Sage Quick Reference (Basic Math)

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latest version at wiki.sagemath.org/quickref

Aim: map standard math notation to Sage commands

Notebook(とコマンドライン) Notebook (and commandline)

セルの評価: ⟨shift-enter⟩
com⟨tab⟩ *command* と補完しようとする.
command?⟨tab⟩ ドキュメントを表示
command??⟨tab⟩ ソースを表示
a.⟨tab⟩ オブジェクト a のメソッドを表示 (more: dir(a))
search_doc('*string or regexp*') ドキュメントへのリンク
search_src('*string or regexp*') ソースへのリンクを表示
lprint() LaTeX 形式の出力に切替える
version() Sage のバージョンを表示
Insert cell: セルの間の青い線をクリック
Delete cell: 内容を消してから backspace

ORGINAL TEXT

Evaluate cell: ⟨shift-enter⟩
com⟨tab⟩ tries to complete *command*
command?⟨tab⟩ shows documentation
command??⟨tab⟩ shows source
a.⟨tab⟩ shows all methods for object a (more: dir(a))
search_doc('*string or regexp*') shows links to docs
search_src('*string or regexp*') shows links to source
lprint() toggle LaTeX output mode
version() print version of Sage
Insert cell: click on blue line between cells
Delete cell: delete content then backspace

数の型 Numerical types

整数: $\mathbb{Z}$ = ZZ e.g. -2 -1 0 1 10^100
有理数: $\mathbb{Q}$ = QQ e.g. 1/2 1/1000 314/100 -42
小数: $\mathbb{R} \approx$ RR e.g. .5 0.001 3.14 -42
複素数: $\mathbb{C} \approx$ CC e.g. 1+i 2.5-3*i

ORGINAL TEXT

Integers: $\mathbb{Z}$ = ZZ e.g. -2 -1 0 1 10^100
Rationals: $\mathbb{Q}$ = QQ e.g. 1/2 1/1000 314/100 -42
Decimals: $\mathbb{R} \approx$ RR e.g. .5 0.001 3.14 -42
Complex: $\mathbb{C} \approx$ CC e.g. 1+i 2.5-3*i

基本的な定数と函数 Basic constants and functions

定数: π = pi e = e i = i ∞ = oo
近似値: pi.n(digits=18) = 3.14159265358979324
函数: sin cos tan sec csc cot sinh cosh tanh sech csch coth log ln exp
ab = a*b $\frac{a}{b}$ = a/b a^b = a^b $\sqrt{x}$ = sqrt(x)
$\sqrt[n]{x}$ = x^(1/n) $|x|$ = abs(x) $\log_b(x)$ = log(x,b)
不定元: e.g. t,u,v,y = var('t u v y')
函数定義: e.g. $f(x) = x^2$
(微分等ができるシンボリックな) 函数として: f(x)=x^2
Python 関数として定義する: f=lambda x: x^2 または
def f(x): return x^2

ORGINAL TEXT

Constants: π = pi e = e i = i ∞ = oo
Approximate: pi.n(digits=18) = 3.14159265358979324
Functions: sin cos tan sec csc cot sinh cosh tanh sech csch coth log ln exp
ab = a*b $\frac{a}{b}$ = a/b a^b = a^b $\sqrt{x}$ = sqrt(x)
$\sqrt[n]{x}$ = x^(1/n) $|x|$ = abs(x) $\log_b(x)$ = log(x,b)
Symbolic variables: e.g. t,u,v,y = var('t u v y')
Define function: e.g. $f(x) = x^2$
As symbolic function (can integrate, etc): f(x)=x^2 or
As Python function: f=lambda x: x^2 or
def f(x): return x^2

式に対する操作 Operations on expressions

factor(...) expand(...) (...).simplify_...
シンボリックな等式: f(x)==g(x)
_ は直前の出力
_+a _-a _*a _/a で等式を操作できる
$f(x) = g(x)$ を解く: solve(f(x)==g(x),x)
solve([f(x,y)==0, g(x,y)==0], x,y)
$x \in [a,b]$ s.t. $f(x) \approx 0$ を探す: find_root(f(x), a, b)
$\sum_{i=k}^{n} f(i)$ = sum([f(i) for i in [k..n]])
$\prod_{i=k}^{n} f(i)$ = prod([f(i) for i in [k..n]])

ORGINAL TEXT

factor(...) expand(...) (...).simplify_...
Symbolic equations: f(x)==g(x)
_ is previous output
_+a _-a _*a _/a manipulates equation
Solve $f(x) = g(x)$: solve(f(x)==g(x),x)
solve([f(x,y)==0, g(x,y)==0], x,y)
find_root(f(x), a, b) find $x \in [a,b]$ s.t. $f(x) \approx 0$
$\sum_{i=k}^{n} f(i)$ = sum([f(i) for i in [k..n]])
$\prod_{i=k}^{n} f(i)$ = prod([f(i) for i in [k..n]])

