

MatDeck 2D Graphs Manual

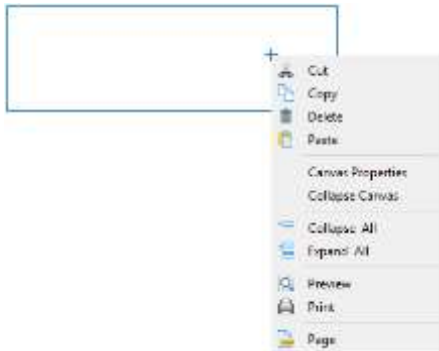
Contents

1.1	Canvas	2
1.2	Vectors and matrices	3
1.3	Graph	4
1.3.1	Example: Graph	5
1.4	Graph tab	6
1.5	Data table	6
1.6	Graph	7
1.7	Titles	7
1.8	Curves	7
1.9	Graph properties	8
1.10	Quadrant	9
1.11	Range	9
1.12	Curve manager	10
1.13	Grid	11
1.14	Toolbox	11
1.15	Perspective	11
1.16	Interpolation	12
1.17	Regression	12
1.18	Examples	13
1.18.1	Example: Graph tab	13
1.18.2	Example: Import from database	14
1.18.3	Example: Import from excel	15
1.18.4	Example: Export and Import to channel	17

1.1 Canvas



The canvas is a container object for several types of objects. In the canvas we can place: formulas, graphs, images, comments, text boxes, bookmarks, tables, data objects, shapes, arrows, lines and trees. To insert a canvas object, press the Canvas icon and click on any unused part of the document in order to place the canvas. You will have to place a canvas before placing a graph, the canvas size must also be big enough to accommodate a graph.



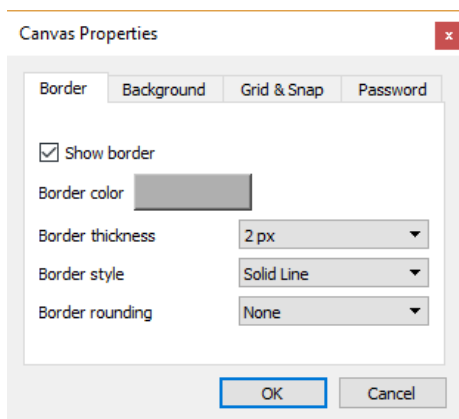
Picture 1: Canvas

A Right mouse click will open the menu shown in Picture , from this menu you can Collapse Canvas and open canvas *Properties*.

The Properties option will open the *Canvas Properties* window which refers to the current canvas only. From the Properties window we can set a grid and a snap (as described in Layout tab icon Canvas Properties, **Error! Reference source not found.**).

By default the canvas borders are off. You can choose whether the borders are on or off, set their colour, thickness, style and rounding all from the *Border* tab (

Picture 2). When you select the canvas, its border colour is blue.



Picture 2: Canvas Properties – border

The canvas background colour can be set from the *Background* tab.

You can resize the canvas if you adjust the indents using the ruler when the cursor is in the canvas.

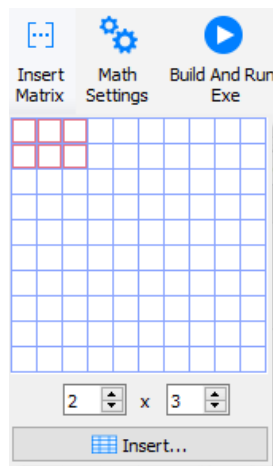
Note:

Settings that we have described in this section, all properties that can be set from Canvas properties context menu option, **refers only to the selected canvas**.

1.2 Matrices

Matrices are used as a store of data for a graph to plot, therefore you must create a matrix and insert data if you want to plot a graph. There are two ways to create a matrix in MatDeck. Matrices with a desirable size are created empty and then you insert data in them afterwards. You can use the [Insert Matrix](#) option from *Maths tab*, where you can choose the size of the matrix.

To create a matrix 2x3 and insert data into it. Choose the matrix size from the *Insert Matrix* option, as shown on Picture , and an empty matrix will appear in the canvas



Picture 3: Insert matrix

$$a := \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

If you wanted to store this matrix inside a variable, you should first create variable **a** with the command `a :=` and repeat the above steps to create a matrix. You can insert data into the matrix simply by placing the cursor inside an empty node of the matrix and typing the desired data.

