

# PSTricks

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## **pst-math**

Special mathematical PostScript functions; v.0.21

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Documentation by  
**Christoph Jorssen**  
**Herbert Voß**

Package author(s):  
**Christoph Jorssen**  
**Herbert Voß**

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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:  
Jacques L'helgoualc'h; Dominik Rodriguez

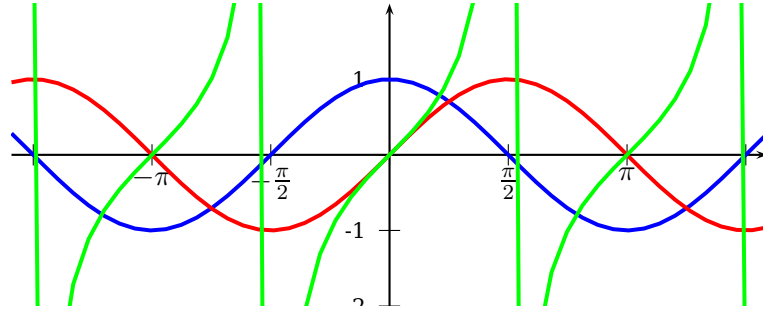
## 1 Trigonometry

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 PS error<sup>1</sup> 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



```

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

```

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

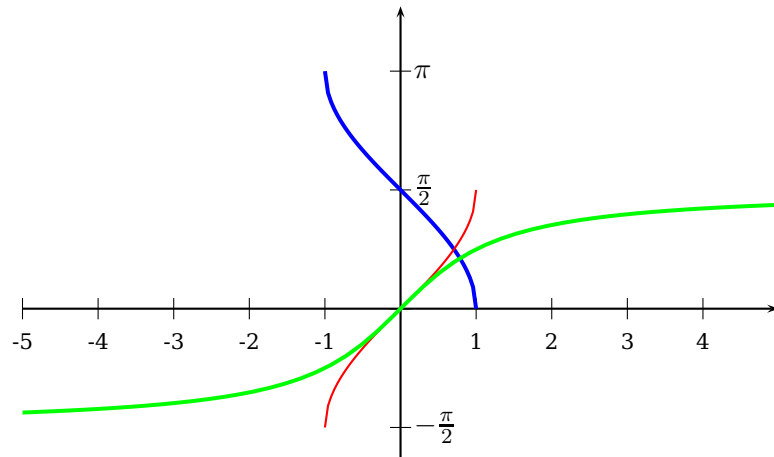
$$\begin{aligned}\arccos : & \begin{cases} [-1, 1] & \rightarrow [0, \pi] \\ x & \mapsto \arccos(x) \end{cases} \\ \arcsin : & \begin{cases} [-1, 1] & \rightarrow [-\frac{\pi}{2}, \frac{\pi}{2}] \\ x & \mapsto \arcsin(x) \end{cases}\end{aligned}$$

<sup>1</sup> TAN is defined with Div PSTricks operator rather than with div PS operator.

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

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

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



```

1 \begin{pspicture}(-5,-2)(5,4)
2 \SpecialCoor % For label positionning
3 \psaxes[labels=x,Dy=\pstPI2]{->}(0,0)(-5,-2)(5,4)
4 \uput[0](!0 PI){$\pi$} \uput[0](!0 PI 2 div){$\frac{\pi}{2}$}
5 \uput[0](!0 PI 2 div neg){$-\frac{\pi}{2}$}
6 \psplot[linewidth=1.5pt,linecolor=blue]{-1}{1}{x ACOS} \psplot[linecolor=red
7 ]{-1}{1}{x ASIN}
8 \psplot[linewidth=1.5pt,linecolor=green]{-5}{5}{x ATAN}
9 \end{pspicture}

