

Pari-GP reference card

(PARI-GP version 2.15.3)

Note: optional arguments are surrounded by braces {}.

To start the calculator, type its name in the terminal: **gp**

To exit **gp**, type **quit**, **\q**, or **<C-D>** at prompt.

Help

| | |
|---|---------------------|
| describe function | ?function |
| extended description | ??keyword |
| list of relevant help topics | ???pattern |
| name of GP-1.39 function <i>f</i> in GP-2.* | whatnow(<i>f</i>) |

Input/Output

| | |
|--|--|
| previous result, the result before | %, %`, %`` , etc. |
| <i>n</i> -th result since startup | % <i>n</i> |
| separate multiple statements on line | ; |
| extend statement on additional lines | \ |
| extend statements on several lines | { <i>seq</i> ₁ ; <i>seq</i> ₂ ;} |
| comment | /* ... */ |
| one-line comment, rest of line ignored | \\ ... |

Metacommands & Defaults

| | |
|--|--------------------------------------|
| set default <i>d</i> to <i>val</i> | default({ <i>d</i> },{ <i>val</i> }) |
| toggle timer on/off | # |
| print time for last result | ## |
| print defaults | \d |
| set debug level to <i>n</i> | \g <i>n</i> |
| set memory debug level to <i>n</i> | \gm <i>n</i> |
| set <i>n</i> significant digits / bits | \p <i>n</i> , \pb <i>n</i> |
| set <i>n</i> terms in series | \ps <i>n</i> |
| quit GP | \q |
| print the list of PARI types | \t |
| print the list of user-defined functions | \u |
| read file into GP | \r <i>filename</i> |
| set debuglevel for domain <i>D</i> to <i>n</i> | setdebug(<i>D</i> , <i>n</i>) |

Debugger / break loop

| | |
|--|--------------------------------|
| get out of break loop | break or <C-D> |
| go up/down <i>n</i> frames | dbg_up({ <i>n</i> }), dbg_down |
| set break point | breakpoint() |
| examine object <i>o</i> | dbg_x(<i>o</i>) |
| current error data | dbg_err() |
| number of objects on heap and their size | getheap() |
| total size of objects on PARI stack | getstack() |

PARI Types & Input Formats

| | |
|---|---|
| t_INT . Integers; hex, binary | ± 31 ; $\pm 0x1F$, $\pm 0b101$ |
| t_REAL . Reals | ± 3.14 , 6.022 E23 |
| t_INTMOD . Integers modulo <i>m</i> | Mod(<i>n</i> , <i>m</i>) |
| t_FRAC . Rational Numbers | <i>n</i> / <i>m</i> |
| t_FFELT . Elt in finite field F _{<i>q</i>} | ffgen(<i>q</i> , 't) |
| t_COMPLEX . Complex Numbers | <i>x</i> + <i>y</i> * I |
| t_PADIC . <i>p</i> -adic Numbers | <i>x</i> + 0(<i>p</i> ^ <i>k</i>) |
| t_QUAD . Quadratic Numbers | <i>x</i> + <i>y</i> * quadgen(<i>D</i> ,{'w'}) |
| t_POLMOD . Polynomials modulo <i>g</i> | Mod(<i>f</i> , <i>g</i>) |
| t_POL . Polynomials | <i>a</i> * <i>x</i> ^ <i>n</i> + ... + <i>b</i> |
| t_SER . Power Series | <i>f</i> + 0(<i>x</i> ^ <i>k</i>) |
| t_RFRAC . Rational Functions | <i>f</i> / <i>g</i> |
| t_QFB . Binary quadratic form | Qfb(<i>a</i> , <i>b</i> , <i>c</i>) |
| t_VEC / t_COL . Row/Column Vectors | [<i>x</i> , <i>y</i> , <i>z</i>], [<i>x</i> , <i>y</i> , <i>z</i>]~ |
| t_VEC integer range | [1..10] |

| | |
|--|---|
| t_VECSMALL . Vector of small ints | Vecsmall([<i>x</i> , <i>y</i> , <i>z</i>]) |
| t_MAT . Matrices | [<i>a</i> , <i>b</i> ; <i>c</i> , <i>d</i>] |
| t_LIST . Lists | List([<i>x</i> , <i>y</i> , <i>z</i>]) |
| t_STR . Strings | "abc" |
| t_INFINITY . $\pm\infty$ | +oo, -oo |

Reserved Variable Names

| | |
|---|-----------------------|
| $\pi \approx 3.14$, $\gamma \approx 0.57$, $C \approx 0.91$, $I = \sqrt{-1}$ | Pi, Euler, Catalan, I |
| Landau's big-oh notation | O |

Information about an Object, Precision

| | |
|---|--|
| PARI type of object <i>x</i> | type(<i>x</i>) |
| length of <i>x</i> / size of <i>x</i> in memory | # <i>x</i> , sizebyte(<i>x</i>) |
| real precision / bit precision of <i>x</i> | precision(<i>x</i>), bitprecision(<i>x</i>) |
| <i>p</i> -adic, series prec. of <i>x</i> | padicprec(<i>x</i> , <i>p</i>), serprec(<i>x</i> , <i>v</i>) |
| current dynamic precision | getlocalprec, getlocalbitprec |

Operators

| | |
|--|--|
| basic operations | +, − , *, / , ^ , sqr |
| $i \leftarrow i+1$, $i \leftarrow i-1$, $i \leftarrow i*j$, ... | i++, i--, i*=j,... |
| Euclidean quotient, remainder | <i>x</i> \/ <i>y</i> , <i>x</i> % <i>y</i> , divrem(<i>x</i> , <i>y</i>) |
| shift <i>x</i> left or right <i>n</i> bits | <i>x</i> << <i>n</i> , <i>x</i> >> <i>n</i> or shift(<i>x</i> , $\pm n$) |
| multiply by 2^n | shiftmul(<i>x</i> , <i>n</i>) |
| comparison operators | <=, <, >=, >, ==, !=, ==, lex, cmp |
| boolean operators (or, and, not) | , &&, ! |
| bit operations | bitand, bitneg, bitor, bitxor, bitnegimply |
| maximum/minimum of <i>x</i> and <i>y</i> | max(<i>x</i> , <i>y</i>), min(<i>x</i> , <i>y</i>) |
| sign of <i>x</i> (gives −1,0,1) | sign(<i>x</i>) |
| binary exponent of <i>x</i> | exponent(<i>x</i>) |
| derivative of <i>f</i> , 2nd derivative, etc. | <i>f</i> ' , <i>f</i> '' , ... |
| differential operator | diffop(<i>f</i> , <i>v</i> , <i>d</i> ,{ <i>n</i> = 1}) |
| quote operator (formal variable) | 'x |
| assignment | x = <i>value</i> |
| simultaneous assignment $x \leftarrow v[1]$, $y \leftarrow v[2]$ | [x,y] = v |

