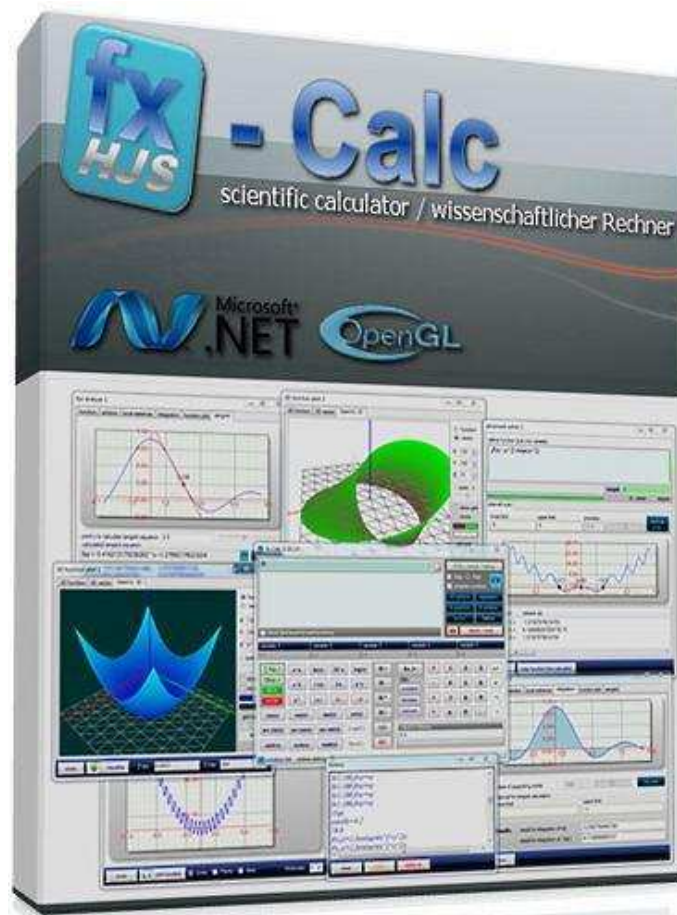


# fx-Calc How-To

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## Fx-Calc – universal desktop calculator for Windows

***fx-Calc*** is actually one of the most advanced desktop calculators for Windows. Starting with a simple calculator window, it allows already calculating self defined functions, sums and product's. It takes for instance just a few clicks to run the Leibnitz iteration to calculate Pi.

***fx-Calc*** let's you define, analyze, visualize and calculate scientific functions and is a full featured replacement and/or enhancement of the old fashioned Windows calculator. In addition to calculation and visualization you can analyze and solve scientific functions and perform linear regression.

Even if the Window concept may not look advanced, it provides the big advantage to open similar windows multiple times and compare the results as needed. This application requires less than 750kbyte memory and is smaller than the windows integrated calc.exe.

To use the interpreter DLL in your own projects, you can obtain a copy and documentation of this DLL directly from the [author](#).

### Unique features:

- definition and immediate calculation of functions with up to 5 variables
- solves equations
- function analysis combined with graphic result presentation
- parametric sum and product calculation
- integrated function library
- integrated library for scientific constants
- 2D function plots including complex graphs
- OpenGL accelerated 3D function plots
- multiple plot and analysis windows to compare different function characteristics
- interactive linear regression module
- automated history
- displays current memory value in separate field
- integrated examples
- is handling complex numbers
- calculates pole points
- tolerance for
  - the use of the multiplication operator
    - $2*a$  is equal to  $2a$
  - spaces in expressions
    - $2*a$  is equal to  $2 * a$  or  $2 a$
  - different brackets ([{
  - accidentally multiple operators

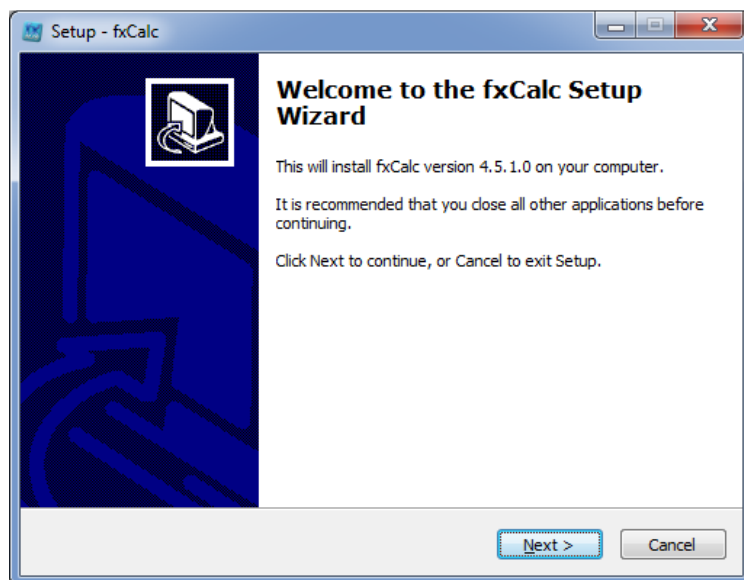
## Installation

System requirements:

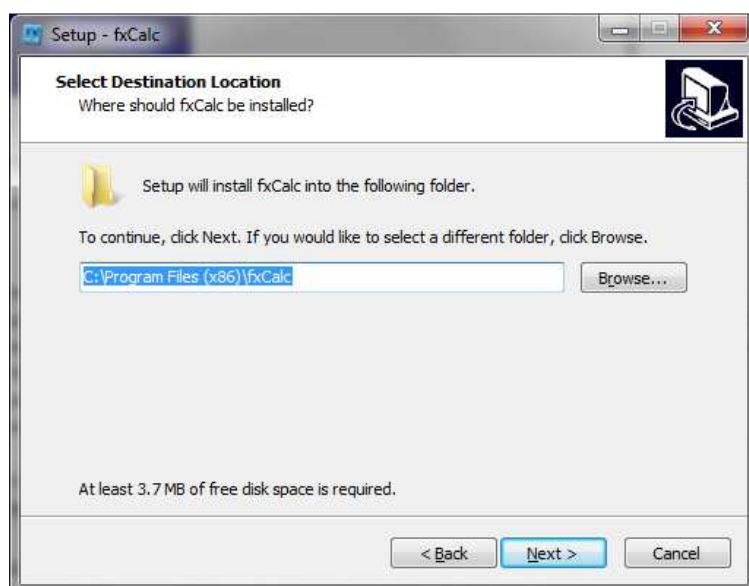
CPU	X86 Dual Core starting from 1,6 GHz
Memory (RAM)	512 MB
HDD	3 MB
Graphics Card	OpenGL 2.0 support required
Operating Systems	Windows Vista, Windows 7, Windows 8 (64 und 32 Bit) (XP very limited, but working)

Fx-Calc requires Microsoft dotNET version 4.0 and above.



The installation is very simple and is done by an automatic setup routine.



This only requires an adjustment of the location - if at all:



The setup creates an entry in the start menu and offers the optional creation of a desktop icon. In addition, the uninstaller is being integrated in the programs section of the system control menu. If no files for your own functions and constants exist, they will be created with initial content. Existing data from previous versions will be migrated to the new version automatically. In addition to the shortcut to the program a further shortcut will point to this documentation, which therefore is offline available:

 fxCalc	06.06.2014 17:00	Shortcut
 Short Documentation	06.06.2014 17:00	Shortcut

Fx-Calc contains a function for automatic update checking. If a new version is available this functionality will offer a shortcut to download the new version at application closing. This kind of internet communication is read only, which means fx-Calc isn't sending any data from your pc to the internet.

## Basic concept

Each calculation starts with the input of the expression in the text box.

fx-Calc calculates your results immediately while you type. The format of mathematical expressions is similar to BASIC and function buttons help to insert functions in correct writing.

In case of any errors in your mathematical expression fx-Calc will display a more specific error message. It disappears automatically as soon as the expression isn't containing anymore errors.



The interpreter is case - sensitive!

By using the keypad you can insert the correct function names into the editor field - so this is just an input help for the mathematical expressions in the text field.

### IMPORTANT:

Fx-Calc is making use of the normal scientific calculation logic, called DAL – Direct Algebraic Logic. So “\*” and “/” is executed prior to “+” and “-”, example:

$$4 + 5 * 3 = 19 \text{ and not } 27 !$$

This is how mathematical terms have to be calculated and somehow different from a simple accounting approach, where you would execute each calculation step by step – regardless of the correct hierarchy.

