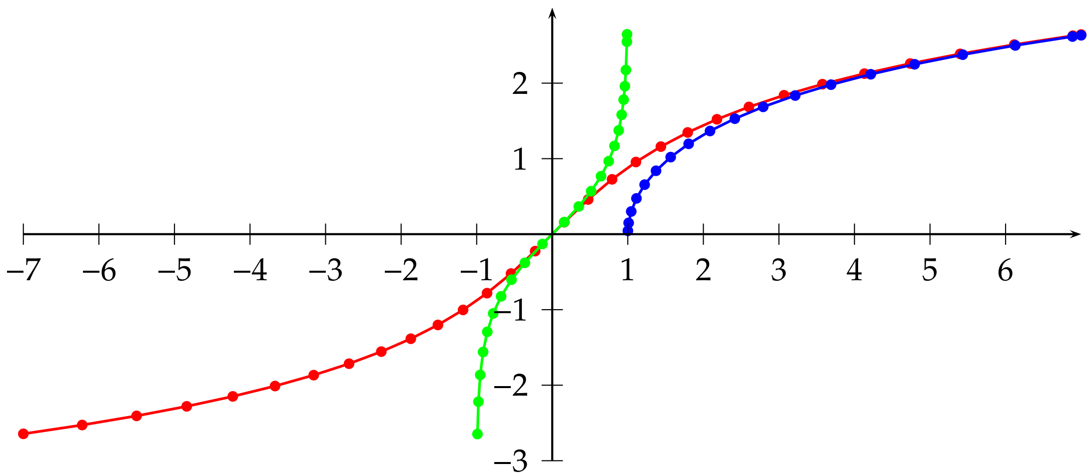

```
\begin{pspicture}(-3,-4)(3,4)
\psset{algebraic=true}
  \psplot[linecolor=red,linewidth=1pt]{-2}{2}{sh(x)}
  \psplot[linecolor=blue,linewidth=1pt]{-2}{2}{ch(x)}
  \psplot[linecolor=green,linewidth=1pt]{-3}{3}{th(x)}
  \psaxes{->}(0,0)(-3,-4)(3,4)
\end{pspicture}
\hspace{1em}
\begin{pspicture}(-3,-4)(3,4)
\psset{algebraic=true, VarStep=true, VarStepEpsilon=.001, showpoints=true}
  \psplot[linecolor=red,linewidth=1pt]{-2}{2}{sh(x)}
  \psplot[linecolor=blue,linewidth=1pt]{-2}{2}{ch(x)}
  \psplot[linecolor=green,linewidth=1pt]{-3}{3}{th(x)}
  \psaxes{->}(0,0)(-3,-4)(3,4)
\end{pspicture}
```



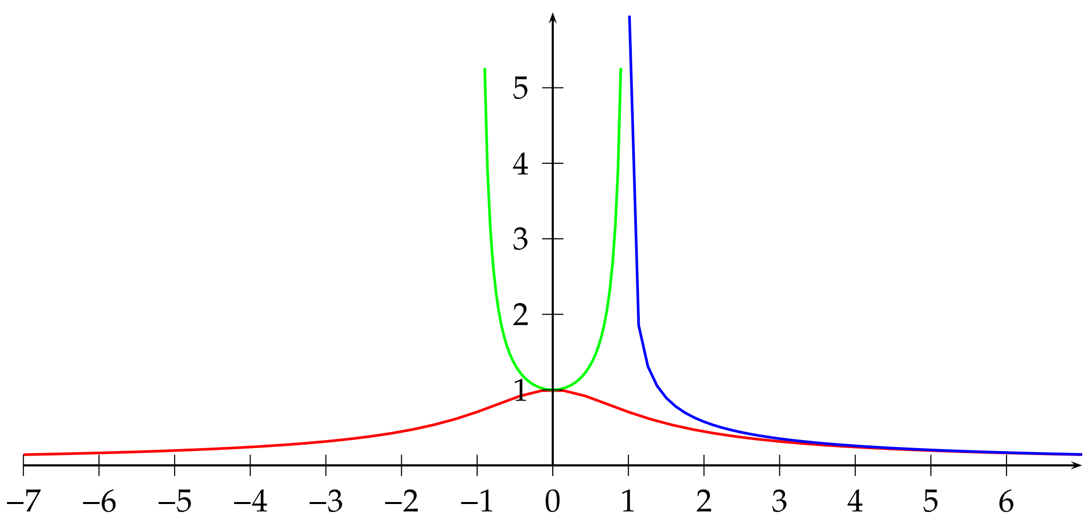


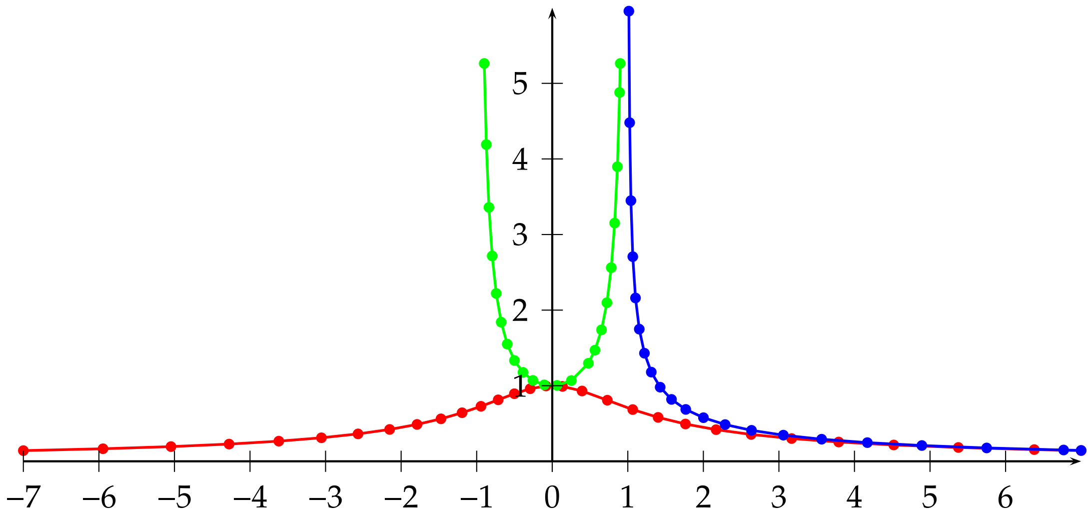

```
\begin{pspicture}(-3,-4)(3,4)
\psset{algebraic=true,linewidth=1pt}
  \psplot[linecolor=red,linewidth=1pt]{-2}{2}{Derive(1,sh(x))}
  \psplot[linecolor=blue,linewidth=1pt]{-2}{2}{Derive(1,ch(x))}
  \psplot[linecolor=green,linewidth=1pt]{-3}{3}{Derive(1,th(x))}
  \psaxes{->}(0,0)(-3,-4)(3,4)
\end{pspicture}
\hspace{1em}
\begin{pspicture}(-3,-4)(3,4)
\psset{algebraic=true, VarStep=true, VarStepEpsilon=.001, showpoints=true}
  \psplot[linecolor=red,linewidth=1pt]{-2}{2}{Derive(1,sh(x))}
  \psplot[linecolor=blue,linewidth=1pt]{-2}{2}{Derive(1,ch(x))}
  \psplot[linecolor=green,linewidth=1pt]{-3}{3}{Derive(1,th(x))}
  \psaxes{->}(0,0)(-3,-4)(3,4)
\end{pspicture}
```






```
\begin{pspicture}(-7,-3)(7,3)
\psset{algebraic=true}
  \psplot[linecolor=red,linewidth=1pt]{-7}{7}{Argsh(x)}
  \psplot[linecolor=blue,linewidth=1pt]{1}{7}{Argch(x)}
  \psplot[linecolor=green,linewidth=1pt]{-.99}{.99}{Argth(x)}
  \psaxes{->}(0,0)(-7,-3)(7,3)
\end{pspicture}\\[\baselineskip]
\begin{pspicture}(-7,-3)(7,3)
  \psset{algebraic, VarStep, VarStepEpsilon=.001, showpoints=true}
  \psplot[linecolor=red,linewidth=1pt]{-7}{7}{Argsh(x)}
  \psplot[linecolor=blue,linewidth=1pt]{1.001}{7}{Argch(x)}
  \psplot[linecolor=green,linewidth=1pt]{-.99}{.99}{Argth(x)}
  \psaxes{->}(0,0)(-7,-3)(7,3)
\end{pspicture}
```






```
\begin{pspicture}(-7,-0.5)(7,6)
\psset{algebraic=true}
  \psplot[linecolor=red,linewidth=1pt]{-7}{7}{Derive(1,Argsh(x))}
  \psplot[linecolor=blue,linewidth=1pt]{1.014}{7}{Derive(1,Argch(x))}
  \psplot[linecolor=green,linewidth=1pt]{-.9}{.9}{Derive(1,Argth(x))}
  \psaxes{->}(0,0)(-7,0)(7,6)
\end{pspicture}\\[\baselineskip]
\begin{pspicture}(-7,-0.5)(7,6)
\psset{algebraic=true}
  \psset{algebraic=true, VarStep=true, VarStepEpsilon=.001, showpoints=true}
  \psplot[linecolor=red,linewidth=1pt]{-7}{7}{Derive(1,Argsh(x))}
  \psplot[linecolor=blue,linewidth=1pt]{1.014}{7}{Derive(1,Argch(x))}
  \psplot[linecolor=green,linewidth=1pt]{-.9}{.9}{Derive(1,Argth(x))}
  \psaxes{->}(0,0)(-7,0)(7,6)
\end{pspicture}
```

28 \psplotDiffEqn – solving diffential equations

A differential euqation of first order is like

$$y' = f(x, y, y') \tag{1}$$

where y is a function of x. We define some vectors $Y = [y, y', \cdots, y^{(n-1)}]$ und $Y' = [y', y'', \cdots, y^{n}]$, depending to the order n. The syntax of the macro is
`\psplotDiffEqn[options]{x0}{x1}{y0}{f(x,y,y',...)}`

- `options`: the `\psplotDiffEqn` specific options and all other of PSTricks, which make sense;
- x_0: the start value;
- x_1: the end value of the definition interval;
- y_0: the initial values for $y(x_0)$ $y'(x_0)$ $\ldots$;
- $f(x, y, y', ...)$: the differential equation, depending to the number of initial values, e.g.: `{0 1}` for y_0 are two initial values, so that we have a differential equation of second order $f(x, y, y')$ and the macro leaves y y' on the stack.

