pst-math

Special mathematical PostScript functions; v.0.67

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July 3, 2023

Contents

Abstract

`pst-math` is an extension to the PostScript language. The files `pst-math.sty` and `pst-math.tex` are only wrapper files for the `pst-math.pro` file, which defines all the new mathematical functions for use with PostScript.

Thanks to:
Denis Bitouzé; Frédéric Bréal; Jacques L'helgoualc'h; Patrice Mégret; Dominik Rodriguez

1 Introduction

pst-math defines \pstPi on TEX level which expects 1,2,3 or 4 as parameter. It is not available on PostScript level.

\pstPI#

\pstPI1 $\Rightarrow \pi$
\pstPI2 $\Rightarrow \frac{\pi}{2}$
\pstPI3 $\Rightarrow \frac{\pi}{3}$
\pstPI4 $\Rightarrow \frac{\pi}{4}$

2 Trigonometry

pst-math introduces natural trigonometric PostScript operators COS, SIN and TAN defined by

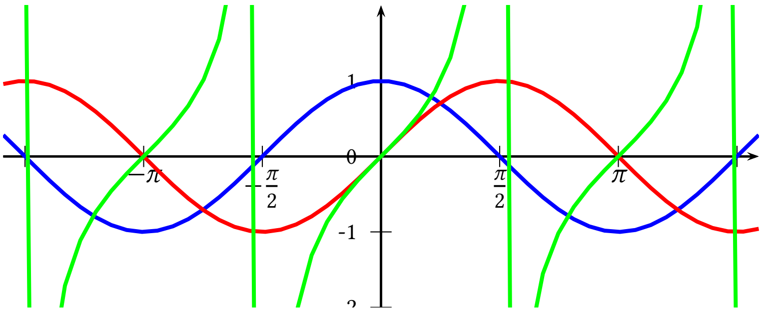
$$\cos : \begin{cases} \mathbb{R} & \to & [-1,1] \\ x & \mapsto & \cos(x) \end{cases}$$

$$\sin : \begin{cases} \mathbb{R} & \to & [-1,1] \\ x & \mapsto & \sin(x) \end{cases}$$

$$\tan : \begin{cases} \mathbb{R}\backslash\{k\frac{\pi}{2}, k \in \mathbb{Z}\} & \to & \mathbb{R} \\ x & \mapsto & \tan(x) \end{cases}$$

where x is in *radians*. TAN does *not* produce a PS error[1] when $x = k\frac{\pi}{2}$.

Stack	*Operator*	*Result*	*Description*
num	COS	real	Return cosine of num radians
num	SIN	real	Return sine of num radians
num	TAN	real	Return tangent of num radians




```
\begin{pspicture}*(-5,-2)(5,2)
\SpecialCoor % For label positionning
\psaxes[labels=y,Dx=\pstPI2]{->}(0,0)(-5,-2)(5,2)
\uput[-90](!PI 0){$\pi$} \uput[-90](!PI neg 0){$-\pi$}
\uput[-90](!PI 2 div 0){$\frac{\pi}2$}
\uput[-90](!PI 2 div neg 0){$-\frac{\pi}2$}
\psplot[linewidth=1.5pt,linecolor=blue]{-5}{5}{x COS}
\psplot[linewidth=1.5pt,linecolor=red]{-5}{5}{x SIN}
\psplot[linewidth=1.5pt,linecolor=green]{-5}{5}{x TAN}
\end{pspicture}
```

1 TAN is defined with Div, a special PSTricks operator rather than with div, the default PS operator.

`pst-math` introduces natural trigonometric postscript operators `ACOS`, `ASIN` and `ATAN` defined by

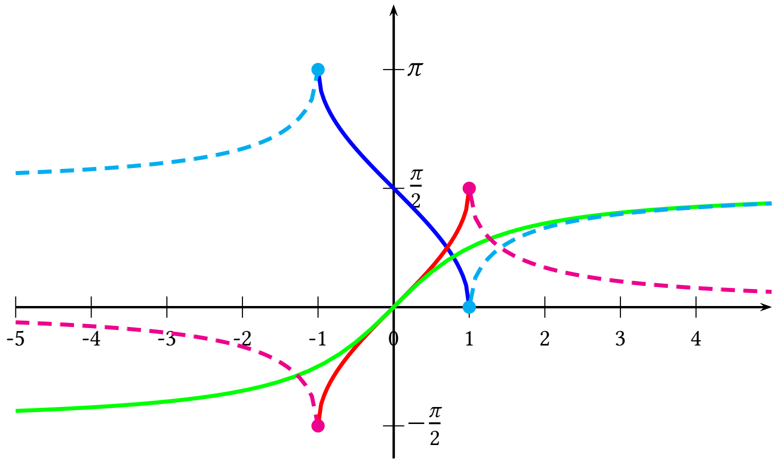
$$\mathrm{acos}:\begin{cases}[-1,1] & \to & [0,\pi]\\ x & \mapsto & \mathrm{acos}(x)\end{cases}$$

