

PSTricks

pst-math

Special mathematical PostScript functions; v.0.64

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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; Jacques L'helgoualc'h; Patrice Mégret; Dominik Rodriguez

1 Introduction

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

<code>\pstPi#</code>

`\pstPi1` $\Rightarrow \pi$
`\pstPi2` $\Rightarrow \frac{\pi}{2}$
`\pstPi3` $\Rightarrow \frac{\pi}{3}$
`\pstPi4` $\Rightarrow \frac{\pi}{4}$

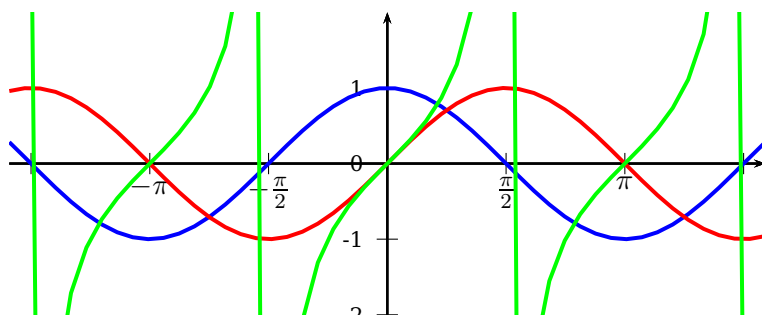
2 Trigonometry

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

$$\begin{aligned} \cos : \begin{cases} \mathbb{R} & \rightarrow [-1, 1] \\ x & \mapsto \cos(x) \end{cases} \\ \sin : \begin{cases} \mathbb{R} & \rightarrow [-1, 1] \\ x & \mapsto \sin(x) \end{cases} \\ \tan : \begin{cases} \mathbb{R} \setminus \{k\frac{\pi}{2}, k \in \mathbb{Z}\} & \rightarrow \mathbb{R} \\ x & \mapsto \tan(x) \end{cases} \end{aligned}$$