```

## 2 Hyperbolic trigonometry

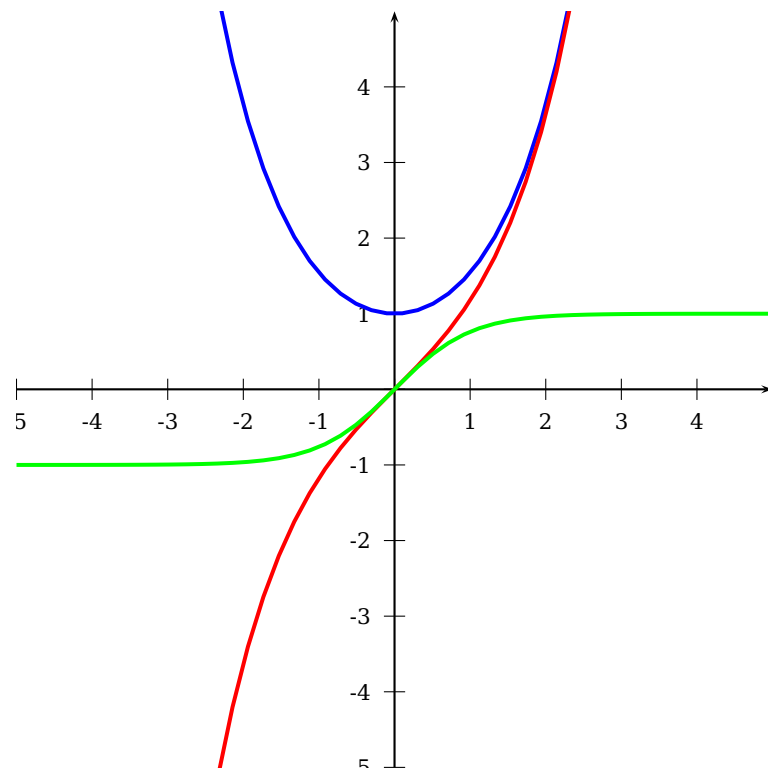
pst-math introduces hyperbolic trigonometric postscript operators COSH, SINH and TANH defined by

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

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

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

<i>Stack</i>	<i>Operator</i>	<i>Result</i>	<i>Description</i>
num	COSH	real	Return hyperbolic cosine of num
num	SINH	real	Return hyperbolic sine of num
num	TANH	real	Return hyperbolic tangent of num



```

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

```

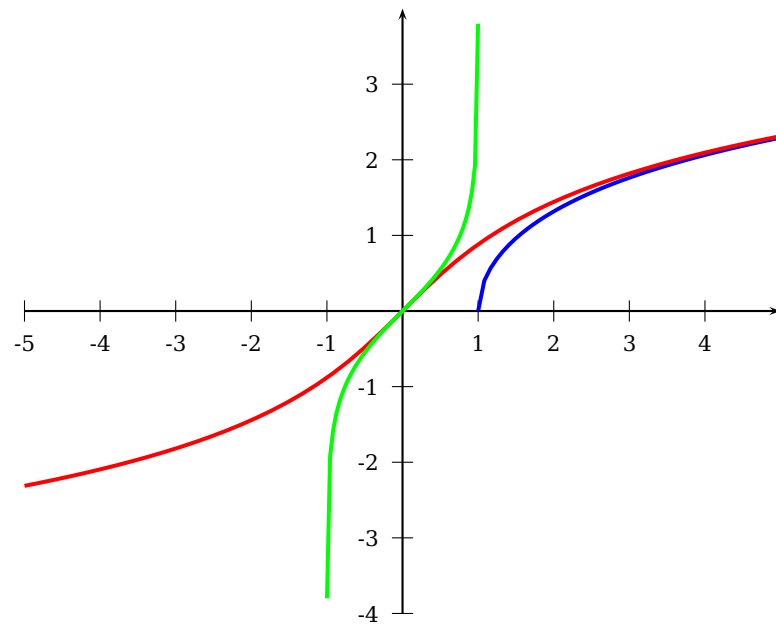
pst-math introduces reciprocal hyperbolic trigonometric postscript operators ACOSH, ASINH and ATANH defined by

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

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

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

<i>Stack</i>	<i>Operator</i>	<i>Result</i>	<i>Description</i>
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



```

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

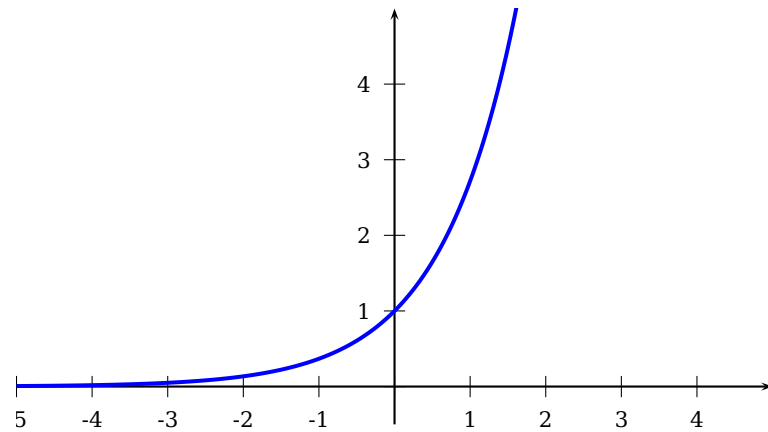
```