$$\mathrm{asin}:\begin{cases}[-1,1] & \to & [-\frac{\pi}{2},\frac{\pi}{2}]\\ x & \mapsto & \mathrm{asin}(x)\end{cases}$$

$$\mathrm{atan}:\begin{cases}\mathbb{R} & \to &]-\frac{\pi}{2},\frac{\pi}{2}[\\ x & \mapsto & \mathrm{atan}(x)\end{cases}$$

Stack	*Operator*	*Result*	*Description*
num	`ACOS`	angle	Return arccosine of num in radians
num	`ASIN`	angle	Return arcsine of num in radians
num	`ATAN`	angle	Return arctangent of num in radians
num	`ASEC`	angle	Return arcsecans of num in radians
num	`ACSC`	angle	Return arccosecans of num in radians

`ATAN` is *not* defined as the already existing PS operator `atan`. `ATAN` needs only *one* argument on the stack.




```
\begin{pspicture}(-5,-2)(5,4)
\SpecialCoor % For label positionning
\psaxes[labels=x,Dy=\pstPI2]{->}(0,0)(-5,-2)(5,4)
\uput[0](!0 PI){$\pi$} \uput[0](!0 PI 2 div){$\frac{\pi}2$}
\uput[0](!0 PI 2 div neg){$-\frac{\pi}2$}
\psset{linewidth=1.5pt,yMaxValue=4}
\psplot[linecolor=blue]{-1}{1}{x ACOS} \psplot[linecolor=red]{-1}{1}{x ASIN}
\psplot[linecolor=green]{-5}{5}{x ATAN}
\psplot[linestyle=dashed,linecolor=cyan,arrows=-*]{-5}{-1}{x ASEC}
\psplot[linestyle=dashed,linecolor=cyan,arrows=*-]{1}{5}{x ASEC}
\psplot[linestyle=dashed,linecolor=magenta,arrows=-*]{-5}{-1}{x ACSC}
\psplot[linestyle=dashed,linecolor=magenta,arrows=*-]{1}{5}{x ACSC}
\end{pspicture}
```

3 Hyperbolic trigonometry

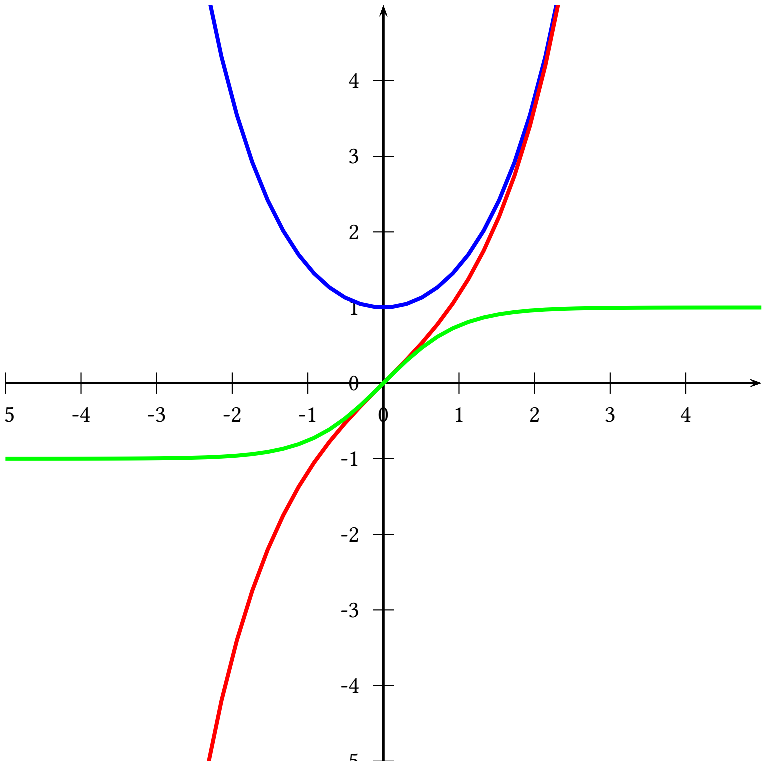
pst-math introduces hyperbolic trigonometric postscript operators COSH, SINH and TANH defined by

$$\cosh\ :\ \begin{cases} \mathbb{R} & \to & [1,+\infty[\\ x & \mapsto & \cosh(x) \end{cases}$$

$$\sinh\ :\ \begin{cases} \mathbb{R} & \to & \mathbb{R} \\ x & \mapsto & \sinh(x) \end{cases}$$

$$\tanh\ :\ \begin{cases} \mathbb{R} & \to &]-1,1[\\ x & \mapsto & \tanh(x) \end{cases}$$

