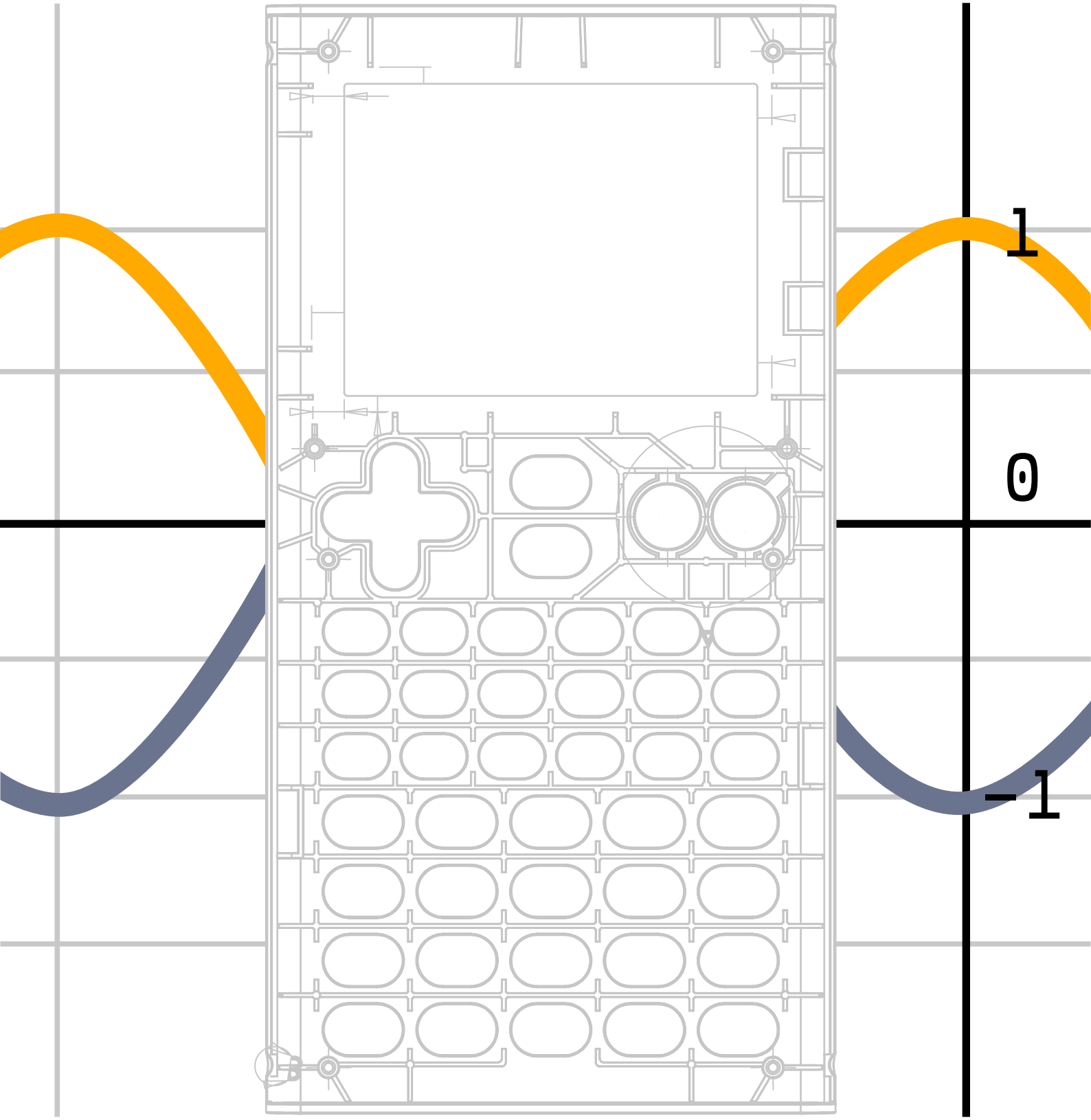
NUMWORKS

User manual



Version 15.3.0

Contents

Chapter 1

Calculation

1.1 Using the application

1.1.1 Doing a calculation

1. When you enter the **Calculation** application, the cursor is in the editing bar at the bottom of the screen. Enter your calculation in this editing bar.
2. Press the (EXE) key. The calculation is performed.

When a calculation is performed, it is displayed at the bottom of the calculation history. In the history line corresponding to this calculation, you will see the calculation you entered at the top left and the result at the bottom right. The exact result is displayed in black while the approximate numerical result is displayed in gray.

Inputs with decimal numbers also give accurate results. Select the decimal result to display the exact result.

For more readability, the result of the calculations involving a decimal number is always given in decimal form: $0.1 + 0.3$ will give 0.4 while $\frac{1}{10} + \frac{3}{10}$ will give $\frac{2}{5}$.

1.1.2 Using the result of the most recent calculation

You can use the exact result of the calculation you just performed in the expression of a new calculation. To do so, press (Ans). The expression `ans` is then displayed in the editing line and represents the result of the most recent calculation. You can then perform mathematical operations on this result.

1.1.3 Using any result in the calculation history

To copy a previous result to the calculation editing bar, use the arrow keys to select the result you want to use (exact or approximate), then press (OK). The result is then displayed in the editing bar at the bottom of the screen.

1.1.4 Using the expression of a calculation already performed in the calculation history

You can copy the expression of a calculation that has already been performed to the calculation editing bar. To do so, select the expression of this calculation using the directional arrows. Then press (ok), the expression of the calculation is then displayed in the edit bar at the bottom of the screen.

1.1.5 Deleting a line in the history

To delete a line in the history, use the arrow keys to select an item from the line and press (clear).
To delete the entire history, select any item in the history using the arrow keys and use the **clear** function ((shift) then (clear)).

1.2 Displaying additional results on a calculation

It is possible to go up in the history to show additional information on the results of particular calculations. When you select a calculation, if a three-point menu appears on the right side of the calculation, additional results are available. Select the three points and press (ok) to display the additional results.

- When the result is an integer, the calculator gives the following additional results: hexadecimal form, binary form and integer factorization where relevant.
- When the result is a fraction, the calculator gives the following additional results: mixed fraction and Euclidean division of the numerator by the denominator.
- When the result or the input is `sin(x)` or `cos(x)`, the calculator gives the following additional results: angle, value of the cosine and sine and a representation of the trigonometric circle.
- When the result is a complex number, the calculator gives the following additional results: absolute value, argument, real part, imaginary part and a representation in the complex plane.
- When the result is a matrix, and if it is possible, the calculator gives the following additional results: the determinant, the inverse, the trace, the scaled form and the reduced scaled form of the matrix.
- When the result contains units, the calculator gives the following additional results: results in commonly used units (for example, in hours, minutes and seconds for time units), results in SI units.

1.3 Performing calculations with complex numbers

1.3.1 Choosing the complex format of the results

Your results can be displayed in rectangular or polar form (choose "real" to force the results to be real). Make this adjustment in the Settings application.
In rectangular form, the calculation of $\sqrt{-1}$ will give the result i. In polar form, the calculation of $\sqrt{-1}$ will give the result $e^{1.570796*i}$. In real form, the calculation of $\sqrt{-1}$ will give the result "unreal".

> In the polar form, the angle in the exponential is always given in radians, even if the calculator is set in degrees mode.

1.3.2 Calculation of an expression with complex numbers

You can perform calculations with complex numbers as well as with real numbers. Your complex numbers can be typed in rectangular or polar form.
For example: if you type $i + e^{i*\frac{\pi}{2}}$, the result will be $2i$ if you are in rectangular mode and $2e^{i*\frac{\pi}{2}}$ if you are in polar mode.

1.3.3 Absolute value, argument, real part, imaginary part, conjugate

You can calculate these values by using the shortcuts available in the **Complex numbers** section of the **Toolbox** menu to which you have access when you press the (paste) key.
You can also manually type the functions used to calculate these values. In the following list are the syntaxes of the corresponding functions :

- Absolute value : `abs(z)`
- Argument : `arg(z)`
- Real part : `re(z)`
- Imaginary part : `im(z)`
- Conjugate : `conj(z)`

1.4 Performing calculations with matrices

1.4.1 Typing a matrix using the keyboard

To type a matrix in the editing bar at the bottom of the screen, use the brackets `[`and `]`, accessible by pressing (shift) then (e^x) or (ln).
For example, type `[[1,0][0,1]]` to type the size 2 identity matrix :

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

When you press (OK), you can see your matrix displayed with the correct formatting in the calculation history.
It is useful to store matrices in variables. To do so, type your matrix then use the function **sto** $\rightarrow$ (by pressing (shift) then (sto→ F / x^y)). Then type the name of the variable you want and press (EXE). For example, to store the size 2 identity matrix in variable M1, write `[[1,0][0,1]] → M1` and press (EXE).