## Short reference table

The following table provides an overview of input elements:

topic	sub topic	examples	comments
numbers	simple numbers	1; 2,579; 3.14256; -0,0015	. and , are both used as decimal separator
	scientific number format	4e-4 6,623e-23	e is followed by the power, basis is 10
	complex numbers	1+1i; 0-4i; 6e-12+i8e3; (12-i3e-5)	complex number in expressions must always contain both elements, real and imaginary - if real or imaginary is 0 then write 0.
operators	+	5+3,14; 546+3+6	any */ operation will be performed prior to this
	-	5-3,14; 546-3-6	any */ operation will be performed prior to this
	*	5*3,14; 546*3*6	<p>this operation has priority over +/-</p> <p>In the following cases the multiplication operator is not required::</p> <p>multiplication of two variables: x*y is the same as xy</p> <p>a number and</p> <p>an opening bracket 2,5*(... is the same as 2,5(</p> <p>a function 2,5*sin(30) .. is the same as 2,4sin(30)</p> <p>a variable 2,5*x is the same as 2,5x</p> <p>a closing and opening bracket ..) * ( .. is the same as )( ..</p>
	/	5/3,14; 546/3/6	this operation has priority over +/-
functions	priority example	4+3*6 = 40 7+1/2 = 7.5	3*6 is calculated first, before 4 is being added. division is performed prior to add 7
	^	x^n 4^3 = 64 5,23^2,77 = 97.77	for raising a number x to the power of n (x and n can be integer, double or even complex)
	using functions	sin(30); f(x)=sin(x); 3^(1/2); 4^2	The both examples show how functions have to be used. Usually it starts with the function identifier followed by the argument in brackets. This is very similar to BASIC syntax. Exceptions for this concept are the power functions, which can make use of the power operator "^".
	In-build functions	all in-build functions	ln(x), exp(x), log(x), x^y, sqrt(x), abs(x), fac(x) (facult), sin(x), cos(x), tan(x), cotan(x), pi, arcsin(x), arccos(x), arctan(x), sinh(x), cosh(x), tanh(x), Con(i); Rec(i);

	degree and radian	trigonometric functions	for trigonometric functions you can chose the type of arguments, degree or radian, by using the radio button in the upper right corner
	self defined	$f(x)=\sin(x);$ $f(\text{hight})=\text{sqrt}(\text{hight}*9,91)$	<p>Any self defined function starts with f( followed by up to 5 parameters, separator is "," and finally again a closing bracket, followed by "=" and the expression, which is making use of the parameters.</p> <p><math>f(\text{argument1},\dots, \text{argument5}) = \text{expression with argument1}...\text{argument5}</math></p> <p>fx-Calc is recognising the arguments and activates the corresponding input fields automatically.</p>

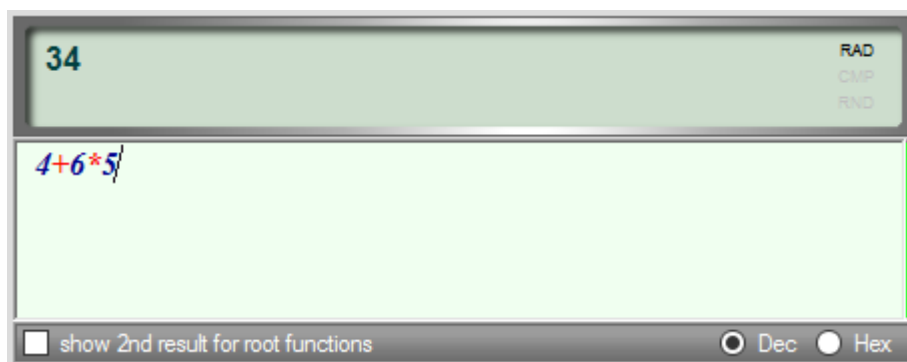
Things to consider:

- A general rule is, if you are uncertain about the need of operators and brackets, use brackets and operators where it makes your expression clear.
- - / \* hierarchy
- Input is case sensitive
- Complex values must always contain both, real and imaginary part – brackets can help to let you consider this, but they are not required)
- This calculator is very tolerant for missing multiplication operators, but using it is reducing the chance of wrong calculation
- You can use all different types of brackets and work with space, if this helps to improve the readability of your expressions

## Simple calculations

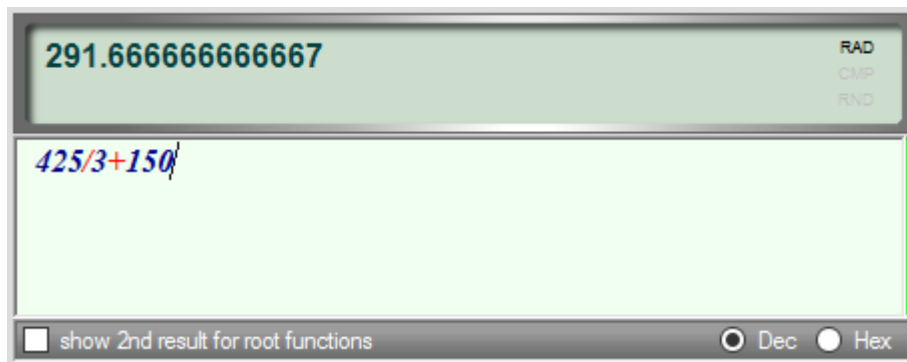
For simple calculations, enter the desired task in the text field - the calculation is happening while you type. fx-Calc is processing expressions using dash-dot hierarchy.

Example:





Or



You can use the scientific number format, example: 5e-5 is equal to 0.00005.  
Furthermore fx-Calc is supporting complex numbers using the following format:

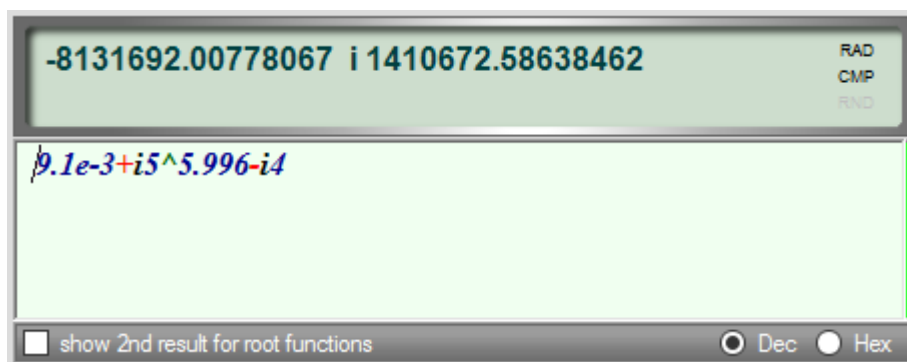
$r \pm iz$

r is the real part

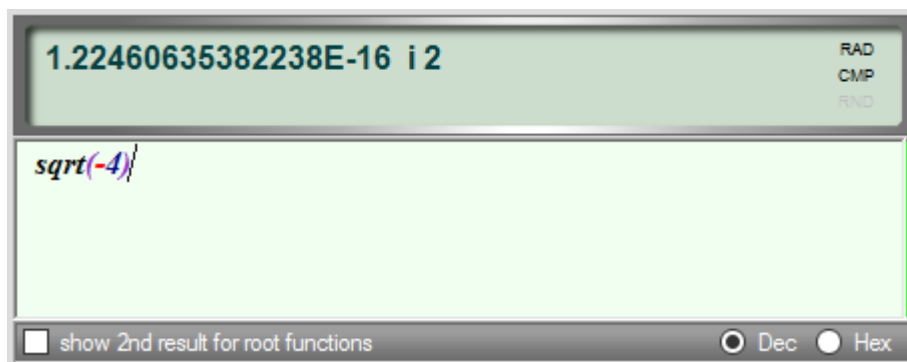
z is the imaginary part, plus or minus in front of i defines the sign of z

Examples:  $4-i1e-3$  or  $0+2i$

Following you have examples for complex number calculation:



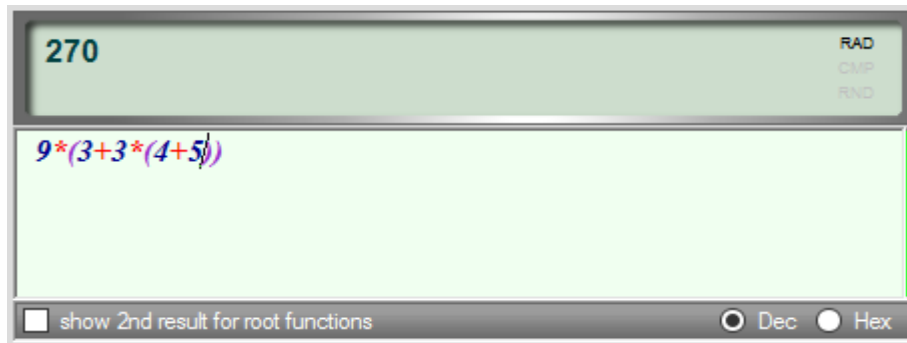
For doing complex number calculation fx-Calc provides functions to conjugate a complex number and to calculate the reciproc value of a complex number. A typical example is to calculate the square root of a negative number:



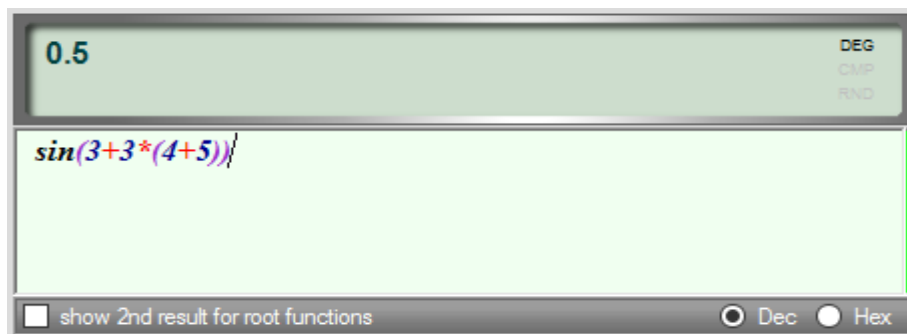
## Calculation with functions and brackets

The principle is also compared to simple arithmetic operations nothing complicated or otherwise. The functions including required brackets will be inserted in the text box when using the corresponding buttons. The dynamic memory allows theoretically unlimited levels of parentheses in mathematical expression - with today's memory sizes, so this shouldn't become a limiting factor in your work with fx-Calc. Again the integrated expression testing is monitoring whether the number of opening and closing brackets are identical.

Example:



and using the sinus function:



All implemented functions can be found on most scientific calculators and by moving your mouse pointer over the function buttons you get hints on the specific function. A special case is to calculate other roots than just square root. The following both examples are showing how this can be simply achieved using the power function,  $y^x$ . (examples for 3rd and 4th root)



## Self defined Functions

Simply speaking a function defines how a specific result can be derived based on certain parameters or variables. These variables can have own names and fx-Calc can manage user-defined functions in it's own small database. fx-Calc allows the use of up to five of these variables.

Each variable name must start with a letter and must be different from integrated function names, just like "sin" or "ln". The variables are automatically detected as you type their function into the text field and the corresponding input fields are activated accordingly and provided with the variable name.