Stack	*Operator*	*Result*	*Description*
num	COSH	real	Return hyperbolic cosine of num
num	SINH	real	Return hyperbolic sine of num
num	TANH	real	Return hyperbolic tangent of num




```
\begin{pspicture}*(-5,-5)(5,5)
\psaxes{->}(0,0)(-5,-5)(5,5)
\psplot[linewidth=1.5pt,linecolor=blue]{-5}{5}{x COSH}
\psplot[linewidth=1.5pt,linecolor=red]{-5}{5}{x SINH}
\psplot[linewidth=1.5pt,linecolor=green]{-5}{5}{x TANH}
\end{pspicture}
```

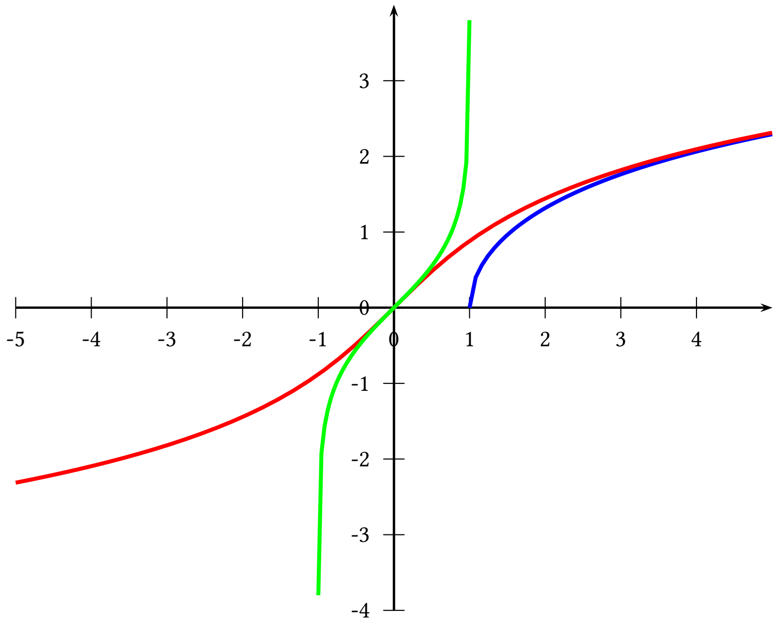
pst-math introduces reciprocal hyperbolic trigonometric postscript operators ACOSH, ASINH and ATANH defined by

$$\text{acosh}\ :\ \begin{cases} [1,+\infty[& \to & \mathbb{R} \\ x & \mapsto & \text{acosh}(x) \end{cases}$$

$$\text{asinh}\ :\ \begin{cases} \mathbb{R} & \to & \mathbb{R} \\ x & \mapsto & \text{asinh}(x) \end{cases}$$

$$\text{atanh} : \begin{cases}]-1,1[& \rightarrow & \mathbb{R} \\ x & \mapsto & \text{atanh}(x) \end{cases}$$

Stack	*Operator*	*Result*	*Description*
num	ACOSH	real	Return reciprocal hyperbolic cosine of num
num	ASINH	real	Return reciprocal hyperbolic sine of num
num	ATANH	real	Return reciprocal hyperbolic tangent of num



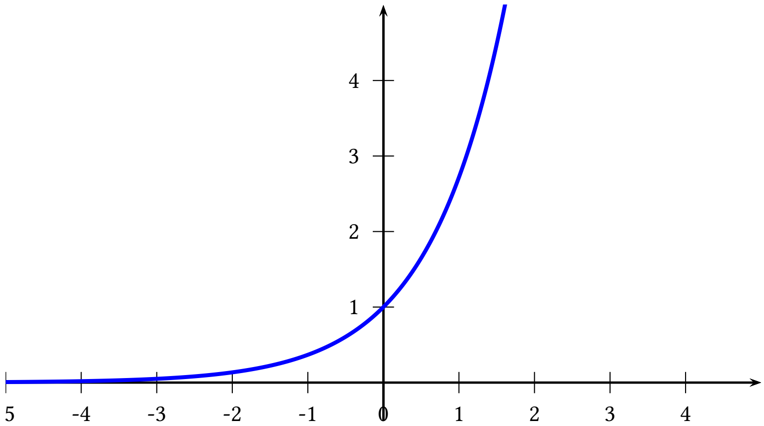

```
\begin{pspicture}(-5,-4)(5,4)
\psaxes{->}(0,0)(-5,-4)(5,4)
\psplot[linewidth=1.5pt,linecolor=blue]{1}{5}{x ACOSH}
\psplot[linewidth=1.5pt,linecolor=red]{-5}{5}{x ASINH}
\psplot[linewidth=1.5pt,linecolor=green]{-.999}{.999}{x ATANH}
\end{pspicture}
```

