

## REMARKS ON HELP FILES IN GEOGEBRA

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**Abstract.** Math software users must know the features of different math software like Maple, GeoGebra, Matlab. Comparing Maple and GeoGebra software (also considering other math software) one can see the differences regarding the commands, tools, the help files, the syntax used and the possibilities of caring out a task. Also, we see that there are tasks that can be carried out using Maple but not with GeoGebra and Matlab, and they must be easily adopted to each one of them. We try to make use of some commands and techniques of Maple for GeoGebra in completing the already existing summary help files in order to have a set of instructions for the teachers and the students who use GeoGebra, meeting this way some of the most necessary needs of them in using GeoGebra tools and commands for doing work.

**Keywords:** Math software; dynamical Geometry program; GeoGebra; computer Algebra system

### 1. Introduction

While using Maple in CEEPUS Summer university in Miskolc we found extremely useful the help files of that software. Our suggestion is that math software users must know these two useful software, others also, and they must be easily adopted to each one of them. We try to put together something similar for GeoGebra in completing the already existing summary help files, specially for constructing graphs, in order to have a set of instructions for the teachers and the students who use GeoGebra, meeting this way some of the most necessary needs of them in using GeoGebra tools and commands for doing work.

### 2. Considerations regarding the plotting

#### 2.1. Maple

With Maple can be plotted graphs of functions putting conditions on their domain and range, on the graphs colours etc. There are different options of plotting:

1. No boundaries on function domain. The syntax and commands are:

$\langle \text{Plot}(\sin(t),t);$   $\langle \text{Plot}(3/x,x), \dots$

2. Boundaries on function domain and range:

$\langle \text{Plot}(\sin(t),t=-\text{Pi}..\text{Pi});$   $\langle \text{Plot}(\sin(x)+\cos(x),x=0..\text{Pi});$

$\langle \text{Plot}(\tan(x),x=-2*\text{Pi}..2*\text{Pi},y=-4..4);$   $\langle \text{Plot}(\sin(x),x=0..\text{infinity}); \dots$

3. Several graphs on a pad and different graphic colours (multiple plots):

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`< Plot((sin(x),x-1/6*x^3),x=0..2,color=(red,blue),style=(point,line));`

4. Point plots:

`< 1=((n,sin(n)),n=1..10)`

There are other plots also.

## 2.2. GeoGebra

Using GeoGebra there are many advantages vs Maple:

- 1 it is possible to see the interaction between algebra objects and the respective geometric objects
- 2 there are many tools at disposal for constructing geometric objects and applying commands
- 3 can be tested a theorem or a math statement or a property
- 4 can be done research work and drawn conclusions on different math topics
- 5 GeoGebra can be used by the students of early age also, and use it like a playing tool
- 6 There are many other things to mention but it is not our purpose here.

## 3. Problems with plottings, solutions, extended files for plotting a parametric functions family

As far as we have seen, using GeoGebra can be plotted the graph of any functions using the following syntax and commands, with the options:

1. No boundaries on the domain. In the input bar, type in (for example)  $f(x)=x+\sin(x)$
2. Boundaries on function domain.

One alternative is: in the input bar type in  $f(x)=\text{Function}[x+\sin(x),-\pi,4*\pi]$  and, the other alternative by using If command is: type in  $f(x)=\text{If}[x>2,1/3*x-1/3]$  by which can be constructed the graph of the given linear function for  $x>2$  (case of one If command) or, type  $f(x)=\text{If}[x<2,\text{If}[x>0,2*x,\cos(x)]]$ . (case of two If commands).

Teachers and students need explanation and instruction on this case.

In this case, the first If, conditioned by  $x<2$ , defines the domain of the function having two representations:  $2*x$  and  $\cos(x)$ . The second If, conditioned by  $x>0$ , defines a sub-domain of the first domain and serves as domain for the first function in the brackets. By this we mean that the first function in the brackets ( $2*x$ ) is related to the second If with  $x>0$ , whereas the second function in the brackets ( $\cos(x)$ ) is related to the first If with  $x<2$ . As result, in construction, we have the part of the graph of the function  $2*x$  for  $0<x<2$  and the part of the cosine for the rest of  $x$  in the given domain ( $-\infty<x\leq 0$ ).

It is very important that the teachers and students take into consideration this helping instruction when are working with such type of function.

For this reason, we have done research on how we can accomplish during the teaching a dynamic demonstration by geometrically presenting on the same pad a family of functions in order to observe and explain and study the properties of this family. In this activity can be applied animation as well.