Bearing all this in mind, a function definition starts always with

**f{**

followed by your variable names, separated by "," like this

**f(a1,b2,c3, ...**

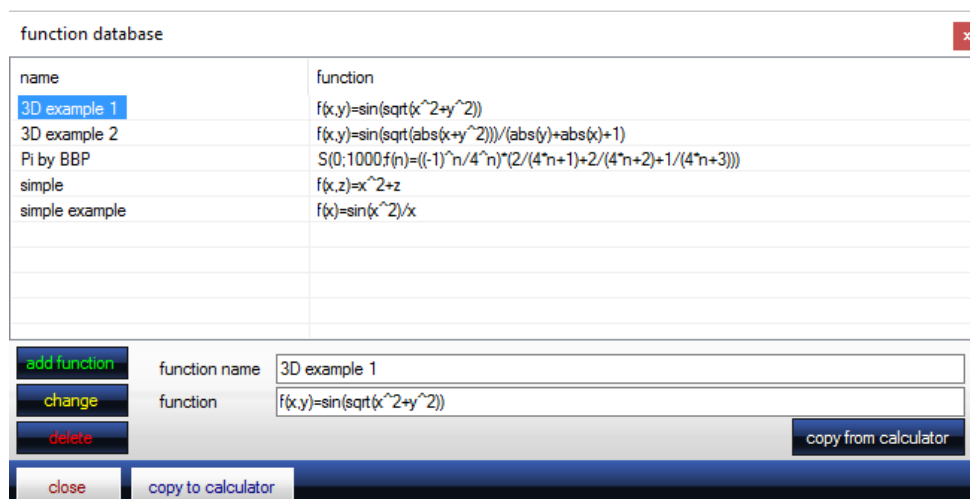
and of course a closing bracket and the formula itself:

**f(a1,b2,c3) = a1 \* b2 \* c3** (very simple example)

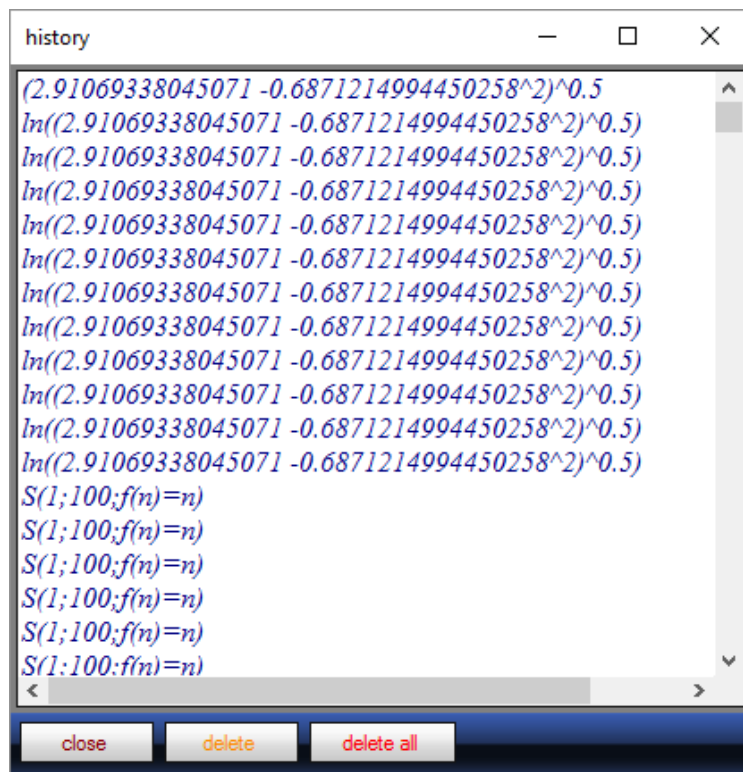
The easiest way to get familiar with this capability is to use some examples:



All variable values (in our example x1 and x2) can be changed to calculate new function results. Every Function can be stored in the function database, which allows recalling a function by simply double clicking the desired entry.



Another possibility in fx-Calc is to recall a history entry:

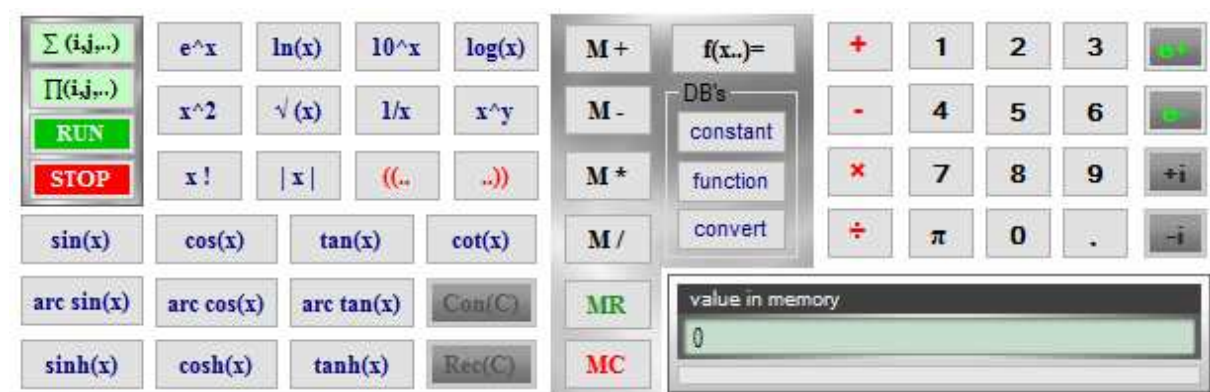


Important: By double clicking the selected item this will be pasted into the calculator immediately. This applies to all three database windows.

## Calculation with memory

fx-Calc supports the extended manipulation of the current value in memory based on all four basic calculation operations. The current memory value is displayed in the lower right corner of the main window. Initially the value is 0 and first thing this can be changed by using M+ or M- button.

MR recalls the value and inserts it in the editor window and MC is clearing the value to 0.



fx-Calc is performing the following memory based calculations:

- M+ is adding the result to memory
- M- memory minus result
- M\* memory times result
- M/ memory divided by result

## Sum and Product

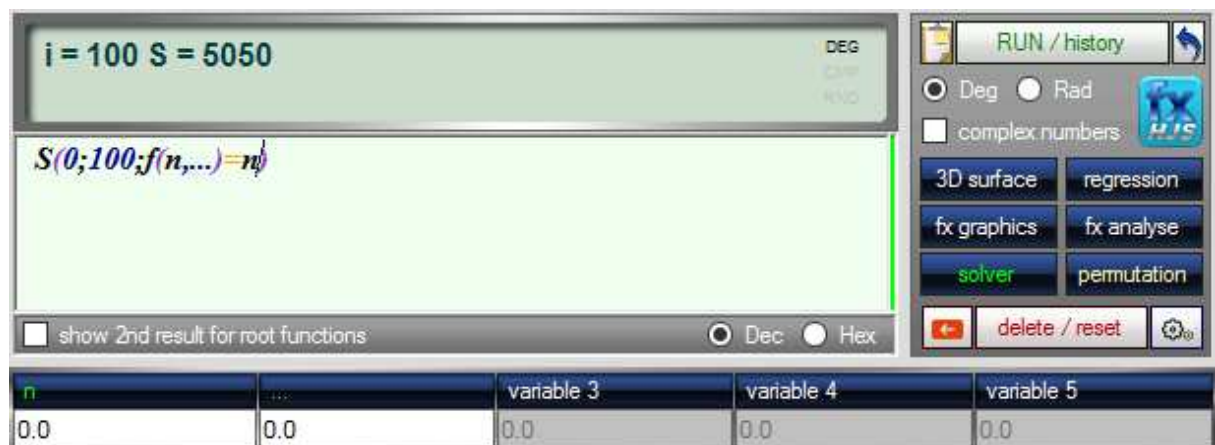
Sum and Product are just slightly more complicated than function definitions.

Apart from a function expression sum and products require a start point and the desired number of iterations. While this is almost easy for sum, it needs to be considered that a starting point = 0 might not be very reasonable for a product.

Another interesting point is to observe how a specific expression behaves and this would require the possibility to let fx-Calc do endless iterations, til this is stopped by the user. This can be achieved by setting the number of iterations to 0 and pressing the STOP button whenever the iteration should be stopped. Again we should look at examples to understand this in more detail:

To sum up all number from 0 to 100 you simply need the following expression:

The following example illustrates the use of a function expression:



X can be set via the corresponding variable field, which again is automatically activated.

Even if as well n is recognised and offered as variable field, any value in this field will be ignored and overwritten by the values from the expression.

$S(0;100;f(n,x)=n/(x+n))$  contains the following elements:

- S stand for sum (P for product)
- start with n from 0
- to 100
- use the following expression  $f(n,X)=n/(X+n)$

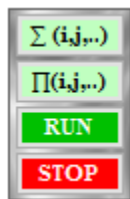
As mentioned, this is exactly the same for products - just use "P" instead of "S".

If the second parameter in our example is set to 0 fx-Calc will run the sum or the product until the STOP button was pressed by the user.

( of course a mathematical exception would stop this process as well )



All four buttons for sum and product can be found on the left upper corner of the fx-Calc keypad.



While this calculator is performing all calculations while you type, this isn't happening for sum and product. The reason is obvious: the number of required iterations.

Therefore you need to click the green RUN button to get your calculation launched.

Prominent examples for sum calculations are Pi and a formula for Panini stickers:

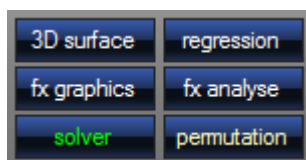
Pi:  $S(0;1000;f(n)=((-1)^n/4^n)(2/(4n+1)+2/(4n+2)+1/(4n+3)))$

Panini:  $S(1;640;f(n)=640/n) \dots$  for a total number of 640 different stickers

## Further functionalities

fx-Calc provides extended capabilities to:

- plot functions in 2D and 3D
- solve and analyse functions
- perform linear regression
- assist with combinatory calculations



Each of those modules starts with an integrated example, which illustrates the parameters and input formats per module. All examples can be easily changed and applied to your specific demand.