4 Other operators

`pst-math` introduces postscript operator `EXP` defined by

$$\exp : \begin{cases} \mathbb{R} & \rightarrow & \mathbb{R} \\ x & \mapsto & \exp(x) \end{cases}$$

Stack	*Operator*	*Result*	*Description*
num	EXP	real	Return exponential of num

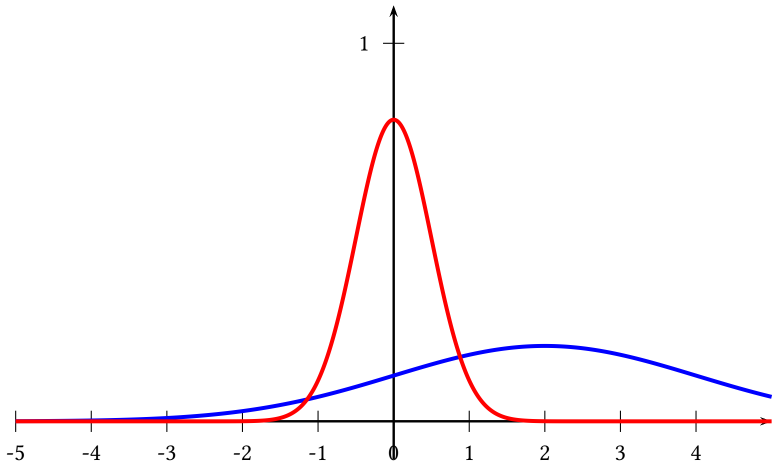



```
\begin{pspicture}*(-5,-1)(5,5)
\psaxes{->}(0,0)(-5,-0.5)(5,5)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x EXP}
\end{pspicture}
```

`pst-math` introduces postscript operator `GAUSS` defined by

$$\text{gauss} : \left\{ \begin{array}{ccc} \mathbb{R} & \to & \mathbb{R} \\ x & \mapsto & \dfrac{1}{\sqrt{2\pi\sigma^2}} \exp - \dfrac{(x-\overline{x})^2}{2\sigma^2} \end{array} \right.$$

Stack	*Operator*	*Result*	*Description*
num1 num2 num3	`GAUSS`	real	Return gaussian of num1 with mean num2 and standard deviation num3

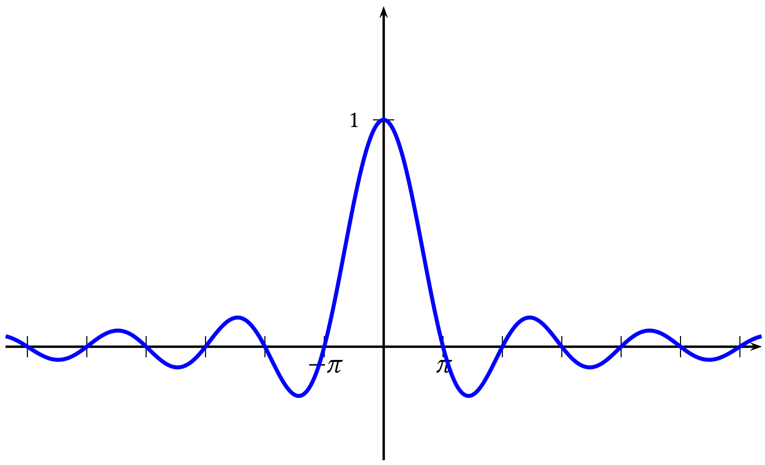



```
\psset{yunit=5}
\begin{pspicture}(-5,-.1)(5,1.1)
\psaxes{->}(0,0)(-5,-.1)(5,1.1)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x 2 2 GAUSS}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x 0 .5 GAUSS}
\end{pspicture}
```

`pst-math` introduces postscript operator SINC defined by

$$\text{sinc} : \left\{ \begin{array}{ccc} \mathbb{R} & \to & \mathbb{R} \\ x & \mapsto & \dfrac{\sin x}{x} \end{array} \right.$$

