

# SymPy Cheatsheet (<https://sympy.org>)

## Basics

SymPy help: `help(function)`  
Declare symbol: `x = Symbol('x')`  
Substitution: `expr.subs(old, new)`  
Numerical evaluation: `expr.evalf()`  
Expanding: `expr.expand()`  
Common denominator: `ratsimp(expr)`  
Simplify expression: `simplify(expr)`

## Constants

$\pi$ : `pi`  
 $e$ : `E`  
 $\infty$ : `oo`  
 $i$ : `I`

## Numbers types

Integers ( $\mathbb{Z}$ ): `Integer(x)`  
Rationals ( $\mathbb{Q}$ ): `Rational(p, q)`  
Reals ( $\mathbb{R}$ ): `Float(x)`

## Basic functions

Trigonometric: `sin cos tan cot`  
Cyclometric: `asin acos atan acot`  
Hyperbolic: `sinh cosh tanh coth`  
Area hyperbolic: `asinh acosh atanh acoth`  
Exponential: `exp(x)`  
Square root: `sqrt(x)`  
Logarithm ( $\log_b a$ ): `log(a, b)`  
Natural logarithm: `log(a)`  
Gamma ( $\Gamma(x)$ ): `gamma(x)`  
Absolute value: `abs(x)`

## Calculus

$\lim_{x \rightarrow a} f(x)$ : `limit(f, x, a)`  
 $\lim_{x \rightarrow a-} f(x)$ : `limit(f, x, a, dir='-')`  
 $\lim_{x \rightarrow a+} f(x)$ : `limit(f, x, a, dir='+')`  
 $\frac{d}{dx} f(x)$ : `diff(f, x)`  
 $\frac{\partial}{\partial x} f(x, y)$ : `diff(f, x)`  
 $\int f(x) dx$ : `integrate(f, x)`  
 $\int_a^b f(x) dx$ : `integrate(f, (x, a, b))`  
Taylor series (at  $a$ , deg  $n$ ): `f.series(x, a, n)`

## Equations

Equation  $f(x) = 0$ : `solve(f, x)`  
System of equations: `solve([f, g], [x, y])`  
Differential equation: `dsolve(equation, f(x))`

## Geometry

Points: `a = Point(xcoord, ycoord)`  
Lines: `l = Line(pointA, pointB)`  
Circles: `c = Circle(center, radius)`  
Triangles: `t = Triangle(a, b, c)`  
Area: `object.area`  
Intersection: `intersection(a, b)`  
Checking tangency: `c.is_tangent(l)`

## Plotting

Plot: `Plot(f, [a, b])`  
Zoom: `+/-`: `R/F` or `PgUp/PgDn` or `Numpad +/-`  
Rotate X,Y axis: `Arrow Keys` or `WASD`  
Rotate Z axis: `Q` and `E` or `Numpad 7` and `9`  
View XY: `F1`  
View XZ: `F2`  
View YZ: `F3`  
View Perspective: `F4`  
Axes Visibility: `F5`  
Axes Colors: `F6`  
Screenshot: `F8`  
Exit plot: `ESC`

## Discrete math

Factorial ( $n!$ ): `factorial(n)`  
Binomial coefficient  $\binom{n}{k}$ : `binomial(n, k)`  
Sum ( $\sum_{n=a}^b expr$ ): `summation(expr, (n, a, b))`  
Product ( $\prod_{n=a}^b expr$ ): `product(expr, (n, a, b))`

## Linear algebra

Matrix definition: `m = Matrix([[a, b], [c, d]])`  
Determinant: `m.det()`  
Inverse: `m.inv()`  
Identity matrix  $n \times n$ : `eye(n)`  
Zero matrix  $n \times n$ : `zeros(n)`  
Ones matrix  $n \times n$ : `ones(n)`

## Printing

L<sup>A</sup>T<sub>E</sub>X print: `print(latex())`  
Python print: `print(python())`  
Pretty print: `pprint()`

## Examples

Find 100 digits of  $\pi^e$ :  
`(pi**E).n(100)`

Expand  $(x+y)^2(x-y)(x^2+y)$ :  
`((x+y)**2 * (x-y) * (x**2+y)).expand()`

Simplify  $\frac{1}{x} + \frac{x \sin x - 1}{x^2 - 1}$ :  
`simplify((1/x) + (x * sin(x) - 1)/(x**2 - 1))`

Check if line passing through points (0,1) and (1,1) is tangent to circle with center at (5,5) and radius 3:  
`Circle(Point(5,5), 3).is_tangent(Line(Point(0,1), Point(1,1)))`

Find roots of  $x^4 - 4x^3 + 2x^2 - x = 0$ :  
`solve(x**4 - 4*x**3 + 2*x**2 - x, x)`

Solve the equations system:  $x + y = 4$ ,  $xy = 3$ :  
`solve([x + y - 4, x*y - 3], [x, y])`

Calculate limit of the sequence  $\sqrt[n]{n}$ :  
`limit(n**(1/n), n, oo)`

Calculate left-sided limit of the function  $\frac{|x|}{x}$  in 0:  
`limit(abs(x)/x, x, 0, dir='-')`

Calculate the sum  $\sum_{n=0}^{100} n^2$ :  
`summation(n**2, (n, 0, 100))`

Calculate the sum  $\sum_{n=0}^{\infty} \frac{1}{n^2}$ :  
`summation(1/n**2, (n, 0, oo))`

Calculate the integral  $\int \cos^3 x dx$ :  
`integrate(cos(x)**3, x)`

Calculate the integral  $\int_1^{\infty} \frac{dx}{x^2}$ :  
`integrate(1/x**2, (x, 1, oo))`

Find 10 terms of series expansion of  $\frac{1}{1-2x}$  at 0:  
`(1/(1-2*x)).series(x, 0, 10)`

Solve the differential equation  $f''(x) + 9f(x) = 1$ :  
`dsolve(f(x).diff(x, x) + 9*f(x) - 1, f(x))`