### 3 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



```

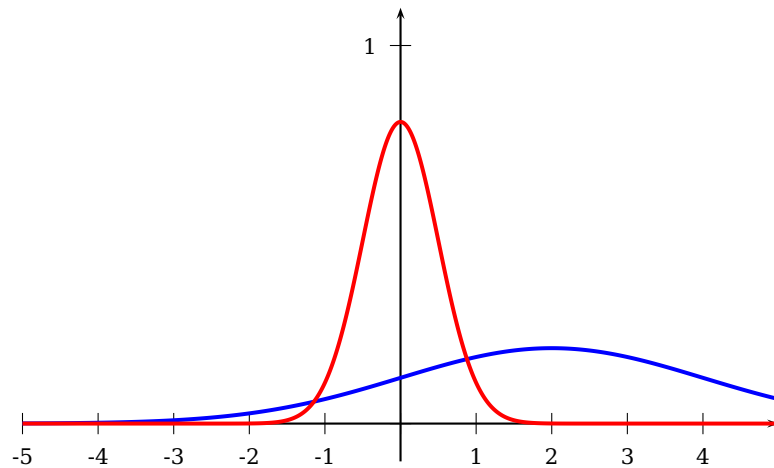
1 \begin{pspicture}*(-5,-1)(5,5)
2 \psaxes{->}(0,0)(-5,-0.5)(5,5)
3 \psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{-5}{5}{x EXP}
4 \end{pspicture}

```

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



```

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

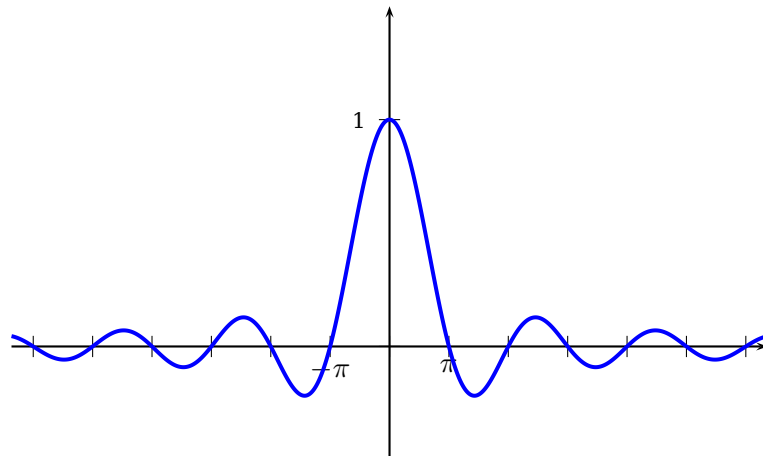
```



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



```

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

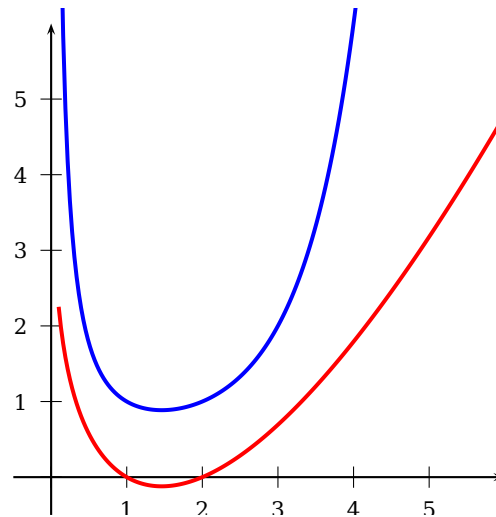
```

