

Introduction to Maple

Information in this document was compiled and updated by Vincent Berardi from:
Introduction to Maple V7/8 by Angie Gardiner

What is Maple?

Maple is a general purpose software package containing tools useful in the study of a wide variety of problems. We can use Maple like a calculator to carry out numerical computation, or we can use the programming features of Maple to produce a more complicated sequence of computations. In addition to numerical computation, we can do symbolic or algebraic computations in Maple. This software package has built-in functions for solving many kinds of equations, for working with matrices and vectors, and for differentiation and integration. It also contains functions which allow us to create visual representations of curves and surfaces from their mathematical descriptions.

Commenting

It is a good idea to include some explanations with your work. In any command line, Maple ignores anything typed after the # symbol. So inserting a line like

```
solve ( 3*x + 2*y - 5*z, z); # Get z in terms of x and y
```

makes your work much easier to follow.

Using Maple

While learning Maple, you will often have questions about how a particular command or function is used. Fortunately, Maple can help you. To ask about a command whose name you know, just type a question mark, followed by the name of the command. Thus

```
?solve
```

gives information on the **solve** command. You will probably find the examples at the end more useful than the technical information at the beginning of the help file.

Let's get started! Go ahead and type along with these examples.

```
2 + 2; 3 * 5; 6 - 2 :
```

4

15

(1)

All three computations were done, although only two results are shown (the : at the end of a command suppresses the output).

Addition +, subtraction -, and division / are standard, and parentheses are used in the usual way. An asterisk * indicates multiplication and a caret ^ is used for powers:

```
( 1 + 2 ) * ( 6 + 7 ) - 12 / 7;
```

$\frac{261}{7}$

(2)

```
3^(2.1);
```

10.04510857

(3)

Whenever possible, Maple tries to compute exact quantities. Our first command gives its answer as a fraction, rather than as a decimal, contrary to what you might expect. The second command gives a decimal, or "floating point" answer because we used this form in our question. To force Maple to give results in floating point (decimal) form, use *evalf*:

Pi;

$$\pi \tag{4}$$

evalf(*Pi*)

$$3.141592654 \tag{5}$$

exp(1)

$$e \tag{6}$$

evalf(%)

$$2.718281828 \tag{7}$$

The % sign stands for the most recently computed quantity.

Be aware that Maple distinguishes upper-case letters from lower-case. Thus *evalf*(*pi*) is not the same as *evalf*(*Pi*).

Standard mathematical functions can be used in Maple so long as we know their names. To compute the quantity

$$|-14| + \sin(1) - \sqrt{2} + e^{\cos(1.6\pi)} + \arctan(3)$$

use *abs*(-14) + *sin*(1) - *sqrt*(2) + *exp*(*cos*(1.6 * *Pi*)) + *arctan*(3);

$$14 + \sin(1) - \sqrt{2} + e^{\cos(1.6\pi)} + \arctan(3) \tag{8}$$

evalf(%)

$$16.03838871 \tag{9}$$

Algebra

Maple knows about variables and algebra. Consider, for example, the expression $(a + b)^2$.

To make long computations easier and more intelligible, we can assign values to variables using ":="

p := (*a* + *b*) ^2; *b* := 1; *p*;

$$(a + b)^2$$

$$1$$

$$(a + 1)^2 \tag{10}$$

Anything we can define or compute in Maple can be assigned to a variable for future reference using ":=". Remember that it is different from the symbol =, which is used to test equality. Observe that no space is allowed between the : and the = in an assignment statement.

Variables can be returned to their original symbolic (unassigned) state. The commands

b := 'b'

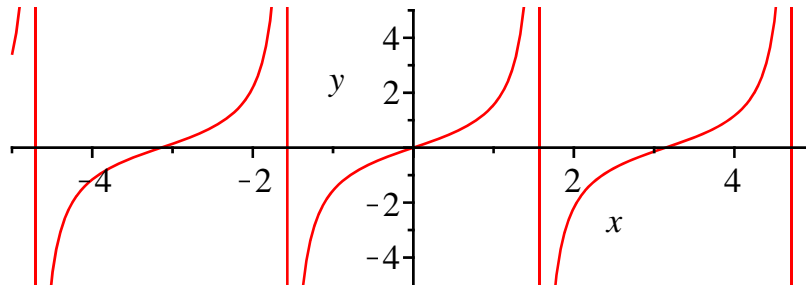
$$b$$

$$\tag{11}$$

p;

It does not accurately represent the vertical asymptotes of $y = \tan(x)$. Better results are obtained with

`plot(tan(x), x = -5..5, y = -5..5);`



Solving Equations

Maple can also solve equations. Consider some examples:

`solve(x^2 + 3*x = 2.1);`

$$0.5856653615, -3.585665361 \quad (20)$$

`solve(x^3 + x = 27);` #This give a complicated answer!

$$\begin{aligned} & \frac{1}{6} (2916 + 12\sqrt{59061})^{1/3} - \frac{2}{(2916 + 12\sqrt{59061})^{1/3}}, -\frac{1}{12} (2916 + 12\sqrt{59061})^{1/3} \\ & + \frac{1}{(2916 + 12\sqrt{59061})^{1/3}} + \frac{1}{2} I\sqrt{3} \left(\frac{1}{6} (2916 + 12\sqrt{59061})^{1/3} \right. \\ & \left. + \frac{2}{(2916 + 12\sqrt{59061})^{1/3}} \right), -\frac{1}{12} (2916 + 12\sqrt{59061})^{1/3} \\ & + \frac{1}{(2916 + 12\sqrt{59061})^{1/3}} - \frac{1}{2} I\sqrt{3} \left(\frac{1}{6} (2916 + 12\sqrt{59061})^{1/3} \right. \\ & \left. + \frac{2}{(2916 + 12\sqrt{59061})^{1/3}} \right) \end{aligned} \quad (21)$$

while the following command does not

`fsolve(x^3 + x = 27);`

$$2.888941572 \quad (22)$$

In general, **solve** looks for exact answers using algebraic methods, whereas **fsolve** uses numerical methods to find approximate solutions in floating-point form. Compare

