MatDeck User Manual

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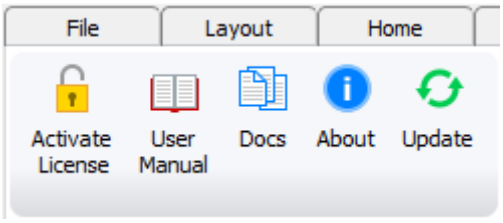
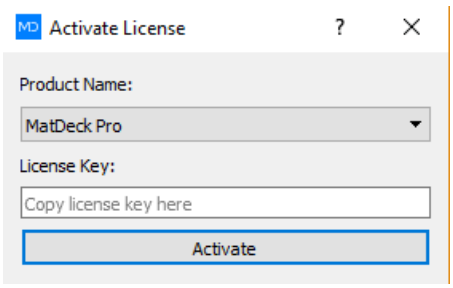
1 Activate license - Help tab

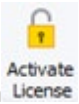


Picture 1: Help tab

From this tab you can activate your version of MatDeck, preview a document and list the examples for better and easier usage of the application.

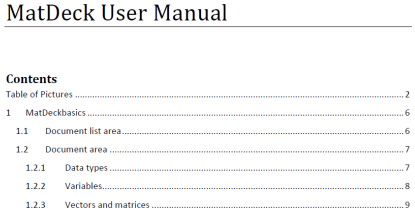


Picture 2: Activate license

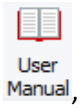
When you press the Activate licence icon 

, a window shown on Picture 2 will open. Enter the key that you have purchased on the LabDeck site and press Activate.

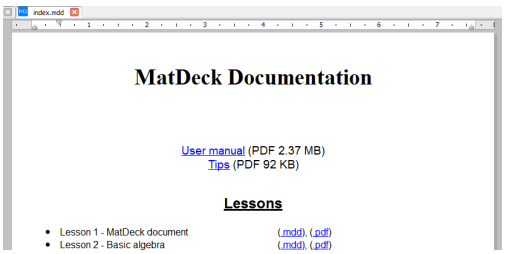
To successfully activate your version of MatDeck you must have internet access.



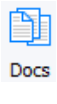
Picture 3: User manual

When you press the User Manual icon 

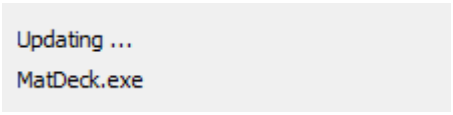
, a new MatDeck document will appear with links to several manuals and tips (Picture 3).



Picture 4: Documentation

When you press the Docs icon 

, a new MatDeck document shown on Picture 4 will open with links to the User Manuals, Tips, lessons and examples. You can get familiar with MatDeck if you walk through Lessons and learn more about the possibilities of the software through the presented examples.



Picture 5: Software updating

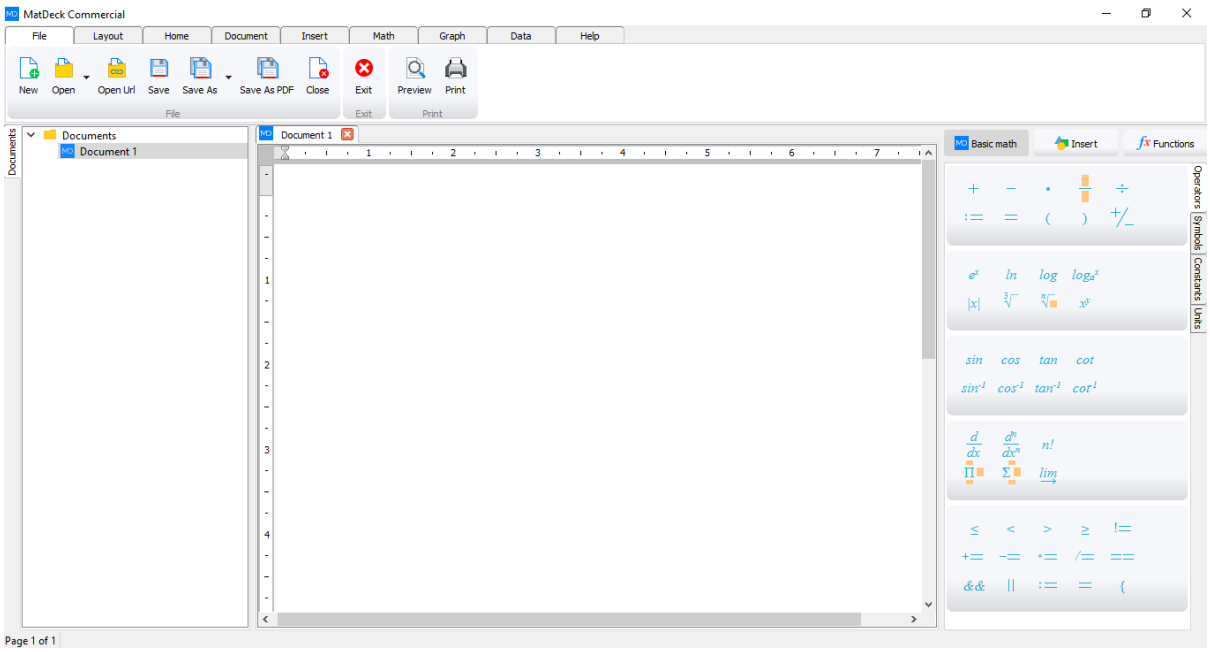
MatDeck automatically checks for software updates every time you open the application. If newer versions are available, a message will appear on the screen asking if you would like to update your version of MatDeck.

If you want to check for updates manually whilst the software is running, press the Update icon

from the Help tab.

2 MatDeck basics

Default layout when you start MatDeck application with one document opened.



Picture 6: MatDeck desktop

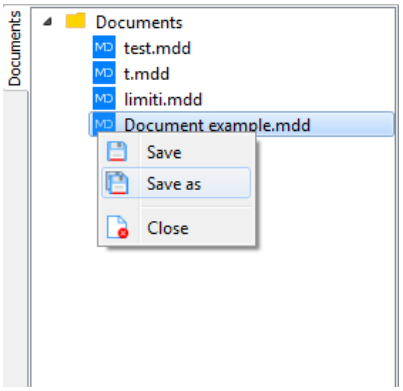
The desktop consists of the following elements:

2.1. **Documents list area**: List of opened documents

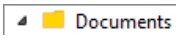
2.2. **Document area**: work area for creating and editing documents, inserting text, formulas, graphs, table and other objects.

2.3. **Insert area**: This area consists of several tabs from which you can insert Mathematical functions, logical operations, symbols, constants, units, shapes and lines and other objects.