pst-math introduces postscript operator GAMMA and GAMMALN defined by

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

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

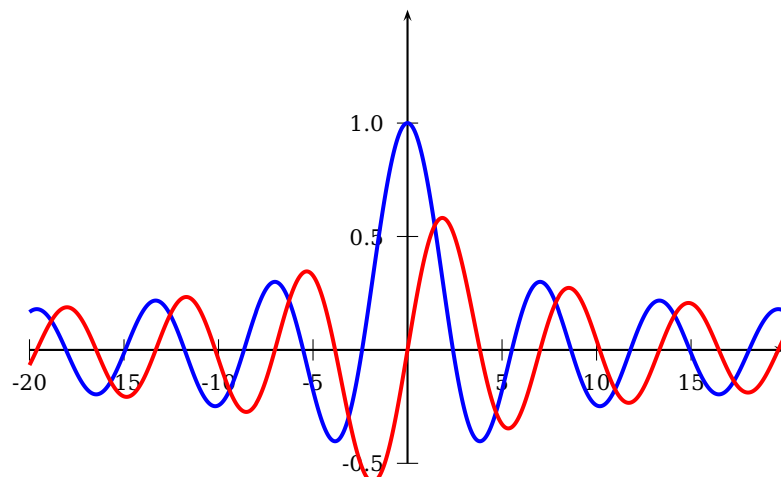
Stack	Operator	Result	Description
num	GAMMA	real	Return $\Gamma$ function of num
num	GAMMALN	real	Return logarithm of $\Gamma$ function of num



```

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

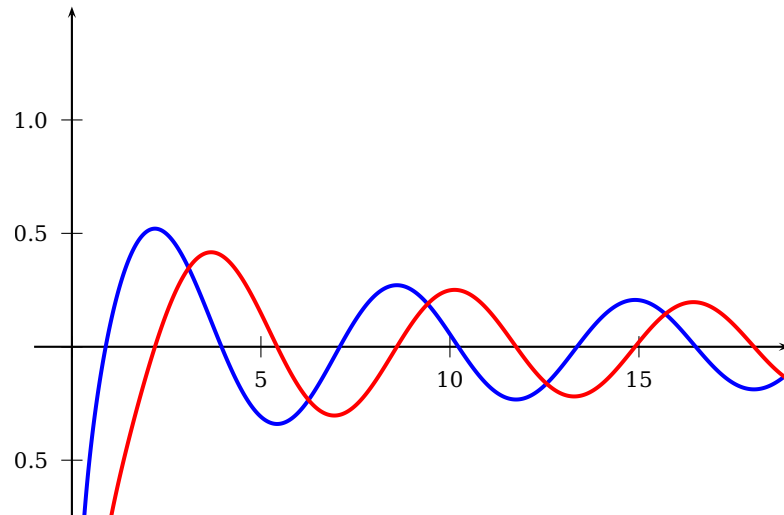
```



```

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

```



```

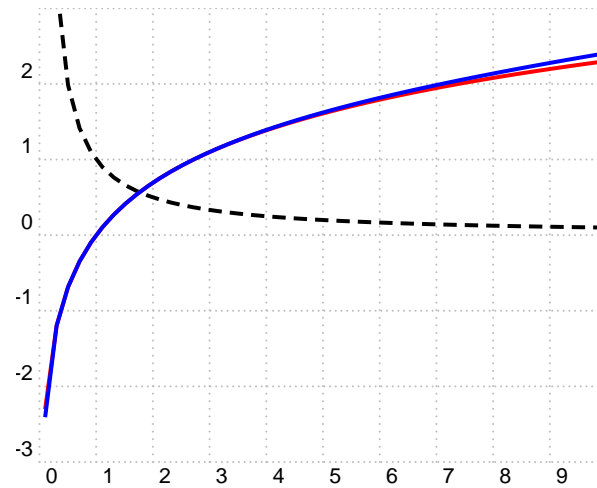
1 \psset{xunit=.5,yunit=3}
2 \begin{pspicture}*(-1.5,-.75)(19,1.5)
3 \psaxes[Dx=5,Dy=.5]{->}(0,0)(-1,-.75)(19,1.5)
4 \psplot[linecolor=blue,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y0}
5 \psplot[linecolor=red,linewidth=1.5pt,plotpoints=1000]{0.0001}{20}{x BESSEL_Y1}
6 %\psplot[linecolor=green,plotpoints=1000]{0.0001}{20}{x 2 BESSEL_Yn}
7 \end{pspicture}

