User's Manual

FUNGRAPH

Version 1.10.0

Mathematical software
Graphs of functions in 2D

Windows 7® - Windows 8® - Windows 10®

VAXA SOFTWARE

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Introduction

FUGP is a Windows application to calculate 2D graphs of mathematical functions.

Please, read this manual carefully in order to learn all the capabilities of the application.

Terms of use

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Before the installation we recommended to make backup of your data and create a restoration point.

You will be able freely to evaluate the software during the time that considers necessary. Passed this period of evaluation you would have or to register it or uninstall it.

To register the software, please see the option "REGISTER APPLICATION" in the help menu of the software.

After paying the registry fee you will receive by email the REGISTRATION KEY of the software.
Once registered the software, it will be able to use the options that were disabled until that moment.

The REGISTRATION KEY is UNIQUE for EACH COMPUTER.

You cannot use the same REGISTRATION KEY for multiple computers.

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Main window*: Left panel*

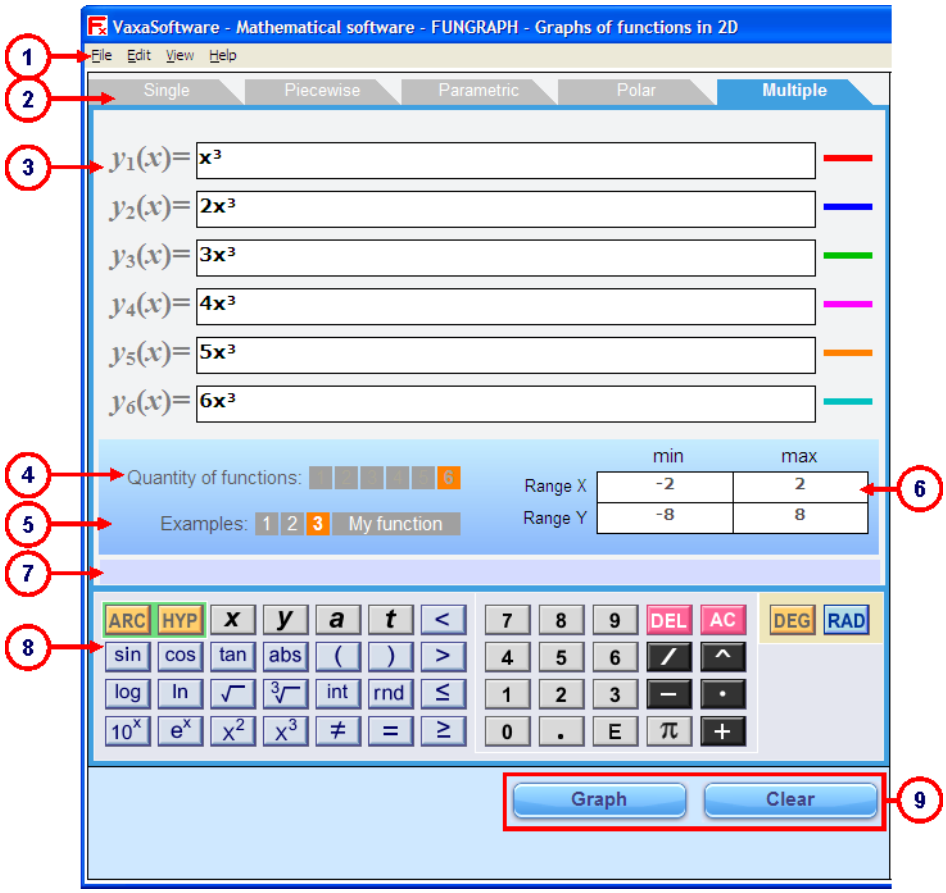

Fig. 1
Main window. Left panel

1 Menu bar

It contains the menus *File*, *Edit, View* and *Help*.

File menu

Graph
Calculate graph of current function.

Print...
Open the Print window to print the current function and its graph.

Exit
Close the application.

Edit menu

Copy graph
Copy current graph into clipboard.

View menu

Full screen graph
Press this menu to switch to full screen mode.
You can also double click on the graph to activate and deactivate the full screen mode.

Single function
Show the *single function* input panel.

Piecewise function
Show the *piecewise function* input panel.

Parametric function
Show the *parametric function* input panel.

Polar function
Show the *polar function* input panel.

Multiple functions
Show the *multiple functions* input panel.

Help menu

User's manual (PDF document)...
Show this manual.

Application registration...
Show the registration form window to register the application.

Disabled functions in the unregistered version
Show the list of disabled functions when the application is not registered.

Home page (www.vaxasoftware.com)...
Connect to VaxaSoftware home page.
An active Internet connection and a browser are required.

About...
Show the Splash window with the version and description of the application.

2 **Type of function** buttons

Allow select 5 types of functions.

