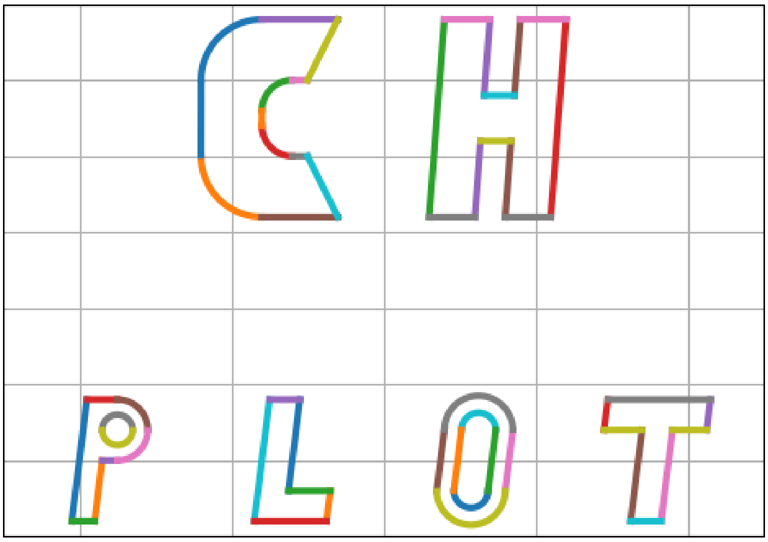
Chplot - Arbitrary functions plotting and computations

Chplot is a Python >= 3.9 module to plot any arbitrary mathematical expressions as well as data series from files, and compute its derivatives and integrals, where it equals zero, and much more!



Installation

You can install `chplot` through Pypi, with the command:

```
python -m pip install chplot
```

You can also install it by cloning this repo and installing it directly:

```
git clone https://github.com/charon25/Chplot.git
cd Chplot
python -m pip install .
```

To check it is properly installed, just run and check it outputs the current version:

```
python -m chplot --version
```

This module requires the following third-party modules:

- matplotlib >= 3.6.1
- mpmath >= 1.2.1
- numpy >= 1.23.4
- scipy >= 1.9.3
- shunting_yard >= 1.0.12
- tqdm >= 4.64.1

Usage

In the rest of this README, the term "expression" will refer to any mathematical expression, possibly with one variable (by default `x` but can be changed).

From a CLI

This module is primarly intended to be used in the command-line. To do this, use the following command:

```
python -m chplot [expression1, [expression2, ...]] [additional-parameters...]
```

Where all the additional parameters are documented in the CLI options section. Note that there can be no expression, as data can come from other sources.

A lot of examples are given in the Examples section.

Important note

You need to surround any expression with double quotes (`"`) if it contains a space (` `). Furthermore, due to the working of the `argparse` Python module and the majority of shells, you may have to surround any expression with double quotes (`"`) if it contains a caret (`^`). Finally, if it starts with a dash (`-`) you may also need to add a space (` `) or a `0` before it. For instance, you need to write `" -x"` or `"0-x"` to get the function `f(x) = -x` and `"x^2"` (instead of just `x^2`) to get the square function.

From Python code

The `chplot` module can also be used from another program. Code snippets:

```python
# Use this to use the built-in PlotParameters class
import chplot

parameters = chplot.PlotParameters()
chplot.plot(parameters)
```

```python
# Use this to use another object and set default values
import chplot

parameters = ... # any object
chplot.set_default_values(parameters) # add any missing field with its default value

chplot.plot(parameters)
```

All the `PlotParameters` arguments are summarized in the CLI options section.

CLI options

No option is mandatory.

CLI options	`PlotParameters` class equivalent	Expected arguments	Effect
$\emptyset$	expressions: list[str]	Any number of expressions (including none of them) or filepaths	The expressions of the mathematical functions to plot and do computations on. If using the CLI, filepaths can also be provided, and There can by none of them.
`-v` `--variable`	variable: str	One string	The variable going of the horizontal axis. Can be more than one character. Note that the variable will override any constant of function with the same name. Defaults to `x`.

CLI options	`PlotParameters` class equivalent	Expected arguments	Effect
`--no-sn`	disable_scientific_notation: bool	$\emptyset$	Disable the automatic conversion of scientific notation in every expression (e.g. `1.24e-1` to `1.24*10^(-1)`). Defaults to False.
`-n` `--n-points`	n_points: int	One positive integer (excluding zero)	The number of points on the horizontal axis for the plotting of the expressions. Defaults to 10001.
`-i` `--integers`	is_integer: bool	$\emptyset$	Forces the points where the expressions are computed to be integers between the specified limits. Defaults to False.
`-x` `--x-lim`	x_lim: tuple[float|str|None, float|str|None]	Two expressions	The horizontal axis bounds (inclusive) where the expression are computed. First argument is the min, second is the max. Any expression (such as `2pi` or `1+exp(2)`) is valid. It is also the graph default horizontal axis, but they can be automatically adjusted to accomodate the plotted data. Defaults to `0 1`.
`-xlog` `--xlog`	is_x_log: bool	$\emptyset$	Forces a logarithmic scale on the horizontal axis. If some horizontal axis bounds are negative, will modify them. Defaults to False.
`-y` `--y-lim`	y_lim: tuple[float|str|None, float|str|None]	Two expressions	The vertical axis bounds (inclusive) of the graph. First argument is the min, second is the max. Any expression (such as `2pi` or `1+exp(2)`) is valid. If not specified, will use matplotlib default ones to accomodate all data. Will restrict the graph to them is specified.
`-z` `--y-zero`	must_contain_zero: bool	$\emptyset$	Forces the vertical axis to contain zero. Defaults to False.
`-ylog` `--ylog`	is_y_log: bool	$\emptyset$	Forces a logarithmic scale on the vertical axis. If some vertical axis bounds are negative, will modify them. Defaults to False.
`-xl` `--x-label`	x_label: str	One string	Label of the horizontal axis. Defaults to nothing.
`-y` `--y-label`	y_label: str	One string	Label of the vertical axis. Defaults to nothing.
`-t` `--title`	title: str	One string	Title of the graph. Defaults to nothing.
`-rl` `--remove-legend`	remove_legend: bool	$\emptyset$	Removes the graph legend. Defaults to False.
`--no-plot`	no_plot: bool	$\emptyset$	Does not show the plot. However, does not prevent saving the figure. Defaults to False.