```

## 4 Numerical integration

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

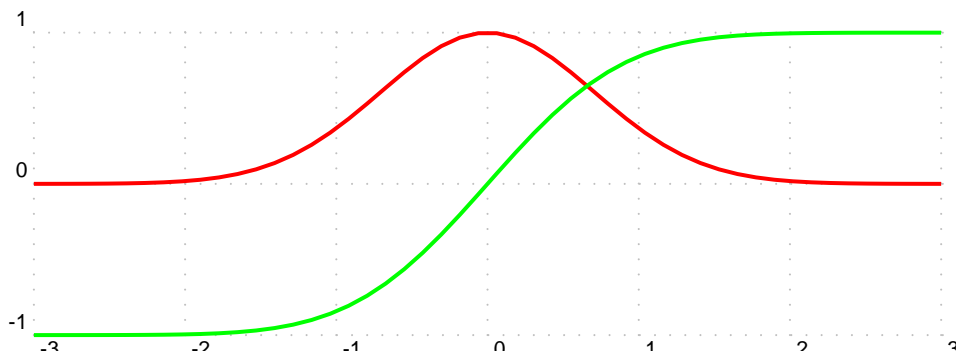
the first two variables are the low and high boundary integral, both can be values or PostScript expressions. /var is the definition of the integrated variable (not x!), which is used in the following function description, which must be inside of braces. The last number is the tolerance for the step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



```

1 \psset{xunit=.75}
2 \begin{pspicture*}[showgrid=true](-0.4,-3.4)(10,3)
3   \psplot[linestyle=dashed,linewidth=1.5pt]{.1}{10}{1 x div}
4   \psplot[linecolor=red,linewidth=1.5pt]{.1}{10}{
5     1      % start
6     x      % end
7     /t     % variable
8     { 1 t div } % function
9     .001   % tolerance
10    SIMPSON } %
11   \psplot[linecolor=blue,linewidth=1.5pt]{.1}{10}{1 x /t { 1 t div } 1 SIMPSON }
12 \end{pspicture*}

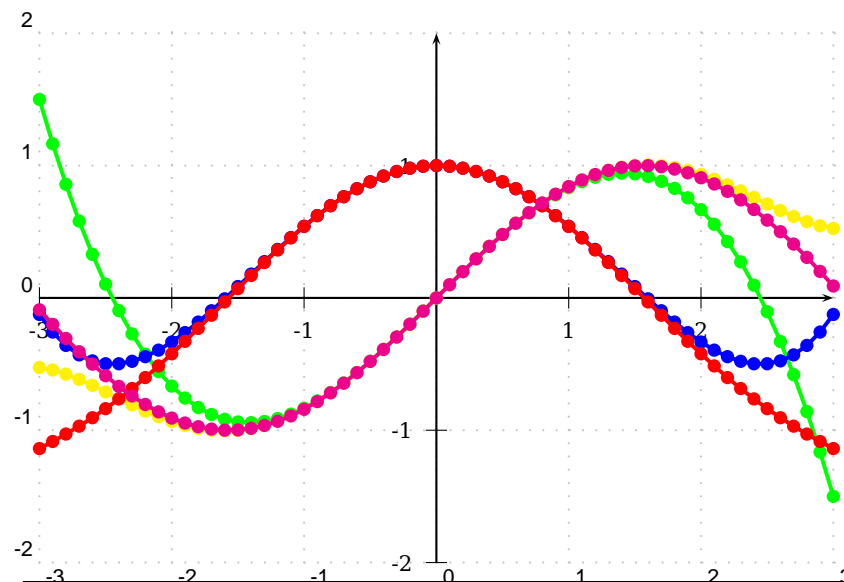
```



```

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

