Example GIAC session

Here follows a sample session, which was started using Insert→Session→Giac.

```
Giac CAS for TeXmacs, released under the GPL license (3.0)
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© 2003-2019 B. Parisse & al (giac), J. van der Hoeven (TeXmacs)
```

```
Xcas (C-like) syntax mode
Type ? for documentation or ?commandname for help on commandname
Type tabulation key to complete a partial command
> f(x):=sin(x)+x
```

$$x \mapsto \sin x + x$$

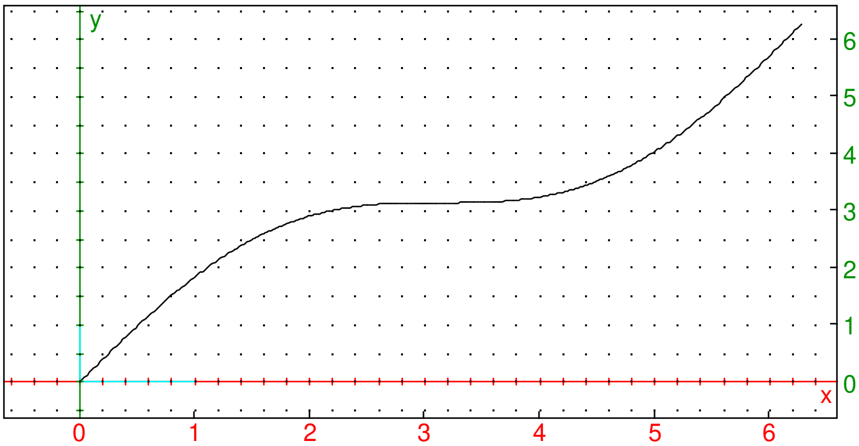
```
> diff(f(x),x)
```

$$\cos x + 1$$

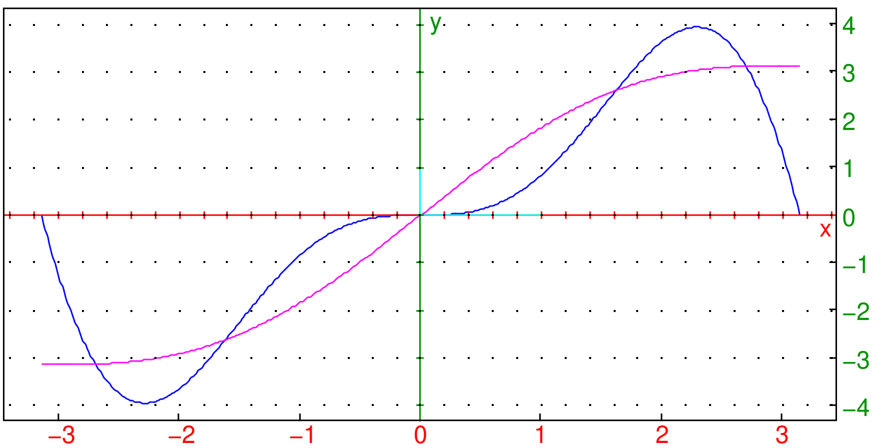
```
> integrate(f(x),x=0..pi)
```

$$\frac{\pi^2+2}{2}+1$$

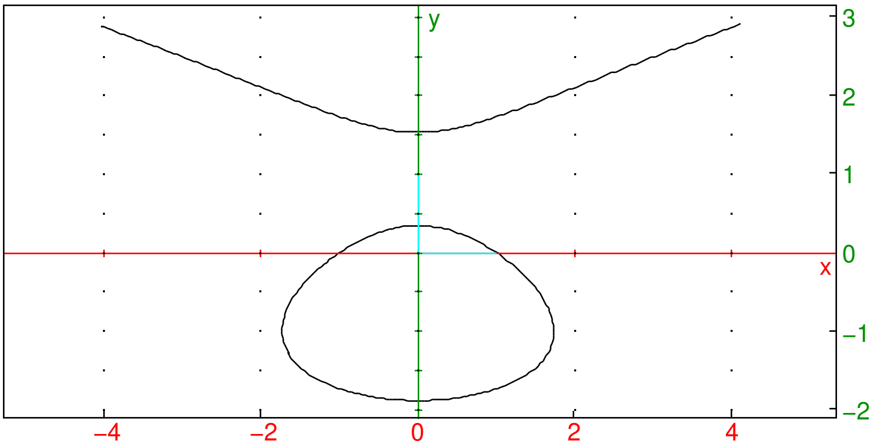
```
> plot(f(x),x=0..2*pi)
```




```
> plot([x^2*sin(x),f(x)],x=-pi..pi,color=[blue,magenta])
```



```
> implicitplot(x^2=y^3-3y+1,x=-4..4,y=-4..4)
```