The new options are:

- `method`: integration method (`euler` for order 1 euler method, `rk4` for 4th order Runge-Kutta method);
- `whichabs`: select the abscissa for plotting the graph, by default it is x, but you can specify a number which represent a position in the vector y;
- `whichord`: same as precedent for the ordinate, by default $y(0)$;
- `plotfuncx`: describe a ps function for the abscissa, parameter `whichabs` becomes useless;
- `plotfuncy`: idem for ordoinate;
- `buildvector`: boolean parameter for specifying the input-output of the f description:

  `true` (default): y is put on the stack element by element, y' must be given in the same way;

  `false` : y is put on the stack as a vector, y' must be returned in the same way;
- `algebraic`: algebraic description for f, `buildvector` parameter is useless when activating this option.

28.1 Variable step for differential equations

A new algorithm has been added for adjusting the step according to the variations of the curve. The parameter `method` has a new possible value : `varrkiv` to activate the Runge-Kutta method with variable step, then the parameter `varsteptol` (real value; `.01` by default) can control the tolerance of the algortihm.

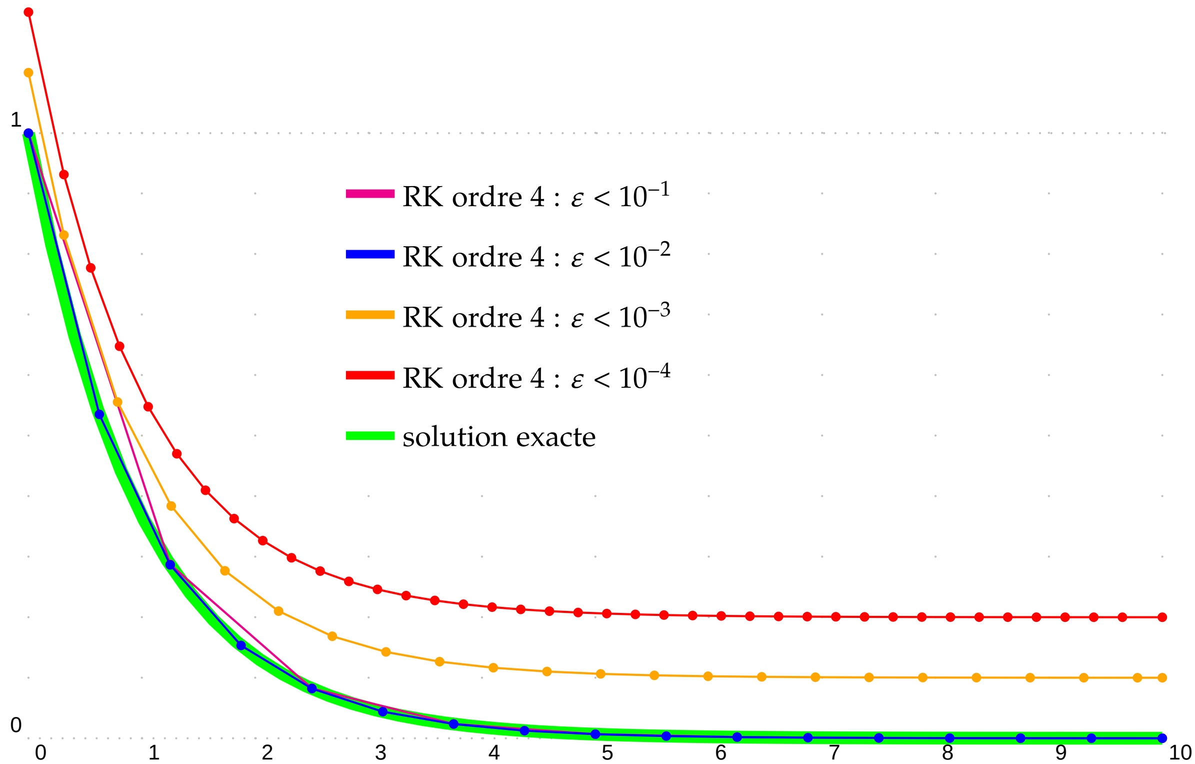


Figure 1: Equation $y' = -y$ with $y_0 = 1$.

```
\def\Funct{neg}\def\FunctAlg{-y[0]}
\psset{xunit=1.5, yunit=8, showpoints=true}
\begin{pspicture}[showgrid=true](0,0)(10,1.2)
  \psplot[linewidth=6\pslinewidth, linecolor=green, showpoints=false
    ]{0}{10}{2.71828182846 x neg exp}
  \psplotDiffEqn[linecolor=magenta, method=varrkiv, varsteptol=.1, plotpoints
    =2]{0}{10}{1}{\Funct}
  \rput(0,.0){\psplotDiffEqn[linecolor=blue, method=varrkiv, varsteptol=.01,
    plotpoints=2]{0}{10}{1}{\Funct}}
  \rput(0,.1){\psplotDiffEqn[linecolor=Orange, method=varrkiv, varsteptol=.001,
    plotpoints=2]{0}{10}{1}{\Funct}}
  \rput(0,.2){\psplotDiffEqn[linecolor=red, method=varrkiv, varsteptol=.0001,
    plotpoints=2]{0}{10}{1}{\Funct}}
  \psset{linewidth=4\pslinewidth,showpoints=false}
  \rput*(3.3,.9){\psline[linecolor=magenta](-.75cm,0)}
  \rput*[l](3.3,.9){\small RK ordre 4 : $\varepsilon<10^{-1}$}
  \rput*(3.3,.8){\psline[linecolor=blue](-.75cm,0)}
  \rput*[l](3.3,.8){\small RK ordre 4 : $\varepsilon<10^{-2}$}
  \rput*(3.3,.7){\psline[linecolor=Orange](-.75cm,0)}
  \rput*[l](3.3,.7){\small RK ordre 4 : $\varepsilon<10^{-3}$}
  \rput*(3.3,.6){\psline[linecolor=red](-.75cm,0)}
  \rput*[l](3.3,.6){\small RK ordre 4 : $\varepsilon<10^{-4}$}
  \rput*(3.3,.5){\psline[linecolor=green](-.75cm,0)}
  \rput*[l](3.3,.5){\small solution exacte}
\end{pspicture}
```