where x is in *radians*. TAN does *not* produce a PS error¹ 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){$\frac{\pi}{2}$}

```

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

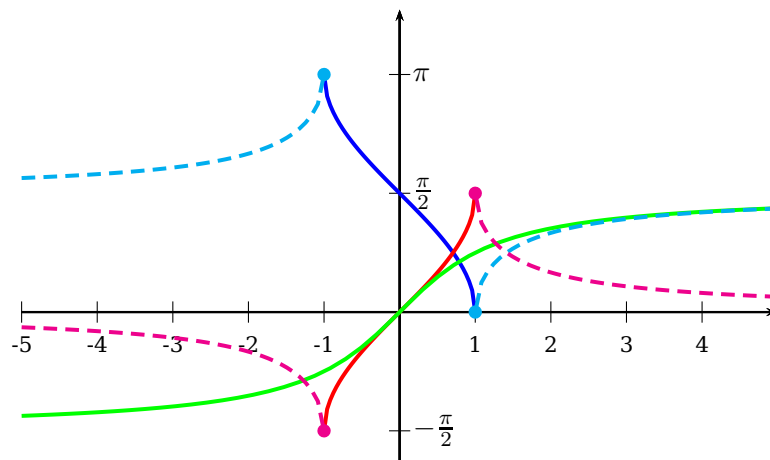
```
\uput[-90](!PI 2 div neg 0){$\frac{\pi}{2}$}
\psplot[linewidth=1.5pt,linecolor=blue]{-5}{5}{x COS}
\psplot[linewidth=1.5pt,linecolor=red]{-5}{5}{x SIN}
\psplot[linewidth=1.5pt,linecolor=green]{-5}{5}{x TAN}
\end{pspicture}
```

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

$$\begin{aligned} \text{acos} : \begin{cases} [-1, 1] & \rightarrow [0, \pi] \\ x & \mapsto \text{acos}(x) \end{cases} \\ \text{asin} : \begin{cases} [-1, 1] & \rightarrow [-\frac{\pi}{2}, \frac{\pi}{2}] \\ x & \mapsto \text{asin}(x) \end{cases} \\ \text{atan} : \begin{cases} \mathbb{R} & \rightarrow]-\frac{\pi}{2}, \frac{\pi}{2}[\\ x & \mapsto \text{atan}(x) \end{cases} \end{aligned}$$

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

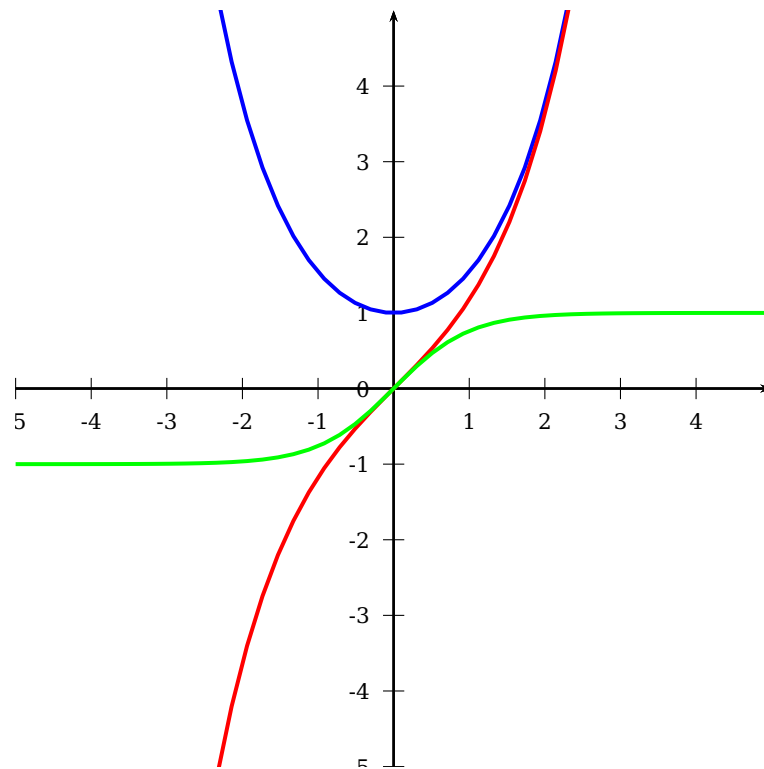
pst-math introduces hyperbolic trigonometric postscript operators COSH, SINH and TANH defined by

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

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

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

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}
```

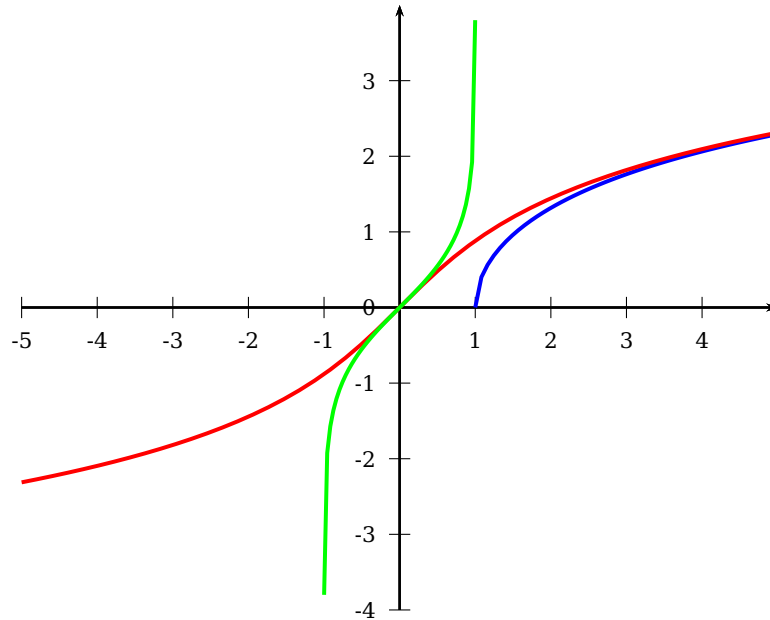
pst-math introduces reciprocal hyperbolic trigonometric postscript operators ACOSH, ASINH and ATANH defined by