CLI options	`PlotParameters` class equivalent	Expected arguments	Effect
`--dis` `--discontinuous`	markersize: int|None	One optional positive integer (excluding zero)	Transforms the style of the graph from a continuous line to discrete points with the specified radius. If present without a value, will defaults to a radius of 1. If the `--integer` flag is also present, will still affect the points radius.
`--square`	square_graph: bool	$\emptyset$	Forces the graph to be a square (aspect ratio of 1). Defaults to False.
`-lw` `--line-width`	line_width: float	One positive float (excluding zero)	Width of the plotted functions. Will not affect regressions. Defaults to 1.5 (`matplotlib` defaut).
`-c` `--constants`	constants: list[str]	One string or more, either a filepath or of the forme `<name>=<expression>`	Adds constants which may be used by any other expressions (including axis bounds). They must either be of the form `<name>=<expression>` (eg `a=4sin(pi/4)`) or be filepath containing lines respecting this format. Note that filepaths are only accepted in the CLI. May override already existing constants and functions. If a constant refers to another one, it should be defined after. Defaults to nothing.
`-f` `--file`	data_files: list[str]	One or more filepaths	Adds data contained in CSV files as new functions to the graph. See the CSV files format section for more details. Defaults to nothing.
`-s` `--save-graph`	save_figure_path: str	One filepath	Saves the graph at the specified path. If not included, will not save the figure (default behavior).
`-d` `--save-data`	save_data_path: str	One filepath	Saves the graph data (x and y values) at the specified path in CSV format. If not included, will not save the data (default behavior).
`-p` `--python-file`	python_files: list[str]	One or more filepaths	Adds functions contained in Python files. See the Additional Python function format for more details. Defaults to nothing.
`--zeros`	zeros_file: str|None	One optional filepath	Computes where the expressions equal zero. If not included, will not compute it (default behavior), else if included without argument, prints the results to the console, else writes it to the given file.
`--int` `--integral`	integral_file: str|None	One optional filepath	Computes the integral of all functions on the entire interval where it is plotted. Note that it does **not** add the antiderive of the functions to the graph, but only computes the area under them on their definition interval. If not included, will not compute it (default behavior), else if included without argument, prints the results to the console, else writes it to the given file.

CLI options	`PlotParameters` class equivalent	Expected arguments	Effect
`--deriv` `--derivative`	derivation_orders: list[int]	At least one positive integer (excluding zero)	Computes and adds to the graph the derivative of the specified orders of every other function. Note that the higher the order, the more inaccuracy and unstability it has. Furthermore, the derivative computation will shave off a few points on each side, so the derivatives are defined on a smaller interval.
`--reg` `--regression`	regression_expression: str	One expression	Computes the coefficients of the given regression to get the best fit to every other function. The regression parameters should have the form `_rX` where X is any string made of digits, letters and underscores and starting with a letter (eg `_ra0`). The regressions will also be added in the final graph. When using the CLI, the expression can also be one of a few default keywords (listed in Regression default keywords).

Options synergies

Every option that computes something based on the functions will act on every function defined before it applies. The order of application is the following (each item applies to all the previous ones):

- Base expressions & file data
- Regressions
- Derivations
- Integrals & zeros

For instance, this means every regression will also be derivated, and every derivative will be integrated.

CSV files format

The `--file` option will accept any CSV file respecting those rules:

- the column delimiter is eitehr a comma (`,`), a semicolon (`;`), a space (` `) or a tabulation (`\t`) ;
- the decimal separator is either a dot (`.`) or a comma (`,`) if the column delimiter is something else (for countries and language using them, such as French or German) ;
- text entry containing the column delimiter must be surrounded by double quotes (`"`) ;
- to have double quotes (`"`) in a text entry, just double them (`""`).

The first column will be considered the horizontal axis data for the entire file. Each subsequent column will be a new function. They might all be of different lengths, and some value may be missing. Any missing value in the first column will ignore the whole line.

The first non numerical line will be used as label for the functions.

Examples

The file

```
x,"First y","Second ""y""",ThirdY,EmptyColumn
0,0,,0,
1,10,100,,
2,20,,2000,
3,30,300,3000,
4,40,400,,
```

Will result in the following functions (represented as (x,y) couples):

- `First y`: (0, 0), (1, 10), (2, 20), (3, 30), (4, 40)
- `Second "y"`: (1, 100), (3, 300), (4, 400)
- `ThirdY`: (0, 0), (2, 2000), (3, 3000)

Note that the last column does not have any values, so it won't be registered at all.