Single button
Show the single function input panel.

Piecewise button
Show the piecewise function input panel.

Parametric button
Show the parametric function input panel.

Polar button
Show the polar function input panel.

Multiple button
Show the multiple function input panel.

3 **Function** input boxes

Allow input functions.

4 **Quantity of parts/functions** buttons

Allow select the quantity of parts or functions. This option is only available for *piecewise* and *multiple* function types.

5 **Example selection and *My function*** buttons

Allow select an example function
To go back to the current user function you have to press the *My function* button.

6 **Range of variables** input boxes

Allow input the range for variables ***x, y, t, a***.

7 **Messages** output box

Shows errors and messages from the virtual keyboard.

8 **Virtual keyboard**

Allows edit mathematical expressions to input functions.

Direct input functions:

Symbol	Description
sin	Sine
cos	Cosine
tan	Tangent
abs	Absolute value
int	Integer part
rnd	Random number within [0, 1)
x^2	Square

Symbol	Description
log	Decimal logarithm
ln	Napierian logarithm
√	Square root
∛	Cube root
10^X	Decimal antilogarithm
e^X	Exponential
x^3	Cube

Trigonometric and hyperbolic functions
Press ARC and/or HYP keys and then SIN, COS or TAN keys to get the following functions:

Symbol	Description
arcsin	Arc sine
arccos	Arc cosine
arctan	Arc tangent

Symbol	Description
sinh	Hyperbolic sine
cosh	Hyperbolic cosine
tanh	Hyperbolic tangent
argsinh	Hyperbolic arg sine
argcosh	Hyperbolic arg cosine
argtanh	Hyperbolic arg tangent

Operator keys

Symbol	Description
+	Addition
·	Multiplication
^	Power

Symbol	Description
-	Subtraction
/	Division

Symbol	Description
=	Equal to
≤	Less than or equal to
<	Less than

Symbol	Description
≠	Not equal to
≥	Greater than or equal to
>	Greater than

Other keys

Symbol	Description
DEG	Angular mode is degrees
RAD	Angular mode is radians
(,)	Parentheses
0123456789	Numeric values
.	Decimal point

Symbol	Description
DEL	Delete left character
AC	Clear current input line
x, y, a. t	Variables x, y, a, t
E	Scientific notation input
π	Pi constant

Decimal separator

This application uses decimal point **.** as decimal separator.

Scientific notation

The scientific notation is used to show very big or very small numbers.
A scientific notation number has a mantissa and a power of 10.
To enter scientific notation numbers we use letter E to input the exponent of 10.

Examples:
5.67×10^{89} is entered as 5.67 E 89
1.23×10^{-34} is entered as 1.23 E-34

Angular units: deg, rad

For trigonometric functions the angular unit for output and input can be selected from 2 formats: degrees and radians.

The angular unit is selected with the following keys:

DEG key: Degrees (°). 1 right angle = 90° (90 degrees).
RAD key: Radians (rad). 1 right angle = π/2 rad.

The current angular unit key is shown in blue color.

Priority sequence

Expressions are calculated from left to right.
However this application determines automatically the calculation sequence according to rules of algebra.

Example:
To calculate $3 + 4 \cdot 7^2$, the sequence is:
1) $7^2 \rightarrow 49$
2) $4 \cdot 49 \rightarrow 196$
3) $3 + 196 \rightarrow 199$ (result)

Priority list of operators and functions:

Priority level	Operators and functions
5	( ) Parentheses
4	Scientific functions: sin, cos, log, ...
3	^
2	· / Implicit multiplication
1	+ –

Implicit multiplication

In many expressions, we can omit the multiplication operator sign · in order to improve legibility.

This application assumes implicit multiplication in the following 3 cases:

1) A numeric value before a variable, function or left-parenthesis.

Examples:

Input line expression	Internal calculation
25 a	25 · a
7 π	7 · π
4 sin 30	4 · sin 30
2 (4+5)	2 · (4+5)
sin 30 cos 50	sin 30 · cos 50

2) A right-parenthesis before a number, variable, function or left-parenthesis.

Examples:

Input line expression	Internal calculation
(1+2) 7	(1+2) · 7
(1+2) a	(1+2) · a
(1+2) cos 5	(1+2) · cos 5
(1+2) (3+4)	(1+2) · (3+4)

3) A variable before another variable, a function or left-parenthesis.

Examples:

Input line expression	Internal calculation
ab	a · b
alog5	a · log 5
a(2+4)	a · (2+4)

◆ **WARNING**
Implicit multiplication has less priority than functions:
So, the expression *sin 2x* is calculated as *(sin 2)·x* and not as *sin (2·x)*.

Implicit power

In many expressions, we can omit the power operator sign ^ in order to improve legibility.

This application assumes implicit power in the following case:

A variable before a number.