You can process all the data in a matrix using a single arithmetic operator of function

$$a - 5 = \begin{bmatrix} -4 & -3 & -2 \\ -1 & 0 & 1 \end{bmatrix} \qquad \ln(a) = \begin{bmatrix} 0 & 0.693 & 1.099 \\ 1.386 & 1.609 & 1.791 \end{bmatrix}$$

In MatDeck there is a group of functions called Matrix and Vector in which you can find a whole range of functions for data manipulation on matrices. For example,

$$\text{rank}(a) = 2 \qquad \text{positivedefinite}(a) = \text{false}$$

There are also several functions that will perform arithmetic operations with matrices, element-by-element rather than using matrix rules, and these are the following: **mul** for element-by-element multiplication, **div** for element-by-element division. For example,

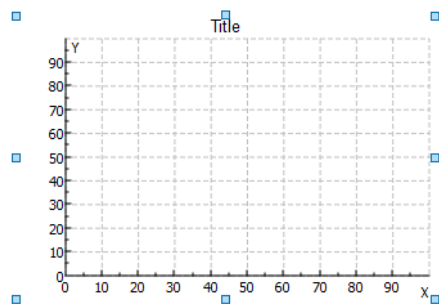
$$\text{mul}(a, a) = \begin{bmatrix} 1 & 4 & 9 \\ 16 & 25 & 36 \end{bmatrix} \qquad \text{div}(a, a) = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

1.3 Graph



We can use graph objects when we want to plot 2D graphs. This object can only be inserted in a canvas. There are two ways of inserting a graph object in the document: press the Graph icon and click in the document, a canvas will be placed and inside it will be the graph object; if we already have a canvas in our document and we want to insert a graph in it, we press the Graph icon and click in the canvas on the position where we want to place it.

To plot a graph you have to define a variable and store data in it. Only data stored in a matrix can be plotted, where the first column of a matrix represents the x-axis data and the second column is the y-axis data in the graph. The minimal number of nodes which can be plotted on a graph is two, so the minimal matrix size for a plot is 2x2. There are several functions that place data in a matrix, and thus prepare them to be drawn in the graph. Those are: **curve2d**, **complexcurve2dre**, **complexcurve2dimg**, **curve2d_param**, **curve2d_param_re**, **curve2d_param_im**.



Picture 4: Graph object

This is what a default graph will look like once it has been inserted into the document (Picture). Use the surrounding blue boxes to make the graph bigger or smaller.

The graph consists of *Title*, *Axes*, *Drawing area* and *Legend*. If you place the cursor on the title or any of the axes and double left click on them, edit mode will open so you could set the Title or rename the Axes.

Legend is displayed in the top right corner of the Drawing area and contains all variables that are added on the selected graph.

If you right click on the Drawing area of the graph a dropdown menu shown on Picture will appear.

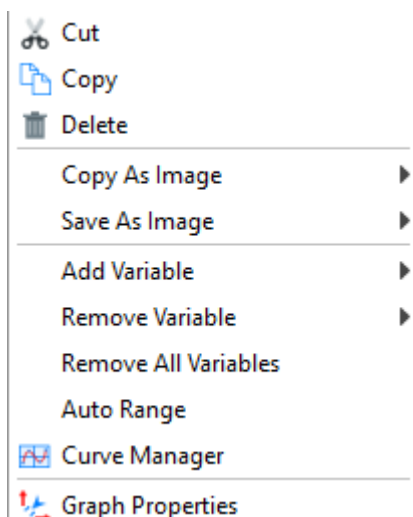
With Copy As Image and Save As Image, you can copy and save the graphs as images. You can choose between three different levels of picture quality.

The Add Variable option will show a list of all variables created in the current document from which you could choose what variable to plot.

The Remove Variable option will show a list of variables that are already plotted on the current graph, from this you can choose what variable you want to remove from the graph. Use the Remove All Variables option to remove all the plots from graph.

The Auto range option will reload the graph and adapt the scope of the axes to the data that is stored in our variables.

Curve Manager and Properties open a new options windows, Graph properties and Display properties have a detailed description in Graph Tab section (Picture and Picture).





Picture 5: Graph dropdown menu


1.3.1 Example: Graph

Create a graph of the trigonometric functions sine and cosine on a $[-2\pi, 2\pi]$ segment and place them on the same graph.

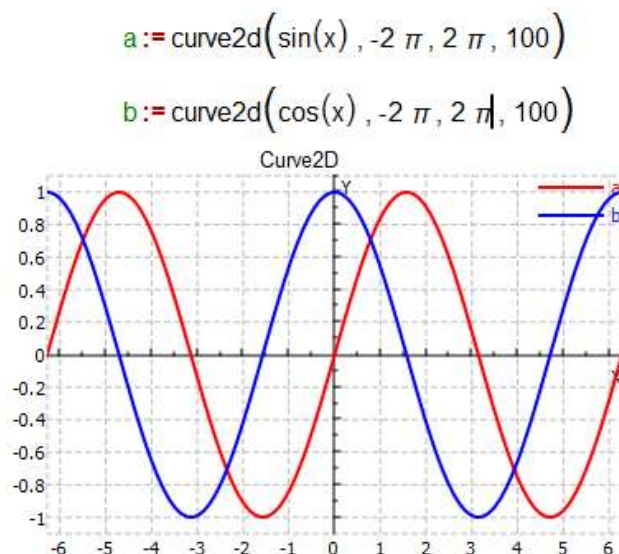
Solution:

Create a new document by pressing New icon  , press the Maths icon  and select a place on the document where you wish to place it. A new canvas object will appear with a Maths object inside it. Now create the new variable **a:=curve2d**, this code will create the new variable a and store the results of the function **curve2d** in it. $a := \text{curve2d}(\sin(x), -2\pi, 2\pi, 100)$

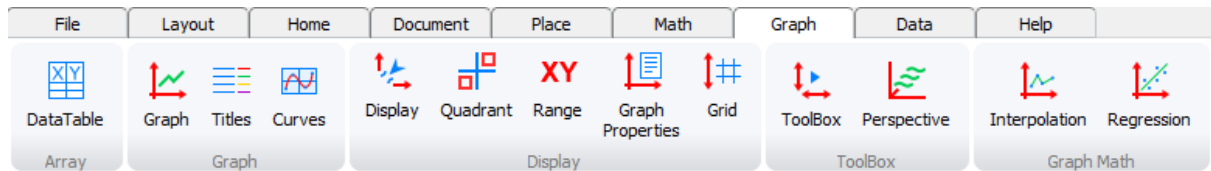
The function curve2d will always be used when we want to draw a graph, it is a function that creates a matrix of two columns and the number of rows can be determined in the fourth argument. The first argument is the function that we want to draw with preferred symbols or values as arguments, the second and third are numerical intervals of values that correspond to the symbol which appears in first argument function. The fourth argument is the number of samples. In the first empty node type **sin** to create new sine function $\sin(x)$, then type symbol **x** as its argument. In the second node type **-2*cpi** (this is a standard way of inserting constants π in to the document, every constant has a character c in front of it), in the next node type **2*cpi** and in the last node type 100 for example.

From the Insert tab select the Graph icon  and click a place on the canvas where you want to place it, a new graph object will appear. Right click the graph and press Add variable option from the content menu, now choose the variable **a**, that we created earlier. A sine function graph will appear.

Let us create another variable **b:=curve2d**. In the first empty node, type **cos** to create new cosine function $\cos(x)$ and type the symbol **x** as its argument. In the second node type **-2*cpi**, in the next node type **2*cpi** and in the last node type 100. Right click the graph and press Add variable option from the content menu, now choose the variable **b**, that we created earlier. A cosine function graph will appear.

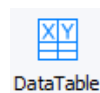


1.4 Graph tab

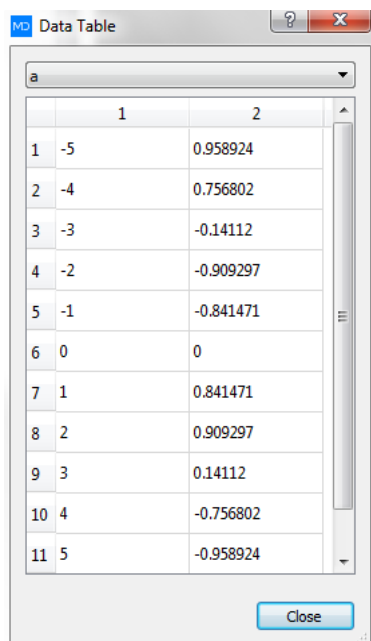


Picture 6: Graph tab

This tab refers to work done with 2D graphs and their settings. Options from this tab can only be used if a graph object is inserted in the document and already selected. The option Graph from this tab is same as the Graph option from the Place tab, when clicked and placed on a document, a new canvas will appear with a graph inside of it.



1.5 Data table



Picture 7: Data table

When you press the Data table icon, the window shown on Picture will open. From the dropdown menu on top of the window, select a variable and the data you would like to see. The menu list will contain all variables that are plotted on the selected graph.

The data set is displayed in a table with two columns, the first one represents data for x axis of the graph and second column is y axis data.



1.6 Graph

This option is the same as the Graph option from the insert tab, which is described in detail in section 1.3 .

1.7 Titles



Name	Title	Color	Origin
a		-----	
b		-----	

Picture 8: Titles table

The Titles icon will create a table containing all the graph variables from the moment of creation. So if you make any change in the graph (add/remove variable) you will have to create new a table because it won't automatically update any changes.

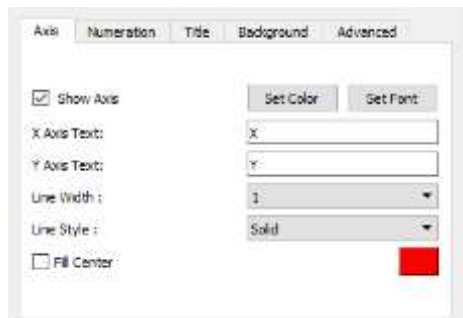
1.8 Curves



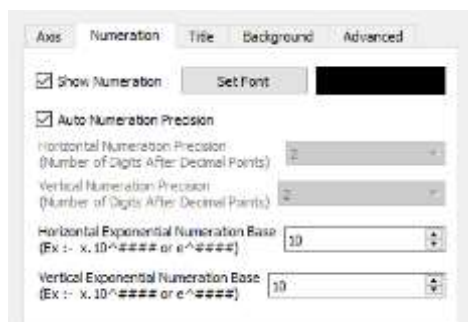
Picture 9: Curve table

When you press the Curves icon, the window from Picture 9 will open. From this window we can see and manage all the curves plotted in a graph. Every cell of the table is editable (double click, drop down menu, arrow change,...) and you can change: whether curves will be displayed, change name, title, colour, amplifier, multiplier, offset, phase, style, origin of the curve. Amplifier, offset, phase and multiplier can be set from the window by choosing which parameters you would like to change, setting up the value and pressing apply. Also there is a reset button to return values to default state.