微分積分 Calculus

$\lim_{x\to a} f(x)$ = limit(f(x), x=a)
$\lim_{x\to a^-} f(x)$ = limit(f(x), x=a, dir='minus')
$\lim_{x\to a^+} f(x)$ = limit(f(x), x=a, dir='plus')
$\frac{d}{dx}(f(x))$ = diff(f(x),x)
$\frac{\partial}{\partial x}(f(x,y))$ = diff(f(x,y),x)
diff = differentiate = derivative
$\int f(x)dx$ = integral(f(x),x)
integral = integrate
$\int_a^b f(x)dx$ = integral(f(x),x,a,b)
次数 n の a に関する Taylor 多項式: taylor(f(x),x,a,n)

ORGINAL TEXT

$\lim_{x\to a} f(x)$ = limit(f(x), x=a)
$\lim_{x\to a^-} f(x)$ = limit(f(x), x=a, dir='minus')
$\lim_{x\to a^+} f(x)$ = limit(f(x), x=a, dir='plus')
$\frac{d}{dx}(f(x))$ = diff(f(x),x)
$\frac{\partial}{\partial x}(f(x,y))$ = diff(f(x,y),x)
diff = differentiate = derivative
$\int f(x)dx$ = integral(f(x),x)
integral = integrate
$\int_a^b f(x)dx$ = integral(f(x),x,a,b)
Taylor polynomial, deg n about a: taylor(f(x),x,a,n)

二次元グラフィックス 2d graphics

line([(x_1,y_1),...,(x_n,y_n)],*options*)
polygon([(x_1,y_1),...,(x_n,y_n)],*options*)
circle((x,y),r,*options*)
text("txt",(x,y),*options*)
options は plot.options にあるものを使用,
例 thickness=*pixel*, rgbcolor=(r,g,b), hue=h
(ただし $0 \le r,b,g,h \le 1$)
縦横比の調整には figsize=[w,h]
plot(f(x),$x_{\min}$,$x_{\max}$,*options*)
parametric_plot((f(t),g(t)),$t_{\min}$,$t_{\max}$,*options*)
polar_plot(f(t),$t_{\min}$,$t_{\max}$,*options*)
グラフの結合: circle((1,1),1)+line([(0,0),(2,2)])
animate(*list of graphics objects* ,*options*).show(delay=20)

ORGINAL TEXT

line([(x_1,y_1),...,(x_n,y_n)],*options*)
polygon([(x_1,y_1),...,(x_n,y_n)],*options*)
circle((x,y),r,*options*)
text("txt",(x,y),*options*)
options as in plot.options,
e.g. thickness=*pixel*, rgbcolor=(r,g,b), hue=h,
where $0 \le r,b,g,h \le 1$
use option figsize=[w,h] to adjust aspect ratio
plot(f(x),$x_{\min}$,$x_{\max}$,*options*)
parametric_plot((f(t),g(t)),$t_{\min}$,$t_{\max}$,*options*)
polar_plot(f(t),$t_{\min}$,$t_{\max}$,*options*)
combine graphs: circle((1,1),1)+line([(0,0),(2,2)])
animate(*list of graphics objects* ,*options*).show(delay=20)

三次元グラフィックス 3d graphics

`line3d([(`x_1`,`y_1`,`z_1`),...,(`x_n`,`y_n`,`z_n`)],`*options*`)`
`sphere((`x`,`y`,`z`),`r`,`*options*`)`
`tetrahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`cube((`x`,`y`,`z`),`*size*`,`*options*`)`
`octahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`dodecahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`icosahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
options の例 `aspect_ratio=[1,1,1]` `color='red'` `opacity`
`plot3d(f(`x`,`y`),[`x_b`,`x_e`],[`y_b`,`y_e`],`*options*`)`
オプションに `plot_points=[`m,n`]` or `plot3d_adaptive` を使う
`parametric_plot3d((f(`t`),g(`t`),h(`t`)),[`t_b`,`t_e`],`*options*`)`
`parametric_plot3d((f(`u`,`v`),g(`u`,`v`),h(`u`,`v`)),`
`[`u_b`,`u_e`],[`v_b`,`v_e`],`*options*`)`
graphics objects を結合するには `+` を使う

