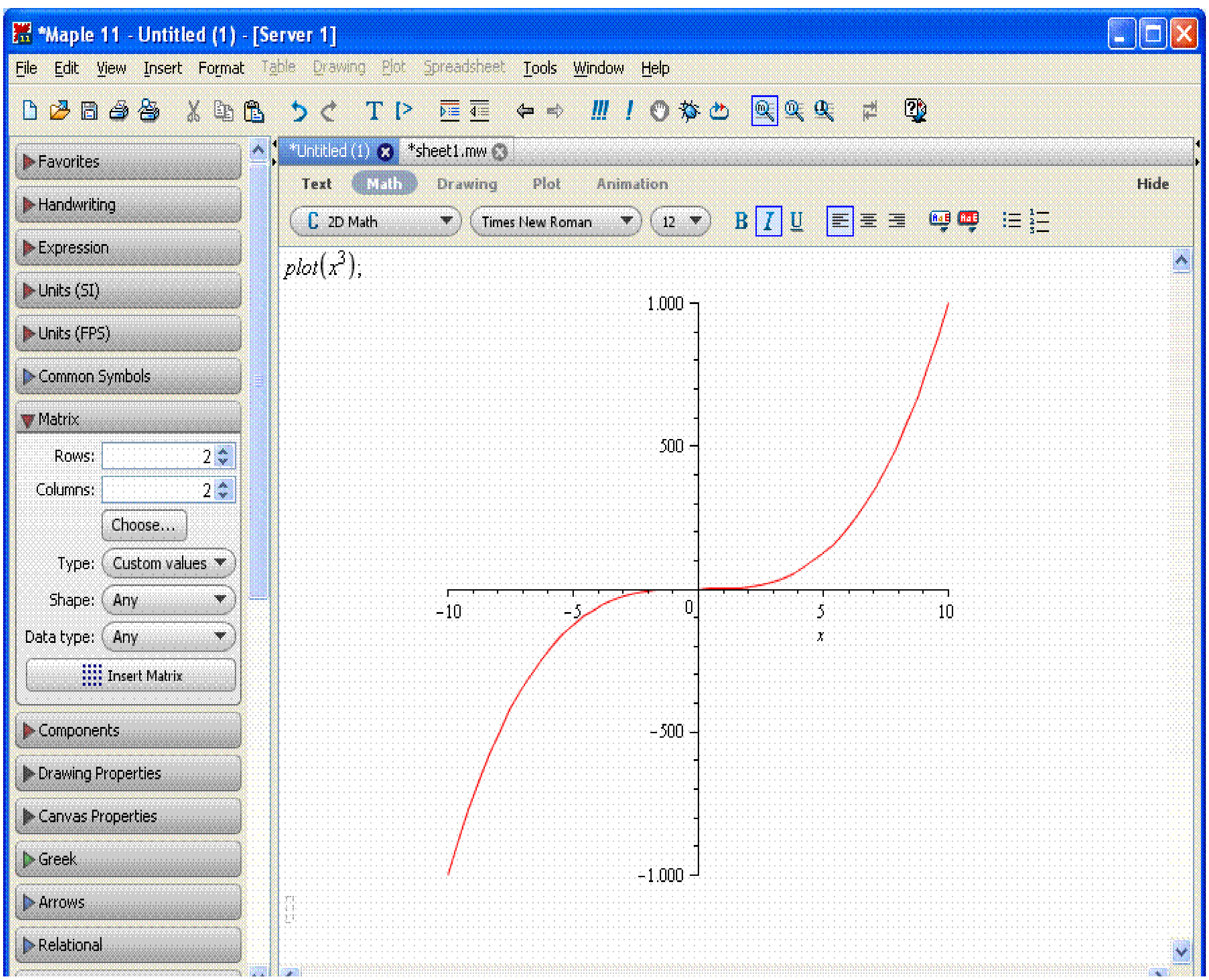
Maple

Properties
- Software package
- implemented in the programing language C
- available for many Operating Systems, e.g. Windows, Unix, Linux
- desined for numerical and **symbolic** expressions

- includes untilities for algebra, calculus, discrete mathematics, graphics, ...

History
- 1980: first development at the University of Waterloo, Canada
- 1988: Waterloo Maple Software was founded in order to sell and improve the software
- currently: version 12

Getting started
- login to one of the machines in the pool in the Piloty building
- open a shell / a terminal
- type: xmaple (or maple, if you would like to work without windows; e.g. remote from home)



Menu bar at the top:
- allows you to save or load and edit your maple session
  e.g. clicking on the ***File*** menu and selecting ***Save*** allows to save the current worksheet
- below the menu bar, there is a collection of shortcut-buttons

Maple Help
- help menu, "Maple Help"
- ?command; e.g. ?solve, if you know the keyword in advance

- the help-window has two panels: the Help Navigator on the left and the help itself on the right
- each help page contains some examples; copying an example and pasting it into the worksheet is possible

Basic Conventions

Entering a command, example

> $restart;$

> $3+4;$

$$7 \quad (1)$$

Arithmetic operators

Addition	$+$	$3+4$
Substraction	-	$x-y$
Multiplication	*	2*x
Division	/	x / y
Exponentiation	^	3^4
Factorial	!	3!