Stack	*Operator*	*Result*	*Description*
num	`SINC`	real	Return cardinal sine of num radians



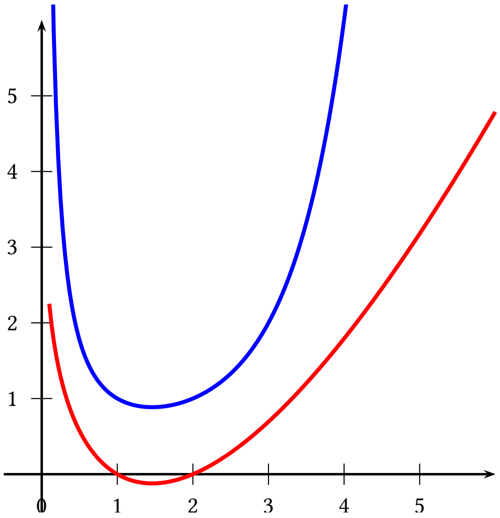

```
\psset{xunit=.25,yunit=3}
\begin{pspicture}(-20,-.5)(20,1.5)
\SpecialCoor % For label positionning
\psaxes[labels=y,Dx=\pstPI1]{->}(0,0)(-20,-.5)(20,1.5)
\uput[-90](!PI 0){$\pi$} \uput[-90](!PI neg 0){$-\pi$}
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-20}{20}{x SINC}
\end{pspicture}
```

`pst-math` introduces postscript operator `GAMMA` and `GAMMALN` defined by

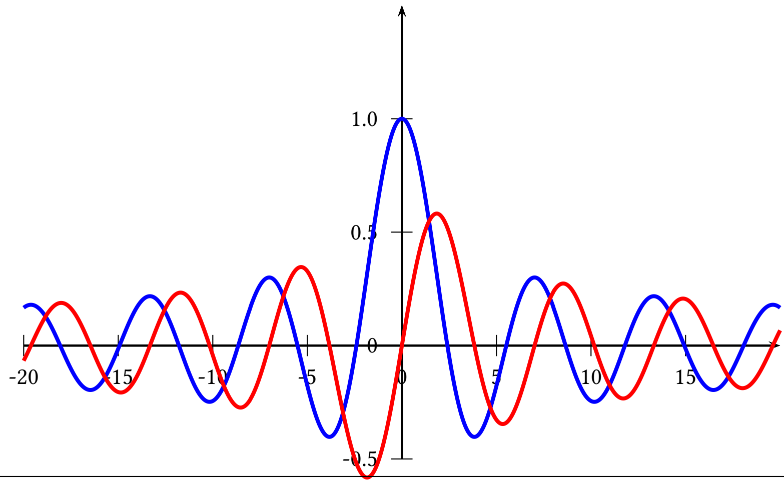
$$:\left\{\begin{array}{ccc} \mathbb{R}\backslash\mathbb{Z} & \rightarrow & \mathbb{R} \\ x & \mapsto & \displaystyle\int_0^\infty t^{x-1}\mathrm{e}^{-t}\,\mathrm{d}t \end{array}\right.$$

$$\ln\ :\left\{\begin{array}{ccc}]0,+\infty[& \rightarrow & \mathbb{R} \\ x & \mapsto & \ln\displaystyle\int_0^t t^{x-1}\mathrm{e}^{-t}\,\mathrm{d}t \end{array}\right.$$

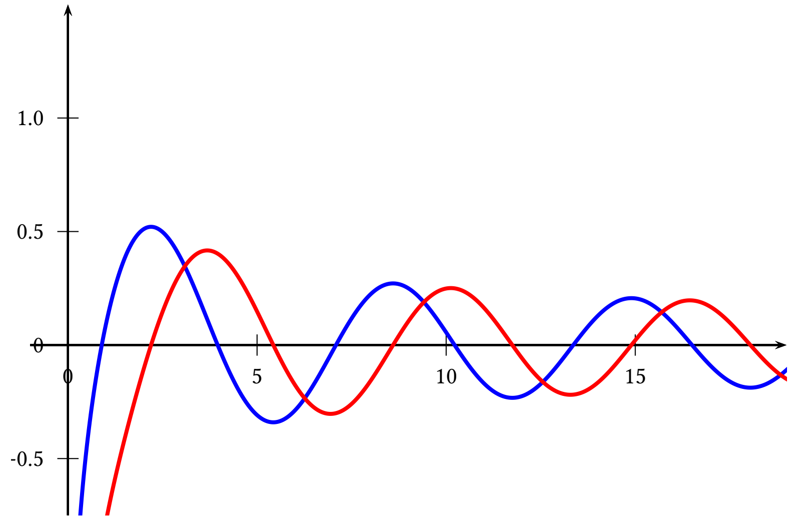
Stack	*Operator*	*Result*	*Description*
num	`GAMMA`	real	Return Γ function of num
num	`GAMMALN`	real	Return logarithm of Γ function of num




```
\begin{pspicture*}(-.5,-.5)(6.2,6.2)
\psaxes{->}(0,0)(-.5,-.5)(6,6)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=200]{.1}{6}{x GAMMA}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=200]{.1}{6}{x GAMMALN}
\end{pspicture*}
```




```
\psset{xunit=.25,yunit=3}
\begin{pspicture}(-20,-.5)(20,1.5)
\psaxes[Dx=5,Dy=.5]{->}(0,0)(-20,-.5)(20,1.5)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-20}{20}{x BESSEL_J0}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{-20}{20}{x BESSEL_J1}
\end{pspicture}
```

