# SymPy Cheatsheet (http://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 funtions

| | |
|---|---|
| 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

| | |
|---|---|
| $\lim_{x\to a} f(x)$: | `limit(f, x, a)` |
| $\lim_{x\to a_-} f(x)$: | `limit(f, x, a, dir='-')` |
| $\lim_{x\to a_+} f(x)$: | `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 (of f(x)): | `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

| | |
|---|---|
| LaTeXprint: | `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)dx
```

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))
```