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

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

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

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



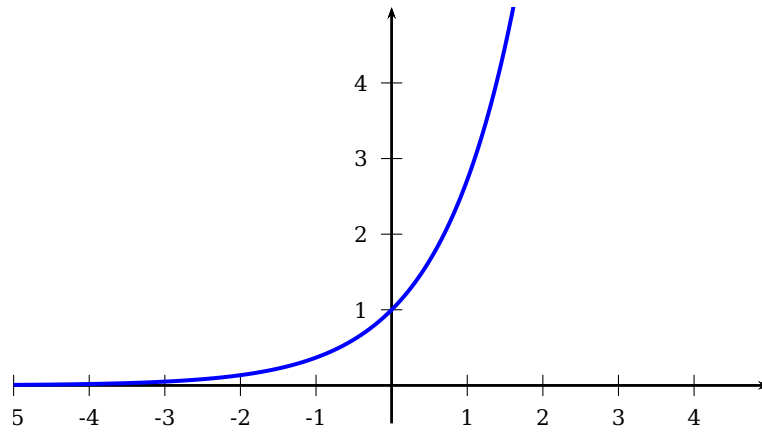
```
\begin{pspicture}(-5,-4)(5,4)
\psaxes{->}(0,0)(-5,-4)(5,4)
\psplot[linewidth=1.5pt,linecolor=blue]{1}{5}{x ACOSH}
\psplot[linewidth=1.5pt,linecolor=red]{-5}{5}{x ASINH}
\psplot[linewidth=1.5pt,linecolor=green]{-.999}{.999}{x ATANH}
\end{pspicture}
```

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

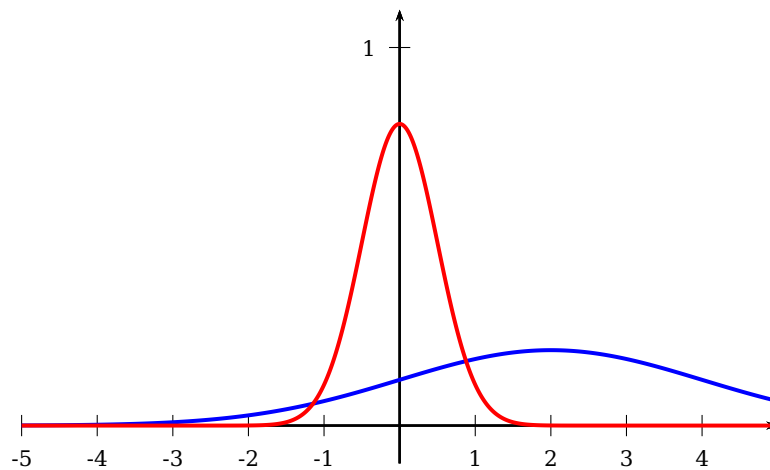


```
\begin{pspicture}*(-5,-1)(5,5)
\psaxes{->}(0,0)(-5,-0.5)(5,5)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x EXP}
\end{pspicture}
```

pst-math introduces postscript operator GAUSS defined by

$$\text{gauss} : \begin{cases} \mathbb{R} & \rightarrow \mathbb{R} \\ x & \mapsto \frac{1}{\sqrt{2\pi\sigma^2}} \exp -\frac{(x - \bar{x})^2}{2\sigma^2} \end{cases}$$