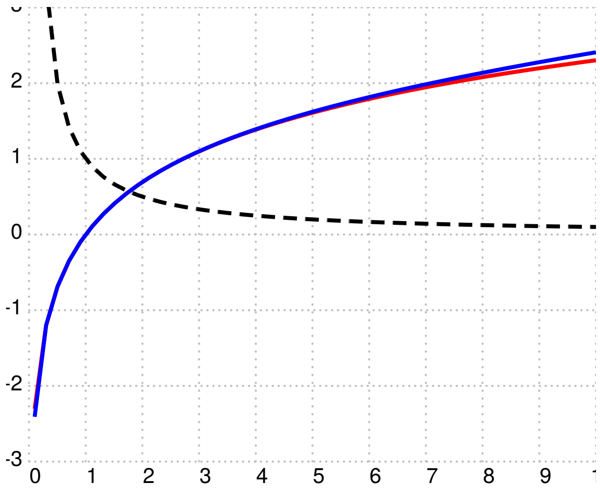



```
\psset{xunit=.5,yunit=3}
\begin{pspicture}*(-1.5,-.75)(19,1.5)
\psaxes[Dx=5,Dy=.5]{->}(0,0)(-1,-.75)(19,1.5)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y0}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y1}
%\psplot[linecolor=green,plotpoints=1000]{0.0001}{20}{x 2 BESSEL_Yn}
\end{pspicture}
```

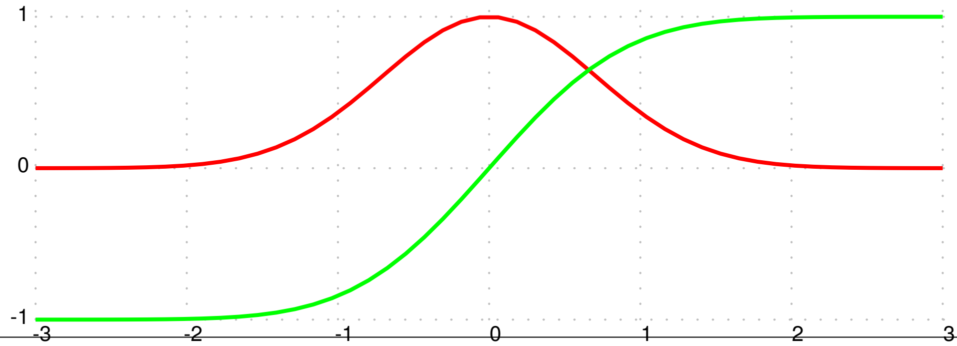
5 Numerical integration

Stack	*Operator*	*Result*	*Description*
num num /var { function } num num	`SIMPSON`	real	Return $\int\limits_a^b f(t)\mathrm{d}t$