```



```

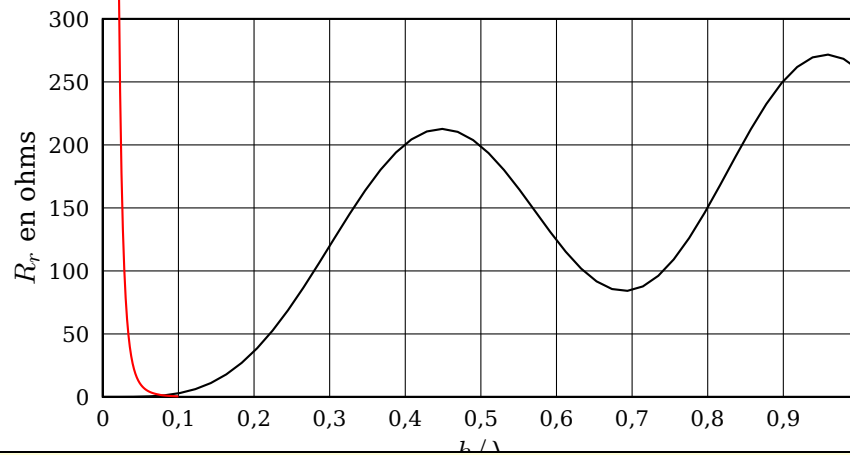
1 \psset{unit=1.75cm}
2 %% successive polynomial developments of sine-cosine
3 \begin{pspicture}[showgrid=true](-3,-2)(3,2)
4 \psaxes{->}(0,0)(-3,-2)(3,2)
5 \psplot[linecolor=green, algebraic=false, plotpoints=61, showpoints=true]
6   {-3}{3}{0 x /tutu
7     {1 0 tutu /toto { toto } .1 SIMPSON sub}
8     .01 SIMPSON }
9 \psplot[linecolor=blue, algebraic=false, plotpoints=61, showpoints=true]
10  {-3}{3}{1 0 x /tata
11    {0 tata /tutu
12      {1 0 tutu /toto { toto } .1 SIMPSON sub}
13      .01 SIMPSON }
14      .01 SIMPSON sub}
15 \psplot[linecolor=yellow, algebraic=false, plotpoints=61, showpoints=true]
16  {-3}{3}{0 x /titi
17    {1 0 titi /tata
18      {0 tata /tutu
19        {1 0 tutu /toto { toto } .1 SIMPSON sub}
20        .01 SIMPSON }
21        .01 SIMPSON sub}
22        .01 SIMPSON }
23 \psplot[linecolor=red, algebraic=false, plotpoints=61, showpoints=true]
24  {-3}{3}{1 0 x /tyty
25    {0 tyty /titi
26      {1 0 titi /tata
27        {0 tata /tutu
28          {1 0 tutu /toto { toto } .1 SIMPSON sub}
29          .01 SIMPSON }
30          .01 SIMPSON sub}
31          .01 SIMPSON }
32          .01 SIMPSON sub}
33 \psplot[linecolor=magenta, algebraic=false, plotpoints=61, showpoints=true]
34  {-3}{3}{0 x /tete
35    {1 0 tete /tyty
36      {0 tyty /titi
37        {1 0 titi /tata
38          {0 tata /tutu
39            {1 0 tutu /toto { toto } .1 SIMPSON sub}

```

```

40 .01 SIMPSON }
41 .01 SIMPSON sub}
42 .01 SIMPSON }
43 .01 SIMPSON sub}
44 .01 SIMPSON }%%% FIVE nested calls
45 \end{pspicture}

```



```

1 % ce code definit la fonction [cos(2pix cos(t))-cos(2pix)]^2 / sin(t) avec x=h/
  lambda
2 \def\F{
3   0.01 3.1
4   /t
5   { TwoPi x mul t COS mul COS TwoPi x mul COS sub 2 exp t SIN div }
6   .01 SIMPSON 60 mul }
7 % D = 2*(cos^2(2pix))/F
8 \def\fd{TwoPi x mul COS dup mul 2 mul \F\space div}
9 \psset{llx=-1.5cm,lly=-0.5cm,urx=0.2cm,ury=0.2cm,
10  xAxisLabel={h/\lambda},xAxisLabelPos={0.5,-45},yAxisLabel={R_r en ohms},
11  yAxisLabelPos={-0.1,150}}
12 \begin{psgraph}[Dy=50,Dx=0.1,xticks=300,0,yticks=1,0,
13  comma=true,axesstyle=frame](0,0)(1,300){10cm}{5cm}
14  \psplot{0}{1}{\F}
15  \psplot[linecolor=red]{0.01}{.1}{\fd}%
16 \end{psgraph}

```

## References

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