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

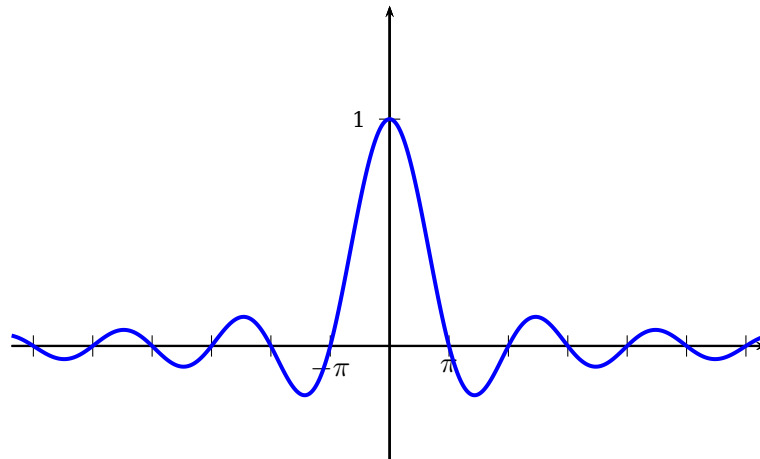


```
\psset{yunit=5}
\begin{pspicture}(-5,-.1)(5,1.1)
\psaxes{->}(0,0)(-5,-.1)(5,1.1)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x 2 2 GAUSS}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x 0 .5 GAUSS}
\end{pspicture}
```

pst-math introduces postscript operator SINC defined by

$$\text{sinc} : \begin{cases} \mathbb{R} & \rightarrow \mathbb{R} \\ x & \mapsto \frac{\sin x}{x} \end{cases}$$

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



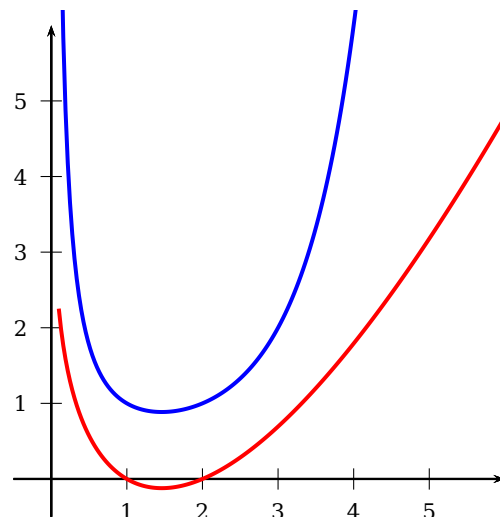
```
\psset{xunit=.25,yunit=3}
\begin{pspicture}(-20,-.5)(20,1.5)
\SpecialCoor % For label positionning
\psaxes[labels=y,Dx=\pstPI1]{->}(0,0)(-20,-.5)(20,1.5)
\uput[-90](!PI 0){$\pi$} \uput[-90](!PI neg 0){$-\pi$}
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-20}{20}{x SINC}
\end{pspicture}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

pst-math introduces postscript operator GAMMA and GAMMALN defined by

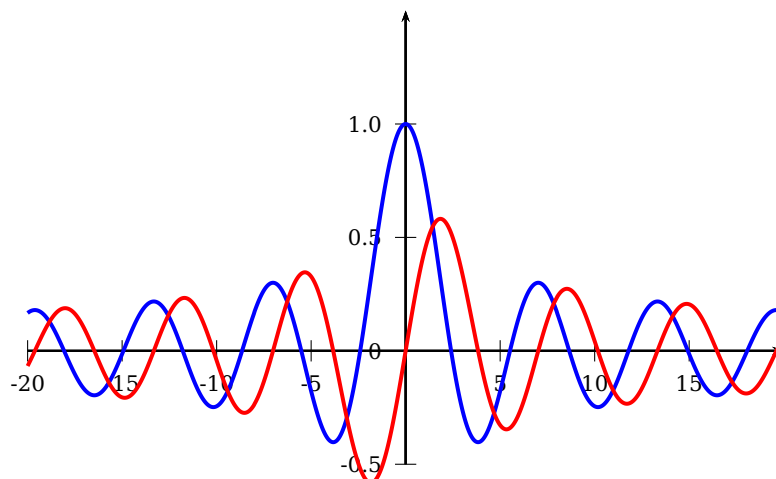
$$\Gamma : \begin{cases} \mathbb{R} \setminus \mathbb{Z} & \rightarrow \mathbb{R} \\ x & \mapsto \int_0^\infty t^{x-1} e^{-t} dt \end{cases}$$

$$\ln \Gamma : \begin{cases}]0, +\infty[& \rightarrow \mathbb{R} \\ x & \mapsto \ln \int_0^t t^{x-1} e^{-t} dt \end{cases}$$

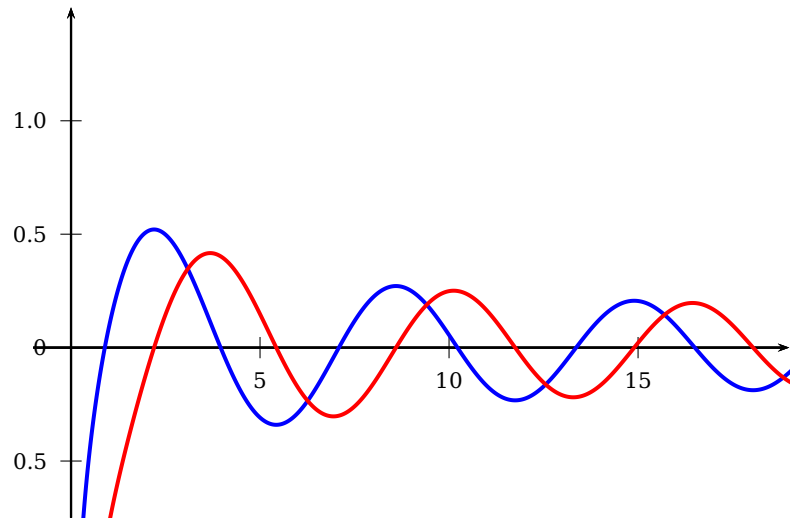
Stack	Operator	Result	Description
num	GAMMA	real	Return Γ function of num
num	GAMMALN	real	Return logarithm of Γ function of num