1.9 Graph properties



Picture 10: Display - Axis tab



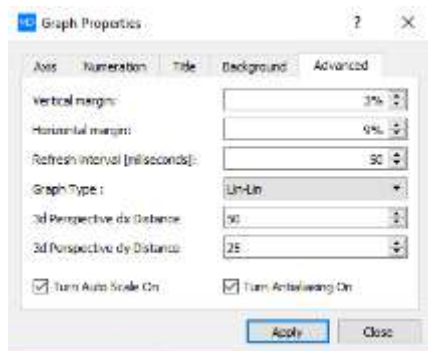
Picture 11: Display - Numeration tab



Picture 12: Display - Title tab



Picture 13: Display - Background tab



Picture 14: Display - Advanced tab

Pressing the *Graph Properties* icon will open a window, as shown on Picture , the same can also be done with a right click to open the content menu and then selecting the option *Graph Properties*; from which you can configure graph axis and numeration, graph title, background colour, margins, perspective distance, refresh interval, etc. As stated before, all these options refer only to the current graph and they are not global settings. From the *Axis tab*(Picture) you can choose if axes are going to be displayed or not, change their names, width, line style, colour and font. Also you can mark the centre of the graph and choose its axis colour.

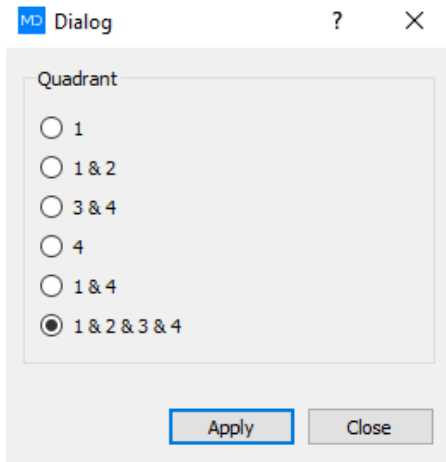
From the *Numeration tab* (Picture)you can choose if axes numeration are going to be displayed or not, set their font, colour, will it be calculated automatically or manually (if you choose manually you will have to set a number of decimal places for each axis) and set exponential numeration bases for each axis.

From the *Title tab*(Picture) you can set the title, choose if it will be displayed or not, set the font and colour. You can also choose to show the Legend on the graph or not. If you plot a large amount of curves, the best practice is to not display a legend but to use a Titles table (section 1.7) instead.

From the *Background tab*(Picture) you can change the background colour of the graph.

From the *Advanced tab*(Picture) you can change margins, refresh intervals and distance for 3D perspective. You can also change axis bases from decimal to logarithmic for both axis or just for one of them. There is also the option to *Turn Auto Scale On*, and when it's turned off you can auto scale the graph with *Auto Range* from right clicking content menu. The *Turn Antialiasing On* option will remove "jaggies" and the staircase effect from plotted curves when it is on.

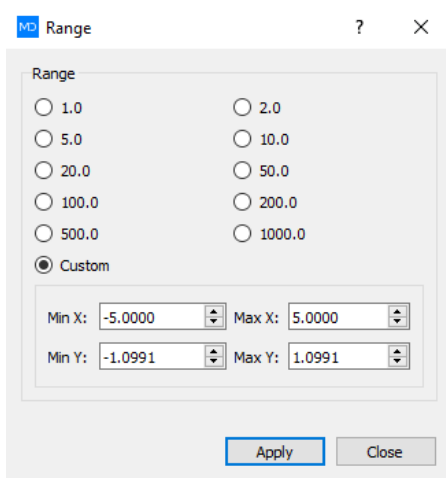
1.10 Quadrant



Press the Quadrant icon and the window shown in Picture will open. This option allows you to pick which quadrants of graph you wish to be seen.

Picture 15: Quadrant window

1.11 Range

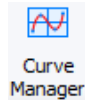


From this window you can change the range of a selected graph to any of the present values or you can click custom to use your own. To use this option, press the Range icon and the window shown in Picture will open.

The four fields, in the bottom of the picture on the left, are only editable if the custom option is selected.