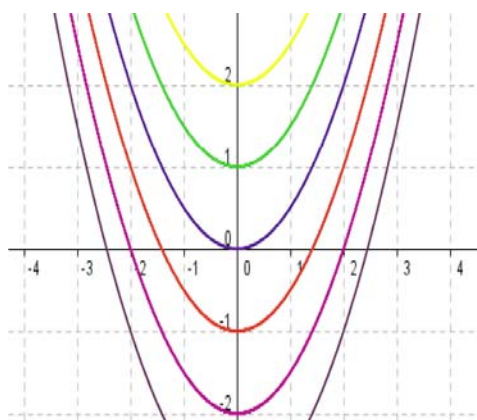
### 3.1. Here we are presenting several examples:

**Example 1.** The family of parametric parabolas of the type:  $f(x)=x^2+a$  (Figure 1)

Procedure:

1. Open e new GeoGebra document
2. Show the coordinate axes and the grid on it
3. In the menu Options set the Point Capturing to On or On (Grid) (meaning activate On).

4. Create the slider  $a$  with the interval:  $\min=-4$ ,  $\max=4$ , and increment 1 (It is recommended that the interval be small and the increment large in order the graphs that will be constructed be far from one another to be easily detected)
5. In the input field enter the function  $f(x)=x^2+a$  to construct the graph(actually, is constructed the graph for  $a=1$ )
6. Insert text for the equation of parabolas ( $f(x)=x^2+a$ ) by using the tool “Insert Text”
7. Create a New Point  $A$  on the constructed graph and attach text with the graph by selecting “Insert Text” tool and directly clicking on the point. The other way is by right clicking: open the dialog box of the inserted text, select Object Properties then Position and, here select  $A$  as Starting Point. With this action the text is stuck or linked with point  $A$ , meaning that, if the point  $A$  is displaced along the curve, the point  $A$  and the text move as one system(the text dialog box can be opened only if it is activated the Move tool (the first one).
8. Right click on the graph and select Trace On
9. Start slowly moving the slider and for every increment is taken a parabola graph positioned in accordance with the value of  $a$ , so is got the family of parabolas graphs for the set of the values of  $a$ . To better detect them from one another, or have a nicer view, we can appoint different colours for them. To achieve this, it is recommended that in the beginning we move slider  $a$  to one of its extremes (left or right). Suppose we have the graph for  $a=4$ .
10. Put the pointer on the respective graph ( $f(x)=x^2+4$ ). (**Hint:** in each move of the slider the text is attached to the graph corresponding to the last value of slider  $a$  we have stopped to. So, the dialog box can be opened only for this graph, not for the others). This way, right click on the graph at this position and in the respective dialog box: click Object Properties-click Colour, where is selected the desired colour for this position of parabola.
11. Now, move slowly until  $a=3$ , where we have the position of parabola  $f(x)=x^2+3$  and which imitates the colour of parabola for  $a=4$ .
12. Right click on the graph at this position and in the respective dialog box: click Object Properties-click Colour, where is selected the desired colour for this position of parabola and different from the previous one. In the same way is proceeded with the other values of  $a$  getting new positions of parabolas with new colours, wherefrom is constructed the family of parabolas. We can construct graphs for all values of  $a$ , but better is to have few of them, otherwise the pad will be very loaded and hoax.

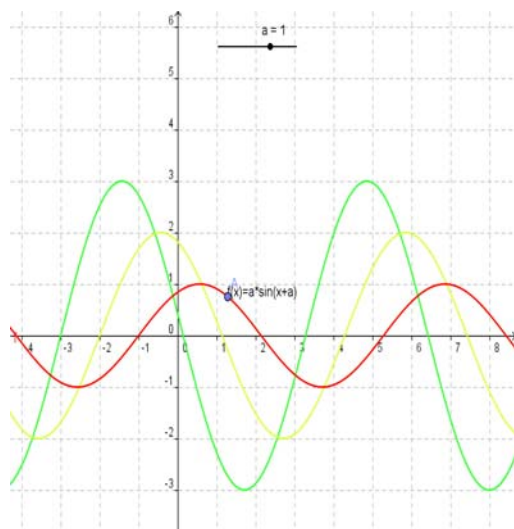


**Figure 1.** Parabolic graphs family (created with GeoGebra)

**Note 1:** In every position of parabola the attached text does not change in accordance with the values of slider a. Nevertheless, the change of the values of a can be read on the algebra window found at Free Objects section.