The file

```
x;y1;y2
0,0;1,0;2,1
0,3;1,2;2,5
0,6;1,55;2,123
1;1,825;2,99
```

Will result in the following functions:

- `y1`: (0, 1), (0.3, 1.2), (0.6, 1.55), (1, 1.825)
- `y2`: (0, 2.1), (0.3, 2.5), (0.6, 2.123), (1, 2.99)

Regression default keywords

When using Chplot from the command line and using the `--regression` command, a keyword can be specified instead of an expression to get usual regression expression. Those keywords are listed below :

Keyword	Mathematical function	Equivalent expression
`const` `constant`	$f(x) = m$	`_rm`
`lin` `linear`	$f(x) = ax + b$	`_ra * x + _rb`

`pN`
`polyN`
`polynomialN`
where $N \in \mathbb{N} $
	$$f(x) = \sum_{i=0}^N a_i x^i$$	`_ra0`
		`_ra1 * x + _ra0`
		`_ra2 * x^2 + _ra1 * x + _r0`
		`...`

`power`	$f(x) = k x^\alpha$	`_rk * x^_ralpha`
`powery`	$f(x) = k x^\alpha + y_0$	`_rk * x^_ralpha + r_y0`
`log`	$f(x) = a \ln(x) + b$	`_ra * ln(x) + _rb`
`exp`	$f(x) = a \mathrm{e}^{bx}$	`_ra * exp(x * _rb)`
`expy`	$f(x) = a \mathrm{e}^{bx} + y_0$	`_ra * exp(x * _rb) + _ry0`

Note that `poly0` is equivalent to `constant` and `poly1` is equivalent to `linear`.

Additional Python function format

Chplot expression can accept functions usable in any expression directly from other Python files. Those file must respect those rules:

- they must be in the same directory as the console when using the CLI (and in the same directory as the python execution when using the code version [NOT TESTED]) ;
- all functions to add must be decorated with the `@plottable` decorator (importable with `from chplot import plottable`). The decorator **must** indicate how many arguments is expected by the function, either directly or with the `arg_count` keyword (i.e. `@plottable(1)` or `@plottable(arg_count=2)`) ;
- all functions must only accept `int` or `float` and must only return **one** value accepted by the `float()` built-in function of Python, such as, but not limited to, `int`, `float` or `bool` (if not, will be considered as the same as a raised Exception) ;
- to indicate an error in the computation (such as a division by zero or the square root of a negative number), the function can either raise an exception or return `math.nan` (or `float('nan')`). Note that an exception will completely stop the

computation at that point while nan will be used in the rest of the expression, which may change the result slightly.

Everything other than those rules is allowed, such as importing other modules. The name of the Python function will be the same as the name used in the expression.

Examples

The Python file functions.py

```
from chplot import plottable
import math

@plottable(1)
def inc(x: float) -> float:
 return x + 1

@plottable(arg_count=2)
def invradius(x: float, y: float) -> float:
 if x == y == 0:
    raise ZeroDivisionError

 return 1 / math.sqrt(x * x + y * y)

def dec(x: float) -> float:
 return x - 1

@plottable
def double(x: float) -> float:
 return x * 2
```

Will define **2** new functions usable in expression: inc and invradius. dec does not have the decorator and will be ignored, and double does not indicate how many parameters it accepts, and therefore will also be ignored (but a warning will be logged).

This means, the following command is valid:

```
python -m chplot "inc(invradius(x, 5))" -x 1 inc(2) -p functions.py
```

Available functions

Chplot is bundled by default with more than 60 mathematical and physical constants and over 200 mathematical functions from the default math module, scipy.special, mpmath as well as custom made ones. They are all described in the following sections. The documentation of functions from math or the third-party modules can be found in their respective wikis: math, scipy.special, mpmath.

There are also the 5 base operations : +, -, *, /, ^.

Constants

nan and _ are valid constants that both evaluates to math.nan. They can be used to remove some points from the graph (for instance with the if or in functions, see below). inf is also a valid constant evaluating to math.inf.

Mathematical constants

chplot name	Name	Usual symbol	Exact value	chplot value
pi	Pi	π	π	$3.141\ 592\ 653\ 589\ 793$

`chplot` name	Name	Usual symbol	Exact value	`chplot` value
`tau`	Tau	τ	2π	$6.283\ 185\ 307\ 179\ 586$
`e`	Euler's number	e	$$\exp(1) = \sum_{n=0}^{+\infty} \frac{1}{n!}$$	$2.718\ 281\ 828\ 459\ 045$
`gaem`	Euler-Mascheroni's constant	γ	$$\lim_{n\to\infty} \left(\sum_{k=1}^n \left(\frac{1}{k}\right) - \log n \right)$$	$0.577\ 215\ 664\ 901\ 532 9$
`phi`	Golden ratio	ϕ	$\frac{1}{2} (1 + \sqrt{5})$	$1.618\ 033\ 988\ 749\ 895$
`sqrt2`	Square root of 2	$\sqrt{2}$	$\sqrt{2}$	$1.414\ 213\ 562\ 373\ 095\ 1$
`apery`	Apery's constant		$$\zeta(3) = \sum_{n=1}^{+\infty} \frac{1}{n^3} $$	$1.202\ 056\ 903\ 159\ 594$
`brun`	Brun's constant	B_2	Sum of the reciprocal of the twin primes	$1.902\ 160\ 583\ 104$
`catalan`	Catalan's constant	G	$$\sum_{n=0}^{+\infty} \frac{(-1)^n}{(2n + 1)^2} $$	$0.915\ 965\ 594\ 177\ 219$
`feigenbaumd`	First Feigenbaum's constant	δ		$4.669\ 201\ 609\ 102\ 990\ 67$
`feigenbauma`	Second Feigenbaum's constant	α		$2.502\ 907\ 875\ 095\ 892\ 82$
`glaisher`	Glaisher-Khinkelin's constant	A	$$\lim_{n\to\infty} \frac{\Pi_{k=1}^{n} k^k}{n^{\frac{n^2}{2} + \frac{n}{2} + \frac{1}{12}}\cdot\mathrm{e}^{-\frac{n^2}{4}}}$$	$1.282\ 427\ 129\ 100\ 622\ 6$
`khinchin`	Khinchin's constant	K_0	$$\prod_{r=1}^{+\infty} \left(1 + \frac{1}{r(r+2)}\right)^{\log_2 r}$$	$2.685\ 452\ 001\ 065\ 306\ 2$
`mertens`	Meissel-Mertens's constant	M	$$\gamma + \sum_{p\text{ prime}}\left(\ln\left(1 - \frac{1}{p}\right) + \frac{1}{p} \right)$$	$0.261\ 497\ 212\ 847\ 642\ 77$