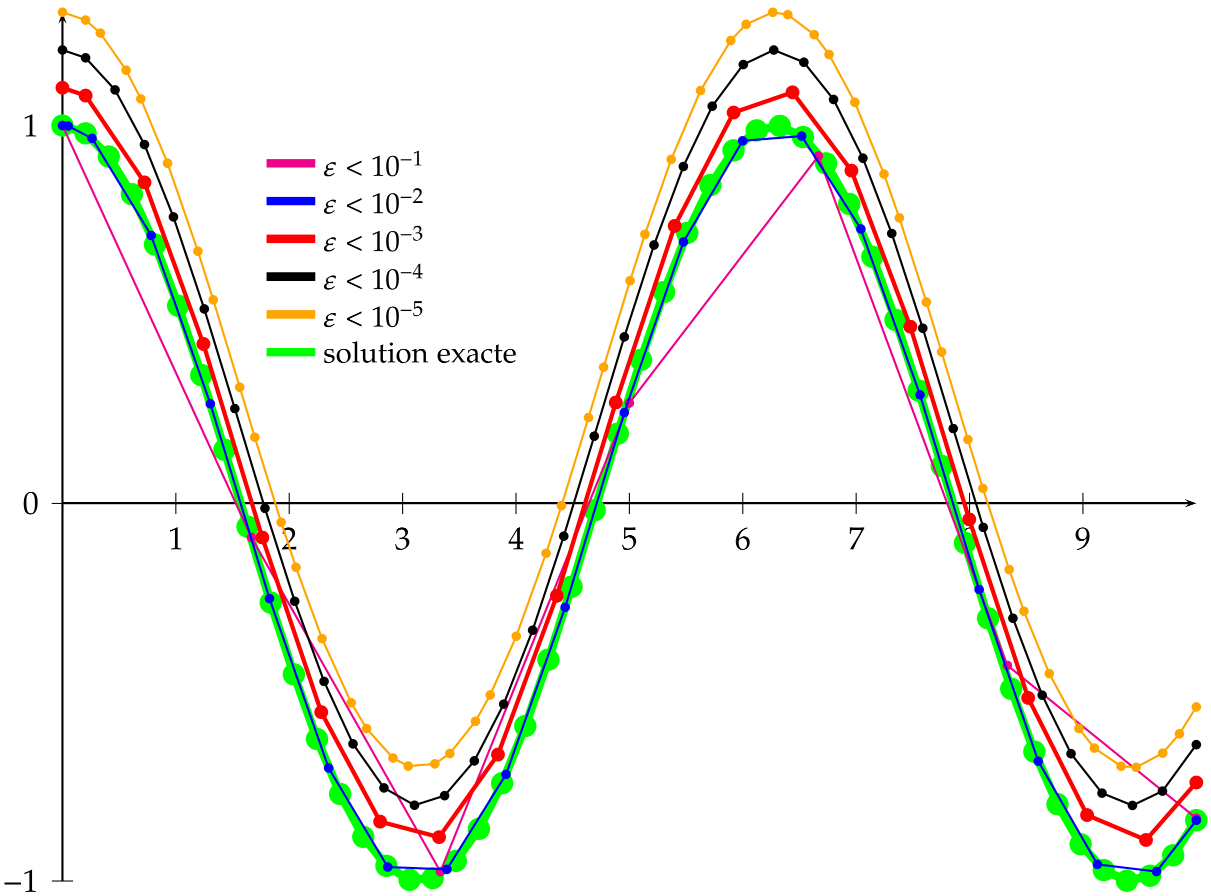


Figure 2: Equation $y'' = -y$

```
\def\Funct{exch neg}
\psset{xunit=1.5, yunit=5, method=varrkiv, showpoints=true}%%
\def\quatrepi{12.5663706144}
\begin{pspicture}(0,-1)(10,1.3)
  \psaxes{->}(0,0)(0,-1)(10,1.3)
  \psplot[linewidth=4\pslinewidth, linecolor=green, algebraic=true]{0}{10}{cos(x)}
  \rput(0,.0){\psplotDiffEqn[linecolor=magenta, plotpoints=7, varsteptol=.1]{0}{10}{1 0}{\Funct}}
  \rput(0,.0){\psplotDiffEqn[linecolor=blue, plotpoints=201, varsteptol=.01]{0}{10}{1 0}{\Funct}}
  \rput(0,.1){\psplotDiffEqn[linewidth=2\pslinewidth, linecolor=red, varsteptol=.001]{0}{10}{1 0}{\Funct}}
  \rput(0,.2){\psplotDiffEqn[linecolor=black, varsteptol=.0001]{0}{10}{1 0}{\Funct}}
  \rput(0,.3){\psplotDiffEqn[linecolor=Orange, varsteptol=.00001]{0}{10}{1 0}{\Funct}}
  \psset{linewidth=4\pslinewidth,showpoints=false}
  \rput*(2.3,.9){\psline[linecolor=magenta](-.75cm,0)}
  \rput*[l](2.3,.9){\small $\varepsilon<10^{-1}$}
  \rput*(2.3,.8){\psline[linecolor=blue](-.75cm,0)}
```

```
  \rput*[l](2.3,.8){\small $\varepsilon<10^{-2}$}
  \rput*(2.3,.7){\psline[linecolor=red](-.75cm,0)}
  \rput*[l](2.3,.7){\small $\varepsilon<10^{-3}$}
  \rput*(2.3,.6){\psline[linecolor=black](-.75cm,0)}
  \rput*[l](2.3,.6){\small $\varepsilon<10^{-4}$}
  \rput*(2.3,.5){\psline[linecolor=Orange](-.75cm,0)}
  \rput*[l](2.3,.5){\small $\varepsilon<10^{-5}$}
  \rput*(2.3,.4){\psline[linecolor=green](-.75cm,0)}
  \rput*[l](2.3,.4){\small solution exacte}
\end{pspicture}
```

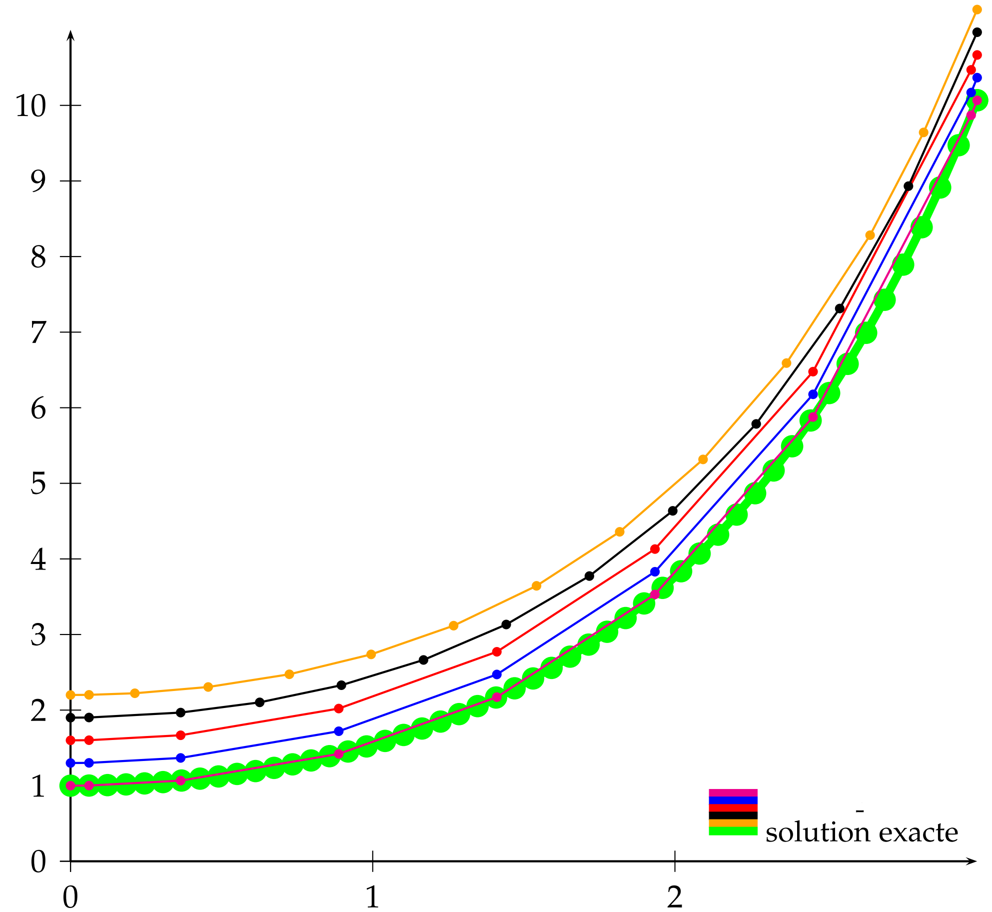


Figure 3: Equation $y'' = y$

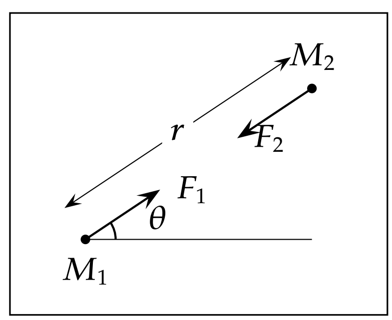
```
\def\Funct{exch}
\psset{xunit=4, yunit=1, method=varrkiv, showpoints=true}%%
\def\quatrepi{12.5663706144}
\begin{pspicture}(0,-0.5)(3,11)
  \psaxes{->}(0,0)(3,11)
  \psplot[linewidth=4\pslinewidth, linecolor=green, algebraic=true]{0}{3}{ch(x)}
  \rput(0,.0){\psplotDiffEqn[linecolor=magenta, varsteptol=.1]{0}{3}{1 0}{\Funct
    }}
  \rput(0,.3){\psplotDiffEqn[linecolor=blue, varsteptol=.01]{0}{3}{1 0}{\Funct}}
```

```
  \rput(0,.6){\psplotDiffEqn[linecolor=red, varsteptol=.001]{0}{3}{1 0}{\Funct}}
  \rput(0,.9){\psplotDiffEqn[linecolor=black, varsteptol=.0001]{0}{3}{1 0}{\
    Funct}}
  \rput(0,1.2){\psplotDiffEqn[linecolor=Orange, varsteptol=.00001]{0}{3}{1 0}{\
    Funct}}
  \psset{linewidth=4\pslinewidth,showpoints=false}
  \rput*(2.3,.9){\psline[linecolor=magenta](-.75cm,0)}
  \rput*[l](2.3,.9){\small $\varepsilon<10^{-1}$}
  \rput*(2.3,.8){\psline[linecolor=blue](-.75cm,0)}
  \rput*[l](2.3,.8){\small $\varepsilon<10^{-2}$}
  \rput*(2.3,.7){\psline[linecolor=red](-.75cm,0)}
  \rput*[l](2.3,.7){\small $\varepsilon<10^{-3}$}
  \rput*(2.3,.6){\psline[linecolor=black](-.75cm,0)}
  \rput*[l](2.3,.6){\small $\varepsilon<10^{-4}$}
  \rput*(2.3,.5){\psline[linecolor=Orange](-.75cm,0)}
  \rput*[l](2.3,.5){\small $\varepsilon<10^{-5}$}
  \rput*(2.3,.4){\psline[linecolor=green](-.75cm,0)}
  \rput*[l](2.3,.4){\small solution exacte}
\end{pspicture}
```

28.2 Equation of second order

Here is the traditionnal simulation of two stars attracting each other according to the classical gravitation law in $\frac{1}{r^2}$. In 2-Dimensions, the system to be solved is composed of four second order differential equations. In order to be described, each of them gives two first order equations, then we obtain a 8 sized vectorial equation. In the following example the masses of the stars are 1 and 20.

$$\left\{\begin{aligned} x_1'' &= \frac{M_2}{r^2}\cos(\theta) \\ y_1'' &= \frac{M_2}{r^2}\sin(\theta) \\ x_2'' &= \frac{M_1}{r^2}\cos(\theta) \\ y_2'' &= \frac{M_1}{r^2}\sin(\theta) \end{aligned}\right. \quad \text{avec} \quad \left\{\begin{aligned} r^2 &= (x_1-x_2)^2+(y_1-y_2)^2 \\ \cos(\theta) &= \frac{(x_1-x_2)}{r} \\ \sin(\theta) &= \frac{(y_1-y_2)}{r} \end{aligned}\right.$$

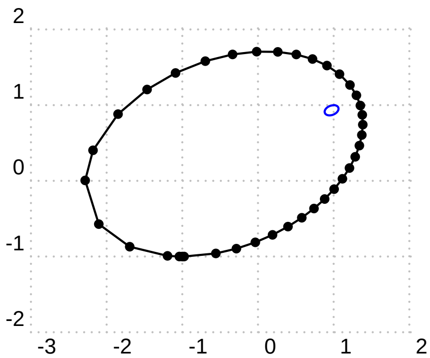


```
                                                                     %% x1 y1 x'1 y'1 x2 y2 x'2 y'2
/yp2 exch def /xp2 exch def /ay2 exch def /ax2 exch def %% mise en variables
/yp1 exch def /xp1 exch def /ay1 exch def /ax1 exch def %% mise en variables
/ro2 ax2 ax1 sub dup mul ay2 ay1 sub dup mul add def    %% calcul de r*r
xp1 yp1                                                 %%
ax2 ax1 sub ro2 sqrt div ro2 div                        %% calcul de x"1
ay2 ay1 sub ro2 sqrt div ro2 div                        %% calcul de y"1
xp2 yp2                                                 %%
3 index -20 mul                                         %% calcul de x"2=-20x"1
3 index -20 mul                                         %% calcul de y"2=-20y"1
```

