



Example GIAC session



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

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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`

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

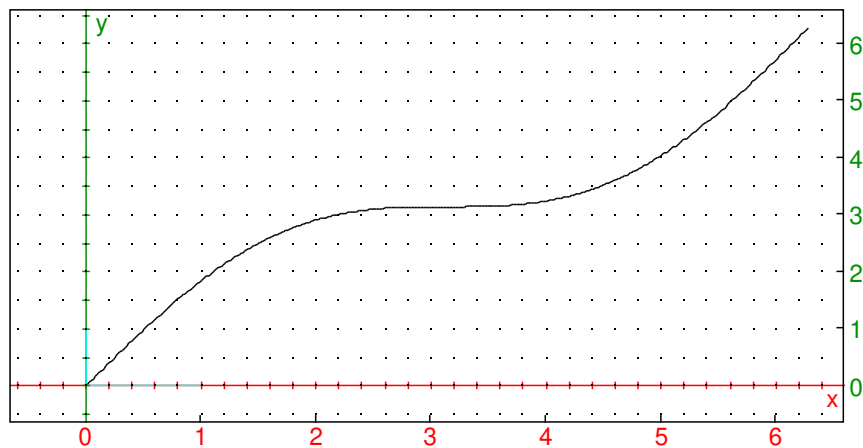
> `diff(f(x),x)`

$$\cos x + 1$$

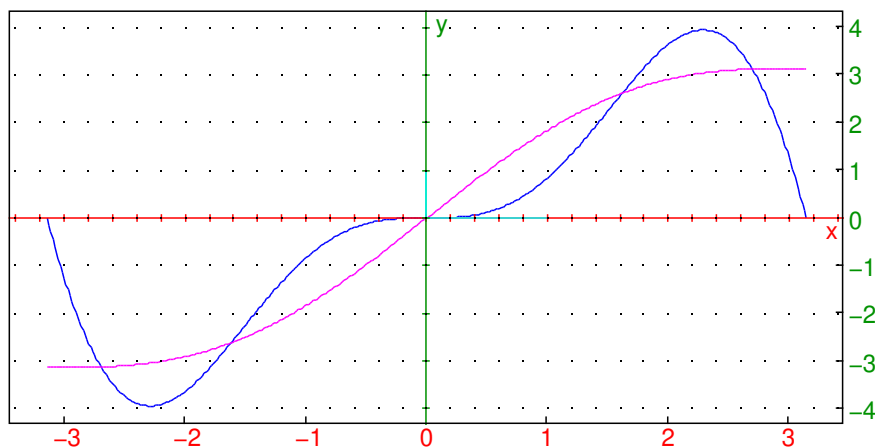
> `integrate(f(x),x=0..pi)`

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

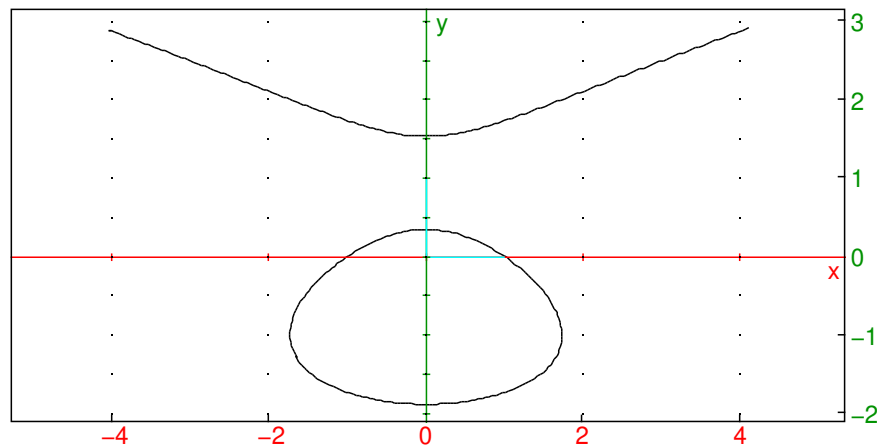
> `plot(f(x),x=0..2*pi)`



> `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_
```

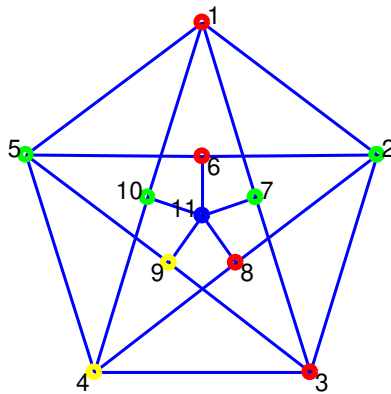
$$e, i, \pi, \gamma, +\infty, 5 \text{ \AA}, 10 \frac{\text{m}}{\text{s}^2}, 1 N_A, 1 R_{\oplus}, 1 \hbar$$