Select Components

| | |
|--|--|
| <i>Caveat</i> : components start at index <i>n</i> = 1. | |
| <i>n</i> -th component of <i>x</i> | component(<i>x</i> , <i>n</i>) |
| <i>n</i> -th component of vector/list <i>x</i> | <i>x</i> [<i>n</i>] |
| components <i>a</i> , <i>a</i> + 1, ..., <i>b</i> of vector <i>x</i> | <i>x</i> [<i>a</i> .. <i>b</i>] |
| (<i>m</i> , <i>n</i>)-th component of matrix <i>x</i> | <i>x</i> [<i>m</i> , <i>n</i>] |
| row <i>m</i> or column <i>n</i> of matrix <i>x</i> | <i>x</i> [<i>m</i> ,], <i>x</i> [, <i>n</i>] |
| numerator/denominator of <i>x</i> | numerator(<i>x</i>), denominator(<i>x</i>) |

Random Numbers

| | |
|----------------------------------|---|
| random integer/prime in $[0, N[$ | random(<i>N</i>), randomprime(<i>N</i>) |
| get/set random seed | getrand, setrand(<i>s</i>) |

Conversions

| | |
|---|-------------------------------------|
| to vector, matrix, vec. of small ints | Col/Vec, Mat, Vecsmall |
| to list, set, map, string | List, Set, Map, Str |
| create (<i>x</i> mod <i>y</i>) | Mod(<i>x</i> , <i>y</i>) |
| make <i>x</i> a polynomial of <i>v</i> | Pol(<i>x</i> ,{ <i>v</i> }) |
| variants of Pol <i>et al.</i> , in reverse order | Polrev, Vecrev, Colrev |
| make <i>x</i> a power series of <i>v</i> | Ser(<i>x</i> ,{ <i>v</i> }) |
| convert <i>x</i> to simplest possible type | simplify(<i>x</i>) |
| object <i>x</i> with real precision <i>n</i> | precision(<i>x</i> , <i>n</i>) |
| object <i>x</i> with bit precision <i>n</i> | bitprecision(<i>x</i> , <i>n</i>) |
| set precision to <i>p</i> digits in dynamic scope | localprec(<i>p</i>) |
| set precision to <i>p</i> bits in dynamic scope | localbitprec(<i>p</i>) |

Character strings

| | |
|---|---------------------------------|
| convert to TeX representation | strtex(<i>x</i>) |
| string from bytes / from format+args | strchr, sprintf |
| split string / join strings | strsplit, strjoin |
| convert time <i>t</i> ms. to h, m, s, ms format | strtime(<i>t</i>) |
| Conjugates and Lifts | |
| conjugate of a number <i>x</i> | conj(<i>x</i>) |
| norm of <i>x</i> , product with conjugate | norm(<i>x</i>) |
| L^p norm of <i>x</i> (L^∞ if no <i>p</i>) | normlp(<i>x</i> ,{ <i>p</i> }) |
| square of L^2 norm of <i>x</i> | norml2(<i>x</i>) |
| lift of <i>x</i> from Mods and <i>p</i> -adics | lift, centerlift(<i>x</i>) |
| recursive lift | liftall |
| lift all t_INT and t_PADIC (\rightarrow t_INT) | liftint |
| lift all t_POLMOD (\rightarrow t_POL) | liftpol |

Lists, Sets & Maps

| | |
|--|--|
| Sets (= row vector with strictly increasing entries w.r.t. cmp) | |
| intersection of sets <i>x</i> and <i>y</i> | setintersect(<i>x</i> , <i>y</i>) |
| set of elements in <i>x</i> not belonging to <i>y</i> | setminus(<i>x</i> , <i>y</i>) |
| symmetric difference $x \Delta y$ | setdelta(<i>x</i> , <i>y</i>) |
| union of sets <i>x</i> and <i>y</i> | setunion(<i>x</i> , <i>y</i>) |
| does <i>y</i> belong to the set <i>x</i> | setsearch(<i>x</i> , <i>y</i> ,{ <i>flag</i> }) |
| set of all <i>f</i> (<i>x</i> , <i>y</i>), $x \in X$, $y \in Y$ | setbinop(<i>f</i> , <i>X</i> , <i>Y</i>) |
| is <i>x</i> a set ? | setisset(<i>x</i>) |

| | |
|--|---|
| Lists . create empty list: <i>L</i> = List() | |
| append <i>x</i> to list <i>L</i> | listput(<i>L</i> , <i>x</i> ,{ <i>i</i> }) |
| remove <i>i</i> -th component from list <i>L</i> | listpop(<i>L</i> ,{ <i>i</i> }) |
| insert <i>x</i> in list <i>L</i> at position <i>i</i> | listinsert(<i>L</i> , <i>x</i> , <i>i</i>) |
| sort the list <i>L</i> in place | listsort(<i>L</i> ,{ <i>flag</i> }) |
| Maps . create empty dictionary: <i>M</i> = Map() | |
| attach value <i>v</i> to key <i>k</i> | mapput(<i>M</i> , <i>k</i> , <i>v</i>) |
| recover value attach to key <i>k</i> or error | mapget(<i>M</i> , <i>k</i>) |
| is key <i>k</i> in the dict? (set <i>v</i> to <i>M</i> (<i>k</i>)) | mapisdefined(<i>M</i> , <i>k</i> ,{& <i>v</i> }) |
| remove <i>k</i> from map domain | mapdelete(<i>M</i> , <i>k</i>) |