Table 3: PostScript source code for the gravitational interaction

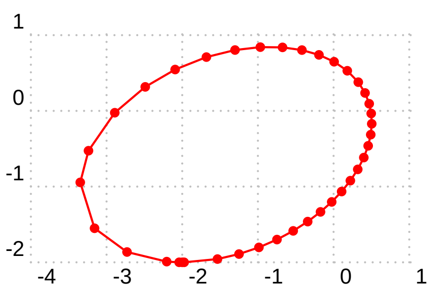
```
y[2]|                                               %% y'[0]
y[3]|                                               %% y'[1]
(y[4]-y[0])/((y[4]-y[0])^2+(y[5]-y[1])^2)^1.5|     %% y'[2]=y"[0]
(y[5]-y[1])/((y[4]-y[0])^2+(y[5]-y[1])^2)^1.5|     %% y'[3]=y"[1]
y[6]|                                               %% y'[4]
y[7]|                                               %% y'[5]
20*(y[0]-y[4])/((y[4]-y[0])^2+(y[5]-y[1])^2)^1.5| %% y'[6]=y"[4]
20*(y[1]-y[5])/((y[4]-y[0])^2+(y[5]-y[1])^2)^1.5  %% y'[7]=y"[5]
```

Table 4: Algebraic description for the gravitational interaction




```
\def\InitCond{ 1 1 .1 0 -1 -1 -2 0}
\begin{pspicture}[shift=-2,showgrid=true](-3,-1.75)(2,1.5)
  \psplotDiffEqn[whichabs=0, whichord=1, linecolor=blue, method=
    rk4, plotpoints=100]{0}{3.95}{\InitCond}{\Grav}
  \psset{showpoints=true,whichabs=4, whichord=5}
  \psplotDiffEqn[linecolor=black, method=varrkiv, varsteptol
    =.0001, plotpoints=200]{0}{3.9}{\InitCond}{\Grav}
\end{pspicture}
```

Figure 4: Gravitational interaction : fixed landmark, trajectory of the stars




```
\def\InitCond{ 1 1 .1 0 -1 -1 -2 0}
\begin{pspicture}[shift=-1.5,showgrid=true](-4,-1.75)(1,1)
  \psplotDiffEqn[linecolor=red, plotpoints=200,method=varrkiv,
    varsteptol=.0001, showpoints=true,
     plotfuncx=y dup 4 get exch 0 get sub,
     plotfuncy=dup 5 get exch 1 get sub ]{0}{3.9}{\InitCond}{\
       Grav}
\end{pspicture}
```

Figure 5: Gravitational interaction : landmark defined by one star

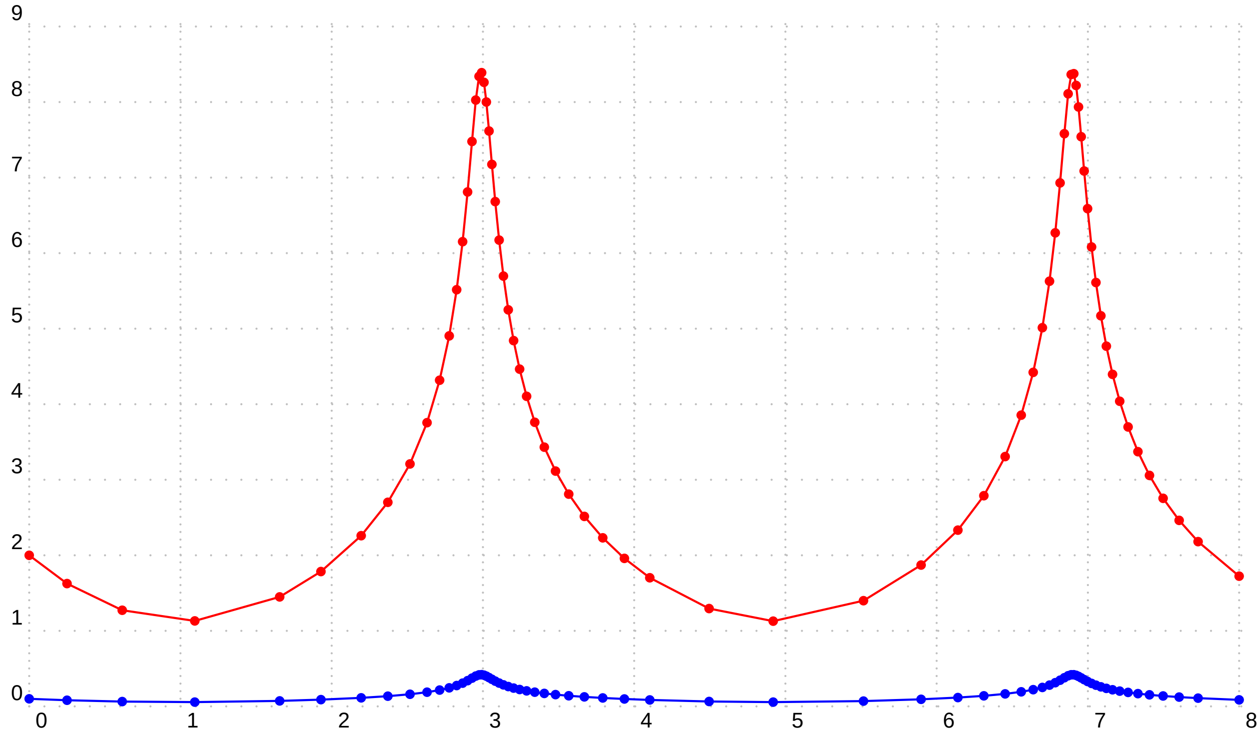
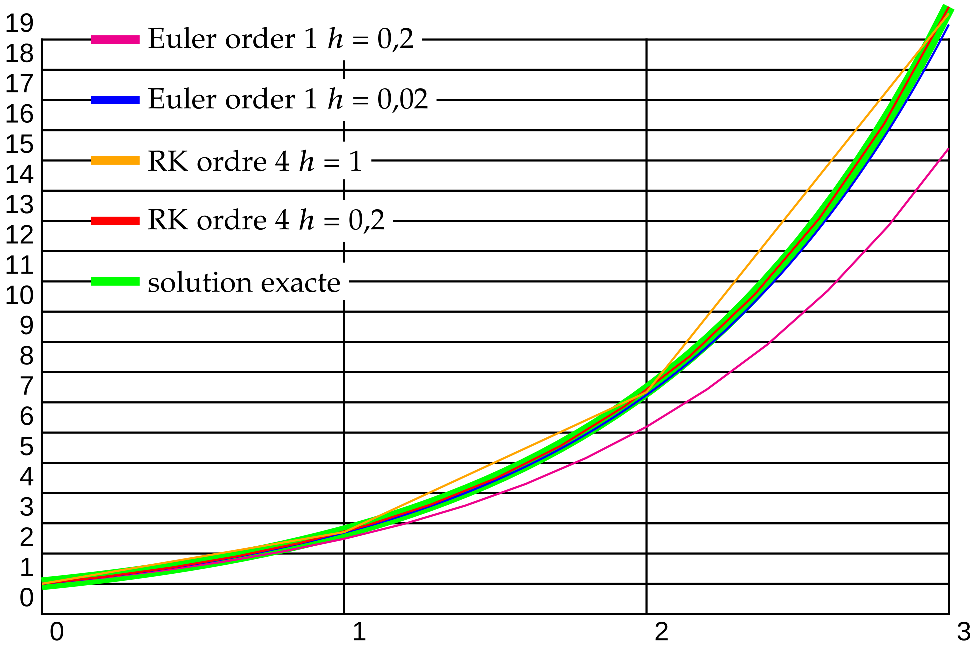


Figure 6: Gravitational interaction : vitessesspeed of the stars

```
\psset{xunit=2}
\begin{pspicture}[showgrid=true](0,0)(8,9)
  \psset{showpoints=true}
  \psplotDiffEqn[linecolor=red, method=varrkiv, plotpoints=2, varsteptol=.0001,
      plotfuncy=dup 6 get dup mul exch 7 get dup mul add sqrt]{0}{8}{\InitCond
        }{\Grav}
  \psplotDiffEqn[linecolor=blue, method=varrkiv, plotpoints=2, varsteptol=.0001,
      plotfuncy=dup 2 get dup mul exch 3 get dup mul add sqrt]{0}{8}{\InitCond
        }{\Grav}
\end{pspicture}
```

28.2.1 Simple equation of first order $y' = y$

For the initial value $y(0) = 1$ we have the solution $y(x) = e^x$. y is always on the stack, so we have to do nothing. Using the `algebraic` option, we write it as `y[0]`. The following example shows different solutions depending to the number of plotpoints with $y_0 = 1$:




```
\psset{xunit=4, yunit=.4}
\begin{pspicture}(3,19)\psgrid[subgriddiv=1]
  \psplot[linewidth=6\pslinewidth, linecolor=green]{0}{3}{Euler x exp}
  \psplotDiffEqn[linecolor=magenta,plotpoints=16,algebraic=true]{0}{3}{1}{y[0]}
  \psplotDiffEqn[linecolor=blue,plotpoints=151]{0}{3}{1}{}
  \psplotDiffEqn[linecolor=red,method=rk4,plotpoints=15]{0}{3}{1}{}
  \psplotDiffEqn[linecolor=Orange,method=rk4,plotpoints=4]{0}{3}{1}{}
  \psset{linewidth=4\pslinewidth}
  \rput*(0.35,19){\psline[linecolor=magenta](-.75cm,0)}
  \rput*[l](0.35,19){\small Euler order 1 $h=0{,}2$}
  \rput*(0.35,17){\psline[linecolor=blue](-.75cm,0)}
  \rput*[l](0.35,17){\small Euler order 1 $h=0{,}02$}
  \rput*(0.35,15){\psline[linecolor=Orange](-.75cm,0)}
  \rput*[l](0.35,15){\small RK ordre 4 $h=1$}
  \rput*(0.35,13){\psline[linecolor=red](-.75cm,0)}
  \rput*[l](0.35,13){\small RK ordre 4 $h=0{,}2$}
  \rput*(0.35,11){\psline[linecolor=green](-.75cm,0)}
  \rput*[l](0.35,11){\small solution exacte}
\end{pspicture}
```