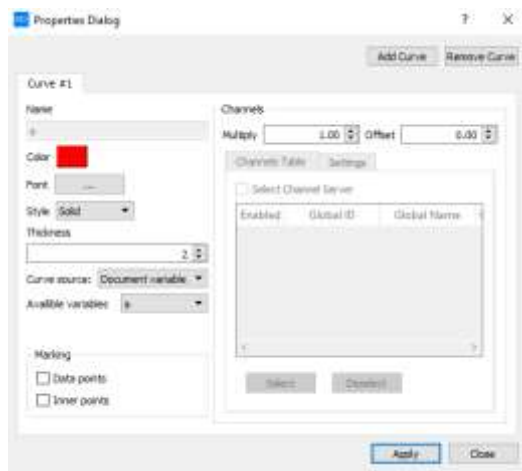
Picture 16: Range window

1.12 Curve manager



To change the curve properties, press the *Curve Manager* icon and the window shown in Picture will open. This is the same as from the right click content menu option; *Curve Manager*. There is a tab for each curve in this window, you can add or remove curves using the *Add Curve* and *Remove Curve* buttons at the top of it. For every curve, the setting is dependent on their features:

Name field: depending on the source of data for the curve, this field can be editable or not, if the source is *Device channel* name, the field is editable, if the source is *Document variable* or *Database table* this field isn't editable and the name of the curve is the same as in the variable or database;



For every curve, you can set a colour, font, style and thickness. You can also choose to mark on the curve: source *Data point* and the way they will be displayed (rectangles, circles, x marks); interpolated *Inner points* and the way they will be displayed (rectangles, circles, x marks).

Curve source contains the following options: Device channel, Document variable and Database table.

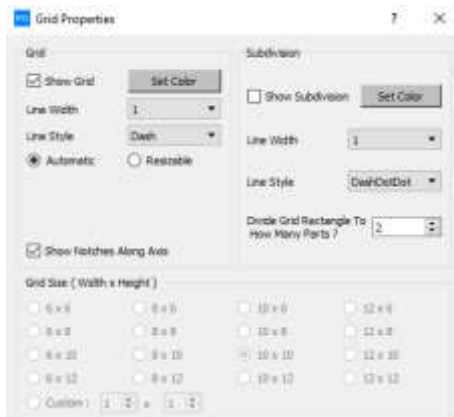
Picture 17: Graph Properties

If *Device channel* is selected, the Channels group of settings on the right hand side of the window will become editable. You can set the curve from the *Multiply* and *Offset* boxes. From the *Channel Table* tab you can establish a channel connection which will be the source of data for the curve. Mark the *Select Channel Server*, insert the Server IP address and Server port, press the *Connect* button and the connection will appear in table below. From the *Settings* tab you can set which columns will be visible in the channel connection table. To finish the process of creating a channel as a source of curve data, mark the connection from the table and press *Select* button.

If *Document variable* is selected as the curve source, the *Available variables* drop down menu will appear; from this you can choose which variable is the source of curve data. The drop down menu will contain a list of all variables created in the current document. The option for the channel group will not be editable in this case.

If *Database table* was selected as the curve source, the *Database tables* drop down menu will appear; from this you can choose which curves from the database will be displayed on the graph. The *Database tables* drop down menu contains all the options where we established a connection to the database from the Data tab of software. That selected database contains the data for at least one of the curves.

1.13 Grid



Picture 18: Graph grid properties

From the window shown in Picture , you can change the graph grid properties: you can show or hide the grid, set line width, style, colour, make the grid resizable, choose its size, show or hide notches along the axis. You can also show or hide subdivision, choose its size by selecting how many parts you would like to divide the grid into, set subdivision line width, style and colour.

1.14 Toolbox

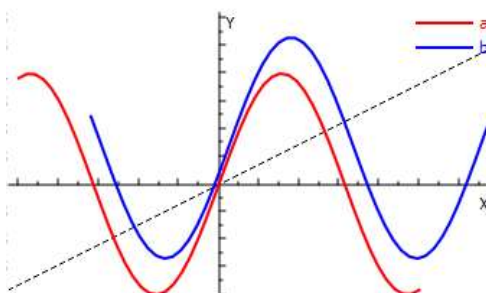


Picture 19: Graph toolbox window

From the Toolbox option, the window shown in Picture will open. You can change multipliers for each of the axes (their default state is 1), and that change will “shrink” or “stretch” the curve depending on your input. This option refers to all curves on graph.

To use the Auto Roll option, select a range by inserting the start and finish value for the x axis, move the blue slider to select a speed of roll. After you have set all parameters, press the Start button.