2.1 Document list area

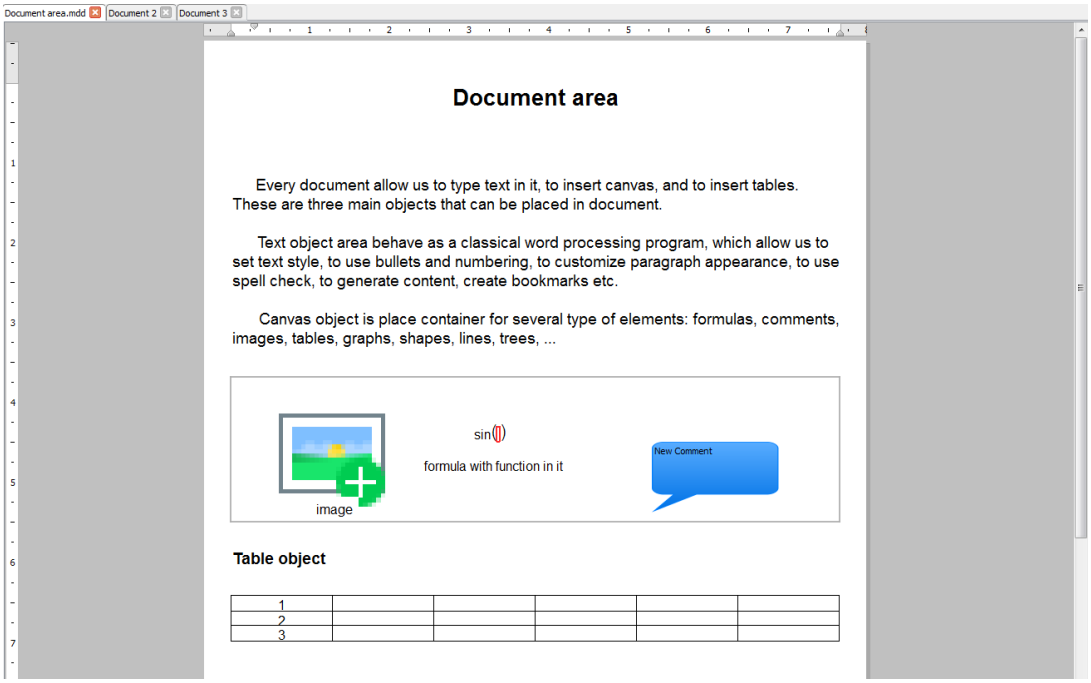


Picture 7:Document list

In this area you can see the list of documents that are open;
When you right button click on 

content menu will appear with the following options: New document, Open document, Open Url;
Right button click on particular file will open content menu with options: Save, Save as (Read Only, Read Only Forbid Copy) and Close.

2.2 Document area



Picture 8: Document preview

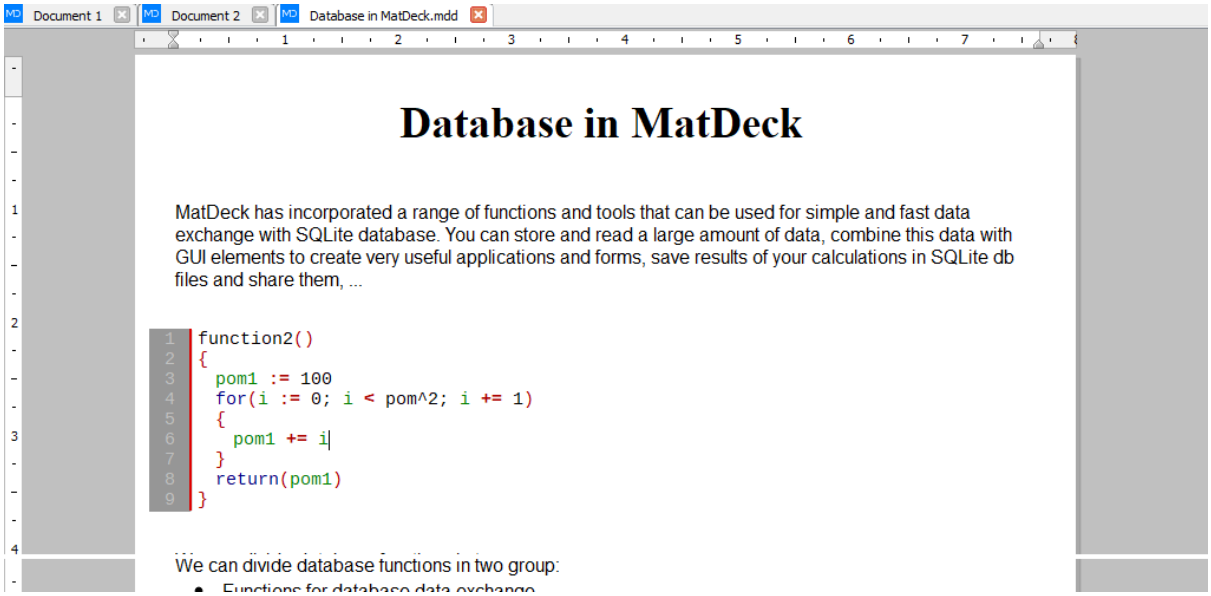
This is a working area in which all opened documents are shown. When a new document is created it will appears like a new tab on top of the area with generic name *Document1*.

There are two types of MatDeck documents, *regular document* and *script document*. The extension for both document types is .mdd and the main difference is that in script documents you can only type and insert MatDeck script language, and in regular MatDeck documents you can insert all types of object (scripts as well).

Regular document

There are two main objects that can be placed in a regular document: text objects, which are default objects on every blank document, and canvas objects. Besides them, the **Ctrl. + I** key combination will turn on script mode and allow you to type script of your choice. To turn script mode off, use the same key combination.

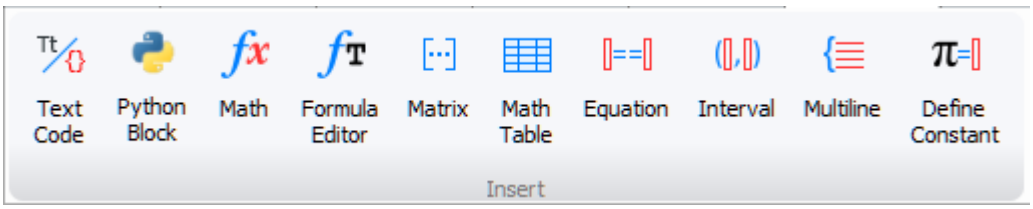
A canvas is a container object for several types of objects. In canvases we can place: formulas, create variables and expressions, vectors and matrices, graphs, images, comments, text boxes, bookmarks, tables, data objects, shapes, arrows, lines and trees. To insert a canvas, press the Canvas icon and click on an empty part of the document to place it.



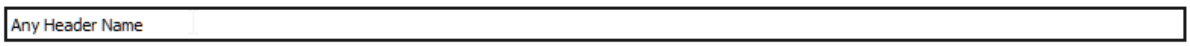
Column Mode

When in Colum Mode, the MD Document is still a live document, with the only exception being the visual aesthetic of a traditional scientific paper. This allows the user to combine their actual working and proof with their written ideas and hypothesises.

To turn it into column mode you will need to go Ctrl + L, this will toggle the document between columns and the standard writing mode. Once the document is column mode, the user may add Math objects and other MD features; these features will automatically be edited and rearranged to fit the column perfectly. For features or functions, the user will no longer need to insert a canvas; they may directly insert them into a column.