Examples:

Input line expression	Internal calculation
a2	a^2
a5	a^5
t2 + 5t + 6	$t^2 + 5t + 6$

◆ **WARNING**
We cannot use implicit power with pi constant (π) or *e* constant.
When pi constant is followed by a numeric value an implicit multiplication is assumed instead of implicit power:

So, π100 is calculated as π · 100 (and not π ^ 100).

About *e* constant:
5e7 is calculated as a scientific notation value $5 \cdot 10^7$ (and not $5 \cdot e$ ^ 7)

Power of functions with exponent previous to its argument (PFEPA

In textbooks the power of a function is shown with exponent previous to its argument:

Example: $\sin^2 30 = (\sin 30)^2$.

In this application we can also enter expressions in this format:

DEG		Internal calculation
$\sin^2$ 30	0.25	(sin 30)^2
$\log^3$ 100	8	(log 100)^3
sin^(4) 30	0.0625	(sin 30)^4
sin^(9) 30	0.001953125	(sin 30)^9

◆ **WARNING**

1) Exponent must be an integer positive number between 2 and 9.

2) If we use the power operator ^ , the exponent must be in parentheses.
Squares and cubes can be entered using x^2 and x^3 keys but without parentheses.

Wrong	Description of error	Right
cos ^ (12) 30	Exponent isn't between 2 and 9	(cos 30) ^ 12
cos ^ 2 30	Exponent must be in parentheses	cos ^{2} 30 *or* cos^(2) 30

Autosaving the user functions

The user functions are saved when application is closed. When application is opened later, the user functions will be available again.

9 **Graph and Clear** buttons

Graph button
Shows the graph of the current function.

Clear button
Clears the current function and its graph.

Main window*: Right panel*

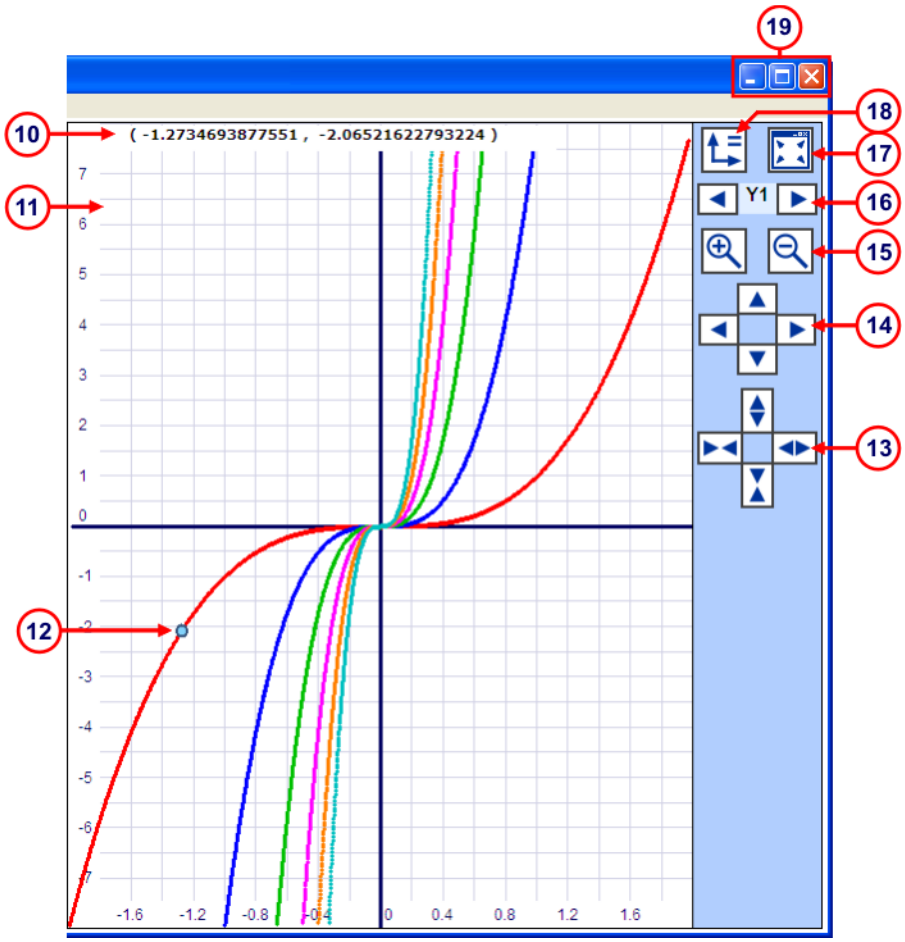

Fig. 2
Main window. Right panel

10 Cursor coordinates

Shows (x, y) coordinates of the cursor. Cursor is shown as a blue circle. Cursor motion is simultaneous with mouse motion.