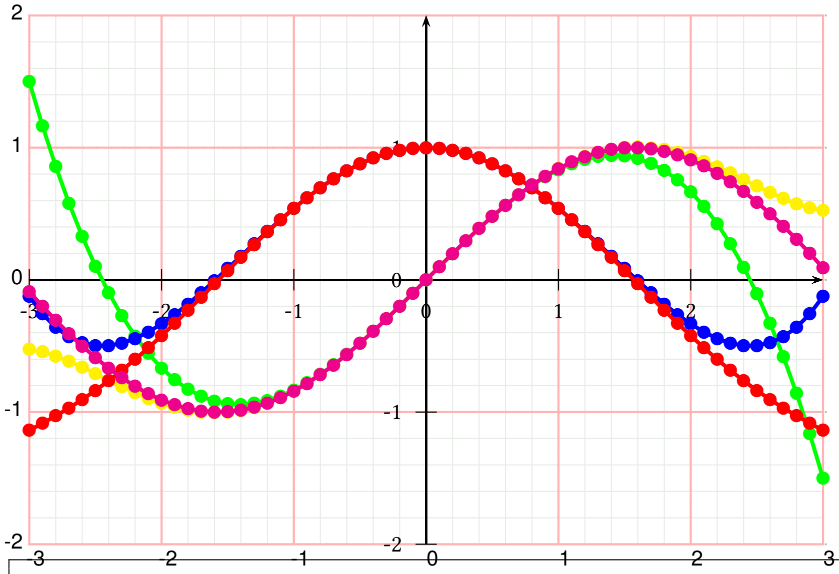
the first two variables are the low and high boundary integral, both can be values or `PostScript` expressions. `/var` is the definition of the integrated variable (not x!), which is used in the following function description, which must be inside of braces. The last number is the tolerance for the step adjustment. The function `SIMPSON` can be nested.




```
\psset{xunit=.75}
\begin{pspicture*}[showgrid=true](-0.4,-3.4)(10,3)
  \psplot[linestyle=dashed,linewidth=1.5pt]{.1}{10}{1 x div}
  \psplot[linecolor=red,linewidth=1.5pt]{.1}{10}{
    1         % start
    x         % end
    /t        % variable
    { 1 t div } % function
    .001      % tolerance
    SIMPSON } %
  \psplot[linecolor=blue,linewidth=1.5pt]{.1}{10}{1 x /t { 1 t div } 1 SIMPSON }
\end{pspicture*}
```




```
%%% Gaussian and relative integral from -x to x to its value sqrt{pi}
\psset{unit=2}
\begin{pspicture}[showgrid=true](-3,-1)(3,1)
  \psplot[linecolor=red,linewidth=1.5pt]{-3}{3}{Euler x dup mul neg exp }
  \psplot[linecolor=green,linewidth=1.5pt]{-3}{3}
    { x neg x /t { Euler t dup mul neg exp } .001 SIMPSON Pi sqrt div}
\end{pspicture}
```




```
\psset{unit=1.75cm}
%%% successive polynomial developments of sine-cosine
\begin{pspicture}[showgrid=true](-3,-2)(3,2)
\psaxes{->}(0,0)(-3,-2)(3,2)
 \psplot[linecolor=green, algebraic=false, plotpoints=61, showpoints=true]
      {-3}{3}{0 x /tutu
             {1 0 tutu /toto { toto } .1 SIMPSON sub}
                .01 SIMPSON }
 \psplot[linecolor=blue, algebraic=false, plotpoints=61, showpoints=true]
      {-3}{3}{1 0 x /tata
             {0 tata /tutu
              {1 0 tutu /toto { toto } .1 SIMPSON sub}
               .01 SIMPSON }
                .01 SIMPSON sub}
 \psplot[linecolor=yellow, algebraic=false, plotpoints=61, showpoints=true]
      {-3}{3}{0 x /titi
             {1 0 titi /tata
              {0 tata /tutu
               {1 0 tutu /toto { toto } .1 SIMPSON sub}
                .01 SIMPSON }
                 .01 SIMPSON sub}
                  .01 SIMPSON }
 \psplot[linecolor=red, algebraic=false, plotpoints=61, showpoints=true]
      {-3}{3}{1 0 x /tyty
             {0 tyty /titi
              {1 0 titi /tata
               {0 tata /tutu
                {1 0 tutu /toto { toto } .1 SIMPSON sub}
                 .01 SIMPSON }
                  .01 SIMPSON sub}
                   .01 SIMPSON }
                    .01 SIMPSON sub}
 \psplot[linecolor=magenta, algebraic=false, plotpoints=61, showpoints=true]
      {-3}{3}{0 x /tete
             {1 0 tete /tyty
              {0 tyty /titi
               {1 0 titi /tata
                {0 tata /tutu
                 {1 0 tutu /toto { toto } .1 SIMPSON sub}
                  .01 SIMPSON }
                   .01 SIMPSON sub}
                    .01 SIMPSON }
                     .01 SIMPSON sub}
                      .01 SIMPSON }%%% FIVE nested calls
```

```
\end{pspicture}
```

6 Random numbers

Package pst-math supports the creation of random number lists where a number will appear only once.

```
\defineRandIntervall(min,max)maxNo
\makeSimpleRandomNumberList% multiple values possible
\makeRandomNumberList % no multiple values!
\getNumberFromList{number}
```

The list of the random numbers is \RandomNumbers, a comma separated list of the values. It can be used for own purpuses.