```
\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}
```

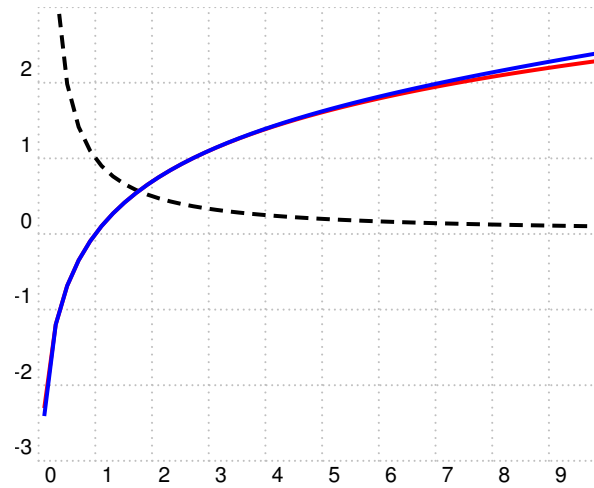


```
\psset{xunit=.5,yunit=3}
\begin{pspicture}*(-1.5,-.75)(19,1.5)
\psaxes[Dx=5,Dy=.5]{->}(0,0)(-1,-.75)(19,1.5)
\psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y0}
\psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y1}
%\psplot[linecolor=green,plotpoints=1000]{0.0001}{20}{x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

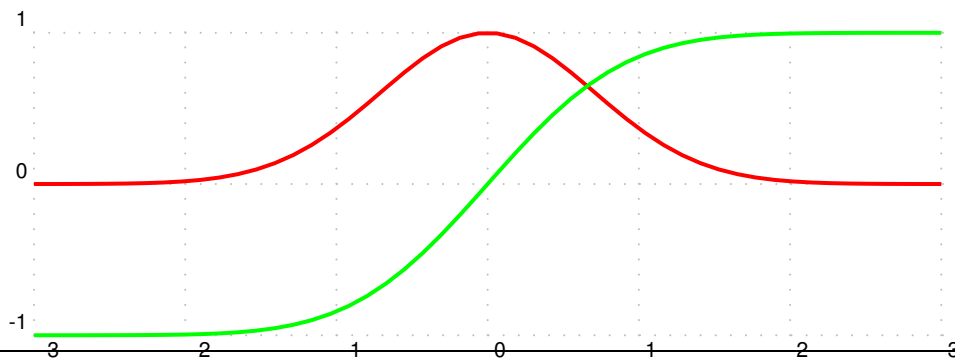
5 Numerical integration

Stack	Operator	Result	Description
num num /var { function } num	SIMPSON	real	Return $\int_a^b f(t)dt$
num			