28.2.2 $y' = \dfrac{2-ty}{4-t^2}$

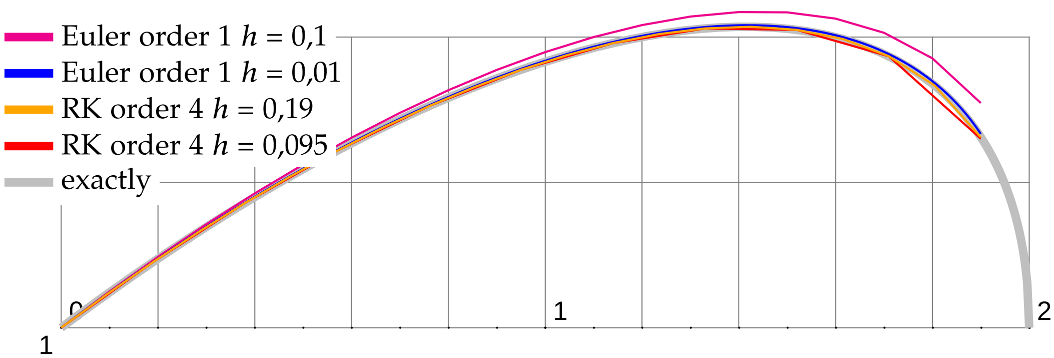
For the initial value $y(0) = 1$ the exact solution is $y(x) = \dfrac{t+\sqrt{4-t^2}}{2}$. The function f described in PostScript code is like (y ist still on the stack):

```
x               %% y x
mul             %% x*y
2 exch sub      %% 2-x*y
```

```
4 x dup mul     %% 2-x*y 4 x^2
sub             %% 2-x*y 4-x^2
div             %% (2-x*y)/(4-x^2)
```

The following example uses $y_0 = 1$.

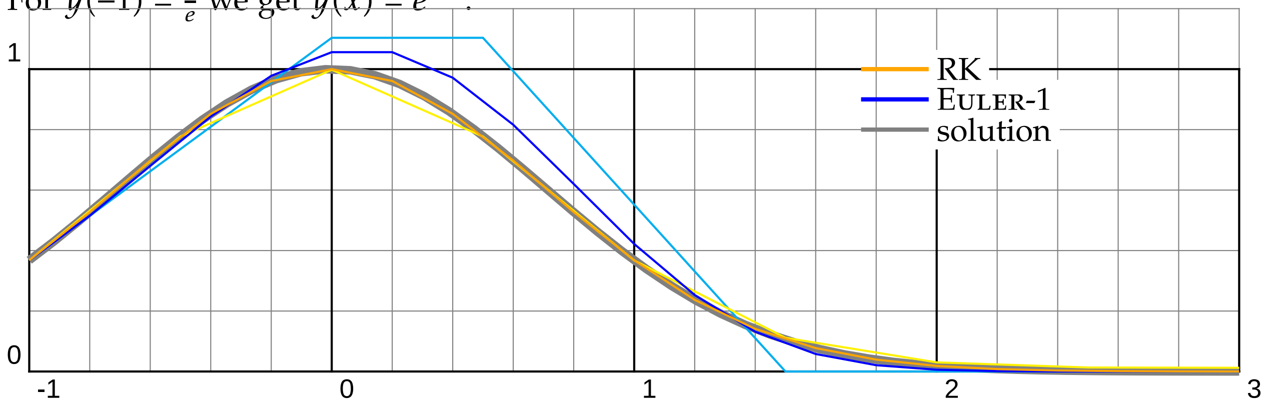
```
\newcommand{\InitCond}{1}
\newcommand{\Func}{x mul 2 exch sub 4 x dup mul sub div}
\newcommand{\FuncAlg}{(2-x*y[0])/(4-x^2)}
```




```
\psset{xunit=6.4, yunit=9.6, showpoints=false}
\begin{pspicture}(0,1)(2,1.7)  \psgrid[subgriddiv=5]
  { \psset{linewidth=4\pslinewidth,linecolor=lightgray}
  \psplot{0}{1.8}{x dup dup mul 4 exch sub sqrt add 2 div}
  \psplot{1.8}{2}{x dup dup mul 4 exch sub sqrt add 2 div} }
  \def\InitCond{1}
  \def\Func{x mul 2 exch sub 4 x dup mul sub div}
  \psplotDiffEqn[linecolor=magenta, plotpoints=20]{0}{1.9}{\InitCond}{\Func}
  \psplotDiffEqn[linecolor=blue, plotpoints=191]{0}{1.9}{\InitCond}{\Func}
  \psplotDiffEqn[linecolor=red, method=rk4, plotpoints=11,%
     algebraic=true]{0}{1.9}{\InitCond}{(2-x*y[0])/(4-x^2)}
  \psplotDiffEqn[linecolor=Orange, method=rk4, plotpoints=21,%
     algebraic=true]{0}{1.9}{\InitCond}{(2-x*y[0])/(4-x^2)}
  \psset{linewidth=4\pslinewidth}
  \rput*(0.3,1.6){\psline[linecolor=magenta](-.75cm,0)}\rput*[l](0.3,1.6){\small Euler order 1 $h=0{,}1$}
  \rput*(0.3,1.55){\psline[linecolor=blue](-.75cm,0)}\rput*[l](0.3,1.55){\small Euler order 1 $h=0{,}01$}
  \rput*(0.3,1.5){\psline[linecolor=Orange](-.75cm,0)}\rput*[l](0.3,1.5){\small RK order 4 $h=0{,}19$}
  \rput*(0.3,1.45){\psline[linecolor=red](-.75cm,0)}\rput*[l](0.3,1.45){\small RK order 4 $h=0{,}095$}
  \rput*(0.3,1.4){\psline[linecolor=lightgray](-.75cm,0)}\rput*[l](0.3,1.4){\small exactly}
\end{pspicture}
```

28.2.3 $y' = -2xy$

For $y(-1) = \frac{1}{e}$ we get $y(x) = e^{-x^2}$.




```
\psset{unit=4}
\begin{pspicture}(-1,0)(3,1.1)\psgrid
  \psplot[linewidth=4\pslinewidth,linecolor=gray]{-1}{3}{Euler x dup mul neg exp }
  \psset{plotpoints=9}
  \psplotDiffEqn[linecolor=cyan]{-1}{3}{1 Euler div}{x -2 mul mul}
  \psplotDiffEqn[linecolor=yellow, method=rk4]{-1}{3}{1 Euler div}{x -2 mul mul}
  \psset{plotpoints=21}
  \psplotDiffEqn[linecolor=blue]{-1}{3}{1 Euler div}{x -2 mul mul}
  \psplotDiffEqn[linecolor=Orange, method=rk4]{-1}{3}{1 Euler div}{x -2 mul mul}
  \psset{linewidth=2\pslinewidth}
  \rput*(2,1){\psline[linecolor=Orange](-0.25,0)}
  \rput*[l](2,1){RK}
  \rput*(2,.9){\psline[linecolor=blue](-0.25,0)}
  \rput*[l](2,.9){\textsc{Euler}-1}
  \rput*(2,.8){\psline[linecolor=gray](-0.25,0)}
  \rput*[l](2,.8){solution}
\end{pspicture}
```

28.2.4 Spirale of Cornu

The integrals of Fresnel :

$$x = \int_0^t \cos \frac{\pi t^2}{2} \mathrm{d}t \tag{2}$$

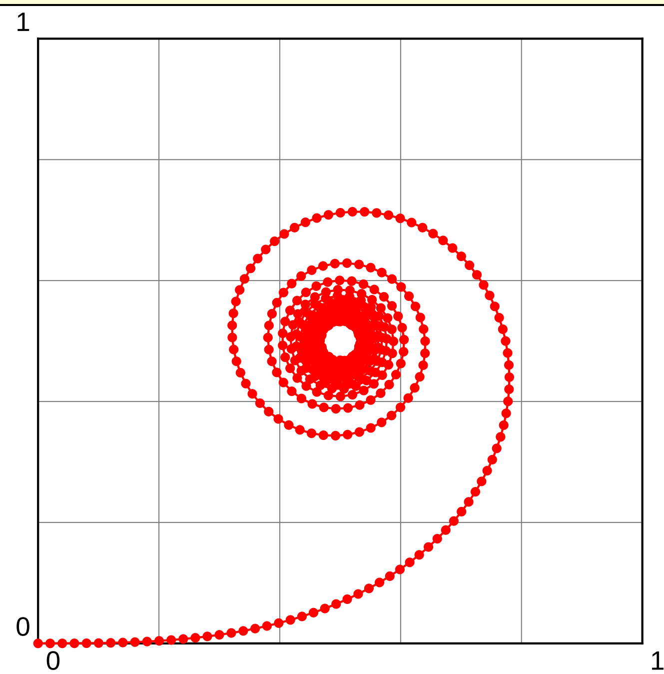
$$y = \int_0^t \sin \frac{\pi t^2}{2} \mathrm{d}t \tag{3}$$

with

$$\dot{x} = \cos\frac{\pi t^2}{2} \tag{4}$$

$$\dot{y} = \sin\frac{\pi t^2}{2} \tag{5}$$

```
\psset{unit=8}
\begin{pspicture}(1,1)\psgrid[subgriddiv=5]
  \psplotDiffEqn[whichabs=0,whichord=1,linecolor=red,method=rk4,algebraic,%
     plotpoints=500,showpoints=true]{0}{10}{0 0}{cos(Pi*x^2/2)|sin(Pi*x^2/2)}
\end{pspicture}
```



28.2.5 Lotka-Volterra

The Lotka-Volterra model describes interactions between two species in an ecosystem, a predator and a prey. This represents our first multi-species model. Since we are considering two species, the model will involve two equations, one which describes how the prey population changes and the second which describes how the predator population changes.