> To make a capital letter press (shift) then (ALPHA / alpha) then press the key with the desired letter.

1.4.2 Performing calculations

You can perform calculations between several matrices:

- Addition of two matrices: `M1+M2`
- Subtraction of two matrices: `M1-M2`
- Multiplication of two matrices (matrix product) : `M1*M2`
- Division of two matrices (inverse multiplication) : `M1/M2` (corresponds to $M1 * M2^{-1}$)

You can also perform calculations between a number and a matrix:

- Multiplication of a matrix by a scalar: `4*M1`
- Power of a matrix: `M1^5`

1.4.3 Inverse, determinant, transpose, trace, size

You can calculate these values by using the shortcuts available in the **Matrix** section of the **Toolbox** menu to which you have access when you press the (paste") key.
You can also manually type the functions used to calculate these values. In the following list are the syntaxes of the corresponding functions:

- Inverse : `inverse(M)`
- Determinant : `det(M)`
- Transpose : `transpose(M)`
- Trace : `trace(M)`
- Size : `dim(M)`

1.5 Performing calculations with units

1.5.1 Typing a calculation with units

You can perform a calculation on an expression using units. All units are prefixed by the _ character and the symbols used for the units are those of the International System of Units.
For example, to calculate the sum of 30 centimeters and 1 meter, the calculation to type is `30_cm+1_m`. The calculator then gives the result with the most suitable unit.

> The list of usable units is available in the Units section of the Toolbox menu accessible via the paste key.

1.5.2 Performing unit conversions

To convert units, use the arrow on the keyboard accessible via shift and then sto→ F. For example, to convert 185 minutes to hours, type: `185_min→_h`.

Chapter 2

Functions

2.1 Getting started

2.1.1 Drawing the graph of a function

1. When you enter the **Functions** application, select the cell to the right of the name of the function you want to plot.
2. Then type the expression of the function you want to plot. The function editing field appears at the bottom of the screen. To use the variable x within the expression of the function, press cut ⋮ x,n,t.
3. Confirm by pressing OK.
4. Then select the **Plot Graph** button at the bottom of the screen or the **Graph** tab at the top of the screen.
5. Confirm by pressing OK.

You are now in the **Graph** tab and your graph is plotted. You can move the cursor on the curve by using the directional arrows and read the coordinates of the point at the bottom of the screen.

> To open the options menu of the curve on which the cursor is located, press OK.

2.1.2 Displaying the table of values

The table of values for the function can be found in the **Table** tab. There are two ways to access it.

- First option: from the **Functions** tab

1. If you are in the **Functions** tab, select the **Display values** button at the bottom of the screen.
2. Confirm by pressing OK.

The value table is then displayed.

- Second option: from any tab

1. Select the **Table** tab at the top of the screen.
2. Confirm by pressing OK.

The value table is then displayed.

2.2 Using the Functions tab

2.2.1 Adding a function to the list

You can add functions to the list.

1. Select the **Add function** cell at the bottom of the function list.
2. Confirm by pressing OK.

A new function appears in the list. You can directly type its expression with the keyboard.

> You can also create a function from the Calculation app. See the Variables section.

2.2.2 Editing the expression of a function

You can change the expression of a function in the list by highlighting it and pressing OK.
The function editing field is then displayed at the bottom of the screen.

> For function composition, use the name of an existing function in the function expression. Here is an example of an expression you can type: $cos(f(x))$.

2.2.3 Change the plot interval of the function

You can change the plot range of a function.

1. Select the name of the function in the list.

2. Confirm by pressing OK to open the options menu for this function.
3. Select the **Plot range** option and press OK.
4. Edit the values and then select **Confirm**.

2.2.4 Polar and parametric curves

1. Select the name of the function in the list.
2. Confirm by pressing OK to open the options menu for this function.
3. Select the **Curve type** option and press OK.
4. Select the type and press OK.

The expression of a polar function needs to use the θ symbol, it can be typed using the x,n,t key.
The expression of a parametric function needs to be typed as a column vector of size 2. The first coefficient is the expression of `x(t)` while the second is the expression of `y(t)`.

2.2.5 Enabling or disabling a function in the list

A disabled function appears in gray in the function list. You can still edit its expression but its graph and table of values will not be shown in the **Graph** and **Table** tabs.

1. To deactivate a function, select the name of the function in the list.
2. Confirm by pressing OK to open the options menu for this function.
3. Select the **Turn on/off** option and press OK to toggle the status of the function.
4. Return to the function list by pressing ⮌.

Do the same if you want to change the status of a function from **Off** to **On**.

2.2.6 Deleting the expression of a function

1. Select the expression of the function you want to delete.
2. Press clear.

The expression of the function has been deleted. You can now enter a new expression.

2.2.7 Removing a function from the list

You can permanently remove a function from the list. However, the first function in the list cannot be deleted.

1. Select the name of the function to be removed from the function list.
2. Confirm by pressing (ok) to open the options menu for this function.
3. Select the option **Delete function** and confirm.

The function disappears from the list.

> You can also delete a function from the list by selecting the name of the function to delete and pressing (clear).

2.2.8 Renaming a function

You can change the name of a function.

1. Select the name of the function in the list.
2. Confirm by pressing (ok) to open the options menu for this function.
3. Select the **Rename** option and press (ok).
4. Type the new name of the function, but make sure that it does not exceed 7 characters.

2.3 Using the Graph tab

2.3.1 Moving the cursor in the graph window

You can move the cursor using the four directional arrows:

- ◁ / ▷: Move the cursor on the curve to the right or left.
- △ / ▽: Move the cursor to a curve above or below the curve you are on.

2.3.2 Adjusting the display window

To access the display window settings, select one of the options under the **Graph** tab and press (ok).
You can choose between four options: **Auto**, **Orthonormal**, **Navigate** and **Axes**.

> When you are in the graph display window, you can press (+) and (−) to zoom in/out.

Auto

Choose **Auto** to automatically adjust the display window. The window then adapts to the different functions displayed to show the points of interest of each different curve. When this setting is enabled. the circle to the right of the setting name is checked in yellow. This setting turns off automatically when you modify the window, either by using another setting or by shifting the window by moving the cursor over the curve.
If you want to disable this setting, for example to add a new function while keeping the same window, you can uncheck the yellow circle by selecting **Auto** and pressing (OK). The window then remains the same, but it will no longer be automatically adapted when adding or removing a function.

Orthonormal

The **Orthonormal** setting makes it possible to obtain an orthonormal coordinate system. When the functions app is in orthonormal mode, the yellow circle to the right of the name of the setting is checked in yellow. You cannot uncheck this option directly, it will be unchecked when the window changes and the graph is no longer orthonormal.

Navigate

Choose **Navigate** to have access to an interactive setting of the display window:

- ◁ / △ / ▷ / ▽: move the window
- + / −: zoom in/zoom out

Axes

In **Axes** you can enter the values of **Xmin**, **Xmax**. **Ymin**, and **Ymax** that define your display window. Validate by selecting the **Validate** button and pressing the (OK).

2.3.3 Moving the cursor to a given abscissa point

1. When the cursor is on the curve of the function for which you are looking for a particular abscissa, press (OK).
2. The plot options menu opens, select **Go to** and confirm.
3. Enter the abscissa of the point on which you want to move the cursor.
4. Select the **Confirm** button and press (OK).

The cursor is now on the point you requested.
You can also type on the keyboard the value of the cursor abscissa to bring it to the requested point.

2.3.4 Displaying the value of the derivative number

You can display the value of the derivative number in the banner at the bottom of the screen.

1. When the cursor is on any curve, press OK.
2. The plot options menu opens. Select **Derivative** then press OK to toggle the switch to the active state.
3. Press ⮌ to return to the graph display window. The value of the derivative number appears in the legend at the bottom of the screen.

Do the same if you want to disable the display of the derivative number.

2.3.5 The Calculate menu

The Calculate menu allows you to identify intersection points, minima and maxima, zeros, calculate integrals and draw tangents with their equation.