For example, elements in the picture above can be inserted without a canvas and directly inside a column, the elements themselves will remain the same and evaluate and run as per normal. To insert an element, you will need to click on the element's image, then you would like to place it.

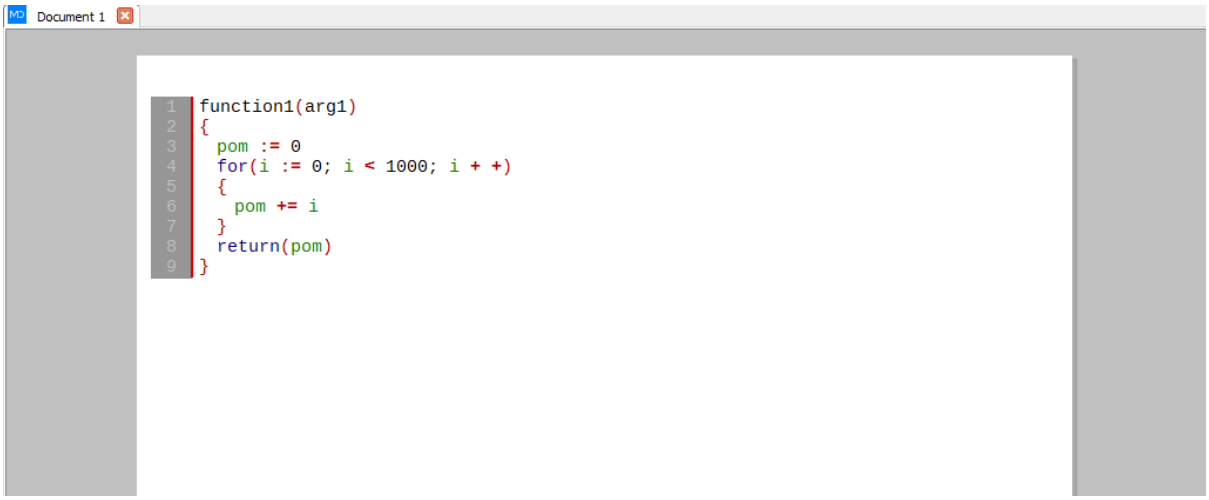


Headers can also be easily inserted by double clicking on the top of any document, form there the user can type in any text as a header. The same can be done for footers.

MatDeck also comes with a large array of editing features for editing. As you can see in the image above, you can change things such as font, size, colour, italics, bold, underline, colour, subscript, superscript and more such as paragraph and line spacing as well as indentations and centring. Look at the YouTube video for a MatDeck Scientific Report Paper.

Script document

In script documents, you can only write in the corresponding language, either Python or MatDeck Script Language. The document is not page based, instead you have one endless page to type scripts, which are the only content you can place in this type of documents.



2.2.1 Data types

Data types that can be created and used in MatDeck application are:

Boolean – a binary variable, having two possible values called “true” and “false”;

Integer – a whole number, a number that is not a fraction;

Double – a fraction number;

Complex – imaginary number, which you can create by typing small letter **i** after whole or fraction number, without the use of spaces;

Vector – a value of this type is fixed-length collection of values of certain type;

Matrix – a value of this type is fixed-length and fixed-width collection of values of certain type;

Table- a value of this type is fixed-length and fixed-width collection of values of certain type with name for each column;
Symbolic value–a value of this type is any value containing symbol which can be multiplied or divided with another number, or can be powered; for example: 2a, $-5x^3$, b^{-2}, ...;
Expression – a value of this type is a combination of symbolic values that can be added, subtracted, divided; for example: 2a+3b, -0.4c – $8.2d^{-1}$, ...
Units - a value which stores a unit of measurement;
String – a value in which we enclose a sequence of characters in double quotes and use them as a single values;
Interval – a value that we use in equations and non-equations as a type of data for displaying results;
Equation – a value that we use to store equations and non-equations in it;
Symbolic function – a value which stores predefined function with symbolic arguments;
Fraction – a value that represents a part of the whole number;
Image – a value that is a data carrier for images.

2.2.2 Variables

MatDeck variables are data holders where can store all types of data. You can place vectors and matrix in them, functions in symbolic or explicit form, other variables and expressions, ...
To create variables with name X and Y type the following commands in the canvas:

X :=5 Y:=3

After creating a variable the letter or string of the variable name will change colour and by default become green. To change the colour of variables use *Maths Settings* option described in section 3.6.8.

To display data saved in variable X simply type following command:

X =

And data will be displayed after the equal sign. Let's create and display a few more variables

Z :=X*Y Z = 15

T := sin(Y) T = 0.141

The number of decimal places in results can also be set from section 3.6.8. Program default angle unit are Radians, to see how to change it go to section 3.6.7.
If you want to use variable **G** in definition of variable **H**, you must define variable **G** above the definition of variable **H**, otherwise **G** will be considered as a symbol in definition of **H**.

To create a complex number and store it in a variable type the following command

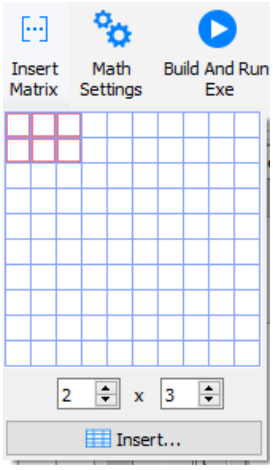
W := 5-4*i*

Complex numbers are created when you use the small letter **i** in this case it will go after number 4, without use of spaces between. When complex a number is created, the letter i style will change and become italic.

2.2.3 Vectors and matrices

There are two ways to create a vector or matrix in MatDeck. Vectors and matrix with a desirable size are created empty and you insert data in them afterwards.
You can use *Insert Matrix* option from *Maths tab* where you choose desirable size of vector or matrix, as described in details in section 3.6.2.

Let's create a matrix 2x3 and insert data into it. Choose matrix size from *Insert Matrix* option, as shown on Picture 9, and an empty matrix will appear in the canvas



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

Picture 9: Insert matrix

If you wanted to store this matrix inside a variable, you should first create a variable **a** with 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 desirable 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 vectors and matrix's. For example,

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

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

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

2.2.4 Using of functions

There are a large number of functions that you can use in MatDeck. From the *Functions* tab you can see all available functions, they are divided into groups, there is a description for each of them and their arguments and also a few simple examples. To find out more about this topic, see section 2.3.3.

As an argument of function you can enter variables that contain data you want to calculate or you can input values directly. When you start typing in a canvas Maths object, autosuggestion will appear to help you insert functions. The second way of inserting them is to double click on the preferred function from *Functions* tab while cursor is active in the canvas.

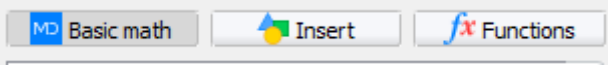
We will create a variable X with value 25 in it, use function *sqrt* to calculate square root of variable X and place the result in a new variable Y. On the other hand we shall calculate the square root of number 25 directly.

$$X := 25$$
$$Y := \mathrm{sqrt}(X) \qquad \mathrm{sqrt}(25) = 5$$
$$Y = 5$$

Depending on the functions and arguments, result can be single value (real or complex number), vector or matrix.