Physical constants

The constants, their values and their units are taken from https://en.wikipedia.org/wiki/List_of_physical_constants.

`chplot` name	Quantity	Symbol	`chplot` value (in SI units)	Units
`a0`	Bohr's radius	a_0	$5.291\ 772\ 109\ 03\times10^{-11}$	m

`chplot` name	Quantity	Symbol	`chplot` value (in SI units)	Units
`alpha`	Fine-structure constant	$\alpha$	$7.297\ 352\ 569\ 3\times10^{-3}$	---
`b`	Wien's wavelength displacement law constant	$b$	$2.897\ 771\ 955\times10^{-3}$	$\text{m}\cdot\text{K}$
`bp`	Wien's entropy displacement law constant	$b_{\text{entropy}}$	$3.002\ 916\ 077\times10^{-3}$	$\text{m}\cdot\text{K}$
`bp`	Wien's frequency displacement law constant	$b'$	$5.878\ 925\ 757\times10^{10}$	$\text{Hz}\cdot\text{K}^{-1}$
`c`	Speed of light in vacuum	$c$	$2.997\ 924\ 58\times10^8$	$\text{m}\cdot\text{s}^{-1}$
`c1`	First radiation constant	$c_1$	$3.741\ 771\ 852\times10^{-16}$	$\text{W}\cdot\text{m}^2$
`c1L`	Second radiation constant	$c_{1L}$	$1.191\ 042\ 972\ 397\ 188\times10^{-16}$	$\text{W}\cdot\text{m}^2\cdot\text{sr}^{-1}$
`c2`	Second radiation constant	$c_2$	$1.438\ 776\ 877\times10^{-2}$	$\text{m}\cdot\text{K}$
`dnuCs`	Hyperfine transistion frequency of Cesium-133	$\Delta\nu_{\text{Cs}}$	$9.192\ 631\ 770\times10^{9}$	$\text{Hz}$
`ec`	Elementary charge	$e$	$1.602\ 176\ 634\times10^{-19}$	$\text{C}$
`Eh`	Hartree's energy	$E_h$	$4.359\ 744\ 722\ 207\ 1\times10^{-18}$	$\text{J}$
`epsilon0` `eps0`	Vacuum electric permittivity	$\varepsilon_0$	$8.854\ 187\ 812\ 8\times10^{-12}$	$\text{F}\cdot\text{m}^{-1}$
`eV`	Electronvolt value in Joule		$1.602\ 176\ 634\times10^{-19}$	$\text{J}$
`F`	Faraday's constant	$F$	$9.648\ 533\ 212\ 331\ 002\times10^4$	$\text{C}\cdot\text{mol}^{-1}$
`G`	Gravitational constant	$G$	$6.674\ 3\times10^{-11}$	$\text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$

chplot name	Quantity	Symbol	chplot value (in SI units)	Units
g	Gravity of Earth	g	$9.806\ 65$	$\text{m}\cdot\text{s}^{-2}$
G0	Conductance quantum	G_0	$7.748\ 091\ 729\times10^{-5}$	S
ge	Electron g-factor	g_e	$-2.002\ 319\ 304\ 362\ 56$	---
GF0	Fermi coupling constant Reduced Fermi constant	$$G^0_F$$	$4.543\ 795\ 7\times10^{14}$	J^{-2}
gmu	Muon g-factor	g_μ	$-2.002\ 331\ 841\ 8$	---
gP	Proton g-factor	g_P	$5.585\ 694\ 689\ 3$	---
h	Planck's constant	h	$6.626\ 070\ 15\times10^{-34}$	$\text{J}\cdot\text{Hz}^{-1}$
hb	Reduced Planck's constant	$\hbar$	$1.054\ 571\ 817\times10^{-34}$	$\text{J}\cdot\text{s}$
kB	Boltzmann's constant	k, k_B	$1.380\ 649\times10^{-23}$	$\text{J}\cdot\text{K}^{-1}$
ke	Coulomb's constant	k_e	$8.987\ 551\ 792\ 3\times10^9$	$\text{N}\cdot\text{m}^2\cdot\text{C}^{-2}$
KJ	Josephson's constant	K_J	$4.835\ 978\ 484\times10^{14}$	$\text{Hz}\cdot\text{V}^{-1}$
m12C	Atomic mass of carbon-12	$m(^{12}\text{C})$	$1.992\ 646\ 879\ 92\times10^{26}$	kg
M12C	Molar mass of carbon-12	$M(^{12}\text{C})$	$1.199\ 999\ 999\ 58\times10^{-2}$	$\text{kg}\cdot\text{mol}^{-1}$
me	Electron mass	m_e	$9.109\ 383\ 701\ 5\times10^{-31}$	kg
mmu	Muon mass	m_μ	$1.883\ 531\ 627\times10^{-28}$	kg
mn	Neutron mass	m_n	$1.674\ 927\ 498\ 04\times10^{-27}$	kg
mp	Proton mass	m_p	$1.672\ 621\ 923\ 69\times10^{-27}$	kg
mt	Top quark mass	m_t	$3.078\ 4\times10^{-25}$	kg
mtau	Tau mass	m_τ	$3.167\ 54\times10^{-27}$	kg