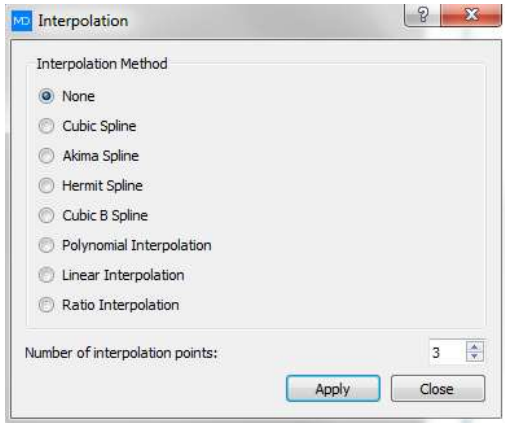
1.15 Perspective



Picture 20: Perspective view

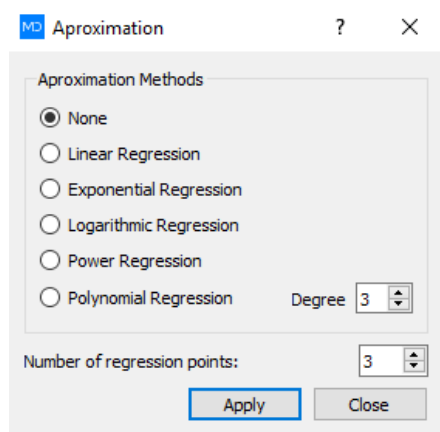
The Perspective option will put every curve displayed on the graph in a different plane and place them according to the imaginary axis displayed as the dashed line in Picture .

1.16 Interpolation



Picture 21: Interpolation

1.17 Regression



Picture 22: Regression

To use interpolations, press the Interpolation icon and the window shown in Picture will open. These settings refer only to the currently selected graph.

If the number of nodes in the source data for the curve is too small and you want to make the curve line more round because of its sharp edges, select the interpolation method you prefer, set the number of interpolation points and press the Apply button. The number of interpolation points is a number in the range of 1-99 and represents the number of points that will be placed between two source nodes.

To use regressions, press the Regression icon and the window shown in Picture will open. These settings refer only to the currently selected graph.

Use this option when you want to find a function that best fits the source data.



The number of regression points is a number in the range of 1-99 and represents the number of points that will be placed between two source nodes.

1.18 Examples


1.18.1 Example: Graph tab


Sketch the graph of $f(x) = (x - 1)^3 + 1$ on interval $[-1, 3]$ with the number of samples set to 20. Create a Data table for this function, interpolate function curve with Hermit spline interpolation, display graph only in first quadrant, the “shrink” function will double its size with respect to x axis, display input data points with blue circles and colour graph curve in orange.




Solution:


Create a new document by pressing the New icon , press Maths icon , select a place on the document where you want to place it, a new canvas object will appear with a Maths object inside it. Create a variable with code `a:=curve2d` and a new variable with function inside it will appear `a:=curve2d(, , ,)`. In the first argument node type $(x-1)$, hold **Shift** and type **6**, that will create a power function node $(x-1)^6$ and then type **-1** at the end. In the second argument node **-1**, in the third argument node type **3** and in the fourth one type **20**.

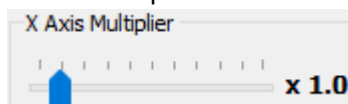
$$a := \text{curve2d}\left((x-1)^3 - 1, -1, 3, 20\right)$$


From the Place tab select Graph icon , select a place on the canvas where you want to place it; a new graph object will appear. From the right mouse click content menu select Add variable option and choose variable **a** we created earlier, a function graph will then appear.

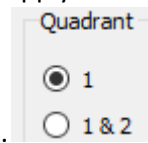
Select the graph object by clicking on it once and pressing the Interpolation icon . Tick the Hermit spline, set Number of interpolation points to 15, press apply and close this window. Notice that the graph curve is now much more rounded than before.

Press Curve Manager icon , press the red quadrant  and the Select colour window will appear, set colour to orange and press OK. Tick on Data point's option, select the Circle from the drop down menu and set colour to blue Data points Circle . With the previous settings we change the graph colour to orange and the draw input data points with blue circles.

Press Toolbox icon , and for the x Axis Multiplier set the value to 2.0. That will double the size of the graph with respect to the x axis.




Press Quadrant icon  Quadrant, then tick option 1, press apply and close this window. After this setting



you should only see the first quadrant of the graph.



Now press Titles icon Titles, a table will appear in the canvas. Place the cursor in the title column and type $f(x)$, now place the cursor in the top left corner of the table (cursor arrow will change to black

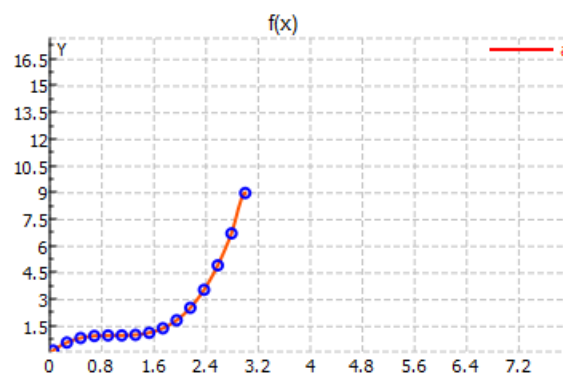
arrow), open Home tab and from the Align icon drop down menu  select Align Center to align all table items.

Place the cursor above the Title of the graph object and double click on title text. A text field will open, type $f(x)$ and press the Enter key from the keyboard.