`solve(tan(x) - x = 2);`

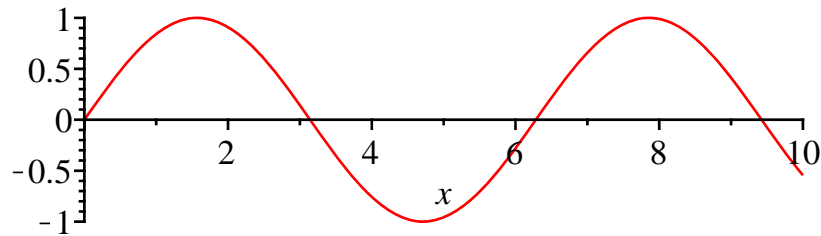
$$\text{RootOf}(-\tan(_Z) + _Z + 2) \quad (23)$$

`fsolve(tan(x) - x = 2);`

$$1.274392662 \quad (24)$$

Notice that **fsolve** may not find all solutions. To understand why not, it is helpful to look at a graph

`plot(sin(x), x = 0..10);`



[This will give you an idea of how many solutions there are and what their approximate location is. Then give **fsolve** a range of x -values in which to search:

$$\text{fsolve}(\sin(x) = 0, x = 2..4); \quad 3.141592654 \quad (25)$$

$$\text{fsolve}(\sin(x) = 0, x = 6..8); \quad 6.283185307 \quad (26)$$

[Often we need to use the solution of an equation in a later problem. To do this, assign a name to it. Here is one example.

$$r := \text{solve}(x^2 + 3*x - 2.1 = 0); \quad 0.5856653615, -3.585665361 \quad (27)$$

[Notice that the answer has the form $r1, r2$, where $r1$ is the first root and $r2$ is the second. Such an object - a bunch of items separated by commas, is called an expression sequence. One picks items out of an expression sequence this way:

$$r[1]; \quad 0.5856653615 \quad (28)$$

$$r[2]; \quad -3.585665361 \quad (29)$$

$$2.888941572 \quad (30)$$

Functions

Although Maple has a large library of standard functions, we often need to define new ones. For example, to define

$$p(x) = 18x^4 + 69x^3 - 40x^2 - 124x - 48$$

[we say

$$p := x \rightarrow 18*x^4 + 69*x^3 - 40*x^2 - 124*x - 48; \quad x \rightarrow 18x^4 + 69x^3 - 40x^2 - 124x - 48 \quad (31)$$

[Think of the symbol \rightarrow as an arrow: it tells what to do with the input x , namely, produce the output $18*x^4 + 69*x^3 - 40*x^2 - 124*x - 48$. Once the function **p** is defined, we can do the usual computations with it, e.g.,

$$p(-2); \quad -224 \quad (32)$$

$$p\left(\frac{1}{2}\right);$$

$$-\frac{441}{4} \quad (33)$$

[It is important to keep in mind that functions and expressions are different kinds of mathematical objects. Mathematicians know this, and so does Maple. Compare the results of the following:

p; # *function*

$$p \quad (34)$$

p(x); # *expression*

$$18x^4 + 69x^3 - 40x^2 - 124x - 48 \quad (35)$$

p(3); # *expression*

$$2541 \quad (36)$$

[It is important to use the expression form if you are inserting your equation into a *solve* or *plot* command. For example,

solve(p(x) = 0); # *finding the roots of p*

$$-4, \frac{3}{2}, -\frac{2}{3}, -\frac{2}{3} \quad (37)$$

Calculus Derivatives

[To compute the derivative of the expression $x^3 - 2x + 9$, say

*diff(x^3 - 2*x + 9, x)*;

$$3x^2 - 2 \quad (38)$$

[To compute the second derivative, say

*diff(x^3 - 2*x + 9, x\$2)*;

$$6x \quad (39)$$

[By analogy, *x\$3* would give the third derivative. Thus one can easily compute derivatives of any order.

[Now suppose that we are given a function *g* defined by

*g := x → x^3 - 2*x + 9*;

$$x \rightarrow x^3 - 2x + 9 \quad (40)$$

[It seems natural to use

diff(g, x);

$$0 \quad (41)$$

[to get the derivative of *g*. However, Maple expects an expression in *x* and so interprets *g* as a constant, giving the wrong result. The command

diff(g(x), x);

$$3x^2 - 2 \quad (42)$$

which uses the expression $g(x)$, works correctly. The subtlety here is an important one: *diff* operates on expressions, not on functions - g is a function while $g(x)$ is an expression. To define the derivative of a function, use Maple's D operator:

$dg := D(g);$

$$x \rightarrow 3x^2 - 2 \quad (43)$$

The result is a function. You can work with it just as you worked with g . Thus you can compute function values and make plots:

$dg(1);$

$$1 \quad (44)$$

$plot(\{ g(x), dg(x) \}, x = -5..5, title = 'g(x) = x^3 - 2x + 9 \text{ and its derivative}');$