### Important hint:

All extended modules contain integrated methods to validate all input fields on a form. If the form should contain invalid input content, it disables all calculation capabilities and enables them again as soon as all errors are corrected. Errors are indicated by:

- red text colour in text boxes

- an information text in a separate textbox underneath the function editor field

## Analyse functions

Analysing functions can be time consuming, specifically for more complex expressions. fx-Calc provides capabilities to look for multiple roots and local extreme values within a defined interval. All this is based on numeric algorithms, making use of scanning a given interval for sign changes of a function or a derivation of it. This is very flexible and stable - but has on the other hand few limitations. So using reasonable interval boundaries and parameters is often very important. Furthermore you should use the function plot to verify the solution. The fx-Calc fx analyse module provides you with:

- roots for functions
- local extreme points
- pole points
- definite integral
- tangent and interactive Newton iteration

Important: The definitions on the function tab will be used in all other tabs. So if you wish to change your function or the setting for trigonometric functions you must do this on the function tab.

f(x) analyse 1

function root local extremas pol points definite integral tangent function plot

enter function (just one variable)  $fx:$

$f(x) = 4\cos(x)/(x^2 - \pi)$

hints/messages:

Interval for analysis

lower limit -5

upper limit 10

full analysis based on default settings

radian / degree

☐ deg

☒ rad

function from calculator

chart option Y max 10 ☐ use upper limit for f(x)

Y min -10 ☐ use lower limit for f(x)

close

## Root calculation, solve functions

Solving equations is very simple by just changing the target value in the root tab:

f(x) analyse 1

function root local extremas pol points definite integral tangent function plot

solution x for f(x) = (default is 0)

precision

partial interval length for scan

scan interval

lower limit  upper limit

solutions x for f(x) = target

x [number]	solution (x)
solution [1] =	-4.71238898038863
solution [2] =	-1.5707963267936
solution [3] =	1.57079632680132
solution [4] =	4.71238898015048
solution [5] =	7.85398163318672

The results for roots, local extreme points and pole-points are displayed in tables, allowing a direct export to the clipboard by using the little button in the right upper corner of each table. You can paste the content directly in Excel or other documents.

## Local extreme points:

f(x) analyse 1

function root local extremas pol points definite integral tangent function plot

precision

partial interval length for scan

interval for scan

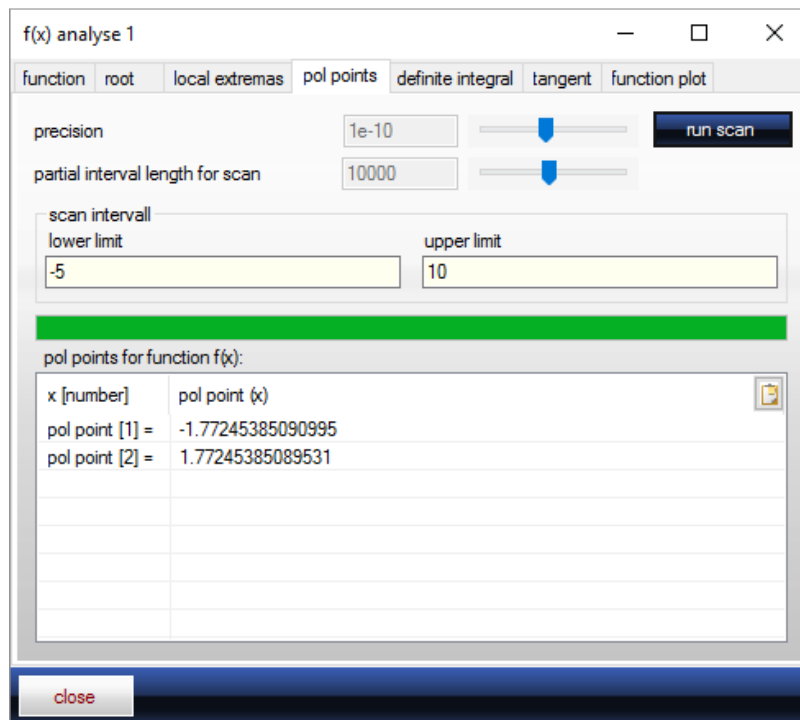
lower limit  upper limit

local min/max points

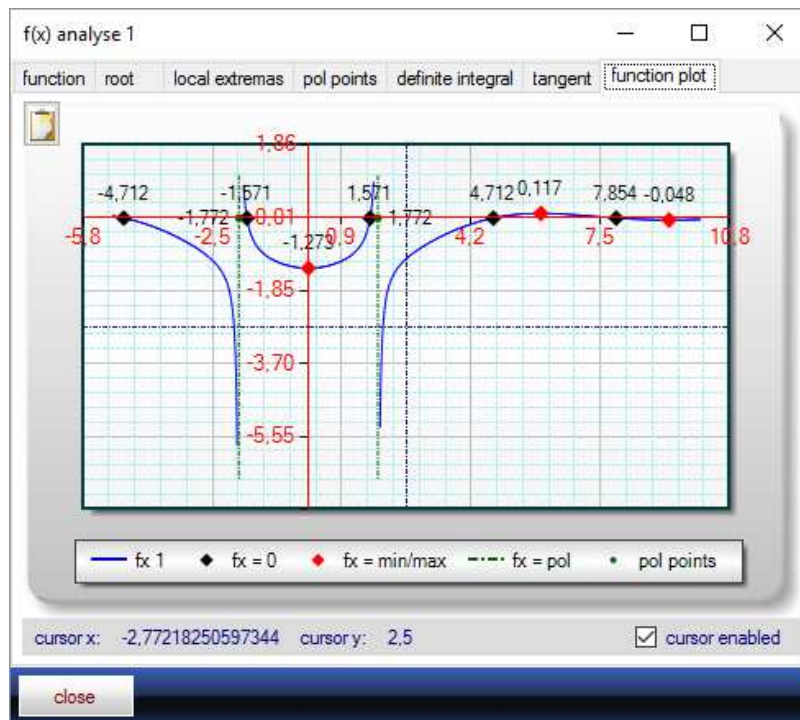
x [e]	y [e]	Typ
xe [1] = 1.56250001339302E-05	ye = -1.27323954467868	min
xe [2] = 5.9284375000003	ye = 0.117199263564625	max
xe [3] = 9.20275000000043	ye = -0.0478462128750335	min



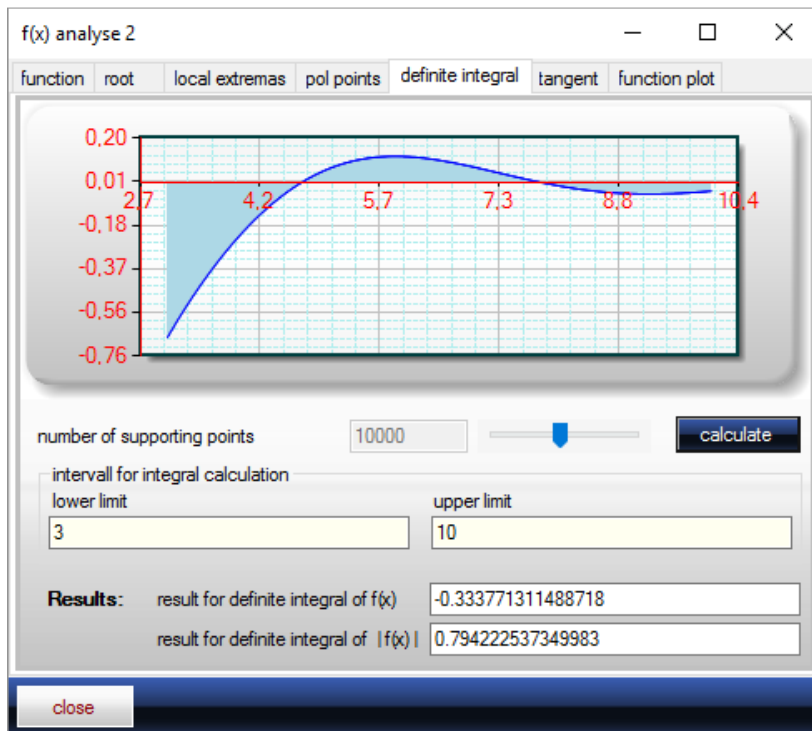
## And finally the pole-points:



The function plot tab let's you verify the correctness of all numerical results and provide an overarching understanding on the functions characteristics within the defined interval:



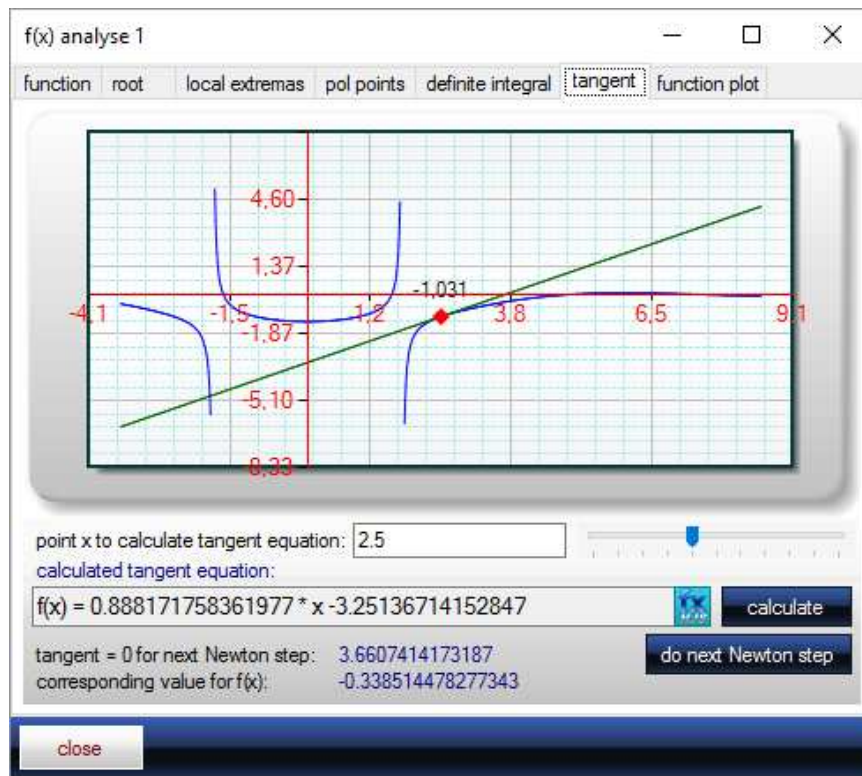
Another functionality of this module allows calculating the definite integral of an function:



fx-Calc allows to open multiple instances of this window at the same time to compare different scenarios.