If you have done all the tasks from this example, the graph at the end will look like the graph on Picture 1.

$$a := \text{curve2d}\left((x-1)^3 + 1, x, -1, 3, 20\right)$$

Name	Title	Color	Origin
a	f(x)	-----	



Picture 1: Graph tab example

1.18.2 Example: Import from database

Import data we exported in example **Error! Reference source not found.** and draw 2D graph with them.

Solution:




New





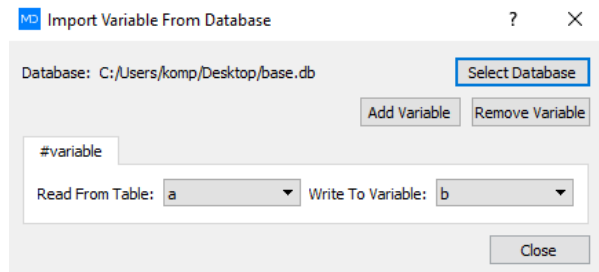
Math

Create a new document by pressing the New icon New, press Maths icon Math, select a place on the document where you want to place it. A new canvas object will appear with a Math object

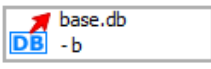
inside it. Create the variable with code $b:=0$, this is the variable in which we are going to import data from the database file.

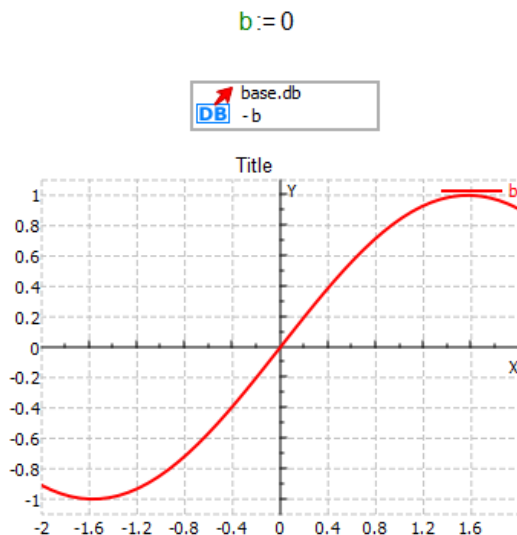
Press the DB Manager icon  and then press the Select database button. A new window will open, select the Desktop of your computer, selected the base.db file and press Open button. Press the **Connect** button and now the connection to the database is established. The connect button now has changed to **Disconnect** button. Press Close to exit this window.


Press the Import icon  then select a place on the canvas where you want to place it, a new Database import object will appear . Place the cursor above this object, using the right mouse click content menu choose Properties and the *Import Variable From Database* window will open. Press Select database button and from the new window that has just opened choose base.db file from your Desktop. Press Add Variable button and a new tab will appear. There are two drop down menus, Read From Table with variable a selected (this is the variable in the database where we have stored our data) and Write To Variable with variable b selected (this is the only variable in our current document, you can always create another variable and choose it for data import). Press Close button to exit this window.



The database import data object will now look like

this  meaning that we have imported data from the database to variable b. Now we shall draw the graph with this data.





From the Place tab select Graph icon  then select a place on the canvas where you want to place it; a new graph object will appear. Using the right mouse button click content menu, select Add variable option and choose variable **b**. A function graph will appear.



As you can see this is the graph of the sine function on interval $[-2, 2]$. The data we have exported earlier to the database were successfully imported and shown on the 2D graph.

1.18.3 Example: Import from excel

*Import data we exported in example **Error! Reference source not found.** and draw 2D graph with them.*

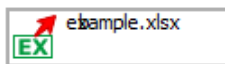
Solution:

Create a new document by pressing the New icon  and then press the Maths icon , select a place on the document where you want to place it, a new canvas object will appear with a Maths object inside it. Create a variable with code $b:=0$, this is the variable in which we are going to

import data from the excel file export.xlsx. Press the Import icon , select a place on the canvas where you want to place it, a new Excel export object will appear . Place the cursor above this object, right click with your mouse on the content menu and choose Properties and an *ExcelReader Object* window will open.

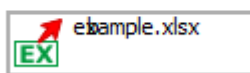
Press the Browse button and from the new windows that you have just opened choose export.xlsx file from your Desktop (file where data was exported). In the Sheets field, choose the excel sheet where your data is saved, the Variable field will automatically display variable b (because it is the only variable in current document). If there is no variable in the document or you simply want to import data in a document, press Add New Variable button, we left variable b as an import location. In the Start Cell field, type the excel cell position as a starting cell from which data will be imported (we inserted A1 in this field), in the End Cell field. Type the excel cell position as an ending cell from which the data will be imported and press the Add button. In the table of imports there will be a new row with the variable b that we have just chose to import data to. Press the Close button to exit this window.