**Note 2:** The same procedure is applied for other families of functions. Here on this paper we have constructed the graphics of the following families:

- Family of straight lines intersected in a fixed point A (increment = 1) - Figure 3.
- Parametric Sinusoidal Family:  $f(x) = a \cdot \sin(x+a)$ , (increment = 1) – Figure 2.
- Parametric Power Family:  $f(x) = x^a$  (increment = 0.5)
- Parametric Exponential Family:  $f(x) = a^x$  (increment = 0.25) - Figure 4.



**Figure 2.** Parametric Sinusoidal Family (created with GeoGebra)

**Note 3:** The above mentioned constructions can be done for parametric functions having boundaries as well, or defined in a certain domain.

Using the same procedure we can construct the graphs of the functions and their inverses on the same pad and simultaneously study their properties and make comparisons from geometrical point of view.

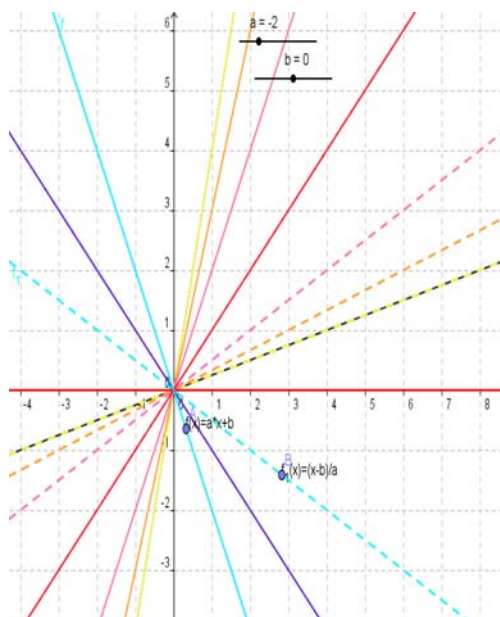
**Ex. 2.** The graph of linear function and its inverse (Figure 3):

Procedure:

1. Follow the steps 1 - 4 of the procedure of Ex. 1
2. Create two sliders a and b(min = -4, max = 4, increment = 1)
3. In the input field enter the function:  $f(x)=a \cdot x+b$  to construct the graph
4. Also, enter the inverse function:  $f^{-1}(x) = (x-b)/a$
5. Insert the text for the equation of the line( $f(x)=a \cdot x+b$ ) by activating “ABC Insert Text” tool
6. Insert the text for the equation of the inverse line( $f(x)=(x-b)/a$ ) by activating “ABC Insert Text” tool
7. Create a New Point A on the graph of  $f(x)$  and a point B on the respective inverse graph and attach text with the graphs by selecting “Insert Text” tool and directly clicking on the points. The

other way is the same: open the dialog box of the text inserted for  $f(x)$ : Properties-Position and here select point A. With this action the text is stuck or linked with point A. Open the dialog box of the text inserted for the inverse function  $f^{-1}(x)$ : Object Properties-Position and here select point B. With this action this text is stuck or linked with point B.

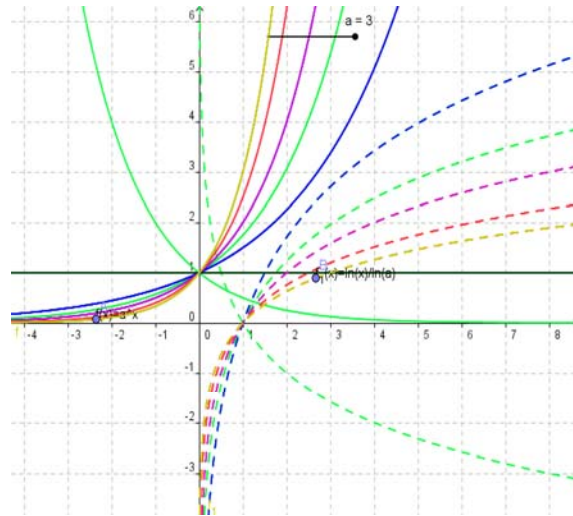
8. Right click on the two constructed graphs and select Trace On
9. Start slowly moving the slider  $a$  (in our case  $b = 0$ ) and for every increment are taken simultaneously the graphs of the linear function and its inverse, positioned in accordance with the value of  $a$ . This way, are got the two families of graphs for the set of the values of  $a$ . To better detect them from one another, or have a nicer view, we can appoint different colours for them. One has to proceed the same way for colouring the graphs, but we have to right - click separately on the two graphs to open the dialog box and select the colour (it is good that they have the same colour). The colouring of the two graphs, for a fixed value of  $a$ , can be done simultaneously as well: in the properties dialog we open the colour panel and we select the colour of the two lines by previewing the colour of the lines noted  $c$  and  $d$  at the left upper corner (the left part of the colour panel). Also, for the family of the inverse functions can be selected a different plotting or drawing style. To do this, put the pointer on the inverse graph, right-click to open the dialog box: Object Properties – Style – Line style where can be selected a dashed or dotted graph. Again, it is recommended that in the beginning we move slider  $a$  to one of its extremes (left or right) and, continue with the steps 11 and 12 of the first example.