The precedence order follows the mathematical conventions:

> $(10-1)\cdot 2$

$$18 \quad (2)$$

> $10-1\cdot 2$

$$8 \quad (3)$$

>

Special commands to access previous results
%   latest one
%%   secoond most recent

%%%   third most recent

```
> #this is a comment
> 2·4; # most recent result becomes 8
                                        8                                   (4)
> % · 12.4; # this computes 8·12.4. 99.2 becomes most recent result
                                       99.2                                 (5)
> %% − %; # computes 8-99.2
                                      -91.2                                 (6)
>
```

Defining Expressions with ":="
- expression: combination of numbers, variables and operators
- Syntax is *name:=expression*
- maybe most used concept in Maple

Example

> $f := (1-x)^2 \cdot x^3;$

$$f := (1-x)^2 x^3 \quad (7)$$

>

If you make a mistake, you can go back with the cursor, change the command-line and re-execute the line.

Basic Data Structures

- fundamental data structures: expression sequences, lists, sets. (e.g. used as parameters in maple commands)

Sequences, implicitely or with command seq(f(i),i=m..n)

> $3, 5, x, 4;$

$$3, 5, x, 4 \quad (8)$$

> $s := 3, 5, x, 4;$

$$s := 3, 5, x, 4 \quad (9)$$

> $s;$

$$3, 5, x, 4 \quad (10)$$

> $t := seq(i^2, i=2..5);$

$$t := 4, 9, 16, 25 \quad (11)$$

>

A list
- is an expression sequence enclosed in square brackets
- preserves order and repetition of elements

A set
- is an expression sequence enclosed in curly brackets
- does not preserve order an does not contain the same element several times

> $list1 := [5, 4, 3, 5, 4, 3];$

$$list1 := [5, 4, 3, 5, 4, 3] \quad \textbf{(12)}$$

> $list2 := [3, 4, 5];$

$$list2 := [3, 4, 5] \quad \textbf{(13)}$$

> $set1 := \{5, 4, 3, 5, 4, 3\};$

$$set1 := \{3, 4, 5\} \quad \textbf{(14)}$$

> $set2 := \{4, 5, 3\};$

$$set2 := \{3, 4, 5\} \quad \textbf{(15)}$$

>

Numerical Computation

Fraction numbers and floating point numbers

- fractions are not reduced to floating point approximations
- exact computations with fractions
- with *evalf*, the fraction can be converted to a floatring point number with D*igits* many digits.

> $x := \frac{9}{8} + \frac{6}{5};$

$$x := \frac{93}{40} \quad \textbf{(16)}$$

> $evalf(\%);$

$$2.325000000 \quad \textbf{(17)}$$

> $evalf(x);$

$$2.325000000 \quad \textbf{(18)}$$

> $Digits := 20;$

$$Digits := 20 \quad \textbf{(19)}$$

> $evalf(x);$

$$2.3250000000000000000 \quad \textbf{(20)}$$

> $\frac{9}{8.0} + \frac{6}{5};$ *# a floating number in the expression leads to implicit evalf*

$$2.3250000000000000000 \quad \textbf{(21)}$$

>

Integer numbers

- arbitrary large integers (as far as there is enough memory)

> 121!;

8094298525273443739681622845449350829970823063097016070457762336284976604 2664\
052171339177399791018273828707418507890495685666343931838274504771621484 11\
4765072176022307209216 0000000000000000000000000000 **(22)**

>

>

Complex Numbers

- a complex number z is of the form a + bi, with i^2= -1 and a,b ∈ℝ. a = Re(z) is the realpart of z and b=Im(z)
  is the imaginary part of z
- two complex numbers are equal if and only if their real parts and their imaginary parts are equal

- Complex numbers are added, subtracted, multiplied, and divided by formally applying the associative,
  commutative and distributive laws of algebra, together with the equation i 2 = -1.
  - Addition : (a+bi) + (c+di) = (a+c) + (c+d)i
  - Substraction : (a+bi) - (c+di) = (a-c) + (c-d)i
  - Multiplication: $(a+bi)\cdot(c+di) = (ac-bd) + (bc+ad)i$
  - Division : $\frac{a+bi}{c+di} = \frac{ac+bd}{c^2+d^2} + \frac{bc-ad}{c^2+d^2}i$, with c or d not equal to 0

- with the given definitions of addition, substraction, multiplication, division, and
  - the additive identity (zero-element) 0 + 0i,
  - the multiplicative identity (one-element) 1 + 0i,
  - the addidive inverse of a number a + bi: -a - bi, and
  - the multiplicative inverse of a + bi: $\frac{a}{a^2+b^2} + \frac{-b}{a^2+b^2}$,

  the complex numbers ℂ are a *field* (dt: Körper)

> $\frac{(3+3\cdot I)}{(2+6\cdot I)}$;

$$\frac{3}{5} - \frac{3}{10}\,\mathrm{I} \tag{23}$$

> $\left(\frac{3}{3^2+5^2} + \frac{(-5)}{3^2+5^2}\cdot I\right)\cdot(3+5\cdot I)$;

$$1 \tag{24}$$

Symbolic Computations

> $\left(\frac{a}{a^2+b^2} + \frac{-b}{a^2+b^2}\cdot I\right)\cdot(a+b\cdot I)$;

$$\left(\frac{a}{a^2+b^2} - \frac{\mathrm{I}\,b}{a^2+b^2}\right)(a+\mathrm{I}\,b) \tag{25}$$

>

> *simplify*(%);

$$1 \tag{26}$$

> ?*assume*

The following expression leads to a surprising answer. Why? Because somewhere above, we already defined x. Thus: be careful and alert!

> *simplify*$(\sin(x)^2\cdot x^4 + \cos(x)^2\cdot x^4)$;

$$\frac{74805201}{2560000} \quad (27)$$

> $simplify(\sin(y)^2 \cdot y^4 + \cos(y)^2 \cdot y^4);$

$$y^4 \quad (28)$$

> *restart*;

> $simplify(\sin(x)^2 \cdot x^4 + \cos(x)^2 \cdot x^4);$

$$x^4 \quad (29)$$

>