For concreteness let us assume that the prey in our model are rabbits, and that the predators are foxes. If we let $R(t)$ and $F(t)$ represent the number of rabbits and foxes, respectively, that are alive at time t, then the Lotka-Volterra model is:

$$\dot{R} = a \cdot R - b \cdot R \cdot F \tag{6}$$

$$\dot{F} = e \cdot b \cdot R \cdot F - c \cdot F \tag{7}$$

where the parameters are defined by:

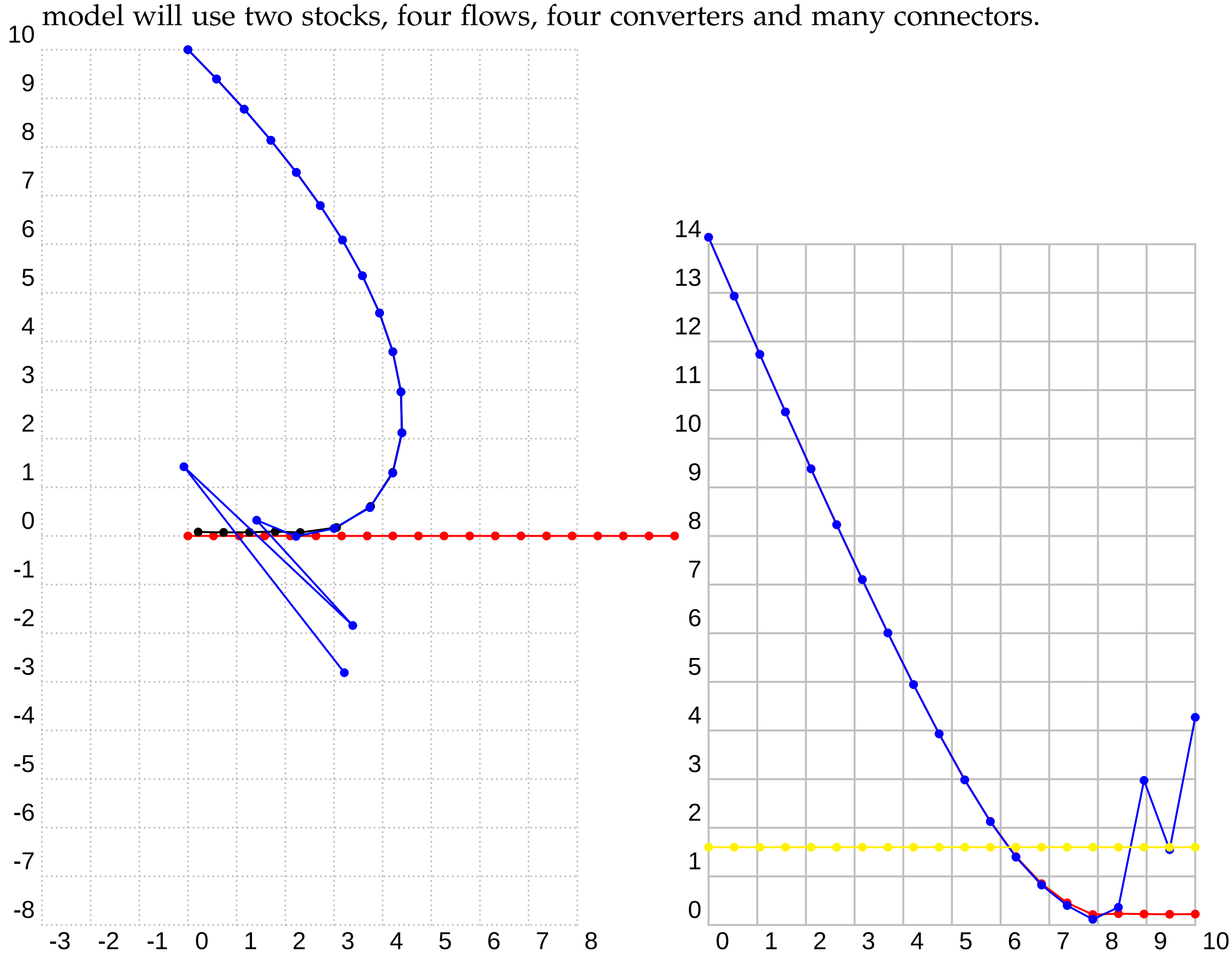
a is the natural growth rate of rabbits in the absence of predation,

c is the natural death rate of foxes in the absence of food (rabbits),

b is the death rate per encounter of rabbits due to predation,

e is the efficiency of turning predated rabbits into foxes.

The Stella model representing the Lotka-Volterra model will be slightly more complex than the single species models we've dealt with before. The main difference is that our model will have two stocks (reservoirs), one for each species. Each species will have its own birth and death rates. In addition, the Lotka-Volterra model involves four parameters rather than two. All told, the Stella representation of the Lotka-Volterra model will use two stocks, four flows, four converters and many connectors.

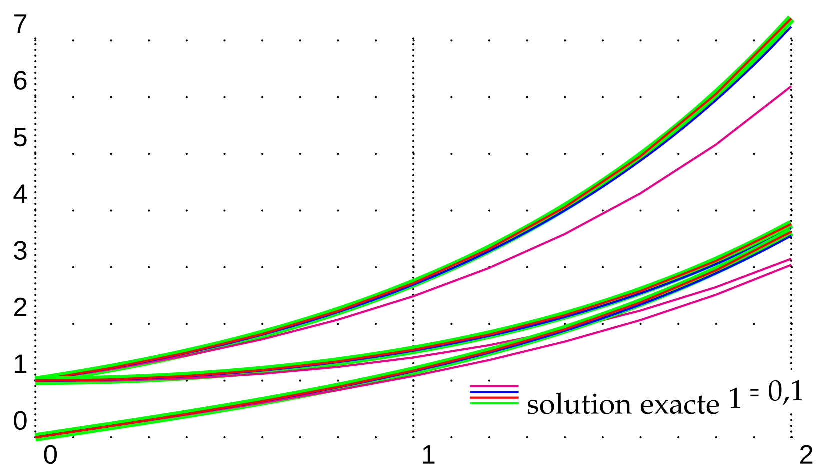



```
\def\InitCond{ 0 10 10}%% xa ya xl
\def\Faiglelapin{\Vaigle*(y[2]-y[0])/sqrt(y[1]^2+(y[2]-y[0])^2)|%
                  -\Vaigle*y[1]/sqrt(y[1]^2+(y[2]-y[0])^2)|%
                  -\Vlapin}
\def\Vlapin{1}  \def\Vaigle{1.6}
\psset{unit=.7,subgriddiv=0,gridcolor=lightgray,method=adams,algebraic,%
```

```
  plotpoints=20,showpoints=true}
\begin{pspicture}(-3,-8)(5,10)\psgrid[griddots=10]
 \psplotDiffEqn[plotfuncy=pop 0,whichabs=2,linecolor=red]{0}{10}{\InitCond}{\Faiglelapin}
 \psplotDiffEqn[whichabs=0,whichord=1,linecolor=black,method=rk4]{0}{10}{\InitCond}{\Faiglelapin}
  \psplotDiffEqn[whichabs=0,whichord=1,linecolor=blue]{0}{10}{\InitCond}{\Faiglelapin}
\end{pspicture}\hfill
\begin{pspicture}(10,12)\psgrid
 \psplotDiffEqn[plotfuncy=dup 1 get dup mul exch dup 0 get exch 2 get sub dup
    mul add sqrt,linecolor=red,method=rk4]{0}{10}{\InitCond}{\Faiglelapin}
 \psplotDiffEqn[plotfuncy=dup 1 get dup mul exch dup 0 get exch 2 get sub dup
    mul add sqrt,linecolor=blue]{0}{10}{\InitCond}{\Faiglelapin}
 \psplotDiffEqn[plotfuncy=pop Func aload pop pop dup mul exch dup mul add sqrt,
    linecolor=yellow]{0}{10}{\InitCond}{\Faiglelapin}
\end{pspicture}
```

28.2.6 $y'' = y$

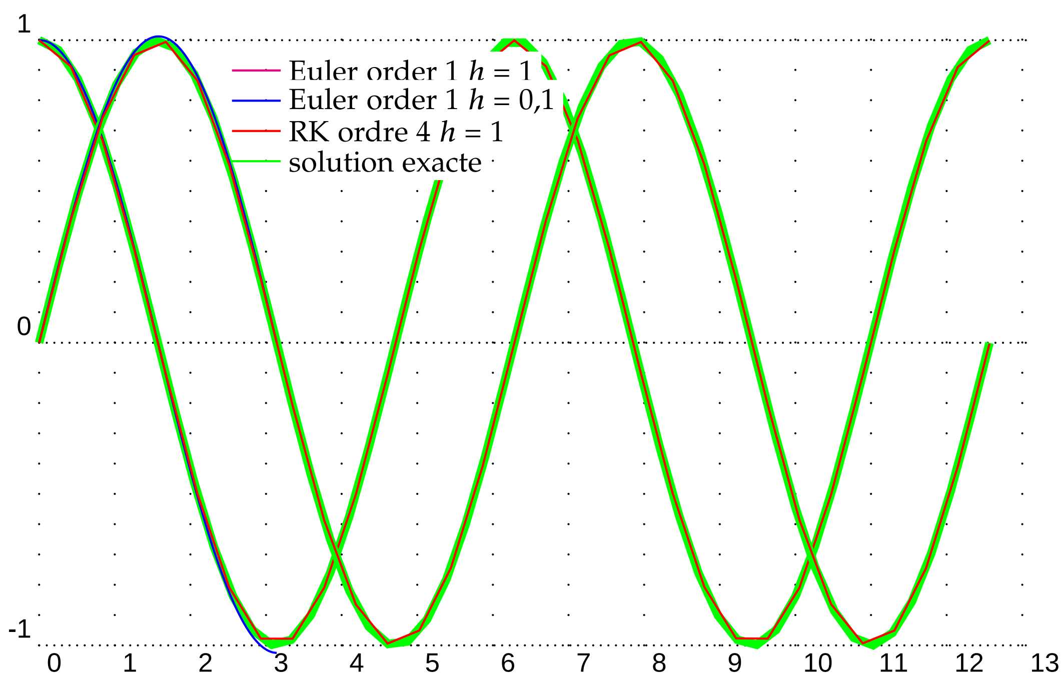
Beginning with the initial equation $y(x) = Ae^{x} + Be^{-x}$ we get the hyperbolic trigonometrical functions.




```
\def\Funct{exch}   \psset{xunit=5cm, yunit=0.75cm}
\begin{pspicture}(0,-0.25)(2,7)\psgrid[subgriddiv=1,griddots=10]
 \psplot[linewidth=4\pslinewidth, linecolor=green]{0}{2}{Euler x exp}  %%e^x
 \psplotDiffEqn[linecolor=magenta, plotpoints=11]{0}{2}{1 1}{\Funct}
 \psplotDiffEqn[linecolor=blue, plotpoints=101]{0}{2}{1 1}{\Funct}
 \psplotDiffEqn[linecolor=red, method=rk4, plotpoints=11]{0}{2}{1 1}{\Funct}
 \psplot[linewidth=4\pslinewidth, linecolor=green]{0}{2}{Euler dup x exp  %%ch(x)
    exch x neg exp add 2 div}
 \psplotDiffEqn[linecolor=magenta, plotpoints=11]{0}{2}{1 0}{\Funct}
 \psplotDiffEqn[linecolor=blue, plotpoints=101]{0}{2}{1 0}{\Funct}
```

```
 \psplotDiffEqn[linecolor=red, method=rk4, plotpoints=11]{0}{2}{1 0}{\Funct}
 \psplot[linewidth=4\pslinewidth, linecolor=green]{0}{2}{Euler dup x exp
    exch x neg exp sub 2 div}  %%sh(x)
 \psplotDiffEqn[linecolor=magenta, plotpoints=11]{0}{2}{0 1}{\Funct}
 \psplotDiffEqn[linecolor=blue, plotpoints=101]{0}{2}{0 1}{\Funct}
 \psplotDiffEqn[linecolor=red, method=rk4, plotpoints=11]{0}{2}{0 1}{\Funct}
 \rput*(1.3,.9){\psline[linecolor=magenta](-.75cm,0)}\rput*[l](1.3,.9){\small\textsc{Euler} ordre 1 $h=1$}
 \rput*(1.3,.8){\psline[linecolor=blue](-.75cm,0)}\rput*[l](1.3,.8){\small\textsc{Euler} ordre 1 $h=0{,}1$}
 \rput*(1.3,.7){\psline[linecolor=red](-.75cm,0)}\rput*[l](1.3,.7){\small RK ordre 4 $h=1$}
 \rput*(1.3,.6){\psline[linecolor=green](-.75cm,0)}\rput*[l](1.3,.6){\small solution exacte}
\end{pspicture}
```