`chplot` name	Quantity	Symbol	`chplot` value (in SI units)	Units
`mu`	Atomic mass constant	m_u	$1.660\ 539\ 066\ 6\times10^{-27}$	kg
`Mu`	Molar mass constant	M_u	$9.999\ 999\ 996\ 5\times10^{-4}$	$\text{kg}\cdot\text{mol}^{-1}$
`mu0`	Vacuum magnetic parmeability	μ_0	$1.256\ 637\ 602\ 12\times10^{-6}$	$\text{N}\cdot\text{A}^{-2}$
`muB`	Bohr's magneton	μ_B	$9.274\ 010\ 078\ 3\times10^{-24}$	$\text{J}\cdot\text{T}^{-1}$
`muN`	Nuclear magneton	μ_N	$5.050\ 783\ 746\ 1\times10^{-27}$	$\text{J}\cdot\text{T}^{-1}$
`NA`	Avogadro constant	N_A	$6.022\ 140\ 76\times10^{23}$	mol^{-1}
`R`	Molar gas constant	R	$8.314\ 462\ 618\ 153\ 24$	$\text{J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$
`re`	Classical electron radius	r_e	$2.817\ 940\ 326\ 2\times10^{-15}$	m
`Rinf`	Rydberg's constant	R_∞	$1.097\ 373\ 156\ 816\times10^7$	m^{-1}
`RK`	Von Klitzing's constant	R_K	$2.581\ 280\ 745\times10^{4}$	Ω
`Ry`	Rydberg's unit of energy	R_y	$2.179\ 872\ 361\ 103\ 5\times10^{-18}$	J
`sigma`	Stefan-Boltzmann's constant	σ	$5.670\ 374\ 419\times10^{-8}$	$\text{W}\cdot\text{m}^{-2}\cdot\text{K}^{-4}$
`sigmae`	Thomson's cross section	σ_e	$6.652\ 458\ 732\ 1\times10^{-29}$	m^2
`VmSi`	Molar volume of silicon	$V_m(\text{Si})$	$1.205\ 883\ 199\times10^{-5}$	$\text{m}^3\cdot\text{mol}^{-1}$
`Z0`	Characteristic impedance of vacuum	Z_0	$3.767\ 303\ 136 \ 68\times10^2$	Ω

Astronomical constants

All the planets data are taken from : https://nssdc.gsfc.nasa.gov.

`chplot` name	Quantity	`chplot` value (in SI units)	Units
`Msun`	Sun mass	$1.988\ 5\times10^{30}$	kg
`Mmercury`	Mercury mass	3.301×10^{23}	kg
`Mvenus`	Venus mass	$4.867\ 3\times10^{24}$	kg

chplot name	Quantity	chplot value (in SI units)	Units
Mearth	Earth mass	$5.972\ 2\times10^{24}$	kg
Mmoon	Moon mass	7.346×10^{22}	kg
Mmars	Mars mass	$6.416\ 9\times10^{23}$	kg
Mjupiter	Jupiter mass	$1.898\ 13\times10^{27}$	kg
Msaturn	Saturn mass	$5.683\ 2\times10^{26}$	kg
Muranus	Uranus mass	$8.681\ 1\times10^{25}$	kg
Mneptune	Neptune mass	$1.024\ 09\times10^{26}$	kg
Mpluto	Pluto mass	1.303×10^{22}	kg
Mcharon	Charon mass	1.586×10^{21}	kg
Rsun	Sun volumetric mean radius	6.957×10^{8}	m
Rmercury	Mercury volumetric mean radius	$2.439\ 7\times10^{6}$	m
Rvenus	Venus volumetric mean radius	$6.051\ 8\times10^{6}$	m
Rearth	Earth volumetric mean radius	6.371×10^{6}	m
Rmoon	Moon volumetric mean radius	$1.737\ 4\times10^{6}$	m
Rmars	Mars volumetric mean radius	$3.389\ 5\times10^{6}$	m
Rjupiter	Jupiter volumetric mean radius	$6.991\ 1\times10^{7}$	m
Rsaturn	Saturn volumetric mean radius	5.8232×10^{7}	m
Ruranus	Uranus volumetric mean radius	$2.536\ 2\times10^{7}$	m
Rneptune	Neptune volumetric mean radius	$2.462\ 2\times10^{7}$	m
Rpluto	Pluto volumetric mean radius	1.188×10^{6}	m
Rcharon	Charon volumetric mean radius	6.06×10^{5}	m
AU	Astronomical unit in meters	$1.495\ 978\ 707\times10^{11}$	m
ly	Light-year in meters	$9.460\ 730\ 472\ 580\ 8\times10^{15}$	m
pc	Parsec in meters	$3.085\ 677\ 581\ 491\ 367\ 3\times10^{11}$	m

From default math module

Documentation: https://docs.python.org/3/library/math.html

chplot name(s)	math name	Number of arguments	Notes
acos	acos	1	
acosh	acosh	1	
asin	asin	1	
asinh	asinh	1	
atan	atan	1	
atanh	atanh	1	
atan2	atan2	2	
cbrt	cbrt	1	