## Tangent calculation

Calculating tangent equations is based on the numerical calculation of the first derivate of given function  $f(x)$  at a specific point  $x$ . The starting point  $x$  is usually the average of the interval for the function analysis and can be easily changed by adjusting the value in the first text box. For reasonable results the function needs to be able to be differentiated within the defined interval.



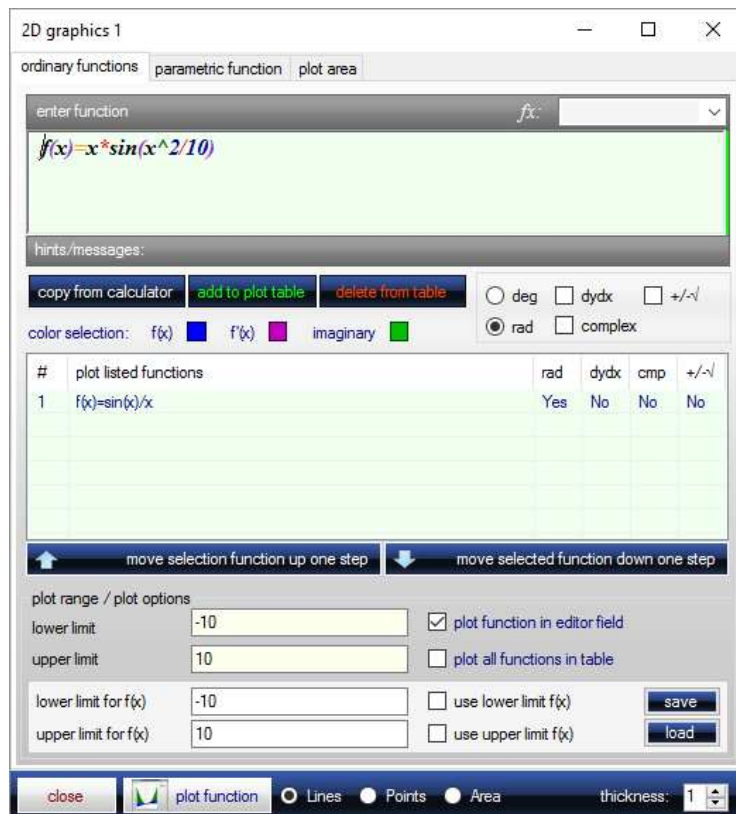
Fx-Calc calculates the tangent equation and provides the possibility to transfer the equation directly to the calculator window to use it for further purpose. On top of this you can use the “do next Newton step” button to perform step wise Newton iteration. While doing so, you can observe how the tangent is getting closer to the next solution for the given function. In most cases the procedure is fairly quick and in this example it took only 5 steps to get to a close result.

## 2D function plots

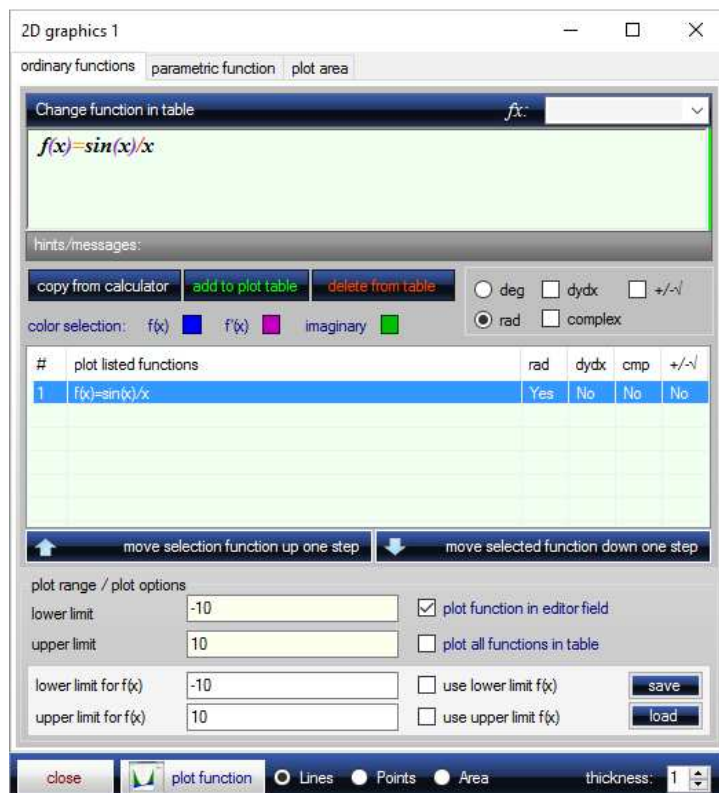
Function plots allow plotting one or multiple functions in one plot area. fx-Calc is plotting the table content and the editor field content. By using the checkboxes on the bottom of the input window it allows to select the following options:

- plot just the editor function (default)
- plot all functions from table
- plot both, editor and table functions

Using upper and lower limits for f(x) might help to visualise functions with significant differences for f(x). Another new feature is to plot parametric functions, which allows visualising the specific behaviour of a function in dependence to a specific parameter.



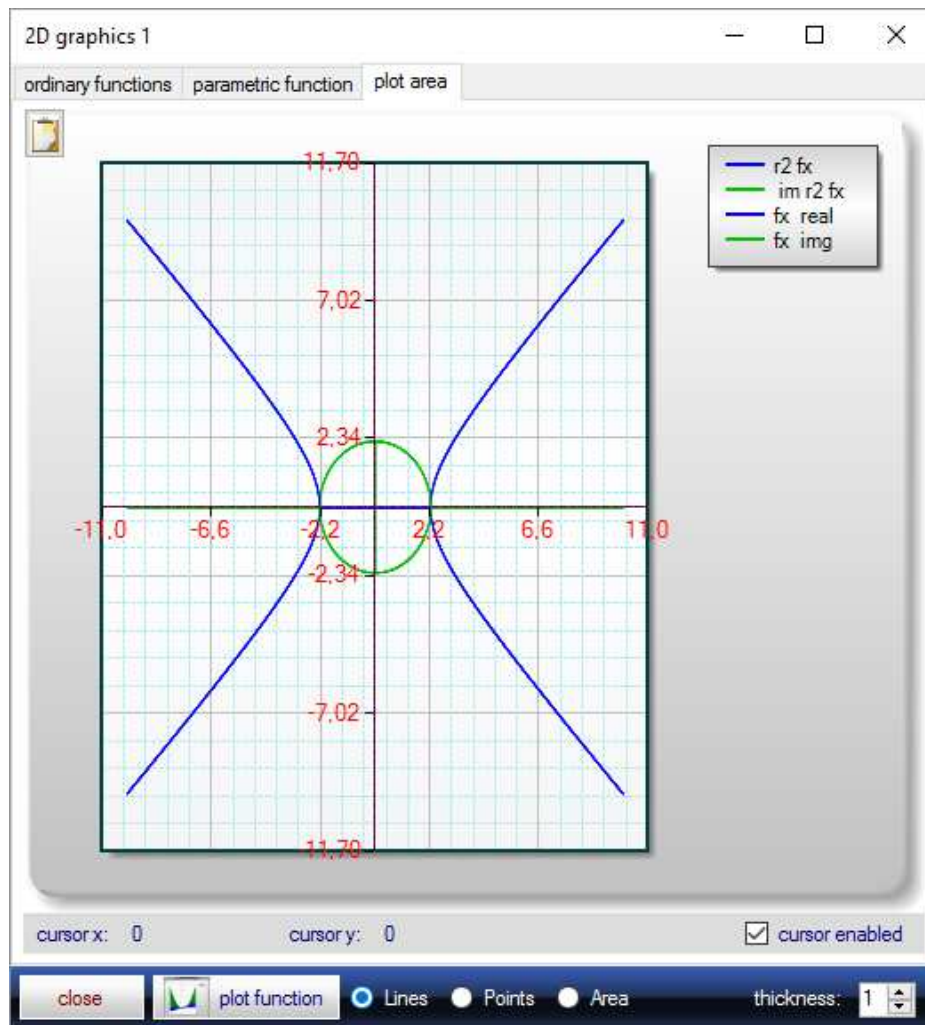
To change a function or its options click on the function in the table and the input dialog is automatically connected to the current selection. Any function change or adjustment of options changes the corresponding table field immediately. This modus is indicated by a changing background colour and the changing headline on top of the editor field:



In order to leave this mode you just have to click on an empty row in the table.