1. When the cursor is located on a particular curve, press OK.
2. The plot options menu opens. Select **Calculate** and press OK.

This takes you to the menu **Calculate**.

Inverse image

The cursor automatically moves to the inverse image you requested. To jump from inverse image to inverse image within the window, use the directional arrows. Be aware that the antecedent must be located in the window to be found.

Intersection

The cursor automatically moves to a point where the curve intersects with another curve. To jump from intersection point to intersection point within the window, use the directional arrows.

Maximum / Minimum

The cursor automatically moves to a local maximum / minimum of the function. To jump from maximum / minimum to maximum / minimum within the window, use the directional arrows.

Zeros

The cursor automatically moves to a point where the function vanishes. To jump from zero to zero inside the window, use the directional arrows.

Tangent

You observe the tangent to the curve at a point. Its equation is given in the legend banner at the bottom of the screen. You can use the directional arrows to draw other tangents or type directly the abscissa of the tangent on the keyboard.

Integral

1. At the bottom of the display window, you are asked to select the lower bound. To do this, use the ◁ and ▷ keys to position the cursor on the lower bound. Confirm with OK. You can also type the value of x\$ with the keyboard.
2. Now select the upper bound in the same way. Confirm by pressing OK. You can return to the previous step by pressing ⮌. You are then asked to select the lower bound again.
3. The value of the integral you want to calculate is shown in the display bar at the bottom of the screen. To calculate a new integral, press ⮌. To exit the **Integral** mode, press OK.

2.4 Using the Table tab

2.4.1 Modifying the interval in the table of values

You can automatically fill in the table of values with values of x\$ in any interval of your choice. There are two ways to do this.

- First option
  1. Select **Set the interval** in the **Table** tab and confirm by pressing OK.
  2. You get to the settings to specify the range of values of x\$. Enter the values of **X start** and **X end** with the numeric keys of the keyboard then the step value between each x value.
  3. Select the **Confirm** button and press OK. The new table now displays the interval you have just specified.
- The second option
  1. Select the **x** cell at the top of the first column of the table and press OK.

2. The options menu for the **x** column opens. Select **Set the interval** and press (OK).
3. You get to the settings to specify the range of values of x\$. Enter the values of **X start** and **X end** with the numeric keys of the keyboard then the step value between each x value.
4. Select the **Confirm** button and press (OK). The new table now displays the interval you have just specified.

2.4.2 Typing values of x into the table

When you select a cell from the first column of the table (**Column x**), you can manually type a value of x\$ using the numerical keys on the keyboard. Once you have entered your value in the cell, confirm by pressing (OK).
You can delete a row from the table by selecting it and pressing (clear).

2.4.3 Deleting all table values

1. Select the **x** cell at the top of the first column of the table and press (OK).
2. Select **Clear column** and press (OK).
3. An empty value table appears on the screen. You can now enter values in the **x** column manually or automatically.

2.4.4 Displaying the derivative function values

You can display the column of the derivative function in the table.

1. Select the name of the function and press (OK).
2. Select **Derivative function column** and press (OK). You have just activated the display of the derivative function column.
3. Press (↩) to return to the table. The derivative function column appears next to the function you selected.

To hide the column of the derivative function, do the same or select the name of the derivative function and press (OK) to open the options of this column and no longer display it.

Chapter 3

Python

The version of Python available on your NumWorks calculator is MicroPython 1.12, compatible with Python 3.4.

3.1 Scripts

3.1.1 The script list

When you enter the application, you can see the list of saved scripts. When you first use the application, four scripts are defined as examples: `squares.py`, `parabola.py`, `mandelbrot.py` and `polynomial.py`.

3.1.2 Adding and removing a script from the list

You can add up to 8 scripts on the list.

1. Select the **Add a script** cell at the bottom of the list.
2. Confirm by pressing OK.

A new script appears on the list. You can then enter a name for your new script.
To delete a script, select the settings icon next to the script name and press OK. Choose **Delete script** and press OK.

3.1.3 Renaming a script

To change a script name, select the settings icon next to the script name and press OK. Choose **Rename script** and press OK to confirm. You can now change the name of the script.

3.1.4 Editing a script

To write to a script, simply select the script name and press (ok). The editor opens and you can write your code inside.

To help you write, press (paste"). A menu will open with some shortcuts to make editing easier. The menu **Loops and Tests** offers pre-filled blocks for `for` and `while` loops, `if` tests and a series of **conditions**. The menu **Catalog** lists the functions present in Python and gives a short description of them. You can also use the (copy ; var) key to display the list of functions defined in your scripts as well as the global variables.

If you want to copy and paste part of a text, select the characters to be copied by holding down the (shift) key and using ◁ or ▷. Then press (shift) and then (copy ; var) to copy the selection. Press (shift) and then (paste") to paste it.

3.1.5 Autocompletion

The script editor has an autocompletion feature. When you begin typing, the app will make a suggestion in gray.

- To accept the suggestion, press the ▷ or (ok) key.
- To decline the suggestion, press (⮌) or just continue typing.
- To get a new suggestion, press the △ or ▽ key.
- All possible suggestions from the prefix you entered are listed in the menu of the (copy ; var) key.

3.1.6 Disabling automatic import into the shell

Automatic import is automatically enabled for your scripts. This means that the command `from script_name import *` is systematically entered when the shell is opened so that you can use the functions you defined in the scripts inside the console.

To disable automatic import of a script, select the settings icon next to the script name and press (ok). Choose **Auto import in shell** and press (ok) to toggle the switch. The switch turns grey and the script will no longer be activated automatically.

3.2 The shell

At the bottom of the list of scripts is the **Python shell** button which allows access to the interactive shell of Python.

The triple arrows **>>>** prompt you to enter a command.

You can use the shortcuts on the (paste") menu to make text entry easier. The menu of the (copy ; var) key displays the list of functions and global variables contained in the imported scripts.

To interrupt the execution of a script, press the ↩ key on the keyboard. If the script is stuck in an infinite loop, press and hold ↩ and repeat until the script is interrupted.

3.3 Modules

The modules present in this version of Python are: `math`, `cmath`, `matplotlib.pyplot`, `random`, `turtle`, `ion`, `time` and `kandinsky` modules.

3.3.1 The math module

Here is the complete description of the `math` module. You can get this list on your calculator by pressing paste and going to **Modules** then **math**.

`e` The constant `e=2.718281828459045`.

`pi` The constant `pi=3.141592653589793`.

`sqrt(x)` Square root, type `sqrt(x)` for $\sqrt{x}$.

`pow(x,y)` Power, type `pow(x,y)` for x^y.

`exp(x)` Exponential, type `exp(x)` for e^x.

`expm1(x)` Exponential minus 1, type `expm1(x)` for $e^x - 1$.

`log(x)` Natural logarithm: `log(x)` calculates $ln(x)$.

`log2(x)` Base-2 logarithm, type `log2(x)` for $\frac{ln(x)}{ln(2)}$.

`log10(x)` Base-10 logarithm, type `log10(x)` for $\frac{ln(x)}{ln(10)} = log(x)$.

`cosh(x)` Hyperbolic cosine.

`sinh(x)` Hyperbolic sine.

`tanh(x)` Hyperbolic tangent.

acosh(x) Inverse hyperbolic cosine.

asinh(x) Inverse hyperbolic sine.

atanh(x) Inverse hyperbolic tangent.

cos(x) Cosine in radians.

sin(x) Sine in radians.

tan(x) Tangent in radians.

acos(x) Arc cosine.

asin(x) Arc sine.

atan(x) Arc tangent.

atan2(y,x) Type `atan2(y,x)` to calculate $atan(\frac{y}{x})$.

ceil(x) Ceiling.

copysign(x,y) Returns `x`with the sign of `y`, for instance `copysign(3,-1)=-3`.

fabs(x) Absolute value, `fabs(x)` returns $\mid x \mid$.

floor(x) Floor, type `floor(x)` to calculate $\lfloor x \rfloor$.

fmod(a,b) `fmod(a,b)` returns a modulo b.

frexp(x) Mantissa and exponent of `x`: for instance, `frexp(10)` returns `(0.625,4)` because $10 = 0.625 \times 2^4$.

ldexp(x,i) Inverse of `frexp(x)`, that is $x \times 2^i$.

modf(x) Fractional and integer parts, for instance `modf(5.1)=(0.1,5.0)`.

isfinite(x) Checks if x is finite.

isinf(x) Checks if x is infinity.

isnan(x) Checks if x is NaN.

trunc(x) Returns x truncated to an integer, for instance trunc(6.7)=6.

radians(x) Converts x from degrees to radians, for instance radians(180) returns 3.141592653589793.

degrees(x) Converts x from radians to degrees, for instance degrees(pi) returns 180.

erf(x) Error function, $erf(x) = \frac{2}{\pi}\int_0^x e^{-t^2}\,\mathrm{d}t$.

erfc(x) Complementary error function, $erfc(x) = 1 - erf(x)$.

gamma(x) Gamma function.

lgamma(x) Log-gamma, $lgamma(x) = ln(gamma(x))$.