`chplot`
name(s)
	`math`
	name
		Number of
		arguments
			Notes

`ceil`	`ceil`	1	
`copysign`	`copysign`	2	
`cos`	`cos`	1	
`cosh`	`cosh`	1	
`degrees`	`degrees`	1	
`dist`	`dist`	4	`dist(x1, y1, x2, y2)` is interpreted as `math.dist((x1, y1), (x2, y2))`
`erf`	`erf`	1	
`erfc`	`erfc`	1	
`exp`	`exp`	1	
`expm1`	`expm1`	1	
`floor`	`floor`	1	
`fmod`	`fmod`	2	
`gamma`	`gamma`	1	
`hypot`	`hypot`	2	
`lgamma` `lngamma`	`lgamma`	1	
`log` `ln`	`log`	1	
`log10`	`log10`	1	
`log1p`	`log1p`	1	
`log2`	`log2`	1	
`radians`	`radians`	1	
`remainder`	`remainder`	2	
`sin`	`sin`	1	
`sinh`	`sinh`	1	
`sqrt`	`sqrt`	1	
`tan`	`tan`	1	
`trunc`	`trunc`	1	

From `scipy.special`

Documentation: https://docs.scipy.org/doc/scipy/reference/special.html

`chplot` name(s)	`scipy.special` name	Number of arguments	Notes
`agm`	`agm`	2	
`Ai`	`airy`	1	First output
`Aip`	`airy`	1	Second output
`bei`	`bei`	1	

chplot name(s)	scipy.special name	Number of arguments	Notes
beip	beip	1	
ber	ber	1	
berp	berp	1	
beta	beta	2	
betainc	betainc	3	
betaincinv	betaincinv	3	
betaln	betaln	2	
Bi	airy	1	Third output
binom binomial	binom	2	
Bip	airy	1	Fourth output
Chi	shichi	1	Second output
Ci	sici	1	Second output
digamma	digamma	1	
eAi	airye	1	First output
eAip	airye	1	Second output
eBi	airye	1	Third output
eBip	airye	1	Fourth output
ellipe	ellipe	1	
ellipeinc	ellipeinc	2	
ellipk	ellipk	1	
ellipkinc	ellipkinc	2	
elliprc	elliprc	2	
elliprd	elliprd	3	
elliprf	elliprf	3	
elliprg	elliprg	3	
elliprj	elliprj	4	
erfcinv	erfcinv	1	
erfi	erfi	1	
erfinv	erfinv	1	
factorial fac	factorial	1	
fresnelc	fresnel	1	Second output
fresnels	fresnel	1	First output
gammainc	gammainc	2	
gammaincc	gammaincc	2	
gammainccinv	gammainccinv	2	

`chplot` name(s)	`scipy.special` name	Number of arguments	Notes
`gammaincinv`	`gammaincinv`	2	
`hurwitz` `hurwitzzeta`	`zeta`	2	
`hyp0f1`	`hyp0f1`	2	
`hyp1f1`	`hyp1f1`	3	
`hyp2f1`	`hyp2f1`	4	
`hyperu`	`hyperu`	3	
`it2struve0`	`it2struve0`	1	
`itmodstruve0`	`itmodstruve0`	1	
`itstruve0`	`itstruve0`	1	
`iv` `besseli`	`iv`	2	
`jv` `besselj`	`jv`	2	
`kei`	`kei`	1	
`keip`	`keip`	1	
`ker`	`ker`	1	
`kerp`	`kerp`	1	
`kv` `besselk`	`kv`	2	
`lambertw`	`lambertw`	1	
`loggamma`	`loggamma`	1	
`modstruve` `struvel`	`modstruve`	2	
`psi`	`psi`	1	
`rgamma`	`rgamma`	1	
`Shi`	`shichi`	1	First output
`Si`	`sici`	1	First output
`sincpi`	`sinc`	1	
`struve` `struveh`	`struve`	2	
`yv` `bessely`	`yv`	2	
`zeta`	`zeta`	1	

From `mpmath`

Documentation: https://mpmath.org/doc/current/

`chplot` name(s)	`mpmath` name	Number of arguments	Notes
`acot`	`acot`	1	

chplot name(s)	mpmath name	Number of arguments	Notes
acoth	acoth	1	
acsc	acsc	1	
acsch	acsch	1	
altzeta eta	altzeta	1	
angerj	angerj	2	
asec	asec	1	
asech	asech	1	
backlunds	backlunds	1	
barnesg	barnesg	1	
betainc2	betainc	4	
chebyt	chebyt	2	
chebyu	chebyu	2	
clcos	clcos	2	
clsin	clsin	2	
cospi cospi	cospi	1	
cot	cot	1	
coth	coth	1	
coulombc	coulombc	2	
coulombf	coulombf	3	
coulombg	coulombg	3	
csc	csc	1	
csch	csch	1	
Ei	ei	1	
ellipf	ellipf	2	
ellippi	ellippi	3	
fac2	fac2	1	
ff	ff	1	
fib	fib	1	
fibonacci	fibonacci	1	
gammainc2	gammainc	3	
gegenbauer	gegenbauer	3	
harmonic	harmonic	1	
hermite	hermite	2	
hyp1f2	hyp1f2	4	
hyp2f0	hyp2f0	3	