GP Programming

| | |
|--|--|
| User functions and closures | |
| <i>x</i> , <i>y</i> are formal parameters; <i>y</i> defaults to Pi if parameter omitted; | |
| <i>z</i> , <i>t</i> are local variables (lexical scope), <i>z</i> initialized to 1. | |
| fun(x, y=Pi) = my(z=1, t); seq | |
| fun = (x, y=Pi) -> my(z=1, t); seq | |
| attach help message <i>h</i> to <i>s</i> | addhelp(<i>s</i> , <i>h</i>) |
| undefine symbol <i>s</i> (also kills help) | kill(<i>s</i>) |
| Control Statements (<i>X</i> : formal parameter in expression <i>seq</i>) | |
| if <i>a</i> \neq 0, evaluate <i>seq</i> ₁ , else <i>seq</i> ₂ | if(<i>a</i> ,{ <i>seq</i> ₁ },{ <i>seq</i> ₂ }) |
| eval. <i>seq</i> for $a \leq X \leq b$ | for(<i>X</i> = <i>a</i> , <i>b</i> , <i>seq</i>) |
| ...for $X \in v$ | foreach(<i>v</i> , <i>X</i> , <i>seq</i>) |
| ...for primes $a \leq X \leq b$ | forprime(<i>X</i> = <i>a</i> , <i>b</i> , <i>seq</i>) |
| ...for primes $\equiv a \pmod q$ | forprimestep(<i>X</i> = <i>a</i> , <i>b</i> , <i>q</i> , <i>seq</i>) |
| ...for composites $a \leq X \leq b$ | forcomposite(<i>X</i> = <i>a</i> , <i>b</i> , <i>seq</i>) |
| ...for $a \leq X \leq b$ stepping <i>s</i> | forstep(<i>X</i> = <i>a</i> , <i>b</i> , <i>s</i> , <i>seq</i>) |
| ...for <i>X</i> dividing <i>n</i> | fordiv(<i>n</i> , <i>X</i> , <i>seq</i>) |
| ... $X = [n, factor(n)]$, $a \leq n \leq b$ | forfactored(<i>X</i> = <i>a</i> , <i>b</i> , <i>seq</i>) |
| ...as above, <i>n</i> squarefree | forsquarefree(<i>X</i> = <i>a</i> , <i>b</i> , <i>seq</i>) |
| ... $X = [d, factor(d)]$, $d \mid n$ | fordivfactored(<i>n</i> , <i>X</i> , <i>seq</i>) |
| multivariable for, lex ordering | forvec(<i>X</i> = <i>v</i> , <i>seq</i>) |

```

loop over partitions of  $n$ 
... permutations of  $S$ 
... subsets of  $\{1, \dots, n\}$ 
...  $k$ -subsets of  $\{1, \dots, n\}$ 
... vectors  $v, q(v) \leq B$ ;  $q > 0$ 
...  $H < G$  finite abelian group
evaluate  $seq$  until  $a \neq 0$ 
while  $a \neq 0$ , evaluate  $seq$ 
exit  $n$  innermost enclosing loops
start new iteration of  $n$ -th enclosing loop
return  $x$  from current subroutine
Exceptions, warnings
raise an exception / warning
type of error message  $E$ 
try  $seq_1$ , evaluate  $seq_2$  on error
Functions with closure arguments / results
number of arguments of  $f$ 
select from  $v$  according to  $f$ 
apply  $f$  to all entries in  $v$ 
evaluate  $f(a_1, \dots, a_n)$ 
evaluate  $f(\dots f(f(a_1, a_2), a_3) \dots, a_n)$ 
calling function as closure
Sums & Products
sum  $X = a$  to  $X = b$ , initialized at  $x$ 
sum entries of vector  $v$ 
product of all vector entries
sum  $expr$  over divisors of  $n$ 
... assuming  $expr$  multiplicative
product  $a \leq X \leq b$ , initialized at  $x$ 
product over primes  $a \leq X \leq b$ 
Sorting
sort  $x$  by  $k$ -th component
min.  $m$  of  $x$  ( $m = x[i]$ ), max.
does  $y$  belong to  $x$ , sorted wrt.  $f$ 
 $\prod g^x \rightarrow$  factorization ( $\Rightarrow$  sorted, unique  $g$ )
Input/Output
print with/without  $\backslash n$ ,  $\text{\TeX}$  format
pretty print matrix
print fields with separator
formatted printing
write  $args$  to file
write  $x$  in binary format
read file into GP
... return as vector of lines
... return as vector of strings
read a string from keyboard
Files and file descriptors
File descriptors allow efficient small consecutive reads or writes
from or to a given file. The argument  $n$  below is always a descriptor,
attached to a file in r(ead), w(rite) or a(ppend) mode.
get descriptor  $n$  for file  $path$  in given  $mode$ 
... from shell  $cmd$  output (pipe)
close descriptor
commit pending write operations
read logical line from file
... raw line from file
write  $s \backslash n$  to file
... write  $s$  to file

```

```

forpart( $p = n, seq$ )
forperm( $S, p, seq$ )
forsubset( $n, p, seq$ )
forsubset( $[n, k], p, seq$ )
forqfvec( $v, q, b, seq$ )
forsubgroup( $H = G$ )
until( $a, seq$ )
while( $a, seq$ )
break( $\{n\}$ )
next( $\{n\}$ )
return( $\{x\}$ )

error(), warning()
errname( $E$ )
iferr( $seq_1, E, seq_2$ )

Results
arity( $f$ )
select( $f, v$ )
apply( $f, v$ )
call( $f, a$ )
fold( $f, a$ )
self()

sum( $X = a, b, expr, \{x\}$ )
vecsum( $v$ )
vecprod( $v$ )
sumdiv( $n, X, expr$ )
sumdivmult( $n, X, expr$ )
prod( $X = a, b, expr, \{x\}$ )
prodeuler( $X = a, b, expr$ )

vecsrt( $x, \{k\}, \{fl = 0\}$ )
vecmin( $x, \{\&i\}$ ), vecmax
vecsearch( $x, y, \{f\}$ )
matreduce( $m$ )

print, print1, printtex
printp
printsep( $sep, \dots$ ), printsep1
printf()
write, write1, writetex( $file, args$ )
writebin( $file, x$ )
read( $\{file\}$ )
readvec( $\{file\}$ )
readstr( $\{file\}$ )
input()

fileclose( $n$ )
fileflush( $n$ )
fileread( $n$ )
filereadstr( $n$ )
filewrite( $n, s$ )
filewrite1( $n, s$ )

```

Pari-GP reference card

(PARI-GP version 2.15.3)

Timers

CPU time in ms and reset timer
CPU time in ms since gp startup
time in ms since UNIX Epoch
timeout command after s seconds

Interface with system

allocates a new stack of s bytes
alias old to new
install function from library
execute system command a
... and feed result to GP
... returning GP string
get $\$VAR$ from environment
expand env. variable in string

```

gettime()
getabstime()
getwalltime()
alarm( $s, expr$ )

allocatemem( $\{s\}$ )
alias( $new, old$ )
install( $f, code, \{gpf\}, \{lib\}$ )
system( $a$ )
extern( $a$ )
externstr( $a$ )
getenv("VAR")
strexpand( $x$ )

