

# Introduction to PARI/GP

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# Introduction

- ▶ PARI is a C library, allowing fast computations.
- ▶ GP is an easy-to-use interactive shell giving access to the PARI functions.
- ▶ GP is the name of gp's scripting language.
- ▶ GP2C, the GP  $\rightarrow$  PARI compiler allows to convert GP scripts to C.

## Basic objects

? 57!

%1 = 40526919504877216755680601905432...

? 2 / 6

%2 = 1/3

? (1+I)^2

%3 = 2\*I

? (x+1)^(-2)

%4 = 1/(x^2+2\*x+1)

? Mod(2,5)^3

%5 = Mod(3,5)

? Mod(x, x^2+x+1)^3

%6 = Mod(1, x^2+x+1)

? a = ffgen([3,5], 'a); a^12 \\ in F\_3^5

%7 = 2\*a^4+2\*a^3+2

## Basic objects

```
? Pi
```

```
%8 = 3.1415926535897932384626433832795028842
```

```
? log(2)
```

```
%9 = 0.69314718055994530941723212145817656807
```

```
? \p100
```

```
? log(2)
```

```
%10 = 0.6931471805599453094172321214581765680755001
```

```
? exp(%)
```

```
%11 = 2.0000000000000000000000000000000000000000000000000000000
```

```
? log(1+x)
```

```
%12 = x-1/2*x^2+1/3*x^3-1/4*x^4+1/5*x^5-...
```

```
? exp(%12)
```

```
%13 = 1+x+O(x^16)
```

# Functions

? ?

- 1: PROGRAMMING under GP
- 2: Standard monadic or dyadic OPERATORS
- 3: CONVERSIONS and similar elementary functions
- 4: functions related to COMBINATORICS
- 5: NUMBER THEORETICAL functions
- 6: POLYNOMIALS and power series
- 7: Vectors, matrices, LINEAR ALGEBRA and sets
- 8: TRANSCENDENTAL functions
- 9: SUMS, products, integrals and similar functions
- 10: General NUMBER FIELDS
- 11: Associative and central simple ALGEBRAS
- 12: ELLIPTIC CURVES
- 13: L-FUNCTIONS
- 14: MODULAR FORMS

# Help

? ?4

? ?atan

atan(x): arc tangent of x.

? ??atan

atan(x):

Principal branch of

$$\tan^{-1}(x) = \log \left( \frac{1+ix}{1-ix} \right) / 2i.$$

? ??

? ??refcard

? ??refcard-nf

? ??tutorial

? ???determinant

algdisc

bnfsunit

charker

ellpadicregulator

forsubgroup

matdet

mathnfmod

matrixqz

mspolygon

polresultant

rnfdet

See also:

Finite abelian groups

Pseudo-bases, determinant

## Vectors and matrices

```
? V = [1, 2, 3];  
? W = [4, 5, 6]~;  
? M = [1, 2, 3; 4, 5, 6];  
? V*W  
%4 = 32  
? M*W  
%5 = [32, 77]~  
? U = [1..10]  
%6 = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```



# Components

```
? V[2]
```

```
%7 = 2
```

```
? W[1..2]
```

```
%8 = [4, 5]~
```

```
? M[2, 2]
```

```
%9 = 5
```

```
? M[1, ]
```

```
%10 = [1, 2, 3]
```

```
? M[, 2]
```

```
%11 = [2, 5]~
```

```
? M[1..2, 1..2]
```

```
%12 = [1, 2; 4, 5]
```

## Polymorphism

```
? factor(91)
```

```
%13 = [7, 1; 13, 1]
```

```
? factor(x^4+4)
```

```
%14 = [x^2-2*x+2, 1; x^2+2*x+2, 1]
```

```
? factor((x^4+1)*Mod(1, a^2-2))
```

```
%15 = [x^2+Mod(-a, a^2-2)*x+1, 1; x^2+Mod(a, a^2-2)*x+1]
```

```
? factor((x^4+4)*Mod(1, 13))
```

```
%16 = [Mod(1, 13)*x+Mod(4, 13), 1; Mod(1, 13)*x+Mod(6, 13)]
```

```
? factor(x^4+1, Mod(1, a^2-2))
```

```
%17 = [x^2+Mod(-a, a^2-2)*x+1, 1; x^2+Mod(a, a^2-2)*x+1]
```

```
? factor(x^4+1, Mod(1, 13))
```

```
%18 = [Mod(1, 13)*x^2+Mod(5, 13), 1; Mod(1, 13)*x^2+Mod(
```

## Numerical summation

```
? intnum(x=0,1,1/(1+x^2))/Pi
```

```
%1 = 0.25000000000000000000000000000000000000000000
```

```
? sumnum(n=1,1/n^2)/Pi^2
```

```
%2 = 0.166666666666666666666666666666666666666667
```

```
? sumalt(n=0,(-1)^n/(2*n+1))*4
```

```
%3 = 3.1415926535897932384626433832795028842
```

```
? sumalt(n=1,(-1)^n*log(n)) % diverging!
```

```
%4 = 0.22579135264472743236309761494744107198
```

```
? 2*exp(2*%)
```

```
%5 = 3.1415926535897932384626433832795028854
```

# Comprehension

```
? [n^2|n<-[1..10]]
%5 = [1,4,9,16,25,36,49,64,81,100]
? [n^2|n<-[1..10],isprime(n)]
%6 = [4,9,25,49]
? [n^2|n<-primes([1,10])]
%7 = [4,9,25,49]
? [a,b] = [1,2];
? print("a=",a," b=",b)
% a=1 b=2
```

## Control structures

- ▶ `if(cond,expr_true{,expr_false})`
- ▶ `while(cond, expr)`
- ▶ `for(var=start,end,expr(var))`
- ▶ `forstep(var=start,end,step,expr(var))`
- ▶ `forprime(var=start,end,expr(var))`
- ▶ `fordiv(N,var,expr(var))`

To configure the memory used by PARI, In the file `.gprc` (or `gprc.txt` under windows) add

```
parisizemax=1G
```

or do

```
default (parisizemax, "1G");
```

if the message 'the PARI stack overflows !' appears.