chplot name(s)	mpmath name	Number of arguments	Notes
hyp2f3	hyp2f3	5	
hyp3f2	hyp3f2	6	
hyperfac	hyperfac	1	
jacobi	jacobi	4	
laguerre	laguerre	3	
legendre	legendre	2	
legenp	legenp	3	
legenq	legenq	3	
lerchphi	lerchphi	3	
li	li	1	Computes li(x, offset=False)
Li	li	1	Computes li(x, offset=True)
lommels1	lommels1	3	
lommels2	lommels2	3	
nzetazeros	nzeros	1	
pcfd	pcfd	2	
pcfu	pcfu	2	
pcfv	pcfv	2	
pcfw	pcfw	2	
polyexp	polyexp	2	
polylog	polylog	2	
primepi	primepi	1	
primezeta	primezeta	1	
rf	rf	1	
riemannr	riemannr	1	
scorergi	scorergi	1	
scorerhi	scorerhi	1	
sec	sec	1	
sech	sech	1	
secondzeta	secondzeta	1	
siegeltheta	siegeltheta	1	
siegelz	siegelz	1	
sinc	sinc	1	
stieltjes	stieltjes	1	
superfac	superfac	1	
W	lambertw	1	
webere	webere	2	
whitm	whitm	3	

`chplot` name(s)	`mpmath` name	Number of arguments	Notes
`whitw`	`whitw`	3	

Probability functions

`chplot` name	Name	Arguments	Expression
`normpdf`	Normal distribution PDF	$x, \mu, \sigma$	$$\frac{1}{\sigma\sqrt{2\pi}}\mathrm{e}^{-\frac{1}{2}\left(\frac{x - \mu}{\sigma} \right)^2}$$
`normcdf`	Normal distribution CDF	$x, \mu, \sigma$	$$\frac{1}{2}\left(1 + \mathrm{erf}\left(\frac{x - \mu}{\sigma\sqrt{2}}\right) \right)$$
`unormpdf`	Unit normal distribution PDF	$x$	$$\frac{1}{\sqrt{2\pi}}\mathrm{e}^{-\frac{x^2}{2}}$$
`unormcdf`	Unit normal distribution CDF	$x$	$$\frac{1}{2}\left(1 + \mathrm{erf}\left(\frac{x}{\sqrt{2}}\right) \right)$$
`tripdf`	Triangle distribution PDF	$x, a, b, c$	$$0 \text{ if } x\leq a \text{ or } x > b$$ $$\frac{2(x-a)}{(b-a)(c-a)} \text{ if } a < x\leq c$$ $$\frac{2(b-x)}{(b-a)(b-c)} \text{ if } c < x\leq b$$
`tricdf`	Triangle distribution CDF	$x, a, b, c$	$$0 \text{ if } x < a$$ $$\frac{(x-a)^2}{(b-a)(c-a)} \text{ if } a\leq x\leq c$$ $$1 - \frac{(b-x)^2}{(b-a)(b-c)} \text{ if } c < x\leq b$$ $$1 \text{ if }b < x $$
`uniformpdf`	Uniform distribution PDF	$x, a, b$	$$0 \text{ if } x < a \text{ or } x > b$$ $$\frac{1}{b-a} \text{ if } a\leq x\leq b$$
`uniformcdf`	Uniform distribution CDF	$x, a, b$	$$0 \text{ if } x < a$$ $$\frac{x-a}{b-a} \text{ if } a\leq x\leq b$$ $$1 \text{ if }b < x $$
`exppdf`	Exponential distribution PDF	$x, \lambda$	$$0 \text{ if } x < 0$$ $$\lambda\mathrm{e}^{-\lambda x} \text{ if } 0\leq x$$
`expcdf`	Exponential distribution CDF	$x, \lambda$	$$0 \text{ if } x < 0$$ $$1 - \mathrm{e}^{-\lambda x} \text{ if } 0\leq x$$
`studentpdf`	Student's t-distribution PDF	$x, \nu$	Wikipedia
`studentcdf`	Student's t-distribution CDF	$x, \nu$	Wikipedia
`betapdf`	Beta distribution PDF	$x, \alpha, \beta$	Wikipedia
`betacdf`	Beta distribution CDF	$x, \alpha, \beta$	Wikipedia
`chi2pdf` `khi2pdf`	Chi-squared distribution PDF	$x, k$	Wikipedia
`chi2cdf` `khi2cdf`	Chi-squared distribution CDF	$x, k$	Wikipedia
`gammapdf`	Gamma distribution PDF	$x, \alpha, \beta$	Wikipedia
`gammacdf`	Gamma distribution CDF	$x, \alpha, \beta$	Wikipedia

chplot name	Name	Arguments	Expression
cauchypdf	Cauchy distribution PDF	x, x_0, γ	$$\frac{1}{\pi\gamma\left(1 + \left(\frac{x - x_0}{\gamma}\right)^2\right)}$$
cauchycdf	Cauchy distribution CDF	x, x_0, γ	$$\frac{1}{\pi}\arctan\left(\frac{x - x_0}{\gamma}\right) + \frac{1}{2}$$

To use the (k, θ) parametrization of the gamma distribution, just apply $\alpha = k$ and $\beta = \frac{1}{\theta}$.