```

Parallel evaluation

These functions evaluate their arguments in parallel (pthreads or MPI); args. must not access global variables (use **export** for this) and must be free of side effects. Enabled if threading engine is not *single* in gp header.

```

evaluate  $f$  on  $x[1], \dots, x[n]$ 
evaluate closures  $f[1], \dots, f[n]$ 
as select
as sum
as vector
eval  $f$  for  $i = a, \dots, b$ 
... for each element  $x$  in  $v$ 
... for  $p$  prime in  $[a, b]$ 
... for  $p = a \bmod q$ 
... multivariate
parforvec( $X = v, f, \{r\}, \{f_2\}, \{flag\}$ )
export  $x$  to parallel world
... all dynamic variables
frees exported value  $x$ 
... all exported values

```

```

parapply( $f, x$ )
pareval( $f$ )
parselect( $f, A, \{flag\}$ )
parsum( $i = a, b, expr$ )
parvector( $n, i, \{expr\}$ )
parfor( $i = a, \{b\}, f, \{r\}, \{f_2\}$ )
parforeach( $v, x, f, \{r\}, \{f_2\}$ )
parforprime( $p = a, \{b\}, f, \{r\}, \{f_2\}$ )
parforprimestep( $p = a, \{b\}, q, f, \{r\}, \{f_2\}$ )

```

Linear Algebra

dimensions of matrix x
multiply two matrices
... assuming result is diagonal
concatenation of x and y
extract components of x
transpose of vector or matrix x
adjoint of the matrix x
eigenvectors/values of matrix x
characteristic/minimal polynomial of x
trace/determinant of matrix x
permanent of matrix x
Frobenius form of x
QR decomposition
apply **matqr**'s transform to v

```

matsize( $x$ )
 $x * y$ 
matmultodiagonal( $x, y$ )
concat( $x, \{y\}$ )
vecextract( $x, y, \{z\}$ )
 $x \sim$ , mattranspose( $x$ )
matadjoint( $x$ )
mateigen( $x$ )
charpoly( $x$ ), minpoly( $x$ )
trace( $x$ ), matdet( $x$ )
matpermanent( $x$ )
matfrobenius( $x$ )
matqr( $x$ )
mathouseholder( $Q, v$ )

```

Constructors & Special Matrices

```

{ $g(x): x \in v$  s.t.  $f(x)$ }
{ $x: x \in v$  s.t.  $f(x)$ }
{ $g(x): x \in v$ }
row vec. of  $expr$  eval'ed at  $1 \leq i \leq n$ 
col. vec. of  $expr$  eval'ed at  $1 \leq i \leq n$ 
vector of small ints

```

```

[g(x) | x <- v, f(x)]
[x | x <- v, f(x)]
[g(x) | x <- v]
vector( $n, \{i\}, \{expr\}$ )
vectorv( $n, \{i\}, \{expr\}$ )
vectorsmall( $n, \{i\}, \{expr\}$ )

```

```

[ $c, c \cdot x, \dots, c \cdot x^n$ ]
[ $1, 2^x, \dots, n^x$ ]
matrix  $1 \leq i \leq m, 1 \leq j \leq n$ 
define matrix by blocks
diagonal matrix with diagonal  $x$ 
is  $x$  diagonal?
 $x \cdot \text{matdiagonal}(d)$ 
 $n \times n$  identity matrix
Hessenberg form of square matrix  $x$ 
 $n \times n$  Hilbert matrix  $H_{ij} = (i + j - 1)^{-1}$ 
 $n \times n$  Pascal triangle
companion matrix to polynomial  $x$ 
Sylvester matrix of  $x$  and  $y$ 

```

Gaussian elimination

```

kernel of matrix  $x$ 
intersection of column spaces of  $x$  and  $y$ 
solve  $MX = B$  ( $M$  invertible)
one sol of  $M * X = B$ 
basis for image of matrix  $x$ 
columns of  $x$  not in matimage
supplement columns of  $x$  to get basis
rows, cols to extract invertible matrix
rank of the matrix  $x$ 
solve  $MX = B \bmod D$ 
image mod  $D$ 
kernel mod  $D$ 
inverse mod  $D$ 
determinant mod  $D$ 

```

Lattices & Quadratic Forms

Quadratic forms

```

evaluate  ${}^t x Q y$ 
evaluate  ${}^t x Q x$ 
signature of quad form  ${}^t y * x * y$ 
decomp into squares of  ${}^t y * x * y$ 
eigenvalues/vectors for real symmetric  $x$ 

```

HNF and SNF

```

upper triangular Hermite Normal Form
HNF of  $x$  where  $d$  is a multiple of  $\det(x)$ 
multiple of  $\det(x)$ 
HNF of  $(x \mid \text{diagonal}(D))$ 
elementary divisors of  $x$ 
 $q$ -rank from elementary divisors
elementary divisors of  $\mathbf{Z}[a]/(f'(a))$ 
integer kernel of  $x$ 
 $\mathbf{Z}$ -module  $\leftrightarrow$   $\mathbf{Q}$ -vector space

```

Lattices

```

LLL-algorithm applied to columns of  $x$ 
... for Gram matrix of lattice
find up to  $m$  sols of qfnorm( $x, y$ )  $\leq b$ 
 $v, v[i] :=$  number of  $y$  s.t. qfnorm( $x, y$ ) =  $i$ 
perfection rank of  $x$ 
find isomorphism between  $q$  and  $Q$ 
precompute for isomorphism test with  $q$ 
automorphism group of  $q$ 

```

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Send comments and corrections to (Karim.Belabas@math.u-bordeaux.fr)

convert `qfauto` for GAP/Magma `qfautoexport($G, \{flag\}$)`
orbits of V under $G \subset \mathrm{GL}(V)$ `qforbits(G, V)`

Polynomials & Rational Functions

all defined polynomial variables `variables()`
get var. of highest priority (higher than v) `varhigher($name, \{v\}$)`
... of lowest priority (lower than v) `varlower($name, \{v\}$)`