3.3.2 The cmath module

This is the complete description of the **cmath** module. You can get this list on your calculator by pressing paste and going to **Modules** then **cmath**.

e The constant e=2.718281828459045.

pi The constant pi=3.141592653589793.

phase(z) Phase of z in radians, for instance phase(1j)=1.570796326794897.

polar(z) Representation of z in polar coordinates: polar(1j) returns (1.0, 1.570796326794897).

rect(z) Representation of z in cartesian coordinates: rect(1,pi/4) returns 0.70710+0.70710j.

exp(x) Exponential function, for instance exp(i*pi/4) returns 0.70710+0.70710j.

log(x) Natural logarithm, for instance `log(1j)` returns `1.570796326794897j`.

sqrt(x) Square root.

cos(x) Cosine.

sin(x) Sine.

3.3.3 The matplotlib.pyplot module

This is the complete description of the `matplotlib.pyplot` module. You can get this list on your calculator by pressing paste and going to **Modules** then **matplotlib.pyplot**.

arrow(x,y,dx,dy) Draws an arrow from point `(x,y)` to point `(x+dx,y+dy)`. It is possible to use an optional argument to adjust the size of the arrow by writing: `head_width = 0.1`. Another optional argument can be used to choose the color of the line by writing: `color="red"`.

axis((xmin,xmax,ymin,ymax)) Sets the display window to `(xmin,xmax,ymin,ymax)`. The `axis()` instruction returns the list of values for the axes boundaries. In addition, `axis("off")` or `axis(False)` hides the axes while `axis("on")` or `axis(True)` displays them. To reset the axes with the automatic setting, you can use the `axis("auto")` instruction.

bar(x,height,bin_width,bottom) Draws a bar plot using the values in the `x` list and the counts in the `height` list. The last two arguments are optional. The `bin_width` argument allows you to set the width of the bars whose default value is 0.8. The `bottom` argument is the list of the starting ordinates of the bars, set to 0 by default. It is possible to place an optional argument to choose the color of the line by writing: `color="red"`.

grid() Displays the grid if it is hidden or hides the grid if it is displayed. The `grid(True)` and `grid(False)` instructions allow you to show or hide the grid.

hist(x,bins) Plots a histogram using the values in the `x` list. The second argument is optional. If the second argument is an integer, it sets the number of rectangles that constitute the histogram. This number is 10 by default. If the second argument is a list, it allows you to choose the bins of the histogram. For example, if `bin` is `[0,1,3,5]`, the bins will be: `[0,1[`, `[1,3[` and `[3,5]`. It is possible to place an optional argument to choose the color of the line by writing: `color="red"`.

plot(x,y) Plots the y list versus the x list. The (x,y) points are connected by segments. If only one y list is given, thex is assumed to be [0,1,2,3...]. The color argument is optional. It allows you to choose the color of the line.

scatter(x,y) Plots a scatterplot based on (x,y) values. The arguments of the function can be numbers or lists of the same length. It is possible to place an optional argument to choose the color of the line by writing: color="red".

show() Draws the figure.

text(x,y,"text") Displays the text set as an argument at the (x,y) coordinates.

3.3.4 The turtle module

This is the complete description of the turtle module. You can get this list on your calculator by pressing paste and going to Modules then turtle.

forward(x) Move forward by x pixels.

backward(x) Move backward by x pixels.

right(a) Turn right by a degrees.

left(a) Turn left by a degrees.

goto(x,y) Move to (x,y) coordinates.

setheading(a) Set the orientation by a degrees.

circle(r) Circle of radius r pixels.

speed(x) Drawing speed (x between 0 and 10).

position() Return the current (x,y) location.

heading() Return the current heading.

pendown() Pull the pen down.

`penup()` Pull the pen up.

`pensize(x)` Set the line thickness to **`x`** pixels.

`write("text")` Writes the text placed as an argument at the position of the turtle.

`isdown()` Return **`True`** if the pen is down.

`reset()` Reset the drawing.

`showturtle()` Show the turtle.

`hideturtle()` Hide the turtle.

`color('c')` or **`color(r,g,b)`** Set the pen color.

`colormode(x)` `colormode(1.0)` changes the color mode to 1.0 and the colors must be defined by tuples of type `(0.5,1.0,0.5)` while `colormode(255)` changes the color mode to 255 and the colors are then defined by tuples of type `(128,255,128)`. By default the color mode is 255.

`blue` Blue color.

`red` Red color.

`green` Green color.

`yellow` Yellow color.

`brown` Brown color.

`black` Black color.

`white` White color.

`pink` Pink color.

orange Orange color.

purple Purple color.

grey Gray color.

3.3.5 The random module

This is the complete description of the **random** module. You can get this list on your calculator by pressing paste and going to **Modules** then **random**.

getrandbits(k) Returns an integer with **k** random bits.

seed(x) Initialize the random number generator.

randrange(start,stop) Returns a random number in **range(start,stop)**.

randint(a,b) Returns an integer in **[a,b]**.

choice(list) Returns a random number in the list.

random() Returns a random floating point number in **[0,1[**.

uniform(a,b) Returns a random floating point number in **[a,b]**.

3.3.6 The kandinsky module

This is the complete description of the **kandinsky** module. You can get this list on your calculator by pressing paste and going to **Modules** then **kandinsky**.

color(r,g,b) Defines the color from the values of **r**,**g**,**b**. You can also simply use a tuple to define a color: **(r,g,b)**.

get_pixel(x,y) Returns the pixel **x**,**y** color as a tuple **(r,g,b)**.

set_pixel(x,y,color) Colors the pixel **x**,**y** of the **color** color.

`draw_string(text,x,y,[color1],[color2])` Displays `text` from the pixel `x`,`y`. The arguments `color1` (text color) and `color2` (background color) are optional.

`fill_rect(x,y,width,height,color)` Fills a rectangle at pixel `(x,y)` with the color `color`.

3.3.7 The ion module

This is the description of the `ion` module. You can get this list on your calculator by pressing paste" and going to **Modules** then **ion**.

`keydown(k)` Returns `True` if the `k` key in argument is pressed and `False` otherwise.
The other items in this menu indicate the syntax used to identify the keys on the keyboard.

3.3.8 The time module

Here is the description of the `time` module. You can get this list on your calculator by pressing paste" and going to **Modules** then **time**.

`monotonic()` Returns the value of the clock at the time the function is called.

`sleep(t)` Pauses execution for `t` seconds.

3.4 Toolbox and var keys

3.4.1 The var key

In the script editor, the menu of the copy ; var key lists the autocompletion suggestions available.
In the execution console, the menu of the key copy ; var lists all the functions defined in your imported scripts (not containing any error) as well as the global variables.

3.4.2 The Toolbox key

The paste" key menu contains four sections for faster editing of your scripts.

Loops and tests Contains instructions for `for` and `while` loops as well as `if` tests.

Modules Contains the functions available in the `math`, `cmath`, `random`, `matplotlib.pyplot`, `ion`, `time`, `turtle` and `kandinsky` modules.

Catalog Contains the functions that can be used in Python, especially those of the modules but also functions like `print()` and `input()`. An alphabetical search with the letters of the keyboard is possible.

Functions Contains instructions for defining a function: `def function(argument):` and `return`.

Chapter 4

Statistics

4.1 Getting started

4.1.1 Entering your data into the table

When you enter the **Statistics** app, you must enter your data into a two-column table. You can add up to 3 data tables.

- In the first column (**Values**), enter the values of your statistical data.
- In the second column (**Sizes**), enter the frequencies/sizes associated with each value in your dataset, i.e. the number of occurrences of each value.

  When you fill in the first column, the second column is automatically filled in with the value 1. This means that each of the values in your statistical data appears only once in the set. Change the size values in the second column if the values in your statistical set appear more than once.