Mathematical and physical constants, including physical units, are typeset properly using the conventional notation whenever possible, as in the example below.

```
> e,i,pi,euler_gamma,inf,5_Angstrom,10_(m/s^2),_NA_,_REarth_,_hbar_
```

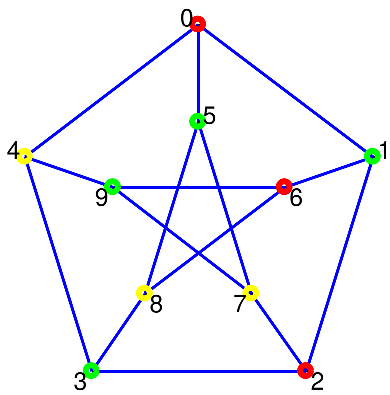
$$\mathrm{e}, \mathrm{i}, \pi, \gamma, +\infty, 5\ \text{Å}, 10\ \frac{\mathrm{m}}{\mathrm{s}^2}, 1\ N_A, 1\ R_\oplus, 1\ \hbar$$

Graphs can be constructed, manipulated with and drawn.

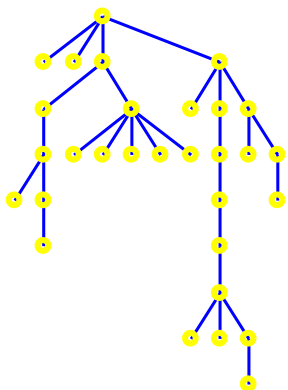
```
> G:=graph("petersen")
```

an undirected unweighted graph with 10 vertices and 15 edges

```
> draw_graph(highlight_vertex(G,vertices(G),greedy_color(G)))
```

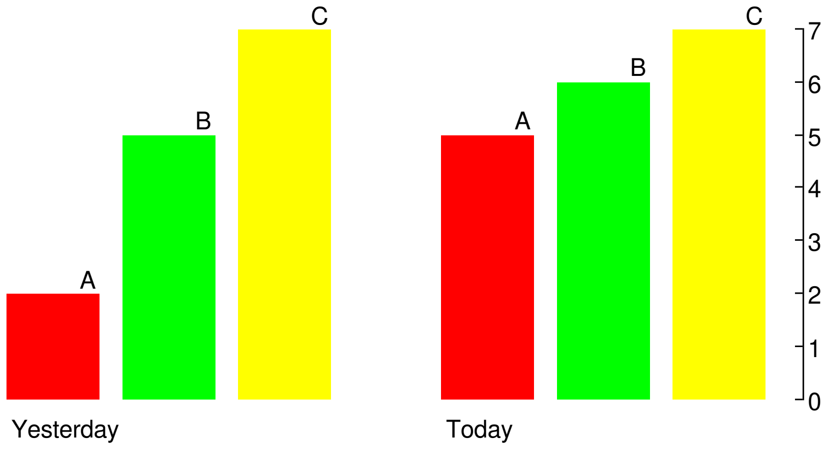



```
> draw_graph(random_tree(30),labels=false)
```

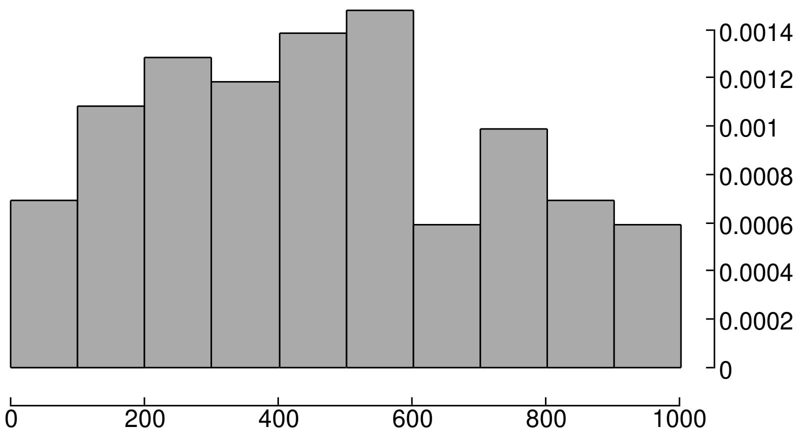


In the following examples it is demonstrated how to create bar plots, histograms and pie charts.