Coefficients, variables and basic operators

degree of f `poldegree(f)`
coef. of degree n of f , leading coef. `polcoef(f, n), pollead`
main variable / all variables in f `variable(f), variables(f)`
replace x by y in f `subst(f, x, y)`
evaluate f replacing vars by their value `eval(f)`
replace polynomial expr. $T(x)$ by y in f `substpol(f, T, y)`
replace x_1, \dots, x_n by y_1, \dots, y_n in f `substvec(f, x, y)`
 $f \in A[x]$; reciprocal polynomial $x^{\deg f} f\left(\frac{1}{x}\right)$ `polrecip(f)`
gcd of coefficients of f `content(f)`
derivative of f w.r.t. x `deriv($f, \{x\}$)`
... n -th derivative of f `derivn($f, n, \{x\}$)`
formal integral of f w.r.t. x `intformal($f, \{x\}$)`
formal sum of f w.r.t. x `sumformal($f, \{x\}$)`

Constructors & Special Polynomials

interpolation polynomial at $(x[1], y[1]), \dots, (x[n], y[n])$, evaluated at t , with error estimate e `polinterpolate($x, \{y\}, \{t\}, \{&e\}$)`
 $T_n/U_n, H_n$ `polchebyshev(n), polhermite(n)`
 $P_n, L_n^{(\alpha)}$ `pollegendre(n), pollaguerre(n, a)`
 n -th cyclotomic polynomial Φ_n `polcyclo(n)`
return n if $f = \Phi_n$, else 0 `poliscyclo(f)`
is f a product of cyclotomic polynomials? `poliscycloprod(f)`
Zagier's polynomial of index (n, m) `polzagier(n, m)`

Resultant, elimination

discriminant of polynomial f `poldisc(f)`
find factors of `poldisc(f)` `poldiscfactors(f)`
resultant $R = \mathrm{Res}_v(f, g)$ `polresultant($f, g, \{v\}$)`
 $[u, v, R], xu + yv = \mathrm{Res}_v(f, g)$ `polresultantext($x, y, \{v\}$)`
solve Thue equation $f(x, y) = a$ `thue($t, a, \{sol\}$)`
initialize t for Thue equation solver `thueinit(f)`

Roots and Factorization (Complex/Real)

complex roots of f `polroots(f)`
bound complex roots of f `polrootsbound(f)`
number of real roots of f (in $[a, b]$) `polsturm($f, \{[a, b]\}$)`
real roots of f (in $[a, b]$) `polrootsreal($f, \{[a, b]\}$)`
complex embeddings of `t_POLMOD` z `conjvec(z)`

Roots and Factorization (Finite fields)

factor f mod p , roots `factormod(f, p), polrootsmod`
factor f over $\mathbf{F}_p[x]/(T)$, roots `factormod($f, [T, p]$), polrootsmod`
squarefree factorization of f in $\mathbf{F}_q[x]$ `factormodSQF($f, \{D\}$)`
distinct degree factorization of f in $\mathbf{F}_q[x]$ `factormodDDF($f, \{D\}$)`
factor n -th cyclotomic pol. Φ_n mod p `factormodcyclo(n, p)`

Roots and Factorization (p -adic fields)

factor f over \mathbf{Q}_p , roots `factorpadic(f, p, r), polrootspadic`
 p -adic root of f congruent to a mod p `padicappr(f, a)`
Newton polygon of f for prime p `newtonpoly(f, p)`
Hensel lift $A/\mathrm{lc}(A) = \prod_i B[i]$ mod p^e `polhensellift(A, B, p, e)`
 $T = \prod (x - z_i) \mapsto \prod [x - \omega(z_i)] \in \mathbf{Z}_p[x]$ `polteichmuller(T, p, e)`
extensions of \mathbf{Q}_p of degree N `padicfields(p, N)`

Pari-GP reference card

(PARI-GP version 2.15.3)

Roots and Factorization (Miscellaneous)

symmetric powers of roots of f up to n `polsym(f, n)`
Graeffe transform of $f, g(x^2) = f(x)f(-x)$ `polgraeffe(f)`
factor f over coefficient field `factor(f)`
cyclotomic factors of $f \in \mathbf{Q}[X]$ `polcyclofactors(f)`

Finite Fields

A finite field is encoded by any element (`t_FFELT`).
find irreducible $T \in \mathbf{F}_p[x]$, $\deg T = n$ `ffinit($p, n, \{x\}$)`
Create t in $\mathbf{F}_q \simeq \mathbf{F}_p[t]/(T)$ `t = ffgen($T, 't$)`
... indirectly, with implicit T `t = ffgen($q, 't$); T = t.mod`
map m from $\mathbf{F}_q \ni a$ to $\mathbf{F}_{q^k} \ni b$ `m = ffembed(a, b)`
build $K = \mathbf{F}_q[x]/(P)$ extending $\mathbf{F}_q \ni a$, `ffextend(a, P)`
evaluate map m on x `ffmap(m, x)`
inverse map of m `ffinvmap(m)`
compose maps $m \circ n$ `ffcompomap(m, n)`
 x as polmod over codomain of map m `ffmaprel(m, x)`
 F^n over $\mathbf{F}_q \ni a$ `fffrobenius(a, n)`
 $\#\{\text{monic irred. } T \in \mathbf{F}_q[x], \deg T = n\}$ `ffnbirred(q, n)`

Formal & p -adic Series

truncate power series or p -adic number `truncate(x)`
valuation of x at p `valuation(x, p)`
Dirichlet and Power Series
Taylor expansion around 0 of f w.r.t. x `taylor(f, x)`
Laurent series of closure F up to x^k `laurentseries(f, k)`
 $\sum a_k b_k t^k$ from $\sum a_k t^k$ and $\sum b_k t^k$ `serconvol(a, b)`
 $f = \sum a_k t^k$ from $\sum (a_k/k!) t^k$ `serlaplace(f)`
reverse power series F so $F(f(x)) = x$ `serreverse(f)`
remove terms of degree $< n$ in f `serchop(f, n)`
Dirichlet series multiplication / division `dirmul, dirdiv(x, y)`
Dirichlet Euler product (b terms) `direuler($p = a, b, expr$)`