Another new and unique option is to plot functions using complex numbers. In this case fx-Calc is plotting two function graphs, one for the real - and another one for the imaginary part of the complex function result. Furthermore you can extend the plot by the derived function. So bottom line you can visualise in one chart:

- multiple functions (editor field and table)
- each with the following options:
  - o derived function
  - o complex extension (imaginary part)
  - o second result for square root
  - o deg/rad for trigonometric functions
- if needed, limited by defined boundaries



To visualise parametric functions the second tab provides you with a dialogue to define:

- the number of functions to plot
- start value for the parameter
- end value for the parameter
- colours
- the interval
- limiting boundaries

2D graphics 1

ordinary functions | **parametric function** | plot area

enter parametric function  $f(x,a)=a*\sin(x/2)$

Fehlermeldung:

function parameter (a)

☐ deg ☒ rad

number of functions: 10

start value for parameter a: 1

end value for parameter a: 5

plot range / plot options

lower limit x: -10

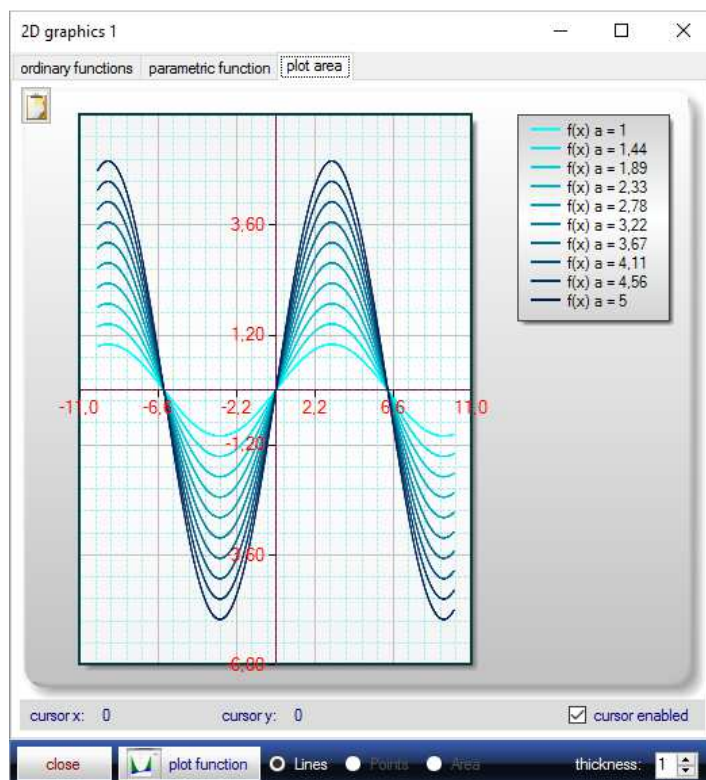
upper limit x: 10

lower limit for f(x): -10 ☐ use lower limit f(x)

upper limit for f(x): 10 ☐ use upper limit f(x)

close plot function Lines Points Area thickness: 1

In result of this you will get the following chart:



For the parametric function chart fx-Calc allows for up to 40 parameter steps per chart. A graphical cursor allows seeing the coordinates for a specific point in this chart.



fx-Calc allows to open multiple instances of this window at the same time to compare different scenarios.

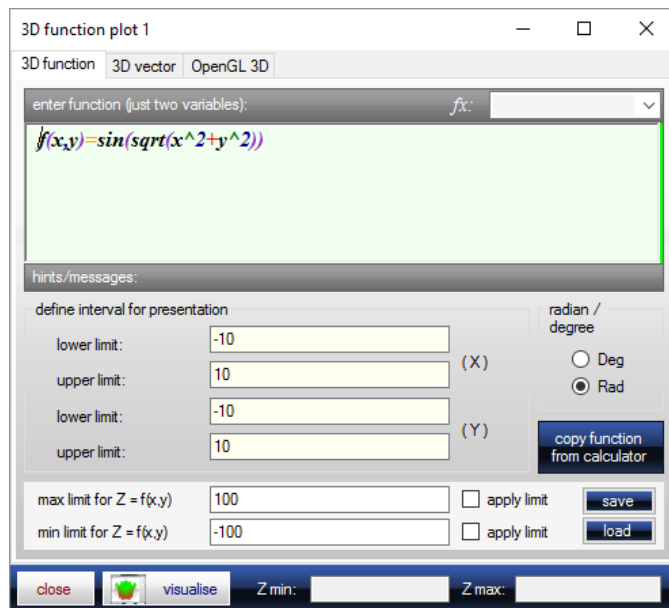
## 3D function plots

Within this module you can visualise 3D function plots for  $Z = f(x,y)$ .

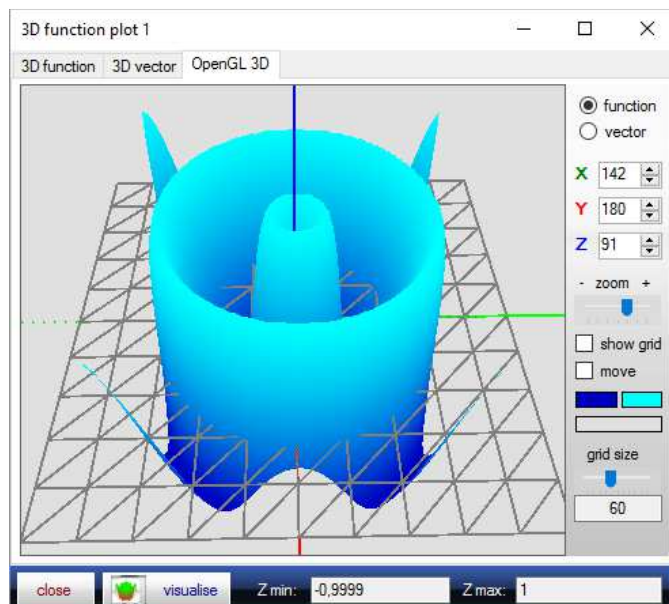
OpenGL provides real time manipulation by using the hardware accelerated graphics interface of your PC. Fx-Calc is allowing for two different methods to define your 3D object:

- define your object as function  $z(x,y)$  or
- define  $x$ ,  $y$  and  $z$  as vector, defined by the polar coordinates  $r$  and  $\phi$

(This will not work on PC's without an OpenGL driver installed on your hardware.)



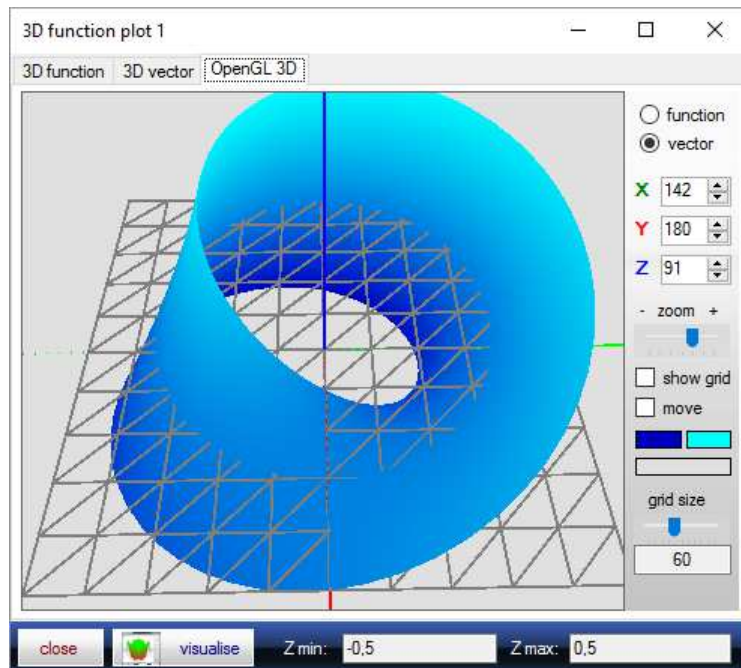
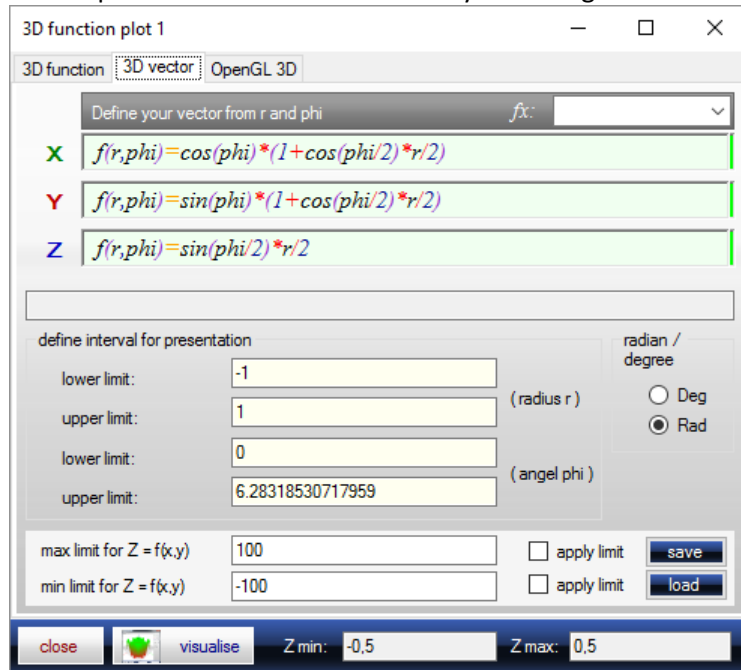
Similar to 2D plots 3D plot provides the possibility to set limits for your  $Z$  - values. In result of those definitions you will get the following 3D chart:



Within this window you can:

- turn the 3D plot with your mouse by keeping the left mouse button pushed
- show this as grid instead of the collard surface
- zoom in and out
- switch on auto rotation (move)

For the polar coordinate based model your dialogue and the corresponding 3D chart is as follows:



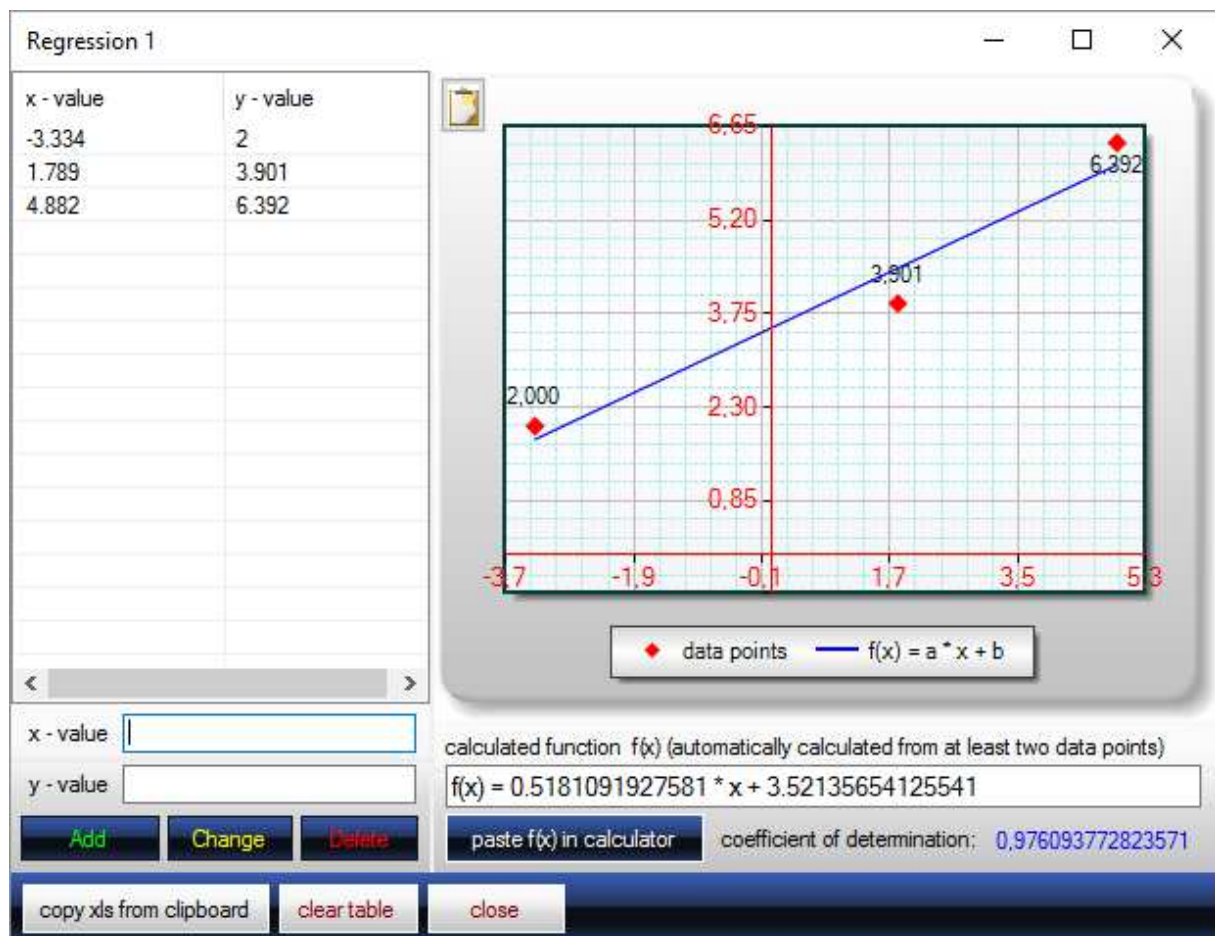
fx-Calc allows to open multiple instances of this window at the same time to compare different scenarios.



## Linear regression

In statistics, simple linear regression is the least squares estimator of a linear regression model with a single explanatory variable. In other words, simple linear regression fits a straight line through the set of  $n$  points in such a way that makes the sum of squared residuals of the model (that is, vertical distances between the points of the data set and the fitted line) as small as possible.

As soon as the table contains two pairs of values, fx-Calc calculates the linear function and is plotting the result. By using the copy button you can transfer the new function to the calculators editor field to use it for calculations.



fx-Calc allows to open multiple instances of this window at the same time to compare different scenarios.

## Combinatory calculations

Sometimes we need to know the number of possible combinations of the elements of a quantitative number of objects, extended by conditions like order and repeated use. Fx-Calc supports this with an inbuilt assistant, making it very easy to make use of the correct formula. Just have a look at the following self-explanatory screen shots:

The screenshot shows a window titled "Combinatoric calculations" with a close button. The title bar includes a minus sign, a maximize button, and a close button. The window content has a title "Combinatorics" and a large green box displaying the result "120". Below this, there are two radio buttons: the first is selected and labeled "number of ways to arrange n distinct objects into a sequence", and the second is labeled "or one of the following cases:". Under the second option, there is a section titled "make your selection" with a table of options:

	with sorting	no sorting
with repeating elements	<input type="radio"/> variation	<input type="radio"/> combination
no repeating elements	<input type="radio"/> variation	<input type="radio"/> combination

At the bottom, there are input fields for "n" (value 5) and "k" (value 1), followed by a "calculate" button. At the very bottom, there are two buttons: "Close" and "copy result to calculator".

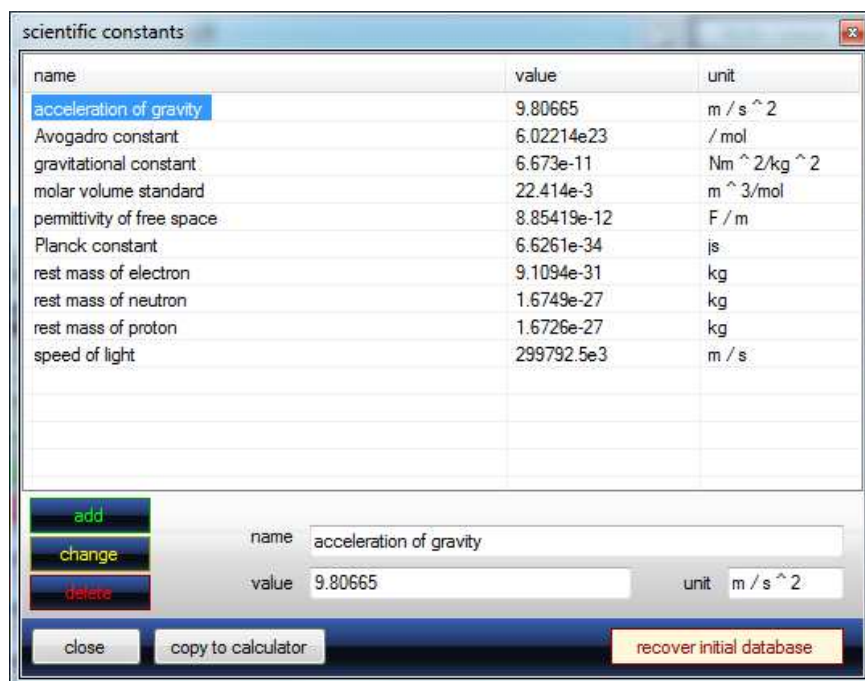
The screenshot shows the same "Combinatoric calculations" window, but with different settings. The result displayed in the green box is "15". The first radio button is now unselected, and the second is selected. In the "make your selection" table, the "no sorting" column is highlighted in blue, and the "combination" option under "no repeating elements" is selected (indicated by a filled radio button).

	with sorting	no sorting
with repeating elements	<input type="radio"/> variation	<input type="radio"/> combination
no repeating elements	<input type="radio"/> variation	<input checked="" type="radio"/> combination

The input fields now show "n" as 6 and "k" as 2. The "calculate" button is still present. The bottom buttons "Close" and "copy result to calculator" remain the same.

## Constant values DB

A small database allows storing of scientific constants. By double clicking a selected entry the corresponding value will be transferred to the editor field and the database window will be closed.



This is a modal window and must be closed to follow up with fx-Calc.

## Calculation and numerical methods

For doing calculations fx-Calc must interpret all inputs. This is done by a specially developed program module for fx-Calc, which converts the input into a faster executable code. This code is then used in calculations and individual iterations.

Fx-Calc uses only numerical methods for solving equations, definite integrals and the determination of extreme values. These methods are well known and adjusted accordingly especially for fx-Calc and improved partly.

Both the interpreter and all calculation methods are core components of the development of fx-Calc.

## Numerical methods

To calculate roots, solutions, definite integrals and extreme values there are generally two ways: Firstly, a mathematical expression is being analysed (symbolic), resolved and calculated. This provides the most accurate results and also provides a rule applicable to all the function in question results. The disadvantage comes with increasing complexity, caused by nesting of functions and it gets more and more difficult to derive an analytic expression. Specifically for definitive integrals we have often the situation that we cannot get to an analytic expression. But even root calculations can quickly come to this point.