◆ **Note**
Cursor coordinates is not shown for *Parametric* or *Polar* functions.

11 Graphic area

Shows the graphic of the function.
Normally the graphic of the function is shown in red color.
However *Piecewise* and *Multiple* functions are shown with several colors.

We can click the right button of mouse to show a contextual menu. Then we can choose the next menus:

Zoom in
Zoom out
Isometric scales X:Y
Copy coordinates
Copy graph
Full screen graph / normal window graph.

We can click and drag in order to move the graphic.

12 Cursor

This cursor is shown as a blue circle. Cursor motion is simultaneous with mouse motion.
The cursor is shown over the graphic according to the current function.

◆ **Note**
Cursor is not shown for *Parametric* or *Polar* functions.

13 X, Y zoom buttons

Set zoom for X–axis and Y–axis separately.

14 Scroll buttons

Move the graphic towards up, down, left and right.

15 Zoom buttons

Allow us zoom in / zoom out.
You can also use the mouse wheel to adjust the zoom.

16 Select function buttons

Allow us select a function for *multiple* functions graphs

17 Full screen graph button

Shows the current graph in full screen.
You can also double click on the graph to activate and deactivate the full screen mode.

18 Isometric scales button

Sets the scales of axes X:Y as 1:1.

19 Window control buttons

These are the classic buttons of the windows of MS-Windows ®.

Minimize button
Minimizes the application to an icon on the desktop.

Maximize / Restore button
Maximizes / restores the application's window size.

Close button
Closes the application. Also we can press Alt + F4 keys on our keyboard.

Range for entry values

General range for entry and results values	$\pm 2.4703282292062327\times10^{-324} \sim \pm 1.797693134862315807\times10^{308}$ and 0 0 is assumed for values within $\pm 2.470328229206232721\times10^{-324}$
sin x cos x	(Degrees: DEG) $\lvert x\rvert \le 5.284602884791370710\times10^{20}$ (Radians: RAD) $\lvert x\rvert \le 9.2233719\times10^{18}$
tan x	(Degrees: DEG) $\lvert x\rvert \ne (2n+1)\cdot 90$ (Radians: RAD) $\lvert x\rvert \ne (2n+1)\cdot \pi/2$
arcsin x, arccos x	$\lvert x\rvert \le 1$
sinh x, cosh x, tanh x	$\lvert x\rvert \le 709.78271289338402$
argsinh x	$\lvert x\rvert \le 1.34078079299425\times10^{154}$
argcosh x	$1 \le x \le 1.34078079299425\times10^{154}$
argtanh	$\lvert x\rvert < 1$
arctan x, $\sqrt[3]{x}$, abs x, int x	$\lvert x\rvert \le 1.79769313486231580778\times10^{308}$
x^2	$\lvert x\rvert \le 1.34078079299425\times10^{154}$
x^3	$\lvert x\rvert \le 5.64380309412236\times10^{102}$
x^y	$x \le 1.79769313486231580778\times10^{308}$ if y is not integer then $x \ge 0$, if $y = 0$ then $x \ne 0$
$\sqrt{x}$, ln x, log x	$0 \le x \le 1.79769313486231580778\times10^{308}$, $x \ne 0$ for ln x and log x
exp x	$-1.79769313486231580778\times10^{308} \le x \le 709.78271289338402$

Shortcut keys

Main window

Alt + F4	Exit
Ctrl + F	Calculate current graph
Ctrl + F4	Exit
Ctrl + P	Print current function and its graph
ESC	Cancel full screen graph and go back to normal window graph
F1	Help: Show User's Manual (PDF document...)
F5	Calculate current graph
Shift + F1	Show *about window*

Specifications

Reference	FUGP
Description	FUNGRAPH is a Windows application to calculate 2D graphs of mathematical functions.
Internal precision	As a rule, precision is ±1 in the 16th digit.
General range of calculation	From $\pm 2.47032822920 \times 10^{-324}$ to $\pm 1.79769313486 \times 10^{308}$ and 0 0 is assumed for values within $\pm 2.47032822920 \times 10^{-324}$
Levels of parentheses	**28 levels**
Types of function graphs	**5 main types of graphs:** *- Single function* *- Piecewise function* *- Parametric function* *- Polar function* *- Multiple function*
Scientific functions and others	**27 Scientific functions and others** sin, cos, tan, arcsin, arccos, arctan, sinh, cosh, tanh, argsinh, argcosh, argtanh, log, ln, $\sqrt{x}$, $\sqrt[3]{x}$, x^2, x^3, 10^x, exp, int, abs, rnd, π, E, Arc, Hyp,
Operators	**6 Operators** (+) Addition, (-) Subtraction, (·) Multiplication, (/) Division, (^) Power, ( ) Implicit multiplication
Angular units	**2 angular units:** Degrees (DEG) and radians (RAD).

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