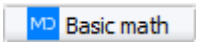
$$\mathrm{sqrt}(16) = 4$$
$$\mathrm{sqrt}(-16) = 0 + 4i$$
$$\mathrm{sqrt}\left(\begin{bmatrix} 1 & 4 & 7 \end{bmatrix}\right) = \begin{bmatrix} 1 & 2 & 2.646 \end{bmatrix}$$
$$\mathrm{sqrt}\left(\begin{bmatrix} 2 & -5 \\ 8 & 16 \end{bmatrix}\right) = \begin{bmatrix} 1.414 & 0 + 2.236i \\ 2.828 & 4 \end{bmatrix}$$

2.3 Insert area

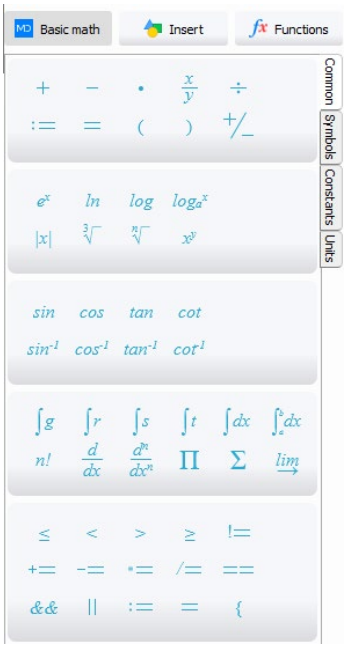


Insert area is divided in three groups: **Basic Maths**, **Insert** and **Functions.** We will walk through each group and all the tabs inside of them.

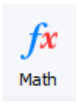
2.3.1 Basic Maths



2.3.1.1 Common tab



Common tab contains the most used mathematical functions and logical operators which are separated into five groups. They can be inserted only in the canvas math object, and we place it with a single click on it, while the cursor is active in canvas.



Picture 10: Common tab

2.3.1.1.1 Example: Operators

Let's write trigonometry/power series formula for sine function

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots = \sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!}$$ *using operators tab as much as we can.*

Solution:

At the beginning we will create variable x and grant it value 2 with command **x := 2**, this variable will be used to check the results . Creating variable **a** allows us to store a formula expression, with command **a :=**, press Σ icon to create sum, press $\frac{x}{y}$ to create fraction. In the numerators position of fraction press $($ icon, insert -1 and press $)$ icon, press x^y icon to create

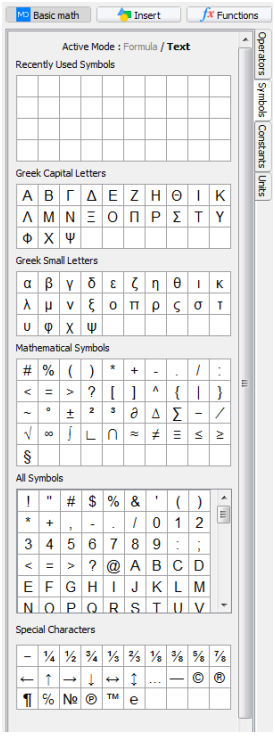
power over -1 and insert n into power position. Pressing the right keyboard arrow and cursor will leave power position, press • icon, insert symbol x and press x^y icon to create a power over x, insert 2n+1 on power position. Now, move the cursor to the denominators position, press (icon, insert 2n+1 and press) icon, press $n!$ icon to create factorial. Finally, place cursor on the sum lower border, insert 0, press right keyboard arrow to move the cursor on the upper border and insert it. To achieve the correct results to three decimal places, we will insert number 12 into upper border of sum. To check if the result is good enough, in new line insert **a=** to preview the result of value a, after that place the cursor anywhere in the canvas and type **sin(2)=.** Now we can compare results and conclude that the formula returns correct result.

$$x := 2$$

$$a := \sum_{n=0}^{12} \frac{(-1)^n \cdot x^{2n+1}}{(2n+1)!} \qquad \sin(2) = 0.909$$

$$a = 0.909$$

2.3.1.2 Symbols tab



Picture 11: Symbols

From this tab you can place various symbols in the document. They can be placed in text, formulas, tables and all other objects.

On Picture 11 you can see a table of all the symbols that can be placed in the document.

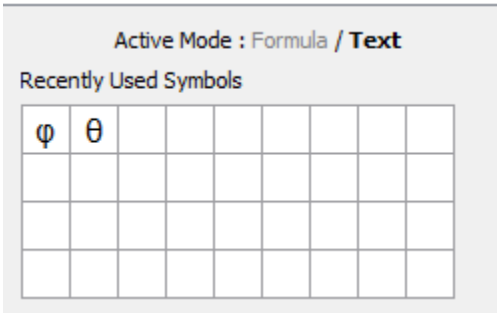
Symbols in this tab are divided in several groups: *Greek Capital Letters, Greek Small Letters, Mathematical Symbols, All Symbols* and *Special Characters*. Above them all is *Recently Used Symbols* group.

2.3.1.2.1 Example: Symbols

Create a table of trigonometric identities for product to sum.

Solution:

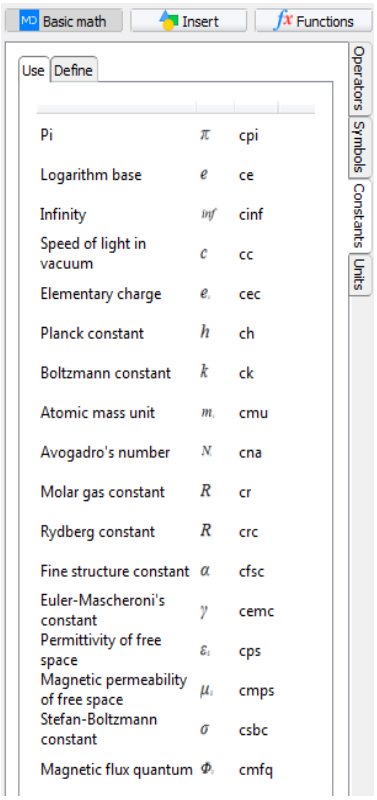
First, let's insert an empty table into the document. In the Place tab, press Table icon and choose a table of five rows and one column, click on the document and an empty table will appear in it. Place the cursor into the first row and type **Product to sum**, place it into the second row, type **2 cos** and press θ icon from Symbols tab, type **cos** again and press φ icon from Symbols tab, press = icon from Symbols tab, type **cos**, press (, θ , - , φ ,) , + icons from Symbols tab, type **cos**, press (, θ , + , φ ,) icons from Symbols tab.