For example, let's consider the following statistical data: 1, 1, 1, 2, 3, 3, 4, 5, 5.
To enter this statistical data in the table, proceed as follows.

Values V1	Sizes N1
1	3
2	1
3	2
4	1
5	2

You can also enter frequencies in the **Sizes** column.

4.1.2 Plotting data as a histogram

Once you have typed your data into the table in the **Data** tab, you can plot it as a histogram.

1. Select the **Histogram** tab at the top of the screen.
2. Confirm by pressing ok.

You then see the histogram that displays your data.

4.1.3 Plotting data as a box-and-whisker plot

Once you have typed your data into the table in the **Data** tab, you can plot it as a box-and-whisker plot.

1. Select the **Box** tab at the top of the screen.
2. Confirm by pressing ok.

You then see the box-and-whisker plot that displays your data.

4.1.4 Displaying statistical variables

Once you have typed your data into the table in the **Data** tab, you can display the statistical variables: mean, standard deviation, median, etc.

1. Select the **Stats** tab at the top of the screen.
2. Confirm by pressing ok.

You then see the table of statistical variables.

4.2 Using the Data tab

4.2.1 Delete a value from the data table

You can delete a row from the table by selecting a cell in that row and pressing clear.
You can change the content of a cell by selecting it and typing a new value with the keyboard.

4.2.2 Clear a column from the table

You can delete all the values in a column of the table.

1. Select the name of the column you want to clear. Confirm by pressing OK.
2. The column options menu opens. Select **Clear column** and confirm with OK.

Clearing the **Values** column also clears the **Sizes** column.
Clearing the **Sizes** column fills this column with the value 1.

4.2.3 Generate a list with a formula

You can create a column of the data table using a formula involving another column.

1. Select the name of the column you want to fill. Confirm by pressing OK.
2. The column options menu opens. Select **Fill with formula** and confirm with OK.
3. Type your formula using the name of another column. For example, if you want column V2 to be filled with the values of V1 divided by 2, write `V1/2` in the text field at the bottom of the screen. Then press **OK**.

To enter a capital letter, press **shift** then **alpha** then the letter to display.

4.2.4 Sort a list by increasing values

You can sort a list in the data table by increasing values. This classification affects the column associated with the list (Values or Numbers).

1. Select the name of the column to sort. Confirm by pressing OK.
2. The column options menu opens. Select **Sort by increasing values** and validate with the OK key.

4.3 Using the Histogram tab

4.3.1 Moving the cursor in the histogram

When you are in the **Histogram** tab, you can read the numbers and frequencies in the bar at the bottom of the screen for each rectangle. The intervals represented by the rectangles are also displayed.
To move the selection to another rectangle in the histogram, use the ◁ and ▷ keys.
To move to another data set, use the △ and ▽ keys.

4.3.2 Setting histogram parameters

You can change the width of the histogram rectangles (bin width) and the start value of the data set.

1. Press OK.
2. The histogram settings menu opens. Enter the values for the width of rectangles and the start of the set. Confirm by selecting the **Validate** button and pressing the OK key.

4.4 Using the Box tab

In the **Box** tab, you can read the statistical variables below the box-and-whisker plot:

- Minimum
- First quartile
- Median
- Third quartile
- Maximum

To move the cursor, use the ◁ and ▷ keys.
To move to another data set, use the △ and ▽ keys.

4.5 Using the Stats tab

The **Stats** tab displays the statistical variables calculated using the data in the **Data** tab:

- Total size
- Minimum
- Maximum
- Range
- Mean
- Standard deviation
- Variance

- First quartile
- Third quartile
- Median
- Interquartile range
- Sum
- Sum of squares
- Sample standard deviation

Chapter 5

Probability

This app lets you study different probability distributions such as Binomial, Normal or Exponential. Input the distribution's parameters and get the corresponding probabilities. It is organized in 3 steps:

1. Choice of probability distribution: select the distribution you need to perform your probability calculations. For example, the normal distribution.
2. Choice of the parameters: type the values of the parameters of the probability density function. For example, standard deviation and mean.
3. Calculate probabilities: define your bounds and calculate the corresponding probability or perform the inverse by typing a probability value to calculate the value of the corresponding bound.

Once you have made a choice and moved on to the next step, you can return to the previous step by pressing ⮌.

5.1 First step: choose the probability distribution

Select the probability distribution you need with the directional arrows. Then confirm by pressing OK to go to the next step.
You can choose between 5 continuous distributions and 3 discrete distributions.
Continuous distributions:

- Uniform distribution
- Exponential distribution
- Normal distribution
- Chi2 distribution

- Student distribution
- Fisher distribution

Discrete distributions:

- Binomial distribution
- Geometric distribution
- Poisson distribution

5.2 Second step: choose the parameters

Type the value of the parameter(s) then select the **Next** button and press (OK) to go to the next step.
At the bottom of the screen, you will see a description of the requested parameters.
In the table below, the parameters requested for each distribution are reminded.

Binomial (n, p) : number of trials and success probability
(natural number, real number in $[0, 1]$)

Uniform (a, b): bounds of the interval
(real number, real number)

Exponential λ: parameter
positive real number

Normal (μ, σ): mean and standard deviation
(real number, positive real number)

Chi2 k : degrees of freedom
positive integer

Student k : degrees of freedom
positive real number

Geometric p : success probability
real number in $]0, 1]$

Poisson λ :parameter
positive real number

Fisher ($d1$, $d2$): degrees of freedom of the numerator and of the denominator
(positive real number, positive real number)

5.3 Third step: calculate probabilities

5.3.1 Calculating a probability

1. Select the bound in which you need to enter your value.
2. Type the value.
3. Confirm by pressing OK.

You can now read the result of the probability calculation.

5.3.2 Modifying the bounds

You can modify the type of bounds for your probability calculations:

- $$X \leq a$$
- $$a \leq X$$
- $$a \leq X \leq b$$
- $$X = a$$

The last option only concerns discrete distributions.
To do so, follow the instructions below.

1. Select the **Bound type** icon at the top left of the screen and press OK.
2. A drop-down menu opens. Choose the type of bounds you want and confirm by pressing OK.

You have changed the type of bounds for calculating your probabilities.

5.3.3 Calculating the inverse

You can calculate a in $P(a \leq X) = p$ from a given p probability value.

1. Select the field in which the probability value is located.
2. Type your value.
3. Confirm by pressing OK.

The calculator will display the value of a.

Chapter 6

Equations

Enter equations in whatever form you desire. The app will then compute the discriminant and exact roots of quadratic equations and give exact solutions of linear systems.

6.1 Solve an equation

6.1.1 Enter an equation

When you open the application, press (OK) to add an equation. A pop-up will appear and suggest equation templates that you can then modify. If you do not wish to use a template, choose **Empty**.

Enter your equation in the text field at the bottom of the screen. You can use any lowercase letter as the unknown value: press (ALPHA alpha) then a letter to display it or simply press the (cut x,n,t) key to display the letter x.

Confirm by pressing (OK) once you have entered your equation.

To display the = sign, press (shift) and then press (π). If you validate without writing a sign = in your equation, it will be automatically added.

6.1.2 Solutions

To get the solution of the equation, select the **Solve equation** button at the bottom of the screen and press (OK).

Quadratic equations

If the input equation is a quadratic equation, the solutions **x0** and **x1** are automatically given in an exact form.

The table also displays the value of the discriminant.

General case

Generally, solutions are computed numerically and their value is often approximated.
When you press the **Solve the equation** button, the application then asks you to set an interval in which to search for the solution.
Set the values of **Xmin** and **Xmax** and press the button **Solve the equation**.
If there are too many solutions, the calculator will only display the first ten.

6.2 Solving a system of equations

6.2.1 Enter a system of equations

To enter a system, simply proceed as before. When you add a second equation, the application displays the equations as a system.
You can use any lowercase letter as the unknown value.
Up to 6 equations can be added.

6.2.2 Solutions

The application solves linear systems with real or complex coefficients.
To get the solutions, select the **Solve the system** button at the bottom of the screen and press OK.
The application gives the solutions in exact form. It also indicates if there is an infinity of solutions or if there is no solution.