**Figure 3.** The graphs of the linear inverses are dashed (created with GeoGebra)

On this paper we have presented the construction of the graphs of:

- Power function family:  $f(x) = x^a$  and its inverse:  $f^{-1}(x) = x^{1/a}$
- Exponential family:  $f(x) = a^x$  and its inverse:  $f^{-1}(x) = \ln(x)/\ln(a)$  (Figure 4)



**Figure 4.** Family of exponential functions and their inverses of dashed curves (created with GeoGebra)

### 3.2. Procedure for saving and printing out the work

**Very important:** After the construction of the family of graphs (as described above) is completed, don't do any other action in order to preserve the view got so far and save it or print it out the way it is (so, be careful with the move of the mouse and don't touch the keys of the key-board). For example, if you move the family of graphs to the upper left corner of the drawing pad or adjust the size of GeoGebra window or try to save the work done you will lose it. Doing something wrong or superficially can also lose the work done and you have to start from the beginning.

**Remark:** The family of graphs created by traces of objects cannot be saved in GeoGebra file. It can be saved as a word document.

#### Saving the created work

The moment you have finished the construction of the family of graphs immediately open the menu File and select there "Export" command.

Procedure:

1. Export the drawing pad to the clipboard (menu File-Export-Drawing Pad to Clipboard, or menu File-Export- Graphics View as Picture)
2. Open a new word processing document
3. Insert the family of graphs from the clipboard (menu Edit-Paste or Ctrl-V) or, before this action you can insert in the window document a table with dimensions 1 x 1 and check the outlook and then paste the graphics inside it.
4. Type in the description of the functions family, their properties and equations.
5. Save it in the usual way an word document is saved

#### Typing the created work

Procedure:

1. Click File menu and select Print Preview

2. On the Print Preview Tab type in the Title of the drawing, the name of the Author, make a selection for the scale(in cm or mm) and for the resolution in percentage(75% or 100%,...) and choose Landscape.
3. Click Print....

#### 4. Our future plans

We plan to further develop the extended help for GeoGebra, which contains besides the detailed description of the commands, some useful examples, and some cross- links to related commands as well.

The aim of the examples is to make it easier to handle the commands, as it can be used in a copy+paste form, and check the result.

#### A sample for the command LowerSum

- 1 Command: LowerSum[f,a,b,n]
- 2 f: function
- 3 a: left limit of the sequence (left bound)
- 4 b: right limit of the sequence (right bound)
- 5 n: the number of subdivisions of the sequence [a,b]
- 6 Description: The command will return the lower sum for the area of the lower approximating rectangles of the area limited by the curve  $y=f(x)$ , the lines: $x=a$ ,  $x=b$  and  $y=0$ .

#### Other Examples:

1.  $f(x)=\cos(x)+\sin(x)$  lowerSum[f(x),0,sqrt(10),10]
2.  $f(x)=\cos(x)+\sin(x)$  lowerSum[f(x),0,22/7,n] (REMARK: Put n as a slider taking values  $n=1,2,\dots,50$ )
3.  $f(x)=2*x^2-5*x+2$  lowerSum[f(x),a,a+b,n]
4. (REMARK: Put a as a slider taking values between -4 and 4, b as a slider taking values between 0 and 5 and n as a slider taking values  $n=1,2,\dots,100$ )
5. See as well: UpperSum, Integral.

#### 5. Benefits

- 1 The students can be further skilled in using GeoGebra tools and commands and other computer techniques..
- 2 Teachers and students have the possibility to dynamically demonstrate and understand the relation between the functions of the same family and their basic properties, the geometrical relation between a function and its inverse
- 3 It is possible to construct on the same pad more than two graphs, to save the work and, the more important, to print it out for purposes of use in papers and books
- 4 This technique gives the answer of constructing graphs of functions relating to many physical problems(of the real world).

#### References

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GeoGebraWiki

### **Biographical notes**

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