Transcendental and p -adic Functions

real, imaginary part of x `real(x), imag(x)`
absolute value, argument of x `abs(x), arg(x)`
square/ n th root of x `sqrt(x), sqrtsn($x, n, \{&z\}$)`
all n -th roots of 1 `rootsof1(n)`
FFT of $[f_0, \dots, f_{n-1}]$ `w = fftinit(n), fft/fftinw(w, f)`
trig functions `sin, cos, tan, cotan, sinc`
inverse trig functions `asin, acos, atan`
hyperbolic functions `sinh, cosh, tanh, cotanh`
inverse hyperbolic functions `asinh, acosh, atanh`
 $\log(x), \log(1+x), e^x, e^x - 1$ `log, loglp, exp, expm1`
Euler Γ function, $\log \Gamma, \Gamma'/\Gamma$ `gamma, lngamma, psi`
half-integer gamma function $\Gamma(n+1/2)$ `gammah(n)`
Riemann's zeta $\zeta(s) = \sum n^{-s}$ `zeta(s)`
 $\sum_{1 \leq n \leq N} n^s$ `dirpowerssum(N, s)`
Hurwitz's $\zeta(s, x) = \sum (n+x)^{-s}$ `zetahurwitz(s, x)`
Lerch $\Phi(z, s, x) = \sum z^n (n+x)^{-s}$ `lerchphi(z, s, x)`
Lerch $L(s, x, t) = \Phi(e^{2i\pi t}, s, x)$ `lerchzeta(s, x, t)`
multiple zeta value (MZV), $\zeta(s_1, \dots, s_k)$ `zetamult($s, \{T\}$)`
all MZVs for weight $\sum s_i = n$ `zetamultall(n)`
convert MZV id to $[s_1, \dots, s_k]$ `zetamultconvert($f, \{flag\}$)`
MZV dual sequence `zetamultdual(s)`
multiple polylog $Li_{s_1, \dots, s_k}(z_1, \dots, z_k)$ `polylogmult(s, z)`

incomplete Γ function ($y = \Gamma(s)$) `incgam($s, x, \{y\}$)`
complementary incomplete Γ `incgamc(s, x)`
 $\int_x^\infty e^{-t} dt/t, (2/\sqrt{\pi}) \int_x^\infty e^{-t^2} dt$ `eint1, erfc`
elliptic integral of 1st and 2nd kind `ellK(k), ellE(k)`
dilogarithm of x `dilog(x)`
 m -th polylogarithm of x `polylog($m, x, \{flag\}$)`
 U -confluent hypergeometric function `hyperu(a, b, u)`
Hypergeometric ${}_pF_q(A, B; z)$ `hypergeom(A, B, z)`
Bessel $J_n(x), J_{n+1/2}(x)$ `besselj(n, x), besseljh(n, x)`
Bessel $I_\nu, K_\nu, H_\nu^1, H_\nu^2, Y_\nu$ `(bessel)i, k, h1, h2, y`
 k -th zero of $J_\nu(x)$ `besseljzero($nu, \{k=1\}$)`
 k -th zero of $Y_\nu(x)$ `besselyzero($nu, \{k=1\}$)`
Airy functions $A_i(x), B_i(x)$ `airy(x)`
Lambert $W: x$ s.t. $xe^x = y$ `lambertw(y)`
Teichmuller character of p -adic x `teichmuller(x)`

Iterations, Sums & Products

Numerical integration for meromorphic functions

Behaviour at endpoint for Double Exponential (DE) methods: either a scalar ($a \in \mathbf{C}$, regular) or $\pm\infty$ (decreasing at least as x^{-2}) or
 $(x-a)^{-\alpha}$ singularity `[a, α]`
exponential decrease $e^{-\alpha|x|}$ `[$\pm\infty, \alpha$], $\alpha > 0$`
slow decrease $|x|^\alpha$ `... $\alpha < -1$`
oscillating as $\cos(kx)$ `$\alpha = k\mathbf{I}, k > 0$`
oscillating as $\sin(kx)$ `$\alpha = -k\mathbf{I}, k > 0$`

numerical integration `intnum($x = a, b, f, \{T\}$)`
weights T for intnum `intnuminit($a, b, \{m\}$)`
weights T incl. kernel K `intfuncinit($t = a, b, K, \{m\}$)`
integrate $(2i\pi)^{-1} f$ on circle $|z-a| = R$ `intcirc($x = a, R, f, \{T\}$)`

Other integration methods

n -point Gauss-Legendre `intnumgauss($x = a, b, f, \{n\}$)`
weights for n -point Gauss-Legendre `intnumgaussinit($\{n\}$)`
quasi-periodic function, period $2H$ `intnumosc($x = a, f, H$)`
Romberg (low accuracy) `intnumromb($x = a, b, f, \{flag\}$)`

Numerical summation

sum of series $f(n), n \geq a$ (low accuracy) `suminf($n = a, expr$)`
sum of alternating/positive series `sumalt, sumpos`
sum of series using Euler-Maclaurin `sumnum($n = a, f, \{T\}$)`
... Sidi summation `sumnumsidi($n = a, f$)`
 $\sum_{n \geq a} F(n)$, F rational function `sumnumrat(F, a)`
... $\sum_{p \geq a} F(p^s)$ `sumeulerrat($F, \{s=1\}, \{a=2\}$)`
weights for sumnum, a as in DE `sumnuminit($\{\infty, a\}$)`
sum of series by Monien summation `sumnummonien($n = a, f, \{T\}$)`
weights for sumnummonien `sumnummonieninit($\{\infty, a\}$)`
sum of series using Abel-Plana `sumnumap($n = a, f, \{T\}$)`
weights for sumnumap, a as in DE `sumnumapinit($\{\infty, a\}$)`
sum of series using Lagrange `sumnumlagrange($n = a, f, \{T\}$)`
weights for sumnumlagrange `sumnumlagrangeinit`

Products

product $a \leq X \leq b$, initialized at x `prod($X = a, b, expr, \{x\}$)`
product over primes $a \leq X \leq b$ `prodeuler($X = a, b, expr$)`
infinite product $a \leq X \leq \infty$ `prodinf($X = a, expr$)`
 $\prod_{n \geq a} F(n)$, F rational function `prodnumrat(F, a)`
 $\prod_{p \geq a} F(p^s)$ `prodeulerrat($F, \{s=1\}, \{a=2\}$)`

Other numerical methods

| | |
|---|---|
| real root of f in $[a, b]$; bracketed root | <code>solve($X = a, b, f$)</code> |
| ...interval splitting, step s | <code>solvestep($X = a, b, s, f, \{flag = 0\}$)</code> |
| limit of $f(t)$, $t \rightarrow \infty$ | <code>limitnum($f, \{\alpha\}$)</code> |
| asymptotic expansion of f (rational) | <code>asypnum($f, \{\alpha\}$)</code> |
| ... $N + 1$ terms as floats | <code>asypnumraw($f, N, \{\alpha\}$)</code> |
| numerical derivation w.r.t x : $f'(a)$ | <code>derivnum($x = a, f$)</code> |
| evaluate continued fraction F at t | <code>contfraceval($F, t, \{L\}$)</code> |
| power series to cont. fraction (L terms) | <code>contfracinit($S, \{L\}$)</code> |
| Padé approximant (deg. denom. $\leq B$) | <code>bestapprPade($S, \{B\}$)</code> |