We now finished the first identity, after repeating the procedure for other three we will have a table that looks like this

Product to sum
2 cos θ cos φ = cos (θ - φ) + cos (θ + φ)
2 sin θ sin φ = cos (θ - φ) - cos (θ + φ)
2 sin θ cos φ = sin (θ + φ) + sin (θ - φ)
2 cos θ sin φ = sin (θ + φ) - sin (θ - φ)

2.3.1.3 Constants tab

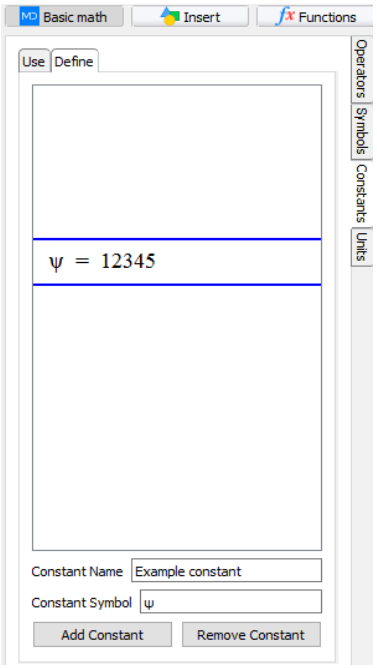


Picture 12: Constants – Use tab

In MatDeck, constants can be used as a part of Math object.

This tab contains constants of all kind. It is divided into two parts, ***Use*** and ***Define*** tabs.

On the ***Use*** tab we can find predefined constants. Second column on Picture 12 shows us how constants will look like when we insert them into the document. The Third column is keywords for inserting constant through formulas. Every keyword begins with the letter **c**. For example, if we want to insert Euler's number *e* we will type **ce** in the Math object.



Picture 13: Constants - Define tab

On the **Define** tab we can define new or remove existing constants.
To define a new constant insert *Constant Name, Constant Symbol* and click on the*Add Constant* button. Newly created constant will appear in constants list above, select it and define her value.
To remove constants we have to mark theconstant on the list that we want to remove and press the*Remove Constant* button.
Predefined constants can't be removed, only subsequently created constants will be listed and only they can be removed.

2.3.1.3.1 Example: Constants

*In this example we are going to create new constants **xyz** and use it in the calculation of variable **a** defined as **a = 15xyz/2e**.*

Solution:

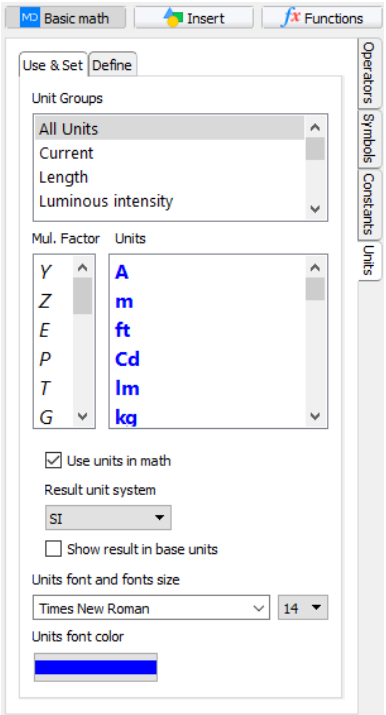
Go to the *Define* tab, enter constant name and constant symbol and press *Add Constant* button. After constant will appear in constant list, select it and enter value. For this example we defined constant
xyz = 4.72 m/s^2. As you can see, we can define constant with or without units.

Now, let's create a new variable in document: type **a :=**, from Operators tab press icon to create fraction, type **15 * cxyz** in the numerators position (when we type cx the auto suggestion will display constant xyz that we created earlier, the system will automatically add letter c in front of the constant), in denominators position type **2*ce** (ce command will create Oilers constant *e*). In a new Maths object type **a=**to view the value of the variable a.

$$a := \frac{15\ xyz}{2\ e}$$

$$a = 13.023\ s^{-2}\ m$$

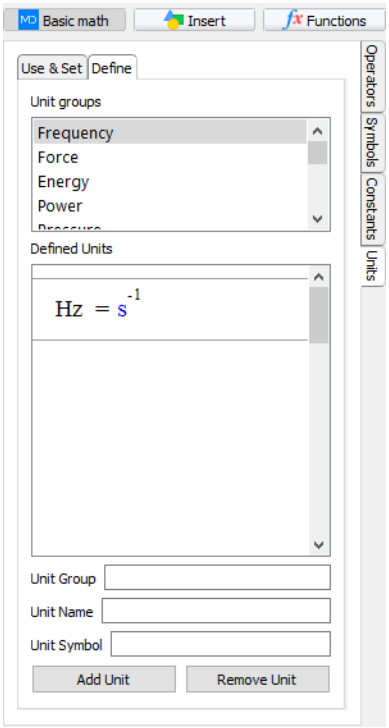
2.3.1.4 Units tab



Picture 14: Units - Use & Set

MatDeck documents allow us to use units in calculations as a part of Maths object.
If we define numerical value with units, the calculation in which we use that numerical value will be in units as well.

Tab **Use & Set** contains predefined units divided in to groups. All settings related to units are placed in this tab, main switch for showing units in document, system in which we want them to be shown (**SI** – International System of Units, **USCS** – United States Customary System), the way of displaying them (base or derived units), units style settings. *Multiplication factor* default state is multiplication and if it is set to other values it will multiply selected unit.
For example, if we choose multiplication factor **m** (milli) and insert **5 A** (amper) it will be defined as **5 mA**.



Picture 15: Units – Define

Tab **Define**, same as in Constants tab, we can use it to define new or remove existing units.
To define a new unit insert *Unit Group*, *Unit Name*, *Unit Symbol* and click on Add Unit button.
If we type a non existing unit group name in *Unit Group* field a new group will be created.Newly created units will appear in units list above, select it and define its value.
To remove an existing unit, select the unit and click *Remove Unit* button.
Predefined units can't be removed, only subsequently created units can be removed.

2.3.1.4.1 Example: Units

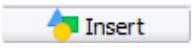
If a base of rectangle is b = 83 meters and a height h = 45 feet, calculate the area of rectangle in square feet.

Solution:

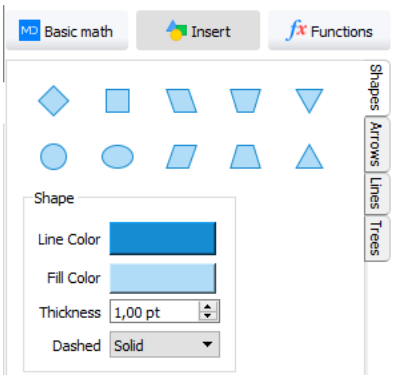
We will first create variables **base** and **height** with given length. Type **base:=83** and insert **m** after them, if ☑ Use units in math option is checked letter m will become blue meaning that it will be consider as a unit. Let's define another variable **height:=45**, and while cursor is behind the number 45 press **ft** from All Units group. These are two ways for inserting unit in document, pressing the preferred unit from list of units while cursor is placed in the canvas, or by typing unit keyword directly into the document.
After we created variables base and height, lets create variable **P:=base*height** and display her value in new Maths object **P=**. The unit in which the result will be shown as depends on what *Result unit system* we choose, as we are asked in this example to calculate area in feet squared, we shall choose USCS from square drop down menu.

$$base := 83\ m$$
$$height := 45\ ft$$
$$P := base \cdot height$$
$$P = 12253.937\ ft^2$$

2.3.2 Insert



2.3.2.1 Shapes tab



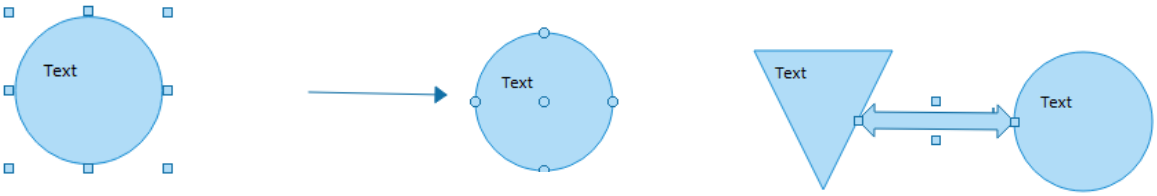
Picture 16: Shapes

This tab is designed for inserting various types of shapes in documents and their formatting. They can be only placed in the canvas object.