Chapter 7

Sequences

7.1 Getting started

7.1.1 Drawing the graph of a sequence

1. When you enter the **Sequence** application, select the **Add sequence** cell and confirm by pressing OK.
2. Choose the type of expression you would like to enter: explicit expression of the sequence (based on n), recursive first order (expression based on the previous term) or recursive second order (expression based on the two previous terms).
3. Type the expression of the sequence you wish to plot. The sequence editing field appears at the bottom of the screen. To use the variable n within the expression of the sequence, press the cut x,n,t key. To use a recursive formula, use the **Toolbox** menu shortcuts by pressing paste. In this case, you must indicate the value of the first term of the sequence.
4. Confirm by pressing OK.
5. Then select the **Plot Graph** button at the bottom of the screen or the **Graph** tab at the top of the screen.
6. Confirm by pressing OK.

You are now in the **Graph** tab and your graph has been plotted. You can move the cursor using the directional arrows and read the coordinates of the points at the bottom of the screen.

> To open the options menu of the graph on which the cursor is located, press OK.

7.1.2 Displaying the table of values

The table of values for the function can be found in the **Table** tab. There are two ways to access it.

- First option: from the **Sequences** tab

  1. If you are in the **Sequences** tab, select the **Display values** button at the bottom of the screen.
  2. Confirm by pressing (OK).

  The value table is then displayed.

- Second option: from any tab

  1. Select the **Table** tab at the top of the screen.
  2. Confirm by pressing (OK).

  The value table is then displayed.

7.2 Using the Sequences tab

7.2.1 Adding a sequence to the list

You can add up to 3 sequences to the list.

1. Select the **Add sequence** cell at the bottom of the list.
2. Confirm by pressing (OK).

Then choose the type of sequence you want to enter and type its expression.

7.2.2 Editing the expression of a sequence

You can change the expression of a sequence on the list by highlighting it and pressing (OK).
The sequence editing field is then displayed at the bottom of the screen.

7.2.3 Enabling or disabling a sequence on the list

A disabled sequence appears in gray in the list. You can still edit its expression but its graph and table of values will not be shown in the **Graph** and **Table** tabs.

1. To deactivate a sequence, select the name of the sequence in the list.

2. Confirm by pressing (ok) to open the options menu for this sequence.
3. Select the **Turn on/off** option and press (ok) to toggle the status of the sequence.
4. Return to the sequence list by pressing (↩).

Do the same if you want to change the status of a sequence from **Off** to **On**.

7.2.4 Deleting the expression of a sequence

1. Select the expression of the sequence you want to delete.
2. Press the (clear) key.

The expression of the sequence has been deleted. You can enter a new expression.

7.2.5 Removing a sequence from the list

You can permanently remove a sequence from the list.

1. Select the name of the sequence to be removed from the sequence list.
2. Confirm by pressing (ok) to open the options menu for this sequence.
3. Select the option **Delete sequence** and confirm.

The sequence disappears from the list.

> You can also delete a sequence from the list by selecting the name of the sequence to delete and pressing (clear).

7.2.6 Changing the type of the sequence

You can choose the type of expression of a sequence: explicit expression of the sequence (based on n), recursive first order (expression based on the previous term) or recursive second order (expression based on the two previous terms).

1. Select the name of the sequence you want to change
2. Confirm by pressing (ok) to open the options menu for this sequence.
3. Select the option **Sequence type** and press (ok).
4. Choose the type of expression you want and confirm by pressing (ok).

The type of the sequence has been changed. If you chose to define the sequence with a recursive expression, you will have to provide the first term.
When you change the type of a sequence, the expression previously entered for that sequence is deleted.

7.2.7 Typing the expression of a recursive sequence

You can enter the expression of a recursive sequence, for example $u_{n+2} = u_{n+1} + u_n$\$.
You can use the two previous terms in the expression (u_{n+1} and u_n\$).
To do so, you can press (paste) when editing the expression and select the term you need.
You can also directly enter the term you want: type `u (n+1)` for u_{n+1} and `u (n)` for u_n.
With a recursive sequence you must define the first terms of the sequence. Enter the required terms in the list below the expression of the recursive sequence.

7.2.8 Changing the first term index

1. Select the name of the sequence to edit
2. Confirm by pressing (ok) to open the options menu for this sequence.
3. Select the line **First term index** and type a value.
4. Press (ok) and (back) to return to the **Sequences** tab.

7.3 Using the Graph tab

7.3.1 Moving the cursor in the graph window

You can move the cursor using the four directional arrows:

- (◁) / (▷): Move the cursor to the right or left.
- (△) / (▽): Move the cursor to a sequence above or below the sequence you are on.

7.3.2 Adjusting the display window

To access the display window settings, select one of the options under the **Graph** tab and press (ok).
You can choose between three options: **Axes**, **Zoom** and **Preadjustment**.

> When you are in the graph display window, you can press the (+) and (−) keys to zoom in/out.

Axes

In **Axes**, you can enter the values of **Xmin** and **Xmax** that define the width of your display window.

If **Yauto** is activated, the height of your display window will be automatically calculated to display all points of the sequence between **Xmin** and **Xmax**. Otherwise, manually enter your **Ymin** and **Ymax** values.
Confirm by selecting the **Confirm** button and pressing OK.

Zoom

Select **Zoom** to access an interactive display window setting:

- ◁ / △ / ▷ / ▽: move the window
- + / −: zoom in/zoom out

Preadjustment

The **Preadjustment** menu offers you 4 predefined display windows:

- **Trigonometrical**: window adapted to the representation of the different trigonometric functions
- **Integer**: window in which the abscissa are integers
- **Orthonormal**: window displaying an orthonormal coordinate system
- **Basic settings**: reset the display window

7.3.3 Moving the cursor to a given index

1. When the cursor is on the sequence for which you are looking for a particular value, press OK.
2. The plot options menu opens, select **Go to** and confirm.
3. Enter the index of the point on which you want to move the cursor.
4. Select the **Confirm** button and press OK.

The cursor is now on the point you requested.
You can also type directly on the keyboard the value of the index to bring it to the requested point.

7.3.4 Calculating the sum of the terms

1. When the cursor is located on a particular sequence, press OK.
2. The plot options menu opens. Select **Sum of terms** and press OK.
3. At the bottom of the display window, you are asked to select the first term. To do so, use the ◁ and ▷ keys to position the cursor on the first term. Confirm with OK. You can also directly type the value of n\$ with the keyboard.
4. Now select the last term in the same way. Confirm by pressing OK. You can return to the previous step by pressing ⮌. You are then asked to select the first term again.
5. The value of the sum you want to calculate is shown in the display bar at the bottom of the screen. To calculate a new sum, press ⮌. To exit the **Sum of terms** mode, press OK.

7.4 Using the Table tab

7.4.1 Modifying the interval in the table of values

You can automatically fill in the table of values with values of n\$ in any interval of your choice. There are two ways to do this.

- First option
  1. Select **Set the interval** in the **Table** tab and confirm by pressing OK.
  2. You get to the settings to specify the range of values of x\$. Enter the values of **N start** and **N end** with the numeric keys of the keyboard then the step value between each n value.
  3. Select the **Confirm** button and press OK. The new table now displays the interval you have just specified.
- The second option
  1. Select the **n** cell at the top of the first column of the table and press OK.
  2. The options menu for the **n** column opens. Select **Set the interval** and press OK.
  3. You go to settings to specify the range of values of x\$. Enter the values of **N start** and **N end** with the numeric keys of the keyboard then the step value between each n value.
  4. Select the **Confirm** button and press OK. The new table now displays the interval you have just specified.

7.4.2 Typing values of n into the table

When you select a cell from the first column of the table (**Column n**), you can manually type a value of n\$ using the numerical keys on the keyboard. Once you have entered your value in the cell, confirm by pressing (OK).
You can delete a row from the table by selecting it and pressing (clear).

7.4.3 Deleting all table values

1. Select the **n** cell at the top of the first column of the table and press (OK).
2. Select **Clear column** and press (OK).
3. An empty value table appears on the screen. You can now enter values in the **n** column manually or automatically.

Chapter 8

Regression

8.1 Getting started

8.1.1 Entering your data into the table

When you enter the **Regression** app, you must enter your data into a two-column table. You can add up to 3 data tables.

- In the first column (X1), enter the values of the first variable of your statistical data set.
- In the second column (Y1), enter the values of the second variable of your statistical data set.

8.1.2 Computing the linear regression

Once you have entered your data into the table, you can plot a linear regression.

1. Select the **Graph** tab at the top of the screen.
2. Confirm by pressing OK.

You then see the points that represent your data as well as the regression line that fits the model equation $y = ax + b$. The a and b coefficients are displayed in the banner at the bottom of the screen.