Elementary Arithmetic Functions

| | |
|--|---|
| vector of binary digits of $ x $ | <code>binary(x)</code> |
| bit number n of integer x | <code>bittest(x, n)</code> |
| Hamming weight of integer x | <code>hammingweight(x)</code> |
| digits of integer x in base B | <code>digits($x, \{B = 10\}$)</code> |
| sum of digits of integer x in base B | <code>sumdigits($x, \{B = 10\}$)</code> |
| integer from digits | <code>fromdigits($v, \{B = 10\}$)</code> |
| ceiling/floor/fractional part | <code>ceil, floor, frac</code> |
| round x to nearest integer | <code>round($x, \{\&e\}$)</code> |
| truncate x | <code>truncate($x, \{\&e\}$)</code> |
| gcd/LCM of x and y | <code>gcd(x, y), lcm(x, y)</code> |
| gcd of entries of a vector/matrix | <code>content(x)</code> |

Primes and Factorization

| | |
|--|---|
| extra prime table | <code>addprimes()</code> |
| add primes in v to prime table | <code>addprimes(v)</code> |
| remove primes from prime table | <code>removeprimes(v)</code> |
| Chebyshev $\pi(x)$, n -th prime p_n | <code>primepi(x), prime(n)</code> |
| vector of first n primes | <code>primes(n)</code> |
| smallest prime $\geq x$ | <code>nextprime(x)</code> |
| largest prime $\leq x$ | <code>precprime(x)</code> |
| factorization of x | <code>factor($x, \{lim\}$)</code> |
| ...selecting specific algorithms | <code>factorint($x, \{flag = 0\}$)</code> |
| $n = df^2$, d squarefree/fundamental | <code>core($n, \{fl\}$), coredisc</code> |
| certificate for (prime) N | <code>primecert(N)</code> |
| verifies a certificate c | <code>primecertisvalid(c)</code> |
| convert certificate to Magma/PRIMO | <code>primecertexport</code> |
| recover x from its factorization | <code>factorback($f, \{e\}$)</code> |
| $x \in \mathbf{Z}$, $ x \leq X$, $\gcd(N, P(x)) \geq N$ | <code>zncoppersmith($P, N, X, \{B\}$)</code> |
| divisors of N in residue class r mod s | <code>divisorslensstra(N, r, s)</code> |

Divisors and multiplicative functions

| | |
|--|---|
| number of prime divisors $\omega(n)$ / $\Omega(n)$ | <code>omega(n), bigomega</code> |
| divisors of n / number of divisors $\tau(n)$ | <code>divisors(n), numdiv</code> |
| sum of (k -th powers of) divisors of n | <code>sigma($n, \{k\}$)</code> |
| Möbius μ -function | <code>moebius(x)</code> |
| Ramanujan's τ -function | <code>ramanujantau(x)</code> |

Combinatorics

| | |
|---|---|
| factorial of x | <code>x!</code> or <code>factorial(x)</code> |
| binomial coefficient $\binom{x}{k}$ | <code>binomial($x, \{k\}$)</code> |
| Bernoulli number B_n as real/rational | <code>bernreal(n), bernfrac</code> |
| $[B_0, B_2, \dots B_{2k}]$ | <code>bernvec(k)</code> |
| Bernoulli polynomial $B_n(x)$ | <code>bernpol($n, \{x\}$)</code> |
| Euler numbers | <code>eulerfrac, eulerreal, eulervec</code> |
| Euler polynomial $E_n(x)$ | <code>eulerpol($n, \{x\}$)</code> |
| Eulerian polynomial $A_n(x)$ | <code>eulerianpol</code> |
| Fibonacci number F_n | <code>fibonacci(n)</code> |
| Harmonic number $H_{n,r} = 1^{-r} + \dots + n^{-r}$ | <code>harmonic(n, r)</code> |
| Stirling numbers $s(n, k)$ and $S(n, k)$ | <code>stirling($n, k, \{flag\}$)</code> |

Pari-GP reference card

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| | |
|---|---|
| number of partitions of n | <code>numbpart(n)</code> |
| k -th permutation on n letters | <code>numtoperm(n, k)</code> |
| ...index k of permutation v | <code>permtomv(v)</code> |
| order of permutation p | <code>permorder(p)</code> |
| signature of permutation p | <code>permsign(p)</code> |
| cyclic decomposition of permutation p | <code>permcycles(p)</code> |

Multiplicative groups $(\mathbf{Z}/N\mathbf{Z})^*$, \mathbf{F}_q^*

| | |
|---|--|
| Euler ϕ -function | <code>eulerphi(x)</code> |
| multiplicative order of x (divides ϕ) | <code>znorder($x, \{o\}$), fforder</code> |
| primitive root mod q / x .mod | <code>znprimroot(q), fprimroot(x)</code> |
| structure of $(\mathbf{Z}/n\mathbf{Z})^*$ | <code>znstar(n)</code> |
| discrete logarithm of x in base g | <code>znlog($x, g, \{o\}$), fflag</code> |
| Kronecker-Legendre symbol $(\frac{x}{y})$ | <code>kronecker(x, y)</code> |
| quadratic Hilbert symbol (at p) | <code>hilbert($x, y, \{p\}$)</code> |

Euclidean algorithm, continued fractions

| | |
|--|---|
| CRT: solve $z \equiv x$ and $z \equiv y$ | <code>chinese(x, y)</code> |
| minimal u, v so $xu + yv = \gcd(x, y)$ | <code>gcdext(x, y)</code> |
| half-gcd algorithm | <code>halfgcd(x, y)</code> |
| continued fraction of x | <code>confrac($x, \{b\}, \{lmax\}$)</code> |
| last convergent of continued fraction x | <code>confracpnqn(x)</code> |
| rational approximation to x (den. $\leq B$) | <code>bestappr($x, \{B\}$)</code> |
| recognize $x \in \mathbf{C}$ as polmod mod $T \in \mathbf{Z}[X]$ | <code>bestapprnf(x, T)</code> |