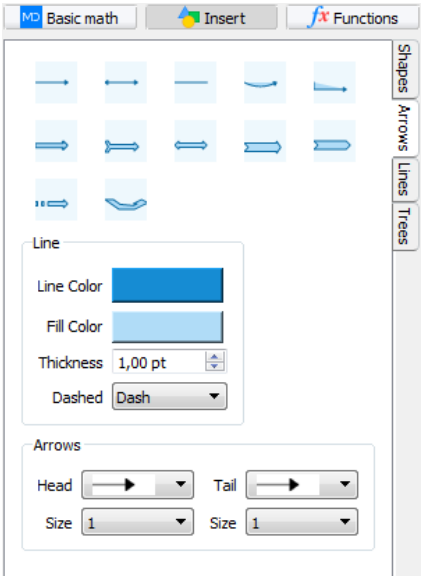
Shape object have text fields inside itself and when the shape is on focus we can resize it by moving surrounding blue boxes.

Shape object has the following style settings: Line Color, Fill Color, Thickness and Dashed.

When snap is active, centre of the shape object will be captured by snap.



2.3.2.2 Arrows tab



Picture 17: Arrows tab

Arrows are links to the objects that can be connected to shapes or can stand alone. They can only be placed in canvas object. To connect an arrow to a shape, place the arrow head on the shape connecting circles (shown on above picture in the middle).

When the arrow is on focus we can resize it by moving surrounding blue boxes.

Arrows have the following style settings: *Line Color, Fill Color, Thickness and Dashed.* Also they have optional parameters: *Head, Size* and *Tail Size* this affects only arrows from the first row on Picture 17.

Active snap does not affect arrow objects, so they can be placed freely on canvas, no matter if snap is on or off.

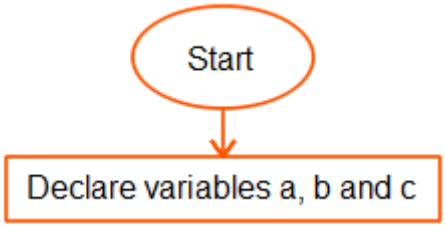
2.3.2.2.1 Example: Shapes and Arrows

Draw a flowchart to find the largest amongst three different numbers entered by user.

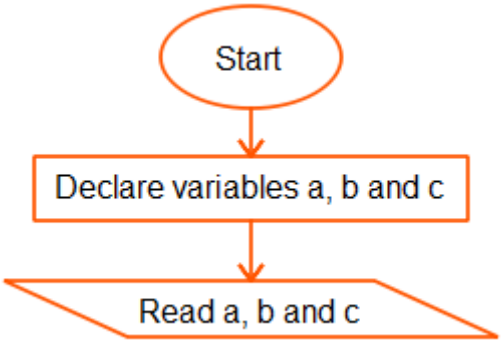
Solution:

We will start with an empty canvas object, from *Shapes tab* we choose ellipse and click on the place that we wanted to position it inside the canvas. Object resize was done by moving blue rectangles placed around that object, we placed the cursor inside the text field of the shape and typed **Start**. To change the style of the inserted shape, select shape and from Shapes tab you can change Line colour and Fill colour, Thickness and Dashed options.

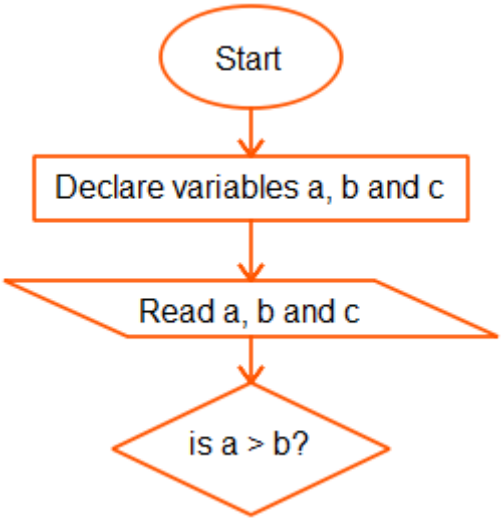
Now, we will choose shape and place it on the canvas, change its size by moving blue rectangles, change the shape style in the same way we changed the style of previous one and placed the cursor inside it to type **Declare variables a, b and c**. From Arrows tab choose arrow and move cursor above first shape, five blue circles will appear representing the possible places to start the selected arrow, choose the one from the bottom of the shape, press and hold left mouse button and move cursor above second shape, choose the top blue circle on this shape and release the arrow. Click on this arrow and change its style from the Arrows tab changing its colour and thickness. From the head drop down menu choose this option.



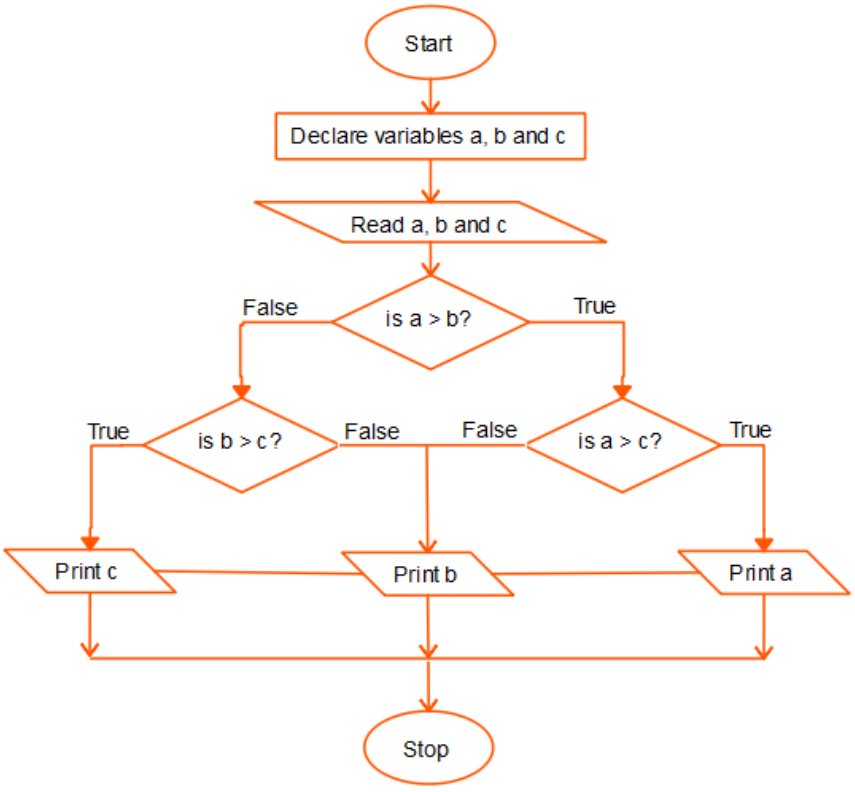
Choose shape, place it on the canvas, change its size, style and type **Read a, b and c** inside it. Again go to Arrows tab, choose arrow and draw this arrow in the same way as we did with the previous arrow. Select the newly created arrow and change its style and head.