8.1.3 Displaying statistical variables

Once you have entered your data into the table in the **Data** tab, you can display the statistical variables: mean, standard deviation, median, etc.

1. Select the **Stats** tab at the top of the screen.

2. Confirm by pressing OK.

You then see the table of statistical variables.

8.2 Using the Data tab

8.2.1 Delete a value from the data table

You can delete a row from the table by selecting a cell in that row and pressing clear.
You can change the content of a cell by selecting it and entering a new value with the keyboard.

8.2.2 Clearing a column of the table

You can delete all the values in a column of the table.

1. Select the name of the column you want to clear. Confirm by pressing OK.
2. The column options menu opens. Select **Clear column** and confirm with OK.

   Clearing the x_i column also clears the y_i column.
   Clearing the y_i column fills this column with the value 0.

8.2.3 Generate a list with a formula

You can create a column of the data table using a formula involving another column.

1. Select the name of the column you want to fill. Confirm by pressing OK.
2. The column options menu opens. Select **Fill with formula** and confirm with OK.
3. Type your formula using the name of another column. For example, if you want column X2 to be filled with the values of X1 divided by 2, write `X1/2` in the text field at the bottom of the screen. Then press **OK**.

To enter a capital letter, press **shift** then **alpha** then the letter to display.

8.2.4 Sort a list by increasing values

You can sort a list in the data table by increasing values. This ranking affects the column associated with the list (X or Y).

1. Select the name of the column to sort. Confirm by pressing OK.
2. The column options menu opens. Select **Sort by increasing values** and validate with the OK key.

8.2.5 Change the regression model

You can change the regression model you use. The available models are:

- Linear
- Proportional
- Quadratic
- Cubic
- Quartic
- Logarithmic
- Exponential
- Power
- Trigonometric
- Logistic

1. Select the name of a column and confirm by pressing (OK).
2. The column options menu opens. Select **Regression** and confirm with (OK).
3. Select your model and press (OK).

8.3 Using the Graph tab

8.3.1 Moving the cursor in the graph window

You can move the cursor using the four directional arrows:

- (◁) / (▷): move the cursor on the line to the right or left or from point to point.
- (△) / (▽): move the cursor from the data points to the regression line or move to another data set.

8.3.2 Predict a value of X or Y

You can look for a specific point on the regression line knowing its abscissa or ordinate: that is, you can predict a value of X given Y and a value of Y given X.

1. Move the cursor to the regression line and press (OK).

2. The regression line menu opens. Select **Prediction given X** if you know the value of X and **Prediction given Y** if you know the value of Y. Confirm by pressing (OK).
3. Type your value, then select the **Confirm** button and press (OK).

The cursor has moved to the desired point. You can read the coordinates of this point at the bottom of the screen.

8.3.3 Change the regression model

You can change the regression model you use. The available models are:

- Linear
- Quadratic
- Cubic
- Quartic
- Logarithmic
- Exponential
- Power
- Trigonometric
- Logistic

1. Move the cursor to a curve and press (OK).
2. The curve options menu opens. Select **Regression** and confirm with (OK).
3. Select your model and press (OK).

8.3.4 Adjusting the display window

To access the display window settings, select one of the options under the **Graph** tab and press (OK).
You can choose between three options: **Axes**, **Zoom** and **Preadjustment**.

> When you are in the graph display window, you can press the (+) and (−) keys to zoom in/out.

Axes

In **Axes**, you can enter the values of **Xmin** and **Xmax** that define the width of your display window.
If **Yauto** is activated, the height of your display window will be automatically calculated to display all points of the curve between **Xmin** and **Xmax**. Otherwise, manually enter your **Ymin** and **Ymax** values.
Confirm by selecting the **Confirm** button and pressing OK.

Zoom

Select **Zoom** to access an interactive display window setting:

- ◁ / △ / ▷ / ▽: move the window
- + / −: zoom in/zoom out

Preadjustment

The **Preadjustment** menu offers you 3 predefined display windows:

- **Integer**: window in which the abscissa are integers
- **Orthonormal**: window displaying an orthonormal coordinate system
- **Basic settings**: reset the display window

8.4 Using the Stats tab

The **Stats** tab displays the statistical variables calculated using the data in the **Data** tab:

- Mean of x_i values and y_i
- Sum of x_i and y_i
- Sum of the squares of x_i and y_i
- Standard deviation of x_i and y_i
- Variance of x_i and y_i
- Number of data points
- Covariance
- Sum of $x_i \times y_i$

- Slope a and y-intercept b of the regression line (or other model coefficients)
- Correlation coefficient r
- Coefficient of determination r^2

Chapter 9

Settings

9.1 Angle measure

If you choose **Degrees**, all arguments of the trigonometric functions will be considered to be in degrees and the inverse trigonometric functions will give results expressed in degrees.

Similarly, if you choose **Radians**, all arguments of the trigonometric functions will be considered as being in radians and the inverse trigonometric functions will give results expressed in radians.

If you choose **Gradians**, all arguments of the trigonometric functions will be considered to be in gradians and the inverse trigonometric functions will give results expressed in gradians.

The unit of angles is displayed in the top banner of the screen as **deg**, **rad** or **gon**.

9.2 Result format

If you choose **Decimal**, the numerical values will be displayed according to calculator presets so that they are as appropriate as possible for each application.

If you choose **Scientific**, the numerical values will be displayed in scientific form. A **sci** indicator then appears in the top banner of the screen to indicate that your results are displayed in scientific notation.

If you choose **Engineering**, the numerical values will be displayed in engineering form. An **eng** indicator then appears in the top banner of the screen to indicate that your results are displayed in engineering notation.

You can choose the number of digits to display for the results by directly modifying the value in the section **Significant figures**. The maximum number of digits that can be displayed is 14.

9.3 Writing format

You can choose the editing mode of mathematical expressions: in one (linear) or in two dimensions (natural).

9.4 Complex format

If you choose **Real**, complex results will not be displayed.
If you choose $a + ib$, complex results will be displayed in rectangular form.
If you choose $re^{i\theta}$, complex results will be displayed in polar form. In this case, the argument in the exponential will always be given in radians, even if the angle unit is set to **Degrees**.

9.5 Brightness

You can adjust the brightness of the screen using the directional arrows.

9.6 Python font size

To change the font size used in the Python application (editor and shell).

9.7 Language

To change the calculator language. You can choose between **English**, **French**, **Spanish**, **German**, **Dutch**, **Italian** and **Portuguese**.

9.8 Country

To change the country of the calculator. You have the choice between **Germany**, **Canada**, **Spain**, **United States**, **France**, **International**, **Italy**, **Netherlands**, **Portugal** and **United Kingdom**.
This setting allows you to define the mathematical conventions used. If you want to use American mathematical definitions and conventions, choose **United States**.

9.9 Exam mode

9.9.1 Activating the exam mode

Select **Exam Mode** in the application **Settings** then press (ok).
An **Activate Exam Mode** button appears. Press (ok) to activate the exam mode.
A message appears indicating that the activation of the exam mode will erase the data. Choose **Confirm** and press (ok).
You are now in exam mode.

9.9.2 What happens when you activate the exam mode?

Enabling the exam mode deletes all recorded data: calculation history, variables, function list, statistical series, Python scripts, etc.
When the exam mode is active, a symbol appears in the yellow band at the top of the screen and the LED on the front edge of the calculator flashes red.

9.9.3 Deactivating the exam mode

You can only exit the exam mode by connecting the calculator to a computer via a USB cable. As soon as you connect the machine, a message appears asking you if you want to exit the exam mode. Choose **Confirm** and press (ok).
You are no longer in exam mode: the symbol **Exam mode** disappears from the display and the LED stops flashing red.

9.10 About

This screen gives you access to the software version number that is installed on your calculator as well as the serial number of your device.

Chapter 10

Variables

You can store numbers, matrices or functions in variables for reuse in future calculations. All variables are listed in the menu that appears when you press the (copy ; var) key on the calculator.

Variable names (expression or function) can be freely chosen using the characters : a..z, A..Z, 0..9 and _. A variable name cannot start with a number nor contain more than 7 characters.

To make a capital letter press (shift) then (ALPHA alpha) then press the key with the desired letter.

10.1 Numbers

The numeric variables available in the calculator are stored in the **Expressions** section in the (copy ; var) menu.