Other functions

chplot name	Arguments	Expression
relu ramp	x	$0 \text{ if } x < 0$ $x \text{ if } 0\leq x$
lrelu	x, a	$a\cdot x \text{ if } x < 0$ $x \text{ if } 0\leq x$
sigm sigmoid	x	$$\frac{1}{1 + \mathrm{e}^{-x}}$$
sign sgn	x	$-1 \text{ if } x < 0$ $0 \text{ if } x = 0$ $+1 \text{ if } x > 0$
lerp	x, m_x, M_x, m_y, M_y	$$m_y + (M_y - m_y)\frac{x - m_x}{M_x - m_x}$$
lerpt	t, m, M	$M + t * (M - m)$
heaviside	x	$0 \text{ if } x < 0$ $\frac{1}{2} \text{ if } x = 0$ $1 \text{ if } x > 0$
rect	x	$0 \text{ if } x < -\frac{1}{2} \text{ or } x > \frac{1}{2}$ $1 \text{ if } -\frac{1}{2} \leq x \leq \frac{1}{2}$
triangle tri	x	$0 \text{ if } x < -1 \text{ or } x > 1$ $1 - \|x\|; \text{ if } -1 \leq x \leq 1$
abs	x	$\|x\|$
min	a, b	$\min(a,b)$
min3	a, b, c	$\min(a,b,c)$
min4	a, b, c, d	$\min(a,b,c,d)$
max	a, b	$\max(a,b)$
max3	a, b, c	$\max(a,b,c)$
max4	a, b, c, d	$\max(a,b,c,d)$
if	x, T, F	$F \text{ if } x < 0$ $T \text{ if } 0\leq x$
ifn	x, T, F	$T \text{ if } x\leq 0$ $F \text{ if } 0 < x$
ifz	x, T, F	$T \text{ if } x = 0$ $F \text{ if } x\neq 0$
in	x, L, U, T, F	$T \text{ if } L\leq x\leq U$ $F \text{ if } x < L \text{ or } U < x$

chplot name	Arguments	Expression
out	x, L, U, T, F	$F \text{ if } L\leq x\leq U$ $T \text{ if } x < L \text{ or } U < x$

Notes :

- `out(x, L, U, T, F) = in(x, L, U, F, T)`
- `if(x, T, F) = in(x, 0, inf, T, F)`
- `ifn(x, T, F) = in(x, -inf, 0, T, F)`
- `ifn(x, T, F) = if(-x, T, F)`
- It is possible to use _ inside one of these function to remove some part of the graph.

Alphabetically-sorted list of every included constants and functions

TODO: mettre à jour ça à la fin

▶ Click to reveal

_	a0	abs	acos	acosh	acot
acoth	acsc	acsch	agm	Ai	Aip
alpha	altzeta	angerj	apery	asec	asech
asin	asinh	atan	atan2	atanh	AU
b	backlunds	barnesg	bei	beip	bent
ber	berp	besseli	besselj	besselk	bessely
beta	betacdf	betainc	betainc2	betaincinv	betaln
betapdf	Bi	binom	binomial	Bip	bp
brun	c	c1	c1L	c2	catalan
cauchycdf	cauchypdf	cbrt	ceil	chebyt	chebyu
Chi	chi2cdf	chi2pdf	Ci	clcos	clsin
copysign	cos	cosh	cospi	cot	coth
coulombc	coulombf	coulombg	csc	csch	degrees
digamma	dnuCs	e	eAi	eAip	eBi
eBip	ec	Eh	Ei	ellipe	ellipeinc
ellipf	ellipk	ellipkinc	ellippi	elliprc	elliprd
elliprf	elliprg	elliprj	em	eps0	epsilon0
erf	erfc	erfcinv	erfi	erfinv	eta
eV	exp	expcdf	expm1	exppdf	F
fac	fac2	factorial	feigenbauma	feigenbaumd	ff
fib	fibonacci	floor	fmod	fresnelc	fresnels
G	g	G0	ga	gamma	gammacdf
gammainc	gammainc2	gammaincc	gammaincinv	gammaincinv	gammapdf
ge	gegenbauer	GF0	glaisher	gmu	gP
h	harmonic	hb	heaviside	hermite	hurwitz
hurwitzzeta	hyp0f1	hyp1f1	hyp1f2	hyp2f0	hyp2f1

hyp2f3	hyp3f2	hyperfac	hyperu	hypot	if
ifn	ifz	in	inf	it2struve0	itmodstruve0
itstruve0	iv	jacobi	jv	kB	ke
kei	keip	ker	kerp	khi2cdf	khi2pdf
khinchin	KJ	kv	laguerre	lambertw	legendre
legenp	legenq	lerchphi	lerp	lerpt	lgamma
Li	li	ln	lngamma	log	log10
log1p	log2	loggamma	lommels1	lommels2	lrelu
ly	M12C	m12C	max	max3	max4
Mcharon	me	Mearth	mertens	min	min3
min4	Mjupiter	Mmars	Mmercury	Mmoon	mmu
mn	Mneptune	modstruve	mp	Mpluto	Msaturn
Msun	mt	mtau	Mu	mu	mu0
muB	muN	Muranus	Mvenus	NA	nan
normcdf	normpdf	nzetazeros	out	pc	pcfd
pcfu	pcfv	pcfw	phi	pi	polyexp
polylog	primepi	primezeta	psi	R	radians
ramp	Rcharon	re	Rearth	rect	relu
remainder	rf	rgamma	riemannr	Rinf	Rjupiter
RK	Rmars	Rmercury	Rmoon	Rneptune	Rpluto
Rsaturn	Rsun	Ruranus	Rvenus	Ry	scorergi
scorerhi	sec	sech	secondzeta	sgn	Shi
Si	siegeltheta	siegelz	sigm	sigma	sigmae
sigmoid	sign	sin	sinc	sincpi	sinh
sqrt	sqrt2	stieltjes	struve	struveh	struvel
studentcdf	studentpdf	superfac	tan	tanh	tau
tri	triangle	tricdf	tripdf	trunc	uniformcdf
uniformpdf	unormcdf	unormpdf	VmSi	W	webere
whitm	whitw	yv	Z0	zeta	

Graph and computations examples

Possible improvements

- Parallelizing computation of expressions.