Place a new shape, type **is a >b?** Inside, connect it with other shapes with arrow and set the style and size for newly created shape and arrow.

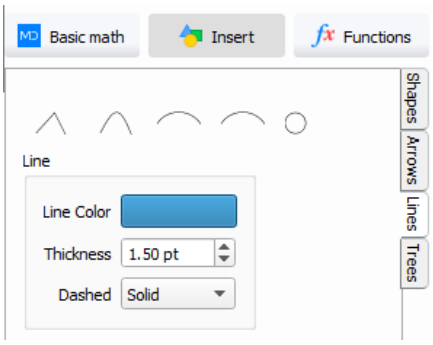


We will continue inserting shapes and arrows until we draw the whole flowchart from the picture bellow.



The text **True** and **False** that lies on the arrows was created as an Text Box object inserted from the Place tab.

2.3.2.3 Lines tab



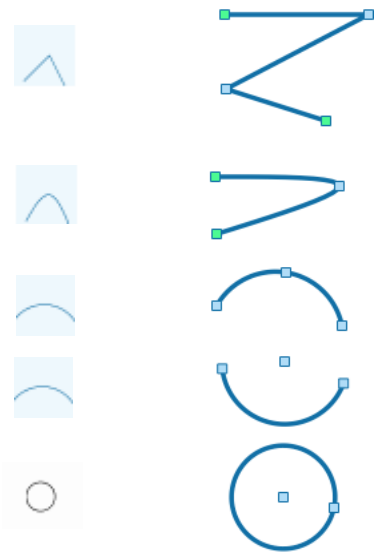
Picture 18: Lines

Lines tab is designed for inserting lines into the canvas object. There are five types of lines: *Noninterpolated polyline*, *Interpolated polyline, Arc* line, Circle Arc line and Circle line.

When we draw lines there are two types of line points, blue rectangle and green rectangle points.
The blue ones are points that can be moved with Ctrl. + left mouse click combination, deleted with a right mouse click and when you hold the left mouse click you can create two points from one.
Green rectangle points can be used to create new points which originate from the selected green point. If we want to move green points without creating new segments, use Ctrl + left mouse click combination.

Lines have the following style settings: *Line Color, Thickness* and *Dashed*.

When snap is active, points of the line will be captured by snap (read more about snap setting on Canvas properties).

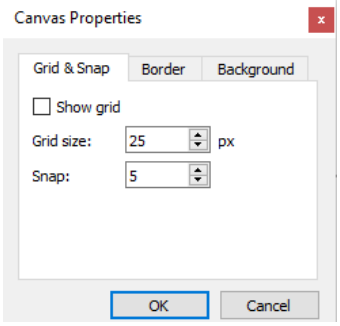


2.3.2.3.1 Example: Lines and snap

Draw resistor symbol for schematic diagram, one in an international IEC style and second in IEEE style.

Solution:

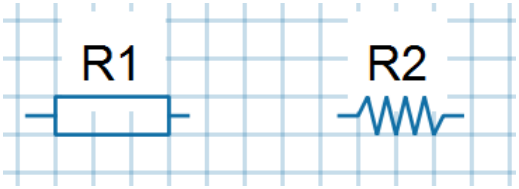
We will start with configuring of canvas grid and snap, so we draw these resistors as easily as we can. On the empty canvas object that we inserted from the Place tab->Canvas icon, press the right mouse button and choose the Properties option. Mark *Show grid* option and in the grid size field choose for example **10 px**, and set the snap value to **4**. We set grid size to such small value because we will zoom in on the document while we draw, so when we finish and zoom out to the default zoom the resistors will be precisely drawn and small enough. On the other hand, snap value were set to 4 this divides the grid square sides into four parts so we have a snap grid (invisible grid of snap) small enough for accurate drawing.



Now we can start, from *Lines tab* choose Noninterpolated polyline, place cursor on the canvas, and hold left mouse button to start

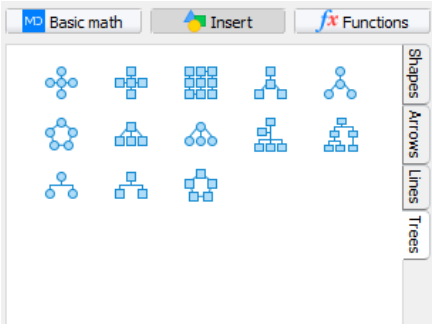
drawing a line. When you position the line on preferred place, release the mouse button and you have drawn your first line. As we already said the blue rectangle points are inner points that we can move with the left mouse click. Green rectangle points are the last points of the line whose movement creates new line segments. Continue with the drawing of resistor while pressing on the green rectangle points, hold the left mouse button and drag the cursor to place the end of the second point of the line in the preferred place. Continue this procedure until you have drawn whole resistor.

During the creation of every line segment, snap will grab line endpoints making it easy to place them on preferred positions. After we create preferred form, we insert *Text box* items from Place tab and enter names of the resistors R1 and R2 inside. At the end resistors will looks like the ones on Picture 19.



Picture 19: Example - Resistors

2.3.2.4 Trees tab



Picture 20: Trees

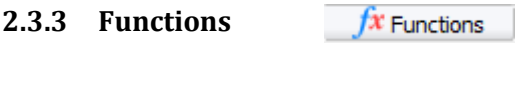
Trees are predefined structures composed of shapes and arrows. They can be placed on the canvas objects.

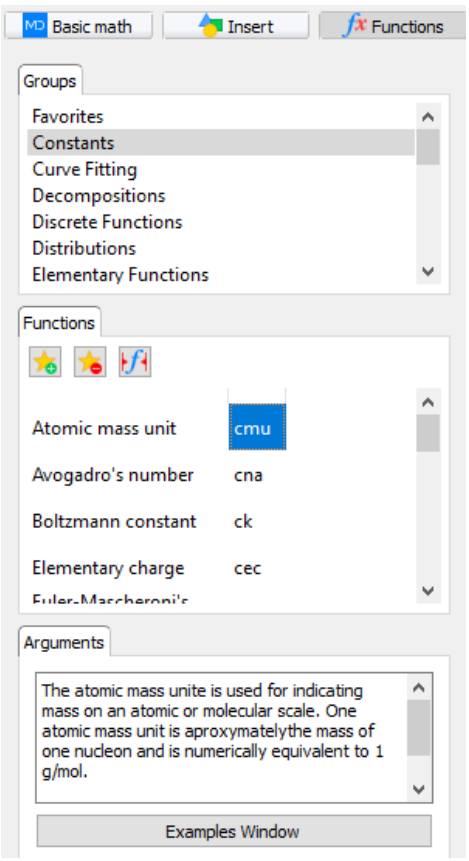
Every component of a tree can be moved up for itself. When the entire tree object is marked we can move it as one object.