Graphs can be constructed, manipulated with and drawn.

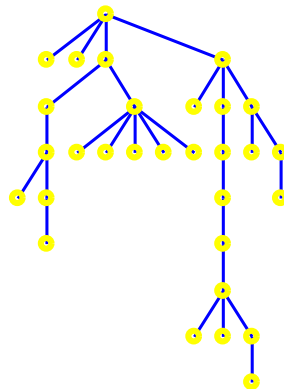
```
> G:=graph("grotzsch")
```

an undirected unweighted graph with 11 vertices and 20 edges

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

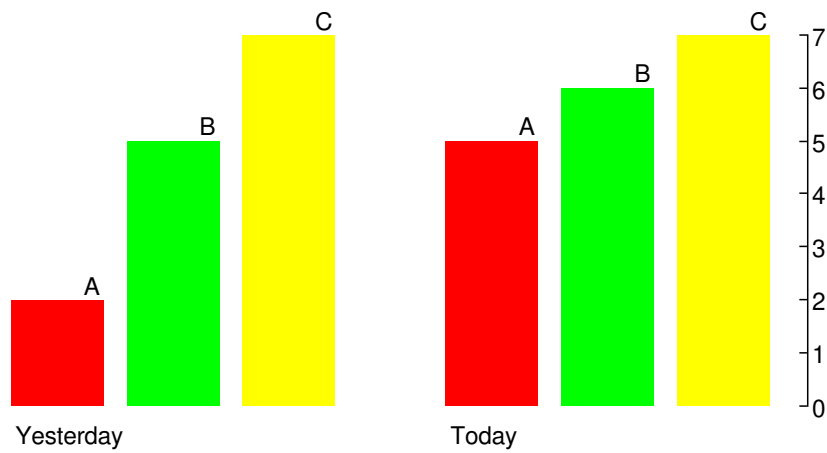


```
> draw_graph(random_tree(30),labels=false)
```

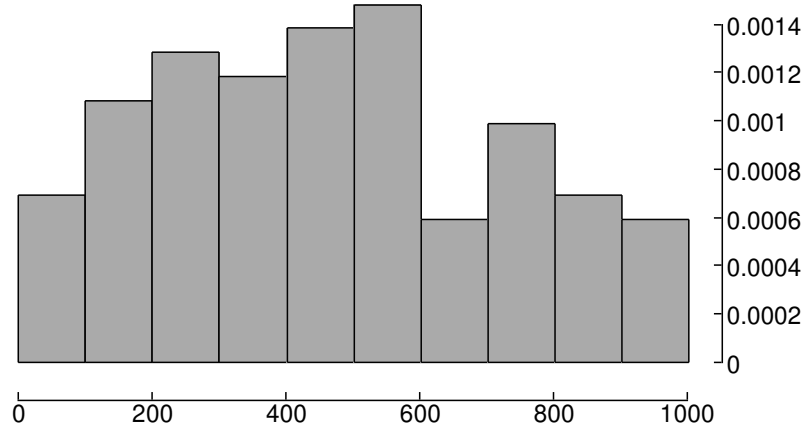


In the following examples it is demonstrated how to create bar plots, histograms and pie charts.

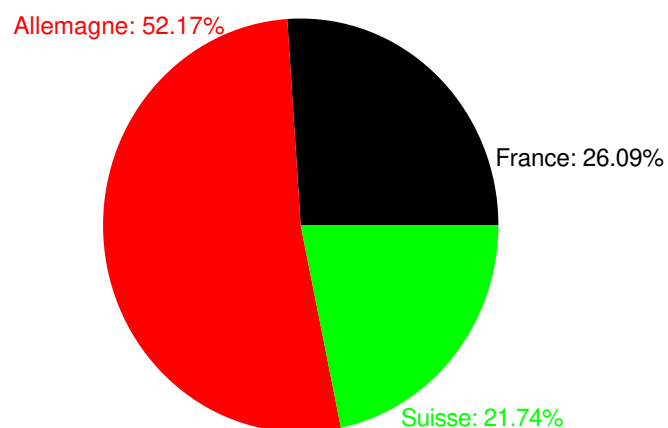
```
> bar_plot([[2,"Yesterday","Today"],["A",2,5],["B",5,6],["C",7,7]])
```



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

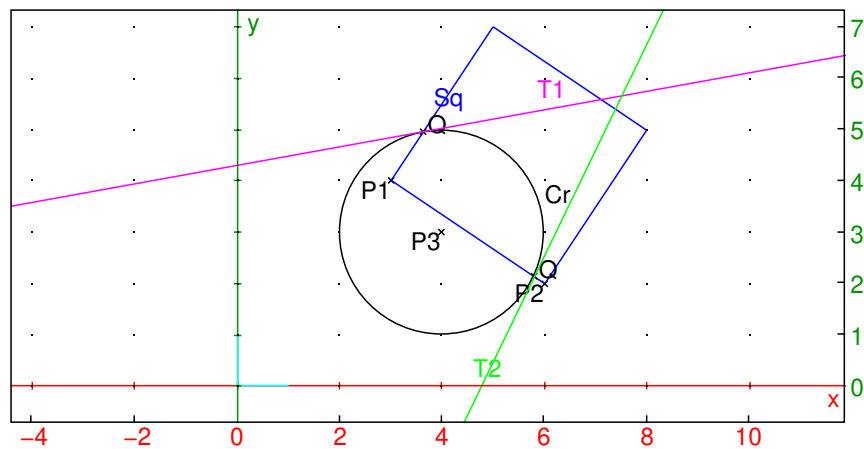