Miscellaneous

| | |
|---|--|
| integer square / n -th root of x | <code>sqrtint(x), sqtrtnint(x, n)</code> |
| largest integer e s.t. $b^e \leq b$, $e = \lfloor \log_b(x) \rfloor$ | <code>logint($x, b, \{\&z\}$)</code> |

Characters

Let $cyc = [d_1, \dots, d_k]$ represent an abelian group $G = \oplus (\mathbf{Z}/d_j\mathbf{Z}) \cdot g_j$ or any structure G affording a .cyc method; e.g. `znstar($q, 1$)` for Dirichlet characters. A character χ is coded by $[c_1, \dots, c_k]$ such that $\chi(g_j) = e(n_j/d_j)$.
 $\chi \cdot \psi$; χ^{-1} ; $\chi \cdot \psi^{-1}$; χ^k `charm, charconj, chardiv, charpow`
order of χ `charorder(cyc, χ)`
kernel of χ `charker(cyc, χ)`
 $\chi(x)$, G a GP group structure `chareval($G, \chi, x, \{z\}$)`
Galois orbits of characters `chargalois(G)`

Dirichlet Characters

| | |
|---|---|
| initialize $G = (\mathbf{Z}/q\mathbf{Z})^*$ | <code>G = znstar($q, 1$)</code> |
| convert datum D to $[G, \chi]$ | <code>znchar(D)</code> |
| is χ odd? | <code>zncharisodd(G, χ)</code> |
| real $\chi \rightarrow$ Kronecker symbol $(D/.)$ | <code>znchartokronecker(G, χ)</code> |
| conductor of χ | <code>zncharconductor(G, χ)</code> |
| $[G_0, \chi_0]$ primitive attached to χ | <code>znchartoprimitive(G, χ)</code> |
| induce $\chi \in \hat{G}$ to $\mathbf{Z}/N\mathbf{Z}$ | <code>zncharinduce(G, χ, N)</code> |
| χp | <code>znchardecompose(G, χ, p)</code> |
| $\prod_p (Q, N) \chi p$ | <code>znchardecompose(G, χ, Q)</code> |
| complex Gauss sum $G_a(\chi)$ | <code>znchargauss(G, χ)</code> |

Conrey labelling

| | |
|---|--|
| Conrey label $m \in (\mathbf{Z}/q\mathbf{Z})^* \rightarrow$ character | <code>znconreychar(G, m)</code> |
| character \rightarrow Conrey label | <code>znconreyexp(G, χ)</code> |
| log on Conrey generators | <code>znconreylog(G, m)</code> |
| conductor of χ (χ_0 primitive) | <code>znconreyconductor($G, \chi, \{\chi_0\}$)</code> |

True-False Tests

| | |
|--|--|
| is x the disc. of a quadratic field? | <code>isfundamental(x)</code> |
| is x a prime? | <code>isprime(x)</code> |
| is x a strong pseudo-prime? | <code>ispseudoprime(x)</code> |
| is x square-free? | <code>issquarefree(x)</code> |
| is x a square? | <code>issquare($x, \{\&n\}$)</code> |
| is x a perfect power? | <code>ispower($x, \{k\}, \{\&n\}$)</code> |
| is x a perfect power of a prime? ($x = p^n$) | <code>isprimepower($x, \&n$)</code> |
| ... of a pseudoprime? | <code>ispseudoprimepower($x, \&n$)</code> |
| is x powerful? | <code>ispowerful(x)</code> |
| is x a totient? ($x = \varphi(n)$) | <code>istotient($x, \{\&n\}$)</code> |
| is x a polygonal number? ($x = P(s, n)$) | <code>ispolygonal($x, s, \{\&n\}$)</code> |
| is pol irreducible? | <code>polisirreducible(pol)</code> |

Graphic Functions

| | |
|---|---|
| crude graph of $expr$ between a and b | <code>plot($X = a, b, expr$)</code> |
| High-resolution plot (immediate plot) | |
| plot $expr$ between a and b | <code>ploth($X = a, b, expr, \{flag\}, \{n\}$)</code> |
| plot points given by lists lx, ly | <code>plothraw($lx, ly, \{flag\}$)</code> |
| terminal dimensions | <code>plotsizes()</code> |
| Rectwindow functions | |
| init window w , with size x, y | <code>plotinit(w, x, y)</code> |
| erase window w | <code>plotkill(w)</code> |
| copy w to w_2 with offset (dx, dy) | <code>plotcopy(w, w_2, dx, dy)</code> |
| slice contents of w | <code>plotclip(w)</code> |
| scale coordinates in w | <code>plotscale(w, x_1, x_2, y_1, y_2)</code> |
| ploth in w | <code>plotrecth($w, X = a, b, expr, \{flag\}, \{n\}$)</code> |
| plothraw in w | <code>plotrecthraw($w, data, \{flag\}$)</code> |
| draw window w_1 at $(x_1, y_1), \dots$ | <code>plotdraw($[[w_1, x_1, y_1], \dots]$)</code> |

Low-level Rectwindow Functions

| | |
|---|--|
| set current drawing color in w to c | <code>plotcolor(w, c)</code> |
| current position of cursor in w | <code>plotcursor(w)</code> |
| write s at cursor's position | <code>plotstring(w, s)</code> |
| move cursor to (x, y) | <code>plotmove(w, x, y)</code> |
| move cursor to $(x + dx, y + dy)$ | <code>plotrmove(w, dx, dy)</code> |
| draw a box to (x_2, y_2) | <code>plotbox(w, x_2, y_2)</code> |
| draw a box to $(x + dx, y + dy)$ | <code>plotrbox(w, dx, dy)</code> |
| draw polygon | <code>plotlines($w, lx, ly, \{flag\}$)</code> |
| draw points | <code>plotpoints(w, lx, ly)</code> |
| draw line to $(x + dx, y + dy)$ | <code>plotrline(w, dx, dy)</code> |
| draw point $(x + dx, y + dy)$ | <code>plotrpoint(w, dx, dy)</code> |

Convert to Postscript or Scalable Vector Graphics

| | |
|---|---|
| The format f is either "ps" or "svg". | |
| as ploth | <code>plotlexport($f, X = a, b, expr, \{flag\}, \{n\}$)</code> |
| as plothraw | <code>plotlrawexport($f, lx, ly, \{flag\}$)</code> |
| as plotdraw | <code>plotexport($f, [[w_1, x_1, y_1], \dots]$)</code> |

Based on an earlier version by Joseph H. Silverman
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