After the closing of the Excel Reader Object window, the Excel import object will look like this

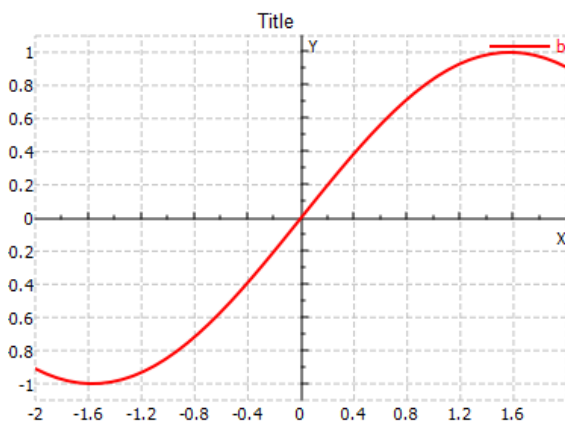


meaning that we have imported data from the excel file to variable b. Now we shall draw a graph with this data.

$b := 0$



From the Place tab select the Graph icon , click the place on the canvas where you want to place it, a new graph object will appear. Right click on the content menu and select the Add variable option and choose variable **b**. A function graph will appear.





1.18.4 Example: Export and Import to channel



1.18.4.1 Example: Export to channel


Export values of sine function on interval [-2, 2] to channel.

Solution:


Create a new document by pressing the  **New**, press the  **Math**, select a place on the document where you want to place it, a new canvas object will appear with a Maths object inside it. Create a variable with the code **a:=curve2d** and a new variable with functions inside it will appear **a:=curve2d(, , , ,)**. For function first argument type **sin** and insert the symbol **x** in the sine function. For the second argument type **-2**, in the third argument type **2** and in the fourth type **30**.

$$a := \text{curve2d}(\sin(x), -2, 2, 30)$$

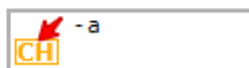
Press the  **Export**, select a place on the canvas where you want to place it, a new Channel export object will appear . Place the cursor above this object, using the right click select the content menu and choose **Properties** and **Export Variable To Channel** window will open.

In the document Variables menu, variable **a** is selected as the only variable in this document and all we have to do is to press the Add button. Variable **a** will appear in the list under, press Close to exit this window. The channel export data object will now look like this  meaning that we have exported data from variable **a** to channel.

Now we have opened the channel from which we are sending the data via variable **a** as a matrix with two rows, in the first row we have placed data for the x axis and in the second, y axis data.

At the end we will save the file by pressing the  **Save** from the File tab, from the Save As window choose where you want to save the file (we placed it on Desktop), type **channel** in the File name field and press the Save button.

$$a := \text{curve2d}(\sin(x), x, -2, 2, 30)$$





1.18.4.2 Example: Import to channel

Import data we exported in example 1.18.4 and draw 2D graph with them.


Solution:




Create a new document by pressing the New icon  and then press the Math icon , select a place on the document where you want to place it, a new canvas object will appear with a maths object inside it. Create a variable with the code $b:=0$, this is the variable in which we are going to import data from the channel that we have created in example 1.18.4.

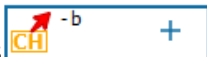
Before we continue with data importing, we have to open a file in which we can export data. This is required because the channels transfer data through TCP protocol, meaning that you have to open a channel (we did this in "chanell.mdd" file) and keep it open until data transfer is finished.




Press the Import icon  and select a place on the canvas where you want to place it, a new

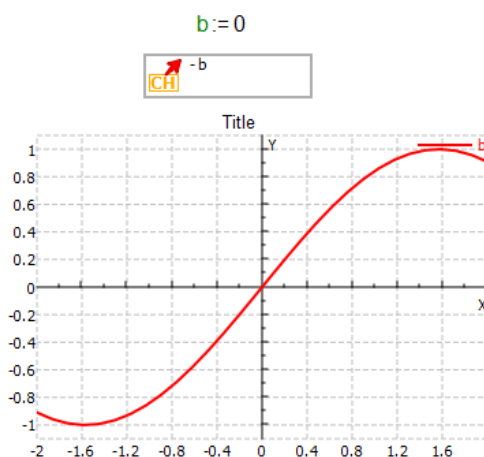
Channel export object will appear . Place the cursor above this object, from the right mouse click content menu and chose Properties and the *Import Variable from Channel* window will open. Press the Add Variable button and a new tab will appear in the channel table. Select a row in the table (this is the only row in the table which presents the channel that we have opened in "chanell.mdd" file), in the *Write To Table* drop down menu, select the variable **b** (variable in which we are going to store data) and press the Select button.

After the closing of the *Import Variable From Channel* window, the channel import object will look

like this  meaning that we have imported data from channel to variable b. Now we shall draw a graph with this data.



From the Place tab select the Graph icon  and select a place on the canvas where you want to place it, a new graph object will appear. From the right mouse click content menu and select the Add variable option and choose variable **b**. A function graph will appear.



As you can see, this is a graph of the sine function on the intervals $[-2, 2]$. The data we have exported earlier through the channel was successfully imported and shown on a 2D graph.