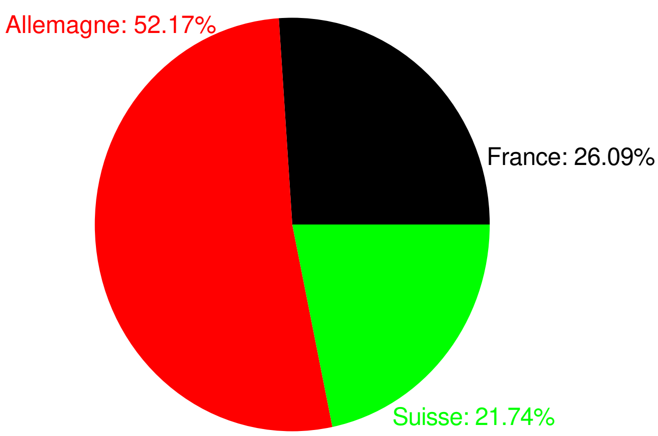
```
> bar_plot([[2,"Yesterday","Today"],["A",2,5],["B",5,6],["C",7,7]])
```




```
> histogram(seq(rand(1000),k,0,100),0,100)
```

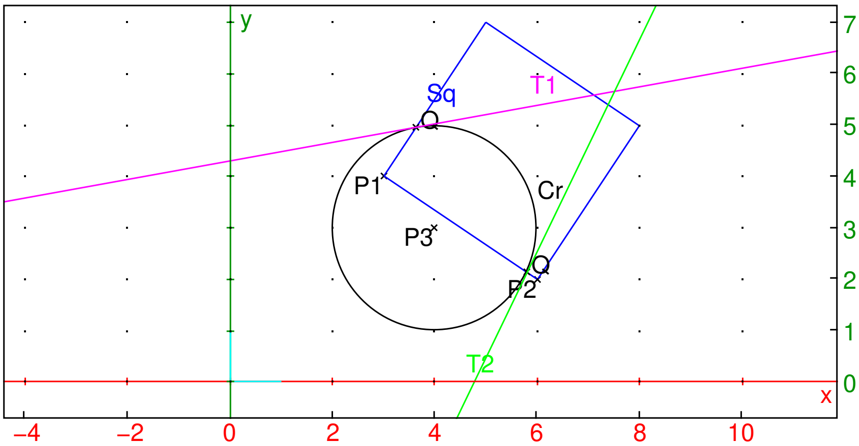



```
> camembert([["France",6],["Allemagne",12],["Suisse",5]])
```



A 2D geometry example:

```
> P1:=point(3,4); P2:=point(6,2); P3:=point(4,3); Sq:=square(P1,P2,color=blue);
  Cr:=circle(P3,2); Q:=inter(Sq,Cr); T1:=tangent(Cr,Q[0],color=magenta);
  T2:=tangent(Cr,Q[1],color=green)
```



The GIAC plugin has a good support for mathematical input mode. Besides the usual algebraic expressions, the following standard notations are supported:

- (partial) derivatives
- integrals, sums and products
- limits
- piecewise defined functions
- simplified notation for powers of trigonometric and other elementary functions (e.g. $\sin^2 x$)
- absolute values, floor, ceiling
- sets, lists, and matrices
- special functions
- complex conjugates, real and imaginary parts
- etc.

When entering derivatives, the function application symbol (entered by pressing `Space`) between the derivative operator and the argument is mandatory, as well as the parentheses around the argument. To hide the latter, one can enter invisible parentheses by pressing `(` `Tab`, which are treated as normal parentheses. Note that they are used around the argument of ln function in the expressions below (parentheses around function arguments are mandatory in GIAC).