To store a number in a variable, type the number then insert the arrow **sto** (by pressing (shift) then (sto→ F x^y)) followed by the desired variable name. For example to store 5 in a type : `5→a`. Then press (EXE) to confirm.

10.2 Matrices

The matrix variables available in the calculator are stored in the **Expressions** section in the (copy ; var) menu.

To store a matrix in a variable, type the matrix to store then insert the arrow **sto** (by pressing (shift) then (sto→ F x^y)) followed by the desired variable name. For example to store $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ in $m1$ type: `[[1,0][0,1]]→m1`. Then press (EXE) to confirm.

10.3 Functions

The functions available in the calculator are stored in the **Functions** section in the (copy ; var) menu.

To store a function in a variable, type the function expression to store then insert the arrow **sto** (by pressing (shift) then (sto→ F x^y)) followed by the desired variable name. For example to store $f(x) = 2x + 3$ type: `2x+3→f(x)`. Then press (EXE) to confirm.

10.4 Sequences

The sequences available in the calculator are stored in the **Sequences** section of the (copy ; var) menu.

It is not possible to create a sequence from an application other than the **Sequences** application.

10.5 The var key

When editing text, you can press (copy ; var) at any time to open the **Variables** menu. This menu allows you to access the different variables stored in the memory.

Press (OK) on the desired variable to insert it in your calculation.

Press (clear ⌫) to delete the selected variable.

Chapter 11

Toolbox

You can press paste" at any time when editing a calculation or expression. A catalogue of functions will open to help you make more specific calculations.

The **Toolbox** catalog is divided into several thematic sub-sections: Calculation, Complex numbers, Combinatorics, etc. Choose the calculation you want to perform and press ok. Complete the space between the parentheses with the arguments you need for each function.

The first three functions in the **Toolbox** catalogue are: **Absolute value**, **n-th root** and **Logarithm to base a**.

`abs(x)` Calculates the absolute value of the argument you enter in parentheses. `abs(-4.5)` gives the value of $|\,-4.5\,|$, that is 4.5.

`root(x,n)` Calculates the n-th root of a number. You must enter n and x in parentheses. `root(x,n)` gives the value of $\sqrt[n]{x}$. The value of n doesn't have to be an integer.

`log(x,a)` Calculates the logarithm to base a. You must enter a and x in parentheses. `log(x,a)` gives the value of $\log_a(x)$.

11.1 Calculation

`diff(f(x),x,a)` Calculates the derivative of a function at a point. `diff(f(x),a)` gives the value of $f'(a)$. For example, to calculate the derivative of a square root at 5: `diff(sqrt(x),x,5)`.

`int(f(x),x,a,b)` Calculates the integral of a function between two bounds. `int(f(x),x,a,b)` gives the value of $\int_a^b f(x)\,\mathrm{d}x$. For example, to calculate the integral of the square root between 0 and 5: `int(sqrt(x),x,0,5)`.

sum(f(n),n,nmin,nmax) Calculates the sums of terms in n. `sum(f(n),n,nmin,nmax)` gives the value of $\sum_{n=n_{min}}^{n_{max}} f(n)$.

product(f(n),n,nmin,nmax) Calculates the products of terms in n. `product(f(n),n,nmin,nmax)` gives the value of $\prod_{n=n_{min}}^{n_{max}} f(n)$.

11.2 Complex numbers

abs(x) Absolute value of a complex number. `abs(2+3i)` gives the value of $\mid 2+3i \mid$.

arg(z) Argument of a complex number. `arg(2+3i)` gives the value of $arg(2+3i)$ in radians.

re(z) Real part of a complex number. For instance, `re(2+3i)` returns 2.

im(z) Imaginary part of a complex number. For instance, `im(2+3i)` returns 3.

conj(z) Conjugate of a complex number. `conj(2+3i)` returns the conjugate of $2+3i$, that $2-3i$.

11.3 Combinatorics

binomial(n,k) Number of ways to choose a subset of size k elements, disregarding their order, from a set of n elements. `binomial(n,k)` returns $\binom{n}{k}$, that is $\frac{n!}{k!(n-k)!}$.

permute(n,k) Number of different ordered arrangements of a k-element subset of an n-set. `permute(n,k)` returns A_n^k, that is $\frac{n!}{(n-k)!}$.

11.4 Probability

11.4.1 Normal distribution

normcdf(a,μ,^2) $P(X < a)$ where X follows the normal distribution $N(\mu, \sigma^2)$.

normcdf2(a,b,μ,^2) $P(a < X < b)$ where X follows the normal distribution $N(\mu, \sigma^2)$.

invnorm(a,μ,^2) Returns m where $P(X < m) = a$ and X follows the normal distribution $N(\mu, \sigma^2)$.

normpdf(x,μ,^2) Probability density function of $N(\mu, \sigma^2)$.

11.4.2 Binomial distribution

binompdf(m,n,p) $P(X = m)$ where X follows the binomial distribution $B(n, p)$.

binomcdf(m,n,p) $P(X \leq m)$ where X follows the binomial distribution $B(n, p)$.

invbinom(a,n,p) Returns m where $P(X \leq m) = a$ and X follows the binomial distribution $B(n, p)$.

11.5 Arithmetic

gcd(p,q) Greatest Common Divisor of two integers. For instance, `gcd(55,11)` returns 11. This function accepts more than two integers as arguments.

lcm(p,q) Least Common Multiple of two integers. For instance, `lcm(13,2)` returns 26. This function accepts more than two integers as arguments.

factor(n) Integer factorization of n. For instance, `factor(24)`returns $2^3 \times 3$.

rem(p,q) Remainder of the Euclidian division of p by q. For instance, `rem(50,45)` returns the remainder of the division of 50 by 45 that is 5.

quo(p,q) Quotient of the Euclidian division of p by q. For instance, `quo(80,39)` returns the quotient of the division of 80 by 39 that is 2.

11.6 Matrix

inverse(M) Inverse of the matrix M. For instance, `inverse([[0.25,0][0,0.25]])`returns $\begin{bmatrix} 4 & 0 \\ 0 & 4 \end{bmatrix}$.

det(M) Determinant of the matrix M. For instance, `det([[1,2][3,4]])` returns -2.

transpose(M) Transpose of the matrix M. For instance, `transpose([[1,2][3,4]])` returns $\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$.

trace(M) Trace of the matrix M. For instance, `trace([[1,2][3,4]])` returns 5.

dim(M) Size of the matrix M. For instance, `dim([[1,2][3,4]])` returns `[2,2]`.

ref(M) Returns the scaled shape of matrix M.

rref(M) Returns the scaled form of matrix M.

11.7 Vectors

The vectors can be row vectors or column vectors.

dot(u,v) Calculates the dot product of two vectors.

cross(u,v) Calculates the cross product of two vectors of size 3.

norm(u) Calculates the Euclidean norm of a vector.

11.8 Units

This section lists all usable units. All units are prefixed with the symbol `_`.

11.9 Random and approximation

random() Generates a random number between 0 and 1.

randint(a,b) Generates a random integer between a and b.

floor(x) Floor function. For instance, `floor(5.8)` returns 5.

frac(x) Fractional part. For instance, `frac(5.8)` returns 0.8.

ceil(x) Ceiling function. For instance, `ceil(5.8)` returns 6.

round(x,n) Rounds a number to n digits after the decimal point. For instance `round(8.6576,2)` returns 8.66.

11.10 Hyperbolic trigonometry

cosh(x) Hyperbolic cosine.

sinh(x) Hyperbolic sine.

tanh(x) Hyperbolic tangent.

acosh(x) Inverse hyperbolic cosine.

asinh(x) Inverse hyperbolic sine.

atanh(x) Inverse hyperbolic tangent.

11.11 Prediction interval

prediction95(p,n) Prediction interval 95%. `prediction95(p,n)` returns $\left[p - 1.96\frac{\sqrt{p(1-p)}}{\sqrt{n}}; p + 1.96\frac{\sqrt{p(}}{\sqrt{}}\right.$

prediction(p,n) Approximation of the prediction interval. `prediction(p,n)` returns $\left[p - \frac{1}{\sqrt{n}}; p + \frac{1}{\sqrt{n}}\right]$.

confidence(f,n) 95% confidence interval. `confidence(f,n)` returns $\left[f - \frac{1}{\sqrt{n}}; f + \frac{1}{\sqrt{n}}\right]$.