28.2.7 $y'' = -y$




```
\def\Funct{exch neg}
\psset{xunit=1, yunit=4}
\def\quatrepi{12.5663706144}%%4pi=12.5663706144
\begin{pspicture}(0,-1.25)(\quatrepi,1.25)\psgrid[subgriddiv=1,griddots=10]
 \psplot[linewidth=4\pslinewidth,linecolor=green]{0}{\quatrepi}{x RadtoDeg cos }%%cos(x)
```

```
 \psplotDiffEqn[linecolor=blue, plotpoints=201]{0}{3.1415926}{1 0}{\Funct}
 \psplotDiffEqn[linecolor=red, method=rk4, plotpoints=31]{0}{\quatrepi}{1 0}{\Funct}
 \psplot[linewidth=4\pslinewidth,linecolor=green]{0}{\quatrepi}{x RadtoDeg sin} %%sin(x)
 \psplotDiffEqn[linecolor=blue,plotpoints=201]{0}{3.1415926}{0 1}{\Funct}
 \psplotDiffEqn[linecolor=red,method=rk4, plotpoints=31]{0}{\quatrepi}{0 1}{\Funct}
 \rput*(3.3,.9){\psline[linecolor=magenta](-.75cm,0)}\rput*[l](3.3,.9){\small Euler order 1 $h=1$}
 \rput*(3.3,.8){\psline[linecolor=blue](-.75cm,0)}\rput*[l](3.3,.8){\small Euler order 1 $h=0{,}1$}
 \rput*(3.3,.7){\psline[linecolor=red](-.75cm,0)}\rput*[l](3.3,.7){\small RK ordre 4 $h=1$}
 \rput*(3.3,.6){\psline[linecolor=green](-.75cm,0)}\rput*[l](3.3,.6){\small solution exacte}
\end{pspicture}
```

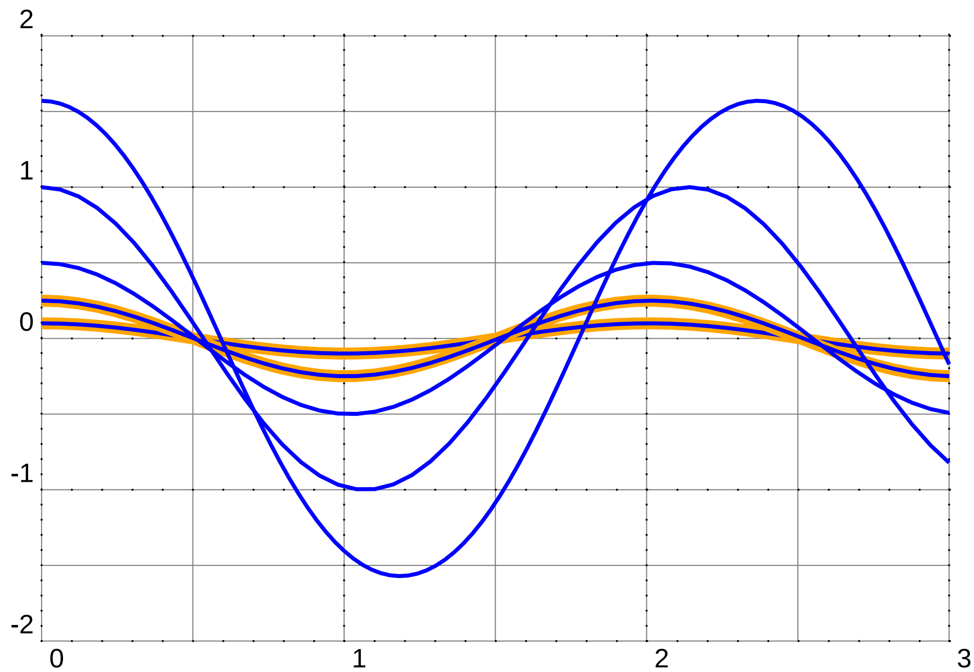
28.2.8 The mechanical pendulum: $y'' = -\frac{g}{l}\sin(y)$

Pour des faibles oscillations $\sin(y) \simeq y$:

$$y(x) = y_0 \cos\left(\sqrt{\frac{g}{l}}x\right)$$

The function f is writen in PostScript code:

```
exch RadtoDeg sin -9.8 mul %% y' -gsin(y)
```

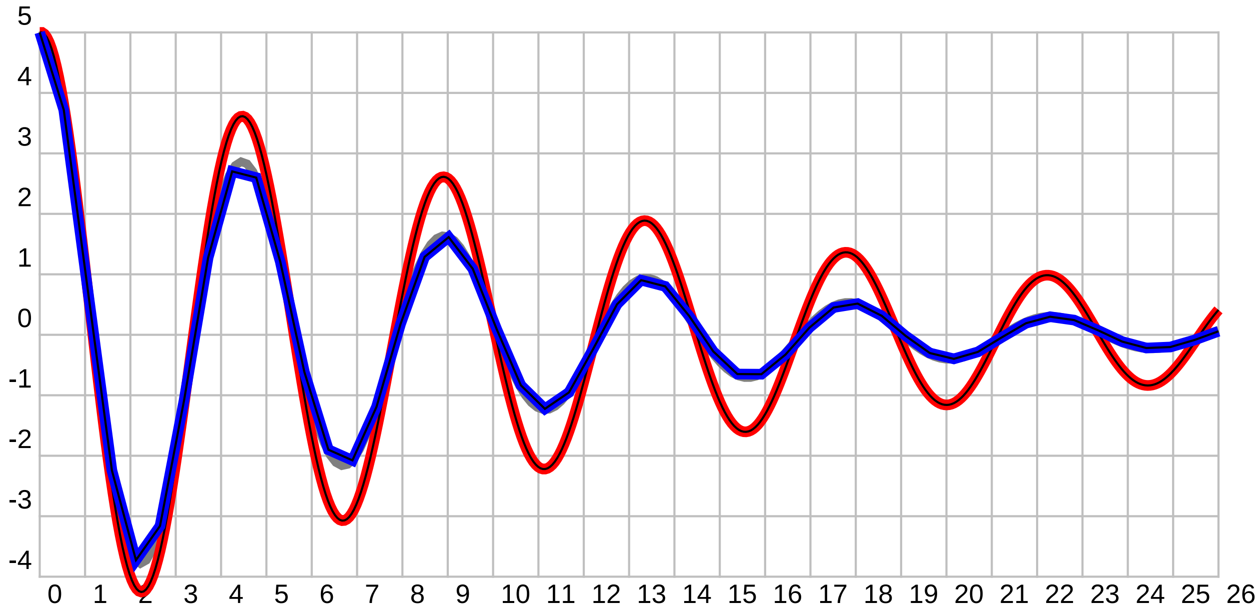



```
\def\Func{y[1]|-9.8*sin(y[0])}
\psset{yunit=2,xunit=4,algebraic=true,linewidth=1.5pt}
\begin{pspicture}(0,-2.25)(3,2.25)\psgrid[subgriddiv=2,griddots=10]
  \psplot[linewidth=3\pslinewidth, linecolor=Orange]{0}{3}{.1*cos(sqrt(9.8)*x)}
  \psset{method=rk4,plotpoints=50,linecolor=blue}
  \psplotDiffEqn{0}{3}{.1 0}{\Func}
  \psplot[linewidth=3\pslinewidth,linecolor=Orange]{0}{3}{.25*cos(sqrt(9.8)*x)}
  \psplotDiffEqn{0}{3}{.25 0}{\Func}
  \psplotDiffEqn{0}{3}{.5 0}{\Func}
  \psplotDiffEqn{0}{3}{1 0}{\Func}
  \psplotDiffEqn[plotpoints=100]{0}{3}{Pi 2 div 0}{\Func}
\end{pspicture}
```