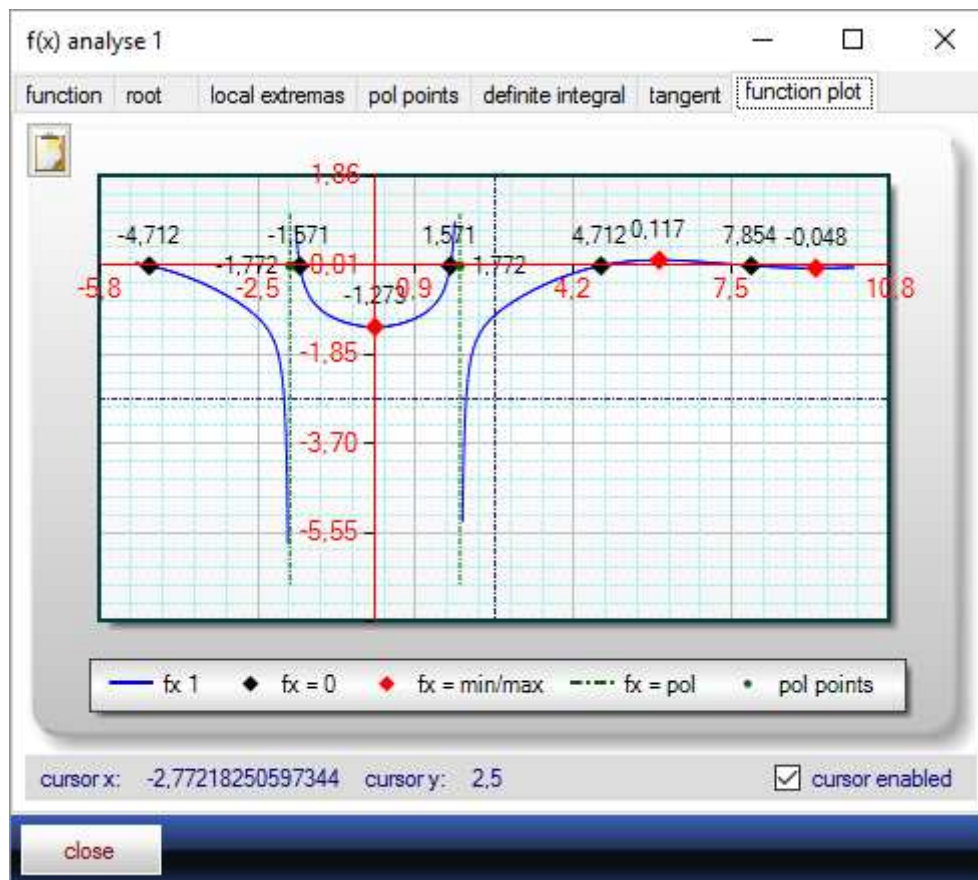
The approach for fx-Calc was to enable this piece of Software to solve almost everything and the only way of doing this is to look for numerical methods to get this achieved.

However, these have some general pre - and disadvantages, which you should know:  
The disadvantages of numerical methods are:

- Necessary definition of the interval to be examined (anything outside of this interval isn't part of the results)
- A defined inaccuracy (termination criterion for required iteration)
- roots higher order are not identified as such

The advantage of the numerical method lies in its universal applicability.

So it is generally very useful addition to be able to verify numerical results based on a chart, which lets you immediately compare the correctness of all results:



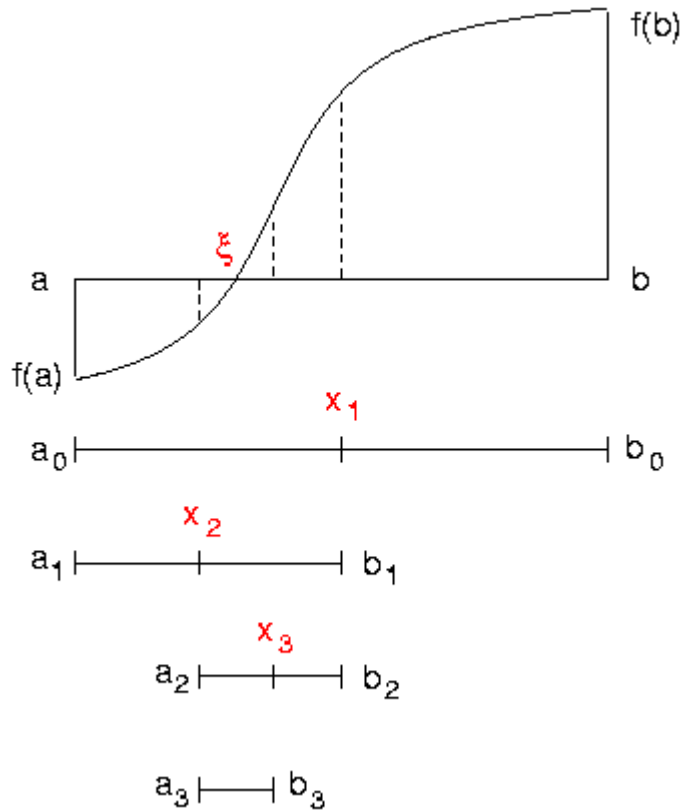
Apart from result verification this chart is gives an immediate idea how a specific function behaves.

## Root calculation

The calculation of roots (solutions for  $f(x)=0$ ) is ultimately more complicated than one might think at first glance. In addition to the sign change, there are special situations such as:

- Vertices of a function, which indeed have no sign change
- Functions with already very small absolute value range

In preparation for the root-finder a function will be analyzed to determine the range of values and optionally transform the function accordingly. Fx-Calc uses for the determination of roots a method called “nested intervals” (bisection), which examines the function in the interval to identify change of sign:



In a second step, the vertices of the function to be determined - is also numerically the difference quotient. This will then also be investigated for roots. The Newton method is not applicable because this converges only in the immediate vicinity of a root and presupposes a continuously differentiable function.

## Root for arguments other than 0

The calculation of the roots is also used directly for the search of solutions for  $f(x)$ , since the target function can be simply defined as:

$$0 = f(x) - \text{target}$$

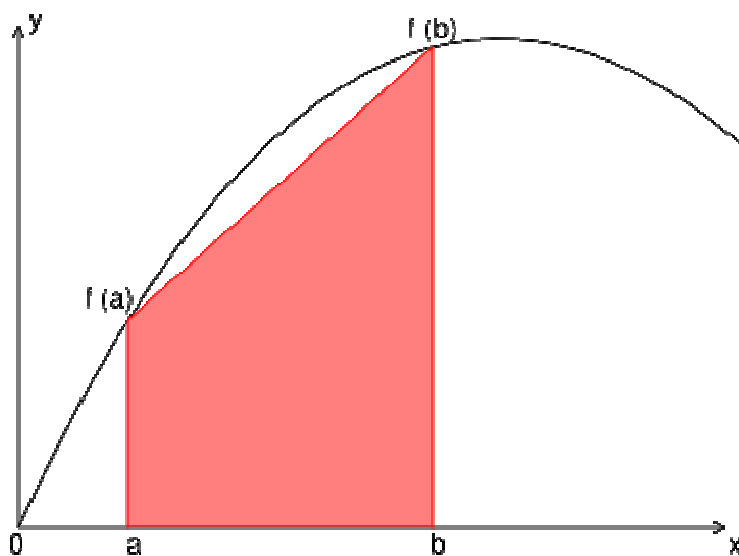
This is being analysed by applying exactly the same methods as just explained for roots.

## Extreme values

The calculation of the extreme values follows the already known from the roots pattern, whereby also here values and transformation of intervals is being used. However, formation of the second derivative on the difference quotient can be quickly unstable and, therefore, has been omitted in favour of the stability on the investigation of peaks of the second derivative. This also explains why fx-Calc does not calculate turnaround points. In any case only the change of sign of the first derivative is relevant to "real" extremes. Again, apply again the identical pre - and disadvantages, as already discussed in the roots section.

## Definite integral

Definite integrals are more frequently the subject of numerical methods than roots and extreme values, since here too often no analytical solution is providing the primitive function  $F(x)$ . In the concrete case fx-Calc uses the tendons trapezoidal formula, which already delivers at 1,000 subintervals a very high accuracy:



Prior to any numerical integral calculation fx-Calc is analysing the function to determine roots and extreme points. Fx-Calc is using those results to define partial integral ranges, which is again increasing precision as much as possible.

The results of the numerical methods were tested with PTS Mathcad Prime using different functions.

## Pole point calculation

For the calculation of poles that function in the denominator of a fractional rational function = 0 while the counter must not be equal 0. So Fx-Calc breaks the function in the denominator and related counters. In a next step the roots of the denominator are being determined using the method already presented and tested whether the counter of the calculated denominator zero is not equal 0. If this is the case, it is a pole. The limitation here is the accuracy of the zeroing calculation and use of this is not 100% accurate information to answer the question whether the counter is 0.

Fx-Calc solves this by the question is answered with "yes" when the absolute value of the counter function of the denominator root is less than  $1e-5$ .

In addition, a second pole point condition is using the trigonometric tangent function. Fx-Calc is determining the solutions for the tangent function argument, which would present a pole if it is an equivalent of  $\pi/2$ .

## Missing poles, roots, extreme values

All the described methods have been tested and adjusted to gain the best possible reliability. Nevertheless it can happen to miss an expected result and this is emphasising the importance to validate results by comparing them by looking at the visualised functions. If the chart is showing characteristics that haven't been found by the numerical methods you can try to repeat the numerical methods with adjusted parameters:

- The first way is to increase the number of sub-intervals and thus perform a more accurate scan of the function.
- Other possibilities are
  - Adjust the interval for the function
  - Change the precision parameter

Of course, the combination of all approaches provides a further improvement in the chances of success. In case of an adjusted precision you should be certain about the things that you are doing here:

Accuracy with a deviation of less than  $1e-15$  are practically not useful, as this would exceed the precision used in the Double data type - the computer will no longer be able to find solutions.

Critical applications are functions with very small or very large value ranges:

-  $|F(x)| < 1e-50$

-  $|F(x)| > 1e + 100$

The software optimises itself in these cases by transforming the function values accordingly.

However, that does not always work. The critical look at the graphic output shows whether you should not work better with a self defined scaling factor here.

## **A message from developer ...**

First of all, I'm coming from Germany and must hope my translation is sufficient - otherwise let me know ;-)

Fx-Calc can be a very powerful tool and its focus on functions rather than algebra has good reason. Most of statistical and algebraic calculation is anyway part of spread sheet software, just like Excel or Open Office. So I didn't see much value in implementing this over and on top of what is included today.

My second point was to design the application to make it as easy as possible to use this tool for your calculation demand. And I think this is achieved.

I'd like to ask for your feedback, specifically if you think something could be better or is going wrong, this will help me to improve the application for you.

***Have fun with fx-Calc,  
Hans Jörg ;-)***