If one of the components of the tree is marked the corresponding tab will open depending on what object of the tree is marked. So if shape object is marked, the Shapes tab will open, and if we mark arrow object, Arrows tab will open.

Active snap does not affect tree objects.

2.3.3 Functions





Picture 21: Functions

Functions area contains lists of all functions that can be used in MatDeck. The area is divided inn three ribbons: *Groups* ribbon, *Functions* ribbon and *Arguments* ribbon.

Groups ribbon contains list of all function groups including Favorites group.

Functions ribbon displays all functions that are in the selected group of Groups ribbon. Every function has a name and a command for insertion into the document.

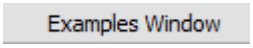
There are three buttons which we use to:

Add selected function in Favorites group;

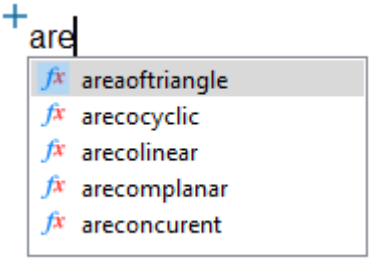
Delete selected function from Favorites group;

Insert selected function into the document.

Arguments ribbon contains descriptions of all function, return values and descriptions of every argument of the function.



Button will open a new window with a few examples of the selected function.



Picture 22: Functions autosuggestion

Functions can be placed on the canvas Math object in two ways: by typing commands for creating function in Math object (second column in Function ribbon), or by double clicking on the function in Functions ribbon while the cursor is active in Math object.
If we choose to insert a function in the first described way, the autosuggestion will help us. When we type the initial letters of a function command the autosuggestion will display all functions which commands begins with those initial letters, as shown on Picture 22.
When a function is placed in a canvas, if you place the cursor on the function and press the F1 key, the function help page will be opened in default web browser of your computer. Use this functionality to become familiar with function syntax and examples.

2.3.3.1 Example: Using of functions

Find the local and global extreme points of function f(x) = x^3 - 3x on interval [-3, 3].

Solution:

We will place an empty canvas object on the document, press Canvas icon, place cursor on document and press the left mouse button to place it. Now place the cursor inside the canvas and start typing **a:=x**, use Shift + 6 combination to place the cursor on subscript position and type **3**, use right keyboard arrow → to move cursor from subscript position, type **-3x**. In this method we will create a function and placed it in the variable a.

Now we will use the function *derivative* to find the first derivative of the function, then we will use the function *nonlinsolve* to find the solutions of nonlinear equation where first derivative is equal to zero. In this way we will find the critical points, candidates for local extremum. When the cursor is on the end of variable **a,** where we defined the function, press Enter key and new formula object will be created with the cursor within it. Type **nonlinsolve** and the function nonlinsolve(▯ , ▯) will appear, in addition we don't have to type whole name of the function, when we start typing the word after the second character typed autosuggestion will show us all functions whose names starts with that combination of characters that we typed. So we can type the whole name of function or just select it from autosuggestion. Place the cursor on the first argument position and type **equation** to create equation object ▯==▯, on the left side of equation we will insert function **derivative** $\frac{d}{dx}$ ▯ , and place variable **a** inside it. On the right side of equation we will place **0**, and as second argument of nonlinsolve function we will place value **x** meaning that we are solving equation with respect to x, type **=**to solve this equation. Solutions are -1 and 1 which are the critical points, we will determine what value is the maximum and what is the minimum if we calculate value of function in this points.

$$a := x^3 - 3x$$

$$\frac{d}{dx} a = 3x^2 - 3$$

$$\text{nonlinsolve}\left(\frac{d}{dx} a == 0 , x\right) = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

$$\text{replace symbols}(a , x , 1) = -2$$

$$\text{replace symbols}(a , x , 3) = 18$$

$$\text{replace symbols}(a , x , -3) = -18$$

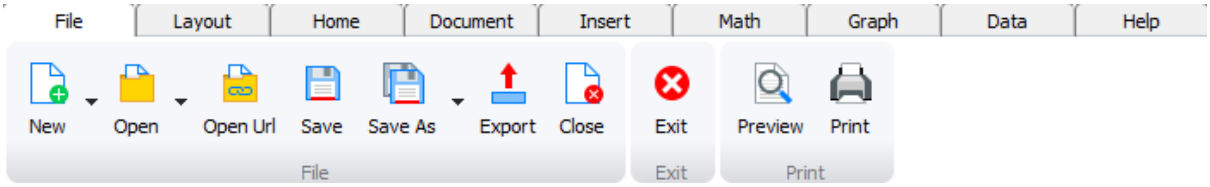
$$\text{replace symbols}(a , x , -1) = 2$$

We will use **replace symbols** function, after we type it it'll look like this replace symbols(▯ , ▯ , ▯). On first argument position type variable a, on second argument place type x meaning that in variable a we replace value x with third argument, and on third argument insert value -1. After we type **=**, we will have value of function in point -1. Repeat this process for values 1, -3 and 3 (-3 and 3 because they are the endpoints of starting interval).

Based on the given results we can conclude that global maxim of function is when x = 3, global minimum when x = -3, local maximum when x = -1 and local minimum when x = 1.

3 Ribbons

3.1 File Tab



Picture 23: File tab

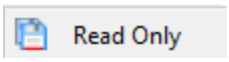
-The New file icon will create a new document with the generic name *Document1, New Script* will create a new script document;

-To open an existing file press *Open* icon

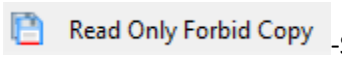
- To open file stored on the internet press Open Url icon and insert file address

-To save a file press *Save* icon

- Save a file under a certain name press *Save as* icon



-Save a file under a certain name with a read only attribute press Read Only icon



-Save a file under a certain name with a read only attribute without being able to copy content press Read Only Forbid Copy icon

-To export the document to a PDF or HTML file, press the Export icon

-To close a file press the *Close* icon

-To exit the application press the *Exit* icon

-To print preview a file press the *Preview* icon

-To print a file press the *Print* icon

3.1.1 Example: File tab

Let's create a simple document, save it to a desirable destination and close it. We will reopen that document, preview it, print it and on then save it like PDF document.

Solution:

When we start the MatDeck application, we need to create a new document by selecting the *New* icon

. We will save this document with name File Example.mdd and place it in a folder called Examples in Desktop. To save it press *Save* icon

and the new a window will open from which we can browse desktop of our computer, select Examples folder, type File Example in *File name* field and press Save button. On the top of the document tab, name will change and now it's name is File Example. At the end, press *Close* icon

to close the current document.

Now we will open this document, press the Open icon

, from the new window that appears browse the Examples folder on Desktop of our computer and select file **Example.mdd**(file that we created a moment ago). After we pressed Open button the document will open.

