
Appendix: Quick reference to *Mathematica*

■ Getting started

Help -> Documentation Center - Can be used to search for commands of interest

?Command - gives a fairly detailed description of a command, e.g., **?Plot** tells you all about this command.
You can use * as a wildcard, for instance **?*Plot*** gives a list of all commands with Plot in their name.
More help can be found in the menu under "Help", in the Function Navigator or Documentation Center.

***** - Times command ($2*3$ gives 6). Spaces can also be used but be careful (e.g, **a=2 3** gives six but **a=23** gives twenty-three)

^ - Power command (2^3 gives 8)

n! - factorial ($3!$ gives 6)

{ } - denotes a list, e.g., $\{2,3,4\}$

() - Places variables together, e.g., $(1+x)/(1-x)$ takes $1+x$ over $1-x$

[] - Generally used to denote that something is a function of something else

%# - grabs previous output number #.

% - grabs the previous line of output regardless of the number

%% - grabs output two lines back. Note: naming outputs is safer (see next section).

f /. object1 -> object2

- tells Mathematica to make replace object1 with object2 in the function

e.g., $3*x^2 /. x \rightarrow 2*y+z$ gives $3*(2*y + z)^2$

■ Avoiding conflict with *Mathematica*

Mathematica tends to use capital letters for its functions, so its often a good idea to use lower case names for your functions and variables.

If you refer to previous entries using **%**, it can be difficult to know exactly what your previous entry was. It is safer to assign a name to the output and then refer to this name later.

For example,

```
myderivative = D[a Sin[b x], x]
```

```
Plot[myderivative /. a -> 1 /. b -> 3, {x, 0, 10}]
```

■ Functions and constants in *Mathematica* (A small fraction!)

Abs [x] - Takes the absolute value of x

E - The exponential constant 2.71838. **E^(x)** can be invoked using **Exp[x]**

I - The square root of negative 1.

Infinity - Self-explanatory.

Log[x] - Takes the natural log of x

Log[b,x] - Takes the log of x in base b

Pi - 3.14159...

Sin[x], Cos[x], Tan[x] - trigonometric functions

ArcSin[x], ArcCos[x], ArcTan[x] - inverse trigonometric functions

Sqrt[x] - Square root

■ Writing equations in *Mathematica*

x=y - Sets x to y immediately and from then on (use **Clear[x]** to unassign x), e.g., **plot1=Plot[x^2,{x,0,10}]**

x:=y - Does nothing until x is called, at which point x is assigned the value y

x==y - Tests whether x equals y BUT makes no assignment

f[x_] := - This is how you define a function (called "f") of x, e.g., **f[x_] := x^2**

f[x] - This gives the function evaluated at x, e.g., **f[3]** gives **9** in the above example

f[x_,y_,...]= - This is how you define a function of several variables

■ A list of helpful commands

Clear[symbol1,symbol2,...] - clears variable or function definitions,
e.g., **Clear[x, y, pop1]**

Clear["Global`*"] - clears all variable or function definitions from memory

Collect[eqn,{terms},Factor] - collects parts of an equation involving "terms" and
factors them separately (if only one "term", the braces aren't needed)
e.g. **Collect[a - b + a x - 2 b x + a^2 x^2 + 2 a b x^2 + b^2 x^2, x, Factor]**

D[f,x] - takes the partial derivative of f with respect to x - e.g. **D[x^2+y Log[x], x]**

D[f, {x, n}] - takes the nth derivative with respect to x - e.g. **D[x^2+y Log[x],{x,2}]**

DSolve[eqn, y[x],x] - solves differential equation for y as a function of x
(SYMBOLICALLY) e.g. **DSolve[{y'[x] == k y[x], y[0]==y0, y[x],x]**

DSolve[eqns, {y1,y2,y3,...}, x] same as above but for a system of eqns
e.g. pred-prey equations **DSolve[{y'[x] == k y-x, z'[x]==x+z}, {y[x],z[x]}, x]**

NDSolve[eqns, y, {x, xmin, xmax}] - same as DSolve but seeks solution NUMERICALLY - e.g. `NDSolve[{y'[x] == 4 y[x], y[3] == 62}, y[x], {x, 0, 20}]`

Expand[expr] - expands an expr e.g. `Expand[(1+x)^2]` gives $1+2x+x^2$

Evaluate[object] - evaluates a symbolic object like interpolating functions

Factor[polynomial] - self explanatory - e.g. `Factor[x^2 + 2 x + 1]`

FindRoot[eqn1==eqn2, {x, x0}] - searches for numerical root of $\text{eqn1}=\text{eqn2}$ starting at x_0 e.g. `FindRoot[Log[x] + x + Arctan[x] == 0, {x, 4}]` tries to find x that satisfies this very ugly - impossible to solve by hand equation, starting at $x=4$.