28.2.9 $y'' = -\frac{y'}{4} - 2y$

Pour $y_0 = 5$ et $y'_0 = 0$ la solution est :

$$5e^{-\frac{x}{8}} \left(\cos(\omega x) + \frac{\sin(\omega x)}{8\omega} \right) \text{ avec } \omega = \frac{\sqrt{127}}{8}$$




```
\psset{xunit=.6,yunit=0.8,plotpoints=500}
\begin{pspicture}(0,-4.25)(26,5.25)
  \psgrid[subgriddiv=0,gridcolor=lightgray,linewidth=1.5pt]
  \psplot[plotpoints=200,linewidth=4\pslinewidth,linecolor=gray]{0}{26}{%
     Euler x -8 div exp x 127 sqrt 8 div mul RadtoDeg dup cos 5 mul exch sin 127
        sqrt div 5 mul add mul}
  \psplotDiffEqn[linecolor=red,linewidth=5\pslinewidth]{0}{26}{5 0}
     {dup 3 1 roll -4 div exch 2 mul sub}
  \psplotDiffEqn[linecolor=black,algebraic]{0}{26}{5 0} {y[1]|-y[1]/4-2*y[0]}
  \psset{method=rk4, plotpoints=50}
  \psplotDiffEqn[linecolor=blue,linewidth=5\pslinewidth]{0}{26}{5 0}{%
      dup 3 1 roll -4 div exch 2 mul sub}
  \psplotDiffEqn[linecolor=black,algebraic=true]{0}{26}{5 0}{y[1]|-y[1]/4-2*y
    [0]}
\end{pspicture}
```

28.3 \psMatrixPlot

This macro allows to visualize a matrix. The datafile must be defined as a PostScript matrix named `/dotmatrix`:

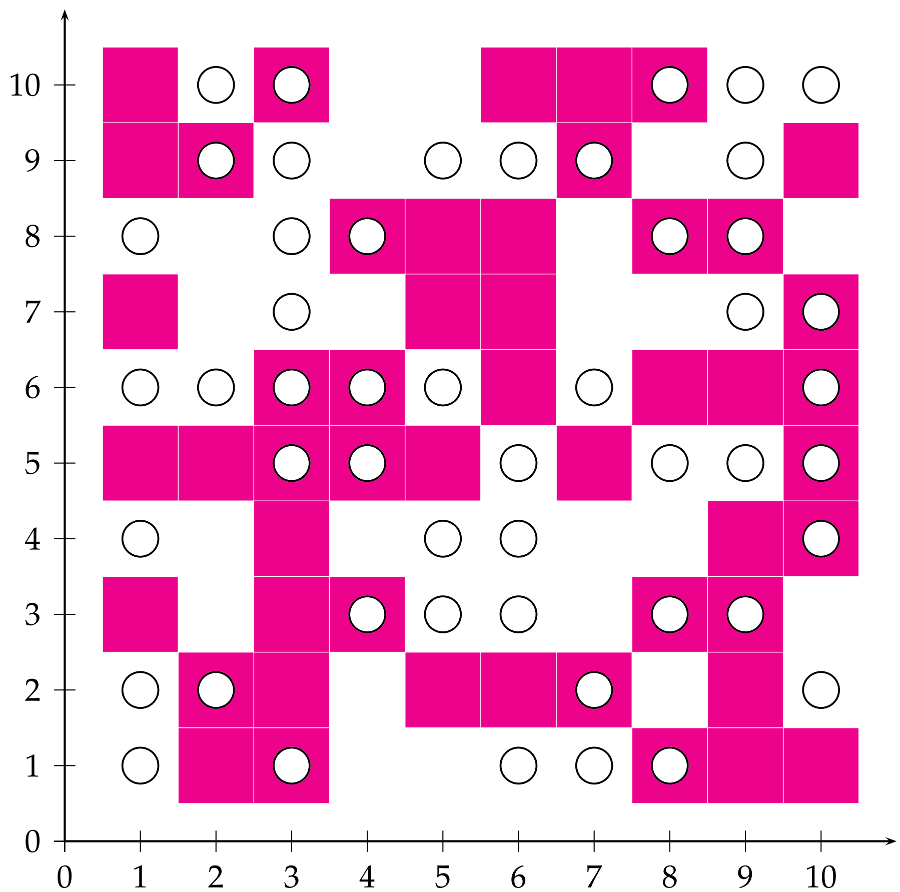
```
/dotmatrix [ %  <------------ important line
0  1  1  0  0  0  0  1  1  1
0  1  1  0  1  1  1  0  1  0
1  0  1  1  0  0  0  1  1  0
0  0  1  0  0  0  0  0  1  1
1  1  1  1  1  0  1  0  0  1
0  0  1  1  0  1  0  1  1  1
1  0  0  0  1  1  0  0  0  1
0  0  0  1  1  1  0  1  1  0
```

```
1  1  0  0  0  0  1  0  0  1
1  0  1  0  0  1  1  1  0  0
] def        %  <------------ important line
```

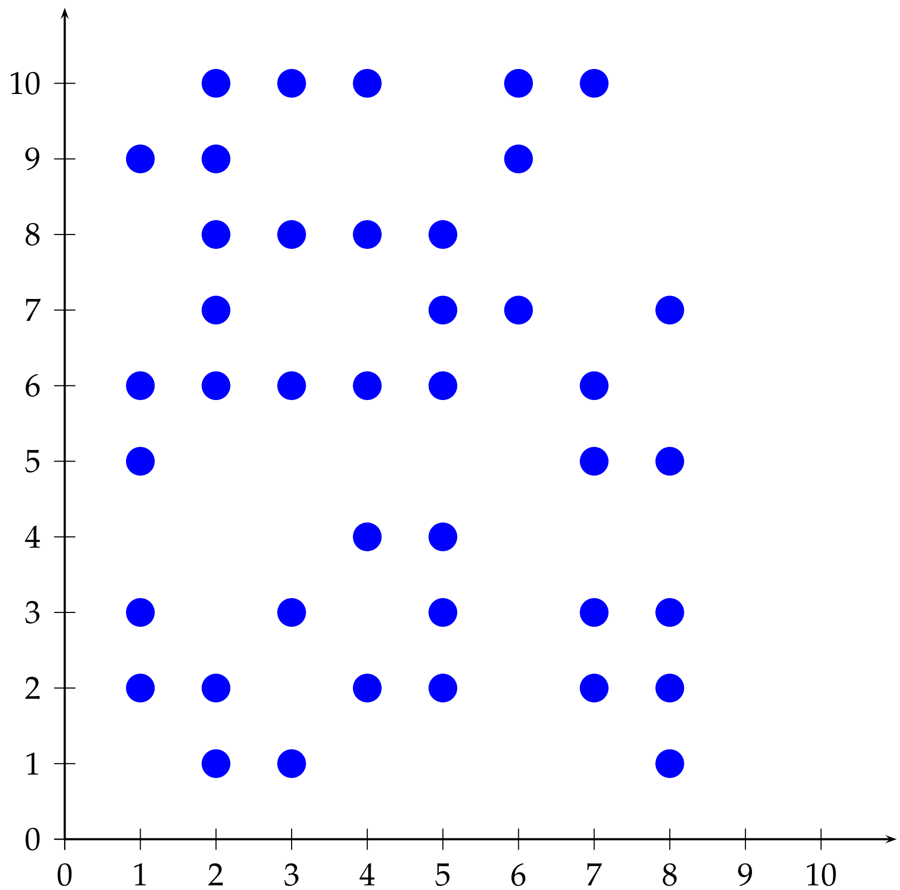
Important is only the value 0, in this case there happens nothing and for all other cases a dot is printed. The syntax of the macro is:

`\psMatrixPlot[options]{rows}{columns}{data file}`

The matrix is scanned line by line from the the first one to the last. In general it looks vice versa than the above listed matrix, the first row 0 1 1 0 0 0 0 1 1 1 is the first plotted line ($y = 1$). With the option `ChangeOrder=true` it looks exactly like the above view.




```
\begin{pspicture}(-0.5,-0.75)(11,11)
  \psaxes{->}(11,11)
  \psMatrixPlot[dotsize=1.1cm,dotstyle=square*,linecolor=magenta]%
    {10}{10}{matrix.dat}
  \psMatrixPlot[dotsize=.5cm,dotstyle=o,ChangeOrder]{10}{10}{matrix.dat}
\end{pspicture}
```




```
\begin{pspicture}(-0.5,-0.75)(11,11)
  \psaxes{->}(11,11)
  \psMatrixPlot[dotscale=3,dotstyle=*,linecolor=blue]{10}{8}{matrix.dat}
\end{pspicture}
```

28.4 PostScript

PostScript uses the stack system and the LIFO system, "'Last In, First Out"'.

29 \resetOptions

Sometimes it is difficult to know what options, which are changed inside a long document, are different to the default one. With this macro all options depending to `pst-plot` can be reset. This depends to all options of the packages `pstricks`, `pst-plot` and `pst-node`.

Function	Meaning on stack before $\to$ after
`add`	$x \quad y \to x + y$
`sub`	$x \quad y \to x - y$
`mul`	$x \quad y \to x \times y$
`div`	$x \quad y \to x \div y$
`sqrt`	$x \to \sqrt{x}$
`abs`	$x \to \|x\|$
`neg`	$x \to -x$
`cos`	$x \to \cos(x)$ (`x in degrees`)
`sin`	$x \to \sin(x)$ (`x in degrees`)
`tan`	$x \to \tan(x)$ (`x in degrees`)
`atan`	$y \quad x \to \angle(\vec{Ox};\vec{OM})$ (`in degrees of` $M(x,y)$)
`ln`	$x \to \ln(x)$
`log`	$x \to \log(x)$
`array`	$n \to v$ (of dimension n)
`aload`	$v \to x_1 \quad x_2 \quad \cdots \quad x_n \quad v$
`astore`	$x_1 \quad x_2 \quad \cdots \quad x_n \quad v \to v$
`pop`	$x \to$
`dup`	$x \quad x \to$
`roll`	$x_1 \quad x_2 \quad \cdots \quad x_n \quad np \to$

Table 5: Some primitive PostScript macros

30 Credits

Hendri Adriaens | Martin Chicoine | Ulrich Dirr | Hubert Gäßlein | Denis Girou | Peter Hutnick | Christophe Jorssen | Uwe Kern | Manuel Luque | Jens-Uwe Morawski | Tobias Nähring | Rolf Niepraschk | Arnaud Schmittbuhl | Timothy Van Zandt

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31 Change log

See file Changes