```
> camembert([["France",6],["Allemagne",12],["Suisse",5]])
```



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).

```
> d/dx ( x ln x - 1/(1-x) )
```

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

```
> d^2/dx^2 ( x ln x - 1/(1-x) )
```

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

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

> assume ($r > 0$)

$$r$$

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

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

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

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

Various notations for derivatives in differential equations are supported.

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

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

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

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

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

$$c_0 e^t + c_1 e^{-t}$$

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

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

Partial derivatives are supported as well.

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

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

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

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

> addtable (fourier, $y(x), Y(s), x, s$)

$$1$$

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

$$(e^{is} + i s^3) Y(s)$$

> eq := euler_lagrange ($x^2 \cdot (y')^2 + 2 y^2$)

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

> dsolve (eq, x, y)

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

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

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

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

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

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

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

$$\sqrt{\pi}$$

$$> \text{assume}(\alpha > 0)$$

$$\alpha$$

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

$$\pi \alpha$$

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

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

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

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

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

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

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

$$> F:=\text{exp2pow}\left(\text{lin}\left(F\right)\right)$$

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

$$> \text{ifourier}\left(F,\omega,x\right)$$

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

$$> h:=\text{fourier}\left(1\right)$$

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

$$> \text{ifourier}\left(h\right)$$

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

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

$$x \geq -3 \wedge x \leq 1$$

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

$$[x \geq -2 \wedge x \leq 2]$$

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

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

A partial fractions decomposition example:

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

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

Simplification and auto-simplification examples:

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

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

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

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

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

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

$$> \text{trigsimplify}\left(\frac{\sum_{n=1}^5 \sin(nx)}{\sum_{n=1}^5 \cos(nx)}\right)$$

$$\tan(3x)$$

$$> \text{assume}(n, \text{integer}); \text{additionally}(n \geq 0)$$

$$\mathbb{Z}, n$$