Random list: 47,13,50,21,8,47,29,3,41,31,34,33,17,43,26,22,12,8,31,44,16,7,28,13,19,30,7,33,22,12
47 13 50 21 8 47 29 3 41 31 34 33 17 43 26 22 12 8 31 44 16 7 28 13 19 30 7 33 22 12

```
\defineRandIntervall(1,50){30}
\makeSimpleRandomNumberList
Random list: \RandomNumbers

\psforeach{\iA}{1,2,..,30}{\getNumberFromList{\iA}~}
```

In the next example a random number appears only *once* in the list. There are no multiple numbers:

25 22 10 2 30 11 14 29 18 3 26 16 24 20 15 19 27 23 9 21 8 17 13 6 12 28 7 5 4 1

```
\defineRandIntervall(1,30){30}
\makeRandomNumberList
\psforeach{\iA}{1,2,..,30}{\getNumberFromList{\iA}~}
```

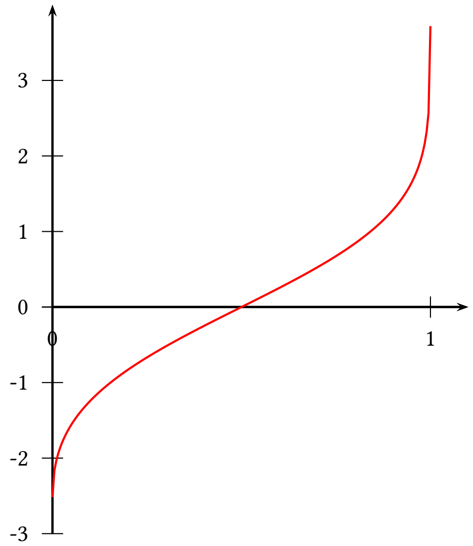
21	5	19	9	15
11	3	22	10	8
12	2	23	6	1
18	4	13	24	16
25	17	7	14	20

96	100	88	2	65	83	5	11	82	85
63	37	87	14	32	47	9	62	60	16
20	53	89	43	61	30	46	31	74	51
91	13	22	72	3	49	70	99	76	95
26	36	28	41	44	50	40	21	64	90
94	56	34	73	59	57	24	39	27	33
75	48	98	15	12	97	7	93	80	66
23	1	18	45	81	54	19	55	17	86
42	78	8	29	25	35	84	58	77	69
52	92	10	38	68	71	4	79	67	6

```
\newcounter{RandNo}
\def\n{5} \def\N{\the\numexpr\n*\n}
\defineRandIntervall(1,\N){\N}
\makeRandomNumberList \setcounter{RandNo}{1}
\begin{pspicture}(\n,\n)
  \psgrid[subgriddiv=0,gridlabels=0pt]
  \multido{\rRow=0.5+1.0}{\n}{\multido{\rCol=0.5+1.0}{\n}{%
     \rput(\rCol,\rRow){\getNumberFromList{\theRandNo}}%
    \stepcounter{RandNo}}}
\end{pspicture}
\setcounter{RandNo}{1}
\def\n{10} \def\N{\the\numexpr\n*\n}
\defineRandIntervall(1,\N){\N}
\makeRandomNumberList \setcounter{RandNo}{1}
\begin{pspicture}(\n,\n)
  \psgrid[subgriddiv=0,gridlabels=0pt]
  \multido{\rRow=0.5+1.0}{\n}{\multido{\rCol=0.5+1.0}{\n}{%
     \rput(\rCol,\rRow){\getNumberFromList{\theRandNo}}%
    \stepcounter{RandNo}}}
\end{pspicture}
```

7 Numerical functions

Stack	Operator	Result	Description
num	`norminv`	real	Return *norminv*(*num*)




```
\psset{xunit=5}
\begin{pspicture}(-0.1,-3)(1.1,4)
\psaxes{->}(0,0)(0,-3)(1.1,4)
\psplot[plotpoints=200,algebraic,linecolor=red]{0}{0.9999}{norminv(x)}
\end{pspicture}
```

These function returns the inverse normal.

References

[1] Denis Girou. “Présentation de PSTricks”. In: *Cahier GUTenberg* 16 (Apr. 1994), pp. 21–70.

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[3] Laura E. Jackson and Herbert Voß. “Die Plot-Funktionen von `pst-plot`”. In: *Die TeXnische Komödie* 2/02 (June 2002), pp. 27–34.

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[11] Timothy van Zandt. *PSTricks - `PostScript` macros for generic TeX*. http://www.tug.org/application/PSTricks, 1993.

[12] Timothy van Zandt and Denis Girou. “Inside PSTricks”. In: *TUGboat* 15 (Sept. 1994), pp. 239–246.

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