ORGINAL TEXT

`line3d([(`x_1`,`y_1`,`z_1`),...,(`x_n`,`y_n`,`z_n`)],`*options*`)`
`sphere((`x`,`y`,`z`),`r`,`*options*`)`
`tetrahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`cube((`x`,`y`,`z`),`*size*`,`*options*`)`
`octahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`dodecahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
`icosahedron((`x`,`y`,`z`),`*size*`,`*options*`)`
options e.g. `aspect_ratio=[1,1,1]` `color='red'` `opacity`
`plot3d(f(`x`,`y`),[`x_b`,`x_e`],[`y_b`,`y_e`],`*options*`)`
add option `plot_points=[`m,n`]` or use `plot3d_adaptive`
`parametric_plot3d((f(`t`),g(`t`),h(`t`)),[`t_b`,`t_e`],`*options*`)`
`parametric_plot3d((f(`u`,`v`),g(`u`,`v`),h(`u`,`v`)),`
`[`u_b`,`u_e`],[`v_b`,`v_e`],`*options*`)`
use `+` to combine graphics objects

離散数学 Discrete math

$\lfloor x \rfloor$ = `floor(x)` $\lceil x \rceil$ = `ceil(x)`
n を k で割った余り = `n%k` $k|n$ iff `n%k==0`
$n!$ = `factorial(n)` $\binom{x}{m}$ = `binomial(x,m)`
ϕ = `golden_ratio` $\phi(n)$ = `euler_phi(n)`
文字列: 例 `s = 'Hello'` = `"Hello"` = `""+"He"+'llo'`
`s[0]='H'` `s[-1]='o'` `s[1:3]='el'` `s[3:]='lo'`
リスト: 例 `[1,'Hello',x]` = `[]+[1,'Hello']+[x]`
タプル: 例 `(1,'Hello',x)` (immutable)
集合: 例 $\{1,2,1,a\}$ = `Set([1,2,1,'a'])` $(=\{1,2,a\})$
集合の内包的記法 ≈ リストの内包表記, 例
$\{f(x) : x \in X, x > 0\}$ = `Set([f(x) for x in X if x>0])`

ORGINAL TEXT

$\lfloor x \rfloor$ = `floor(x)` $\lceil x \rceil$ = `ceil(x)`
Remainder of n divided by k = `n%k` $k|n$ iff `n%k==0`
$n!$ = `factorial(n)` $\binom{x}{m}$ = `binomial(x,m)`
ϕ = `golden_ratio` $\phi(n)$ = `euler_phi(n)`
Strings: e.g. `s = 'Hello'` = `"Hello"` = `""+"He"+'llo'`
`s[0]='H'` `s[-1]='o'` `s[1:3]='el'` `s[3:]='lo'`
Lists: e.g. `[1,'Hello',x]` = `[]+[1,'Hello']+[x]`
Tuples: e.g. `(1,'Hello',x)` (immutable)
Sets: e.g. $\{1,2,1,a\}$ = `Set([1,2,1,'a'])` $(=\{1,2,a\})$
List comprehension ≈ set builder notation, e.g.
$\{f(x) : x \in X, x > 0\}$ = `Set([f(x) for x in X if x>0])`

線形代数 Linear algebra

$\begin{pmatrix}1\\2\end{pmatrix}$ = `vector([1,2])`
$\begin{pmatrix}1&2\\3&4\end{pmatrix}$ = `matrix([[1,2],[3,4]])`
$\begin{vmatrix}1&2\\3&4\end{vmatrix}$ = `det(matrix([[1,2],[3,4]]))`
Av = `A*v` A^{-1} = `A^-1` A^t = `A.transpose()`
methods: `nrows()` `ncols()` `nullity()` `rank()` `trace()`...

ORGINAL TEXT

$\begin{pmatrix}1\\2\end{pmatrix}$ = `vector([1,2])`
$\begin{pmatrix}1&2\\3&4\end{pmatrix}$ = `matrix([[1,2],[3,4]])`
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Av = `A*v` A^{-1} = `A^-1` A^t = `A.transpose()`
methods: `nrows()` `ncols()` `nullity()` `rank()` `trace()`...

Sage のモジュールとパッケージ Sage modules and packages

`from` *module_name* `import *`   (多くが既に読み込み済)
例 `calculus coding combinat crypto functions games geometry graphs groups logic matrix numerical plot probability rings sets stats`
`sage.`*module_name*`.all.`⟨tab⟩ export されたコマンドを表示
Std packages: Maxima GP/PARI GAP Singular R Shell...
Opt packages: Biopython Fricas(Axiom) Gnuplot Kash...
`%`*package_name* then use package command syntax
`time` *command*   timing information を表示

ORGINAL TEXT

`from` *module_name* `import *`   (many preloaded)
e.g. `calculus coding combinat crypto functions games geometry graphs groups logic matrix numerical plot probability rings sets stats`
`sage.`*module_name*`.all.`⟨tab⟩ shows exported commands
Std packages: Maxima GP/PARI GAP Singular R Shell...
Opt packages: Biopython Fricas(Axiom) Gnuplot Kash...
`%`*package_name* then use package command syntax
`time` *command*   to show timing information