For[start, test, increment, body] - repeats procedure “body”, starting from “start” until the “test” condition is met, adding “increment” each time, e.g., `For[i=1, i≤10, i=i+1, Print[i]]` prints out integers 1 through 10.

Integrate[f, x] - finds indefinite integral of f with respect to x e.g., `Integrate[Log[x], x]`

Integrate[f, {x, xmin, xmax}] - computes definite integral from x_{\min} to x_{\max} e.g., `Integrate[Log[x], {x, 1, 6}]`

ListPlot[list] - plots a list of integers, e.g., `ListPlot[{2, 4, 3, 5, 4}]`

ListPlot[{x1, y1}, {x2, y2}, ...] - plots a series of $\{x, y\}$ values, e.g., `ListPlot[{1, 2}, {2, 1}, {5, 7}]` To join the points with a line use:
`ListPlot[{1, 2}, {2, 1}, {5, 7}], PlotJoined->True]` (in *Mathematica 5*)
`ListPlot[{1, 2}, {2, 1}, {5, 7}], Joined->True]` (in more recent versions)

N[f] - gives a numerical value for an expression - e.g. `N[Pi]` gives 3.14159

Part[eqn, i] - grabs the i th part of eqn, e.g., `Part[3x^2+x^3, 2]` gives x^3

Plot[f, {x, xmin, xmax}] - plots f versus x on the interval $[x_{\min}, x_{\max}]$ e.g., `Plot[x^2, {x, 0, 2}]` NOTE: Plot has lots of options e.g. AxesLabel, Grid, AxesOrigin, etc. See the manual for a complete list and usage e.g., `Plot[x^2, {x, 0, 2}, PlotStyle->Dashed]` makes a dashed curve.

Plot3D[f, {x, xmin, xmax}, {y, ymin, ymax}] - makes a 3D plot of f

Show[graphics, options] - displays graphic objects using options e.g. `Show[popplot1, PlotJoined->True]`

Simplify[expr] - does its best to simplify an expression, expr

Solve[eqns, vars] - tries to solve one or a system equations for the vars specified (SYMBOLICALLY)- e.g. `Solve[{x+y ==1, x-y ==4}, {x,y}]`

NSolve[eqns, vars] - does the same thing as `Solve`, but does it NUMERICALLY (See also `FindRoot`)

Sum[f, {i, imin, imax}] - sums `f` from `i` to `imax` i.e. `f[1] + f[2] + f[3] + ...` (only really interesting if `f` depends on `i`) - e.g. `Sum[i, {i, 1,4}]` gives 10.

Reduce[{eqns}] - can be used to determine if a statement is true or false
e.g., `Reduce[{a + b > 1, a < 0, b < 0}]`

RSolve[eqns, vars] - solves a discrete-time equation for `y` as a function of `x` (SYMBOLICALLY) e.g. `RSolve[{n[t+1] == R n[t], n[0]==n0}, n[t],t]`

Table[f, {i, imin, imax}]- makes a table in list format of the function `f` with `i` values that run from `imin` to `imax` - e.g. `Table[i, {i, 1,4}]` gives `{1,2,3,4}`.

■ Libraries

Mathematica has some libraries or packages that it does not load automatically.

The Documentation Center will tell you if a function needs a library.

For example, to plot error bars on a list plot, you will need:

`Needs["ErrorBarPlots`"]`

`ErrorListPlot[
 {{{1, 1}, ErrorBar[0.2]}}, {{2, 2}, ErrorBar[0.1]}}, {{3, 4}, ErrorBar[0.3]}},
 {{4, 6}, ErrorBar[0.4]}}, {{5, 7}, ErrorBar[0.8]}},
 Joined → True, PlotRange → {{0, 6}, {0, 8}}`