> $\frac{\mathrm{d}}{\mathrm{d}x}\left(x \ln x - \frac{1}{1-x}\right)$

$$\ln x + 1 - \frac{1}{(1-x)^2}$$

> $\frac{\mathrm{d}^2}{\mathrm{d}x^2}\left(x \ln x - \frac{1}{1-x}\right)$

$$\frac{x^3 - 3\,x^2 + 5\,x - 1}{x^4 - 3\,x^3 + 3\,x^2 - x}$$

In the following example, the stationary points of the function f are computed.

> $\mathrm{assume}\,(r>0)$

$$r$$

> $f:=\mathrm{unapply}\left(\frac{\ln x}{r}-\frac{r\,x}{x+1},x\right)$

$$x\mapsto\frac{\ln x}{r}-\frac{r\,x}{x+1}$$

> $\mathrm{solve}\left(\frac{\mathrm{d}}{\mathrm{d}x}\,f(x)=0,x\right)$

$$\left[\frac{r^2+r\sqrt{r^2-4}-2}{2},\frac{r^2-r\sqrt{r^2-4}-2}{2}\right]$$

Various notations for deriatives in differential equations are supported.

> $\mathrm{dsolve}\left(\frac{\mathrm{d}^2\,y}{\mathrm{d}x^2}-y=2\sin x,x,y\right)$

$$c_0\,\mathrm{e}^x+c_1\,\mathrm{e}^{-x}-\sin x$$

> $\mathrm{dsolve}\,(y''-y=2\sin x\wedge y(0)=0\wedge y'(0)=1,x,y)$

$$\mathrm{e}^x-\mathrm{e}^{-x}-\sin x$$

> $\mathrm{dsolve}\,(\ddot{x}=x,t,x)$

$$c_0\,\mathrm{e}^t+c_1\,\mathrm{e}^{-t}$$

> $\mathrm{simplify}\,(\mathrm{dsolve}\,(y^{(3)}=t+y,t,y))$

$$c_0\,\mathrm{e}^t+c_1\cos\left(\frac{1}{2}\sqrt{3}\,t\right)\mathrm{e}^{-\frac{t}{2}}+c_2\,\mathrm{e}^{-\frac{t}{2}}\sin\left(\frac{1}{2}\sqrt{3}\,t\right)-t$$

Partial derivatives are supported as well.

> $\mathrm{collect}\left(\frac{\partial^3}{\partial x\,\partial y^2}\left(\frac{y\,\mathrm{e}^{-x}}{x^2+y^2}\right)\right)$

$$\frac{2\,y\,(3\,x^4+12\,x^3+2\,x^2\,y^2-12\,x\,y^2-y^4)\,\mathrm{e}^{-x}}{(y^2+x^2)^4}$$

> $\frac{\partial^2}{\partial x\,\partial y}\,g\,(x,x\,y)$

$$x\,y\,g^{(2,2)}\,(x,x\,y)+x\,g^{(1,2)}\,(x,x\,y)+g^{(2)}\,(x,x\,y)$$

> $\mathrm{addtable}\,(\mathrm{fourier},y\,(x),Y\,(s),x,s)$

$$1$$

> $T:=\mathrm{fourier}\left(y\,(x+1)-\frac{\mathrm{d}^3}{\mathrm{d}x^3}\,y\,(x),x,s\right)$

$$(\mathrm{e}^{\mathrm{i}\,s}+\mathrm{i}\,s^3)\,Y\,(s)$$

> $\mathrm{eq}:=\mathrm{euler\_lagrange}\,(x^2\cdot(y')^2+2\,y^2)$

$$\frac{\mathrm{d}^2}{\mathrm{d}x^2}\,y\,(x)=\frac{-2\,\frac{\mathrm{d}}{\mathrm{d}x}\,y\,(x)\,x+2\,y\,(x)}{x^2}$$

> $\mathrm{dsolve}\,(\mathrm{eq},x,y)$

$$\frac{\left(-\frac{c_0}{3\,x^3}+c_1\right)x^3}{x^2}$$

Integrals, sums and products are entered in the usual way.

> $\displaystyle\int \frac{1}{(x^2+9)^3}\,\mathrm{d}x$

$$\frac{x^3+15\,x}{216\,(x^2+9)^2}+\frac{\arctan\left(\frac{x}{3}\right)}{648}$$

> $\displaystyle\int_0^{\pi/4} \sqrt{\tan x}\,\mathrm{d}x$

$$\frac{\pi\sqrt{2}-\sqrt{2}\ln\left(\sqrt{2}+2\right)+\sqrt{2}\ln\left(-\sqrt{2}+2\right)}{4}$$

> $\displaystyle\int_{-\infty}^{+\infty} \mathrm{e}^{-x^2}\,\mathrm{d}x$

$$\sqrt{\pi}$$

> $\mathrm{assume}\,(\alpha>0)$

$$\alpha$$

> $\displaystyle\int_0^{+\infty} \ln\left(1+\frac{\alpha^2}{x^2}\right)\mathrm{d}x$

$$\pi\,\alpha$$

> $\displaystyle\sum_{k=1}^{+\infty}\frac{1}{1+\pi^2\,k^2}$

$$\frac{1}{\mathrm{e}^2-1}$$

> $\displaystyle\prod_{k=1}^{10}\left(1-\frac{1}{2\,k^2}\right)$

$$\frac{103376401778279}{275188285440000}$$

Heaviside function and Dirac δ-distribution are associated with upright Greek symbols ϑ and δ, respectively.

> $F:=\mathrm{fourier}\left(\frac{x}{x^2-x+1},x,\omega\right)$

$$\pi\left(\mathrm{i}\,\vartheta\,(-\omega)\,\mathrm{e}^{\frac{\omega\sqrt{3}-\mathrm{i}\omega}{2}}-\mathrm{i}\,\vartheta\,(\omega)\,\mathrm{e}^{\frac{-\omega\sqrt{3}-\mathrm{i}\omega}{2}}+\mathrm{e}^{-\frac{1}{2}\mathrm{i}\omega}\,\mathrm{e}^{-\frac{3|\omega|\mathrm{e}^{-\frac{\ln(3)}{2}}+\ln(3)}{2}}\right)$$

> $F:=\mathrm{exp2pow}\,(\mathrm{lin}\,(F))$

$$\pi\,\mathrm{i}\,\vartheta\,(-\omega)\,\mathrm{e}^{\frac{\omega\sqrt{3}-\mathrm{i}\omega}{2}}-\pi\,\mathrm{i}\,\vartheta\,(\omega)\,\mathrm{e}^{-\frac{\omega\sqrt{3}+\mathrm{i}\omega}{2}}+\pi\,\mathrm{e}^{\frac{-\mathrm{i}\omega\sqrt{3}-3|\omega|}{2\sqrt{3}}}\,\sqrt{3}^{-1}$$

> $\mathrm{ifourier}\,(F,\omega,x)$

$$\frac{x}{x^2-x+1}$$

> $h:=\mathrm{fourier}\,(1)$

$$2\,\pi\,\delta\,(x)$$

> $\mathrm{ifourier}\,(h)$

$$1$$

GIAC can determine domain of an univariate real function and solve inequalities.

> $\mathrm{domain}\left(\sqrt{3-\sqrt{2-\sqrt{1-x}}},x\right)$

$$x \geqslant -3 \wedge x \leqslant 1$$

> $\mathrm{solve}\,(|2\,x^2-3| \leqslant 5, x)$

$$[x \geqslant -2 \wedge x \leqslant 2]$$

> $\mathrm{solve}\,(x-|x-|x^2-3\,x-2||-1>0, x)$

$$\left[x > \frac{\sqrt{13}+1}{2} \wedge x < \frac{\sqrt{13}+3}{2}, x > \frac{\sqrt{21}+3}{2} \wedge x < \frac{\sqrt{29}+5}{2}\right]$$

A partial fractions decomposition example:

> $\mathrm{partfrac}\left(\frac{x^4-44\,x^3+22\,x^2-11\,x+1}{x^5+3\,x^4+x^3-x^2-4}, x\right)$

$$-\frac{31}{18\,(x-1)}-\frac{479}{15\,(x+2)^2}+\frac{1742}{225\,(x+2)}+\frac{-251\,x+107}{50\,(x^2+1)}$$

Simplification and auto-simplification examples:

> $\mathrm{simplify}\left(\sqrt{5+2\,\sqrt{6}}+\sqrt{9-2\,\sqrt{6}-4\,\sqrt{5-2\,\sqrt{6}}}\right)$

$$2\,\sqrt{2}+2$$

> $\mathrm{simplify}\left(\cot\left(\mathrm{atan}\left(\frac{12}{13}\right)+\mathrm{acos}\left(\frac{4}{5}\right)\right)\right)$

$$\frac{16}{87}$$

> $\mathrm{trigsimplify}\left(1-\frac{1}{4}\sin^2(2\,x)-\sin^2 y-\cos^4 x\right)$

$$\sin^2 x-\sin^2 y$$

> $\mathrm{trigsimplify}\left(\frac{\sum_{n=1}^{5}\sin(n\,x)}{\sum_{n=1}^{5}\cos(n\,x)}\right)$

$$\tan(3\,x)$$

> $\mathrm{assume}\,(n, \mathrm{integer}); \mathrm{additionally}(n \geqslant 0)$

$$\mathbb{Z}, n$$

> $\Gamma\,(n+1)$

$$n!$$

> $\cos\,(n\,\pi)$

$$(-1)^n$$

Binomial coefficients are entered using the binom tag.

> $\binom{49}{7}$

$$85900584$$

An expression with the wide bar accent is interpreted as the complex conjugate. Additionally, the usual notation for real and imaginary parts is supported.

> $\text{csolve}\left(z^2 \cdot \bar{z} = \Re(z) - 8\,\mathrm{i}, z\right)$

$$[-2\,\mathrm{i}]$$

Substitution of parameters in an expression can be executed using the | symbol, obtained by pressing `| Tab`.

> $\cos^2 y + y \sin x | x = \frac{\pi}{3}, y = \frac{\pi}{4}$

$$\left(\frac{\sqrt{2}}{2}\right)^2 + \frac{\pi\sqrt{3}}{4 \cdot 2}$$

The invisible addition symbol, entered with `+ Tab Tab Tab Tab`, translates to `+`.

> $7\,{}^{3}\!/_{4}$

$$\frac{31}{4}$$

The invisible symbol, entered with `. Tab Tab Tab`, is interpreted as the underscore (_). It is useful for e.g. differentiating between e.g. `x0` and `x_0`, which are both typeset (and, in math input mode, entered) as x_0. However, in the latter case the invisible symbol is appended to x, as in the example below. Since the subscript of a symbol is simply appended to the symbol for input in Giac, the concatenation yields `x_0`. The invisible symbol is also used for entering physical units, which begin with _, and physical constants, which begin and end with _ in Giac.

> $\text{simplify}\left(x_0 - x_0\right)$

$$-x_0 + x_0$$

> $\text{mksa}\left(12.3\ \mathrm{km}^2\right)$

$$12300000.0\ \mathrm{m}^2$$

> $\text{mksa}(c)$

$$299792458.0\ \mathrm{m\,s}^{-1}$$

Bold symbols may be used, which is useful for denoting matrices and vectors. Bold symbols are input as double symbol, e.g. **G** is `GG` in Giac. Note that indices in Giac are 0-based by default. For 1-based indices, switch to Maple mode.

> $\mathbf{A} := \text{matrix}\left(4, 4, (j, k) \mapsto k + j^{k+1}\right)$

$$\begin{pmatrix} 0 & 1 & 2 & 3 \\ 1 & 2 & 3 & 4 \\ 2 & 5 & 10 & 19 \\ 3 & 10 & 29 & 84 \end{pmatrix}$$

> $\det(\mathbf{A})$

$$-24$$

> $\mathbf{A}^{-1}$

$$\begin{pmatrix} -\frac{17}{6} & -\frac{3}{2} & \frac{3}{2} & -\frac{1}{6} \\ \frac{17}{6} & \frac{23}{4} & -\frac{7}{2} & \frac{5}{12} \\ -\frac{7}{6} & -4 & \frac{5}{2} & -\frac{1}{3} \\ \frac{1}{6} & \frac{3}{4} & -\frac{1}{2} & \frac{1}{12} \end{pmatrix}$$

> $\mathbf{v} := [-1, 3, 7]$

$$[-1, 3, 7]$$

The expression below is computed as ℓ^2-norm of **v**.

> $\|\mathbf{v}\|$

$$\sqrt{59}$$

If A is a matrix, then its element a_{ij} can be fetched using the common notation, as below. Note that the indices in the subscript must be enclosed within invisible parentheses and separated by (invisible) comma.

> $\mathbf{A}_{32}$

$$29$$

> $\mathbf{v}_1 + \mathbf{v}_2$

$$10$$

Limits are entered like in the examples below. Note that the body of a limit must be parenthesed (use invisible parentheses when appropriate) and prepended by the function application symbol.

> $\lim\limits_{x \to 0} \dfrac{1 - \frac{1}{2}x^2 - \cos\left(\frac{x}{1-x^2}\right)}{x^4}$

$$\frac{23}{24}$$

> $\lim\limits_{x \to 0^+} \mathrm{e}^{-1/x}$

$$0$$

> $\lim\limits_{x \to 1^-} \sin(\pi\, x)^{1/\ln(1-x)}$

$$\mathrm{e}$$

> $\lim\limits_{n \to +\infty} \left(\sqrt[3]{n^3 - 2\,n^2 + n - 1} - n\right)$

$$-\frac{2}{3}$$

It can be shown that be shown that the series $\sum_{n=0}^{\infty} s(n)$, where s is defined below, converges to $\frac{1}{\pi}$ (J. M. Borwein et al., 1989). We prove the convergence using the criterion of D'Alembert and compute the number of significant digits in the approximation of π using the first 11 terms.

> $s(n) := \binom{2\,n}{n}^3 \dfrac{42\,n + 5}{2^{12\,n+4}}$

$$n \mapsto \binom{2\,n}{n}^3 \frac{42\,n + 5}{2^{12\,n+4}}$$

> $\lim\limits_{n \to +\infty} \dfrac{s(n+1)}{s(n)} < 1$

$$\mathrm{true}$$

> $p := \left(\sum\limits_{n=0}^{10} s(n)\right)^{-1}$

$$\frac{3323069989462289682259517650700861 44}{1057766030126511894982930619077044 45}$$

> $\mathrm{simplify}\,(1 + \lfloor -\log_{10}(2\,|\pi - p|)\rfloor)$

$$20$$

The symbol ε stands for `epsilon()` in GIAC, which is by default set to 10^{-12}.
> $125.483\,\varepsilon$

$$1.25483 \times 10^{-10}$$

Finite sequences, lists, and sets can be generated as in the examples below. The symbol $|$ is entered by pressing `| Tab Tab Tab Tab`.
> $\text{euler}\,(k) \,|\, k = 1 \ldots 20$

$$1, 1, 2, 2, 4, 2, 6, 4, 6, 4, 10, 4, 12, 6, 8, 8, 16, 6, 18, 8$$

> $[\text{ithprime}\,(j) \,|\, j = 1 \ldots 20]$

$$[2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71]$$

> $A := \{k^2 \,|\, k = 1 \ldots 10\}$

$$\{1, 4, 9, 16, 25, 36, 49, 64, 81, 100\}$$

> $B := \{1 + 8\,k \,|\, k = 1 \ldots 10\}$

$$\{9, 17, 25, 33, 41, 49, 57, 65, 73, 81\}$$

> $C := \{9, 18, 27\}$

$$\{9, 18, 27\}$$

Set operations are entered in the usual way.
> $A \setminus B$

$$\{1, 4, 16, 36, 64, 100\}$$

> $(A \cap B) \cup C$

$$\{9, 25, 49, 81, 18, 27\}$$

Using the notation $a \in A$ we get the 1-based index of the element a in the set A, or 0 if $a \notin A$.
> $19 \in A, 57 \in B$

$$0, 7$$

The usual notation for composition of functions is supported.
> $(\cos \circ \sin)(\pi)$

$$1$$

> $f := x \mapsto x^2 + 1; g := y \mapsto y - 1$

$$x \mapsto x^2 + 1, y \mapsto y - 1$$

> $(f \circ g)(4)$

$$10$$

Conditionals are entered like in the examples below.
> $1 == 2$

$$\text{false}$$

> $1 \neq 0$

$$\text{true}$$

> $\text{assume}\,(h \geqslant 0)$

$$h$$

> $h < h+1$

$$\text{true}$$

> $\sin(h) - h \leqslant 2$

$$\text{true}$$

Polynomials may be entered as lists of coefficients with double-struck brackets.

> $p := [\![-1,3,2]\!];\ q := [\![2,0,-2,1]\!]$

$$[\![-1,3,2]\!],\ [\![2,0,-2,1]\!]$$

> $p \cdot q$

$$[\![-2,6,6,-7,-1,2]\!]$$

> $\text{expand}\,(\text{poly2symb}\,(p+q,x))$

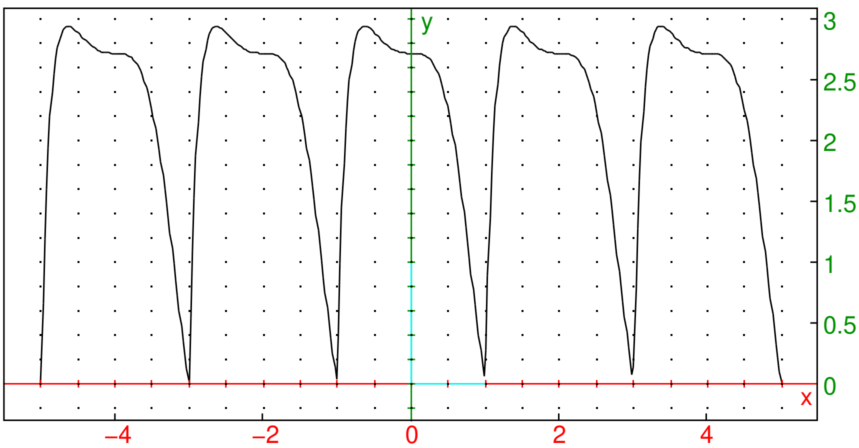
$$2\,x^3 - x^2 + x + 3$$

Periodic functions can be defined, as demonstrated below.

> $h := \text{periodic}\,((1-x^4)\,\mathrm{e}^{1-x^3}, x = -1\ldots1)$

$$\left(1-\left(x-2\left\lfloor\frac{x+1}{2}\right\rfloor\right)^4\right)\mathrm{e}^{1-\left(x-2\left\lfloor\frac{x+1}{2}\right\rfloor\right)^3}$$

> $\text{plot}\,(h, x = -5\ldots5)$

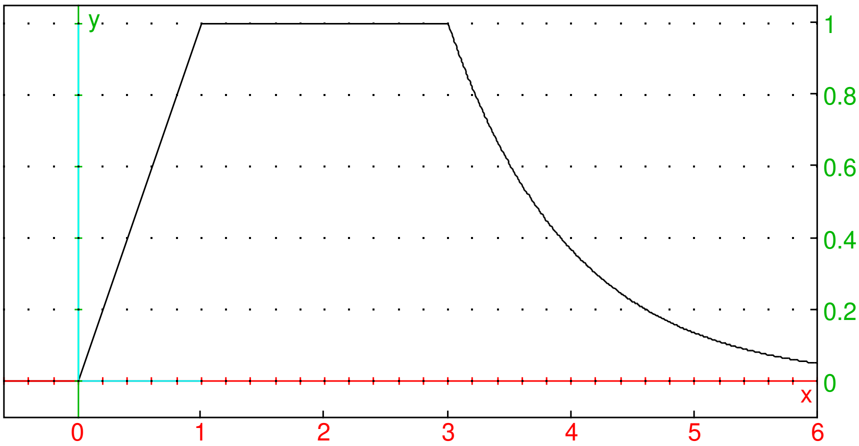


Piecewise functions are supported as well. Note that a textual “condition” (a text tag) is interpreted as “otherwise”, no matter of its contents.

> $f(x) := \begin{cases} 0, & x<0 \\ x, & x<1 \\ 1, & x<3 \\ \mathrm{e}^{3-x}, & \text{in all other cases} \end{cases}$

$$x \mapsto \begin{cases} 0, & x<0 \\ x, & x<1 \\ 1, & x<3 \\ \mathrm{e}^{3-x}, & \text{otherwise} \end{cases}$$

> $\text{plot}(f(x), x = -1...6)$



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