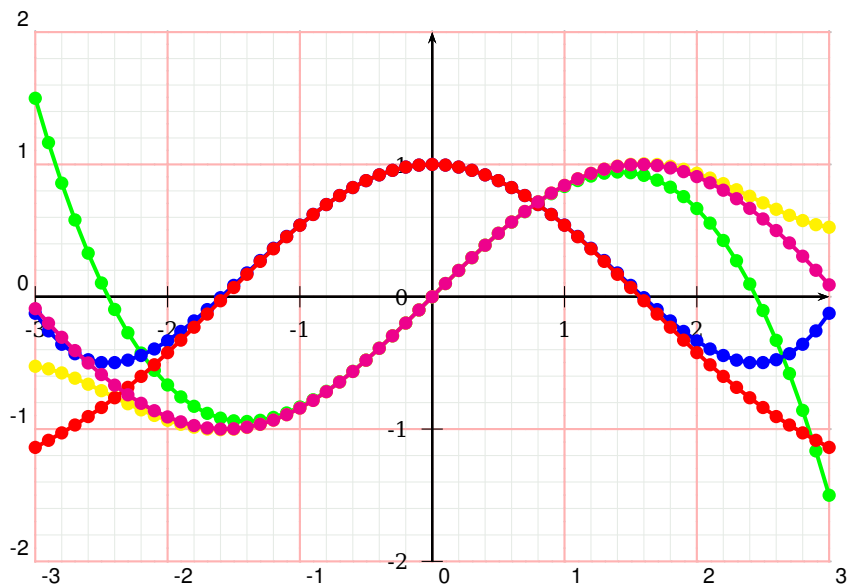
the first two variables are the low and high boundary integral, both can be values or PostScript expressions. /var is the definition of the integrated variable (not x!), which is used in the following function description, which must be inside of braces. The last number is the tolerance for the step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

Random list:

28,49,19,37,4,3,17,45,39,17,10,13,8,38,45,30,43,50,24,12,2,14,15,48,12,8,21,22,24,26
 28 49 19 37 4 3 17 45 39 17 10 13 8 38 45 30 43 50 24 12 2 14 15 48 12 8 21 22 24 26

```

\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 no multiple numbers:

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

```

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

```

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

23	1	36	14	3	10
31	5	16	27	15	28
13	4	24	32	35	18
30	11	20	34	26	21
33	17	9	8	25	22
12	2	29	6	7	19

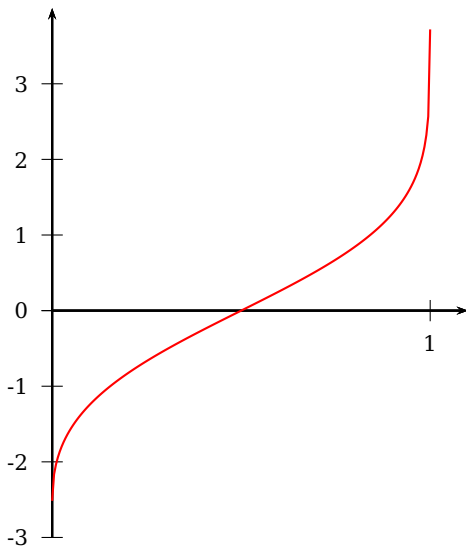
```

\newcounter{RandNo} \setcounter{RandNo}{1}
\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{6} \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 $\text{norminv}(\text{num})$



```
\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}
```

This function returns the inverse normal.

References

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