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

$$n!$$

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

$$(-1)^n$$

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.

> `csolve`($z^2 \cdot \bar{z} = \Re(z) - 8i, z$)

$$[-2i]$$

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

> `cos2 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 `+`.

> `73/4`

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

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.

> `simplify`($x_0 - x_0$)

$$-x_0 + x_0$$

> `mksa`(12.3 km^2)

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

> `mksa`(c)

$$299792458.0 \text{ m s}^{-1}$$

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.

> `A:=matrix`($4, 4, (j, k) \mapsto k + j^{k+1}$)

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

> `det`(**A**)

$$-24$$

> **A**⁻¹

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

> **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 parenthesized (use invisible parentheses when appropriate) and prepended by the function application symbol.

> $\lim_{x \rightarrow 0} \frac{1 - \frac{1}{2}x^2 - \cos\left(\frac{x}{1-x^2}\right)}{x^4}$

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

> $\lim_{x \rightarrow 0^+} e^{-1/x}$

$$0$$

> $\lim_{x \rightarrow 1^-} \sin(\pi x)^{1/\ln(1-x)}$

$$e$$

> $\lim_{n \rightarrow +\infty} \left(\sqrt[3]{n^3 - 2n^2 + n - 1} - n \right)$

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

It can 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.

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

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

> $\lim_{n \rightarrow +\infty} \frac{s(n+1)}{s(n)} < 1$

$$\text{true}$$

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

$$\frac{332306998946228968225951765070086144}{105776603012651189498293061907704445}$$

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

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

> 125.483 ε

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

Finite sequences, lists, and sets can be generated as in the examples below. The symbol `|` is entered by pressing `| Tab Tab Tab Tab`.

> euler(k) | $k = 1 \dots 20$

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

> [ithprime(j) | $j = 1 \dots 20$]

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

> $A := \{k^2 \mid k = 1 \dots 10\}$

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

> $B := \{1 + 8k \mid k = 1 \dots 10\}$

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

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

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

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)(π)

$$1$$

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

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

> (f \circ g)(4)

$$10$$

Conditionals are entered like in the examples below.

> 1 \equiv 2

$$\text{false}$$

> 1 \neq 0

$$\text{true}$$

> assume ($h \geq 0$)

h

> $h < h + 1$

true

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

true

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

> $p := \llbracket -1, 3, 2 \rrbracket; q := \llbracket 2, 0, -2, 1 \rrbracket$

$\llbracket -1, 3, 2 \rrbracket, \llbracket 2, 0, -2, 1 \rrbracket$

> $p \cdot q$

$\llbracket -2, 6, 6, -7, -1, 2 \rrbracket$

> expand (poly2symb ($p + q, x$))

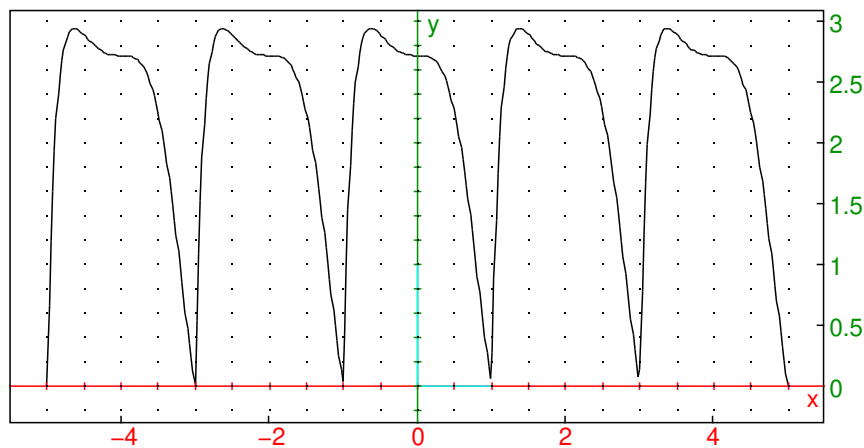
$2x^3 - x^2 + x + 3$

Periodic functions can be defined, as demonstrated below.

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

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

> plot ($h, x = -5 \dots 5$)

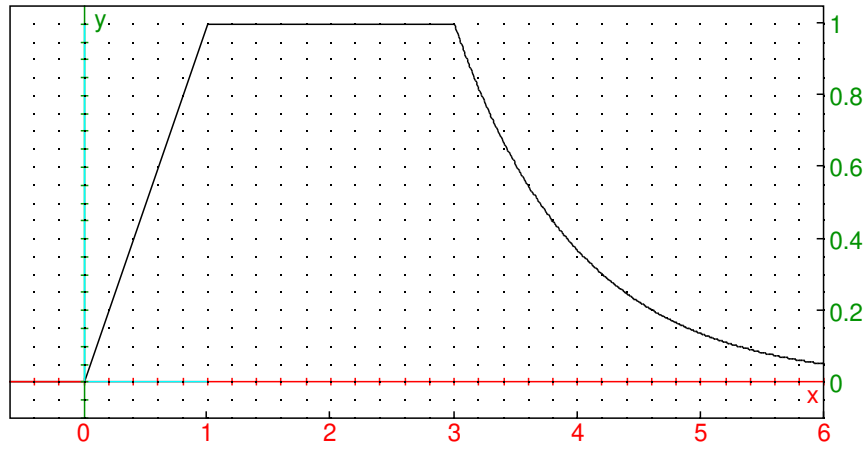


Piecewise functions are supported as well. Note that a textual “condition” (a [text](#) tag) is interpreted as “otherwise”, no matter of its contents.

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

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

```
> plot(f(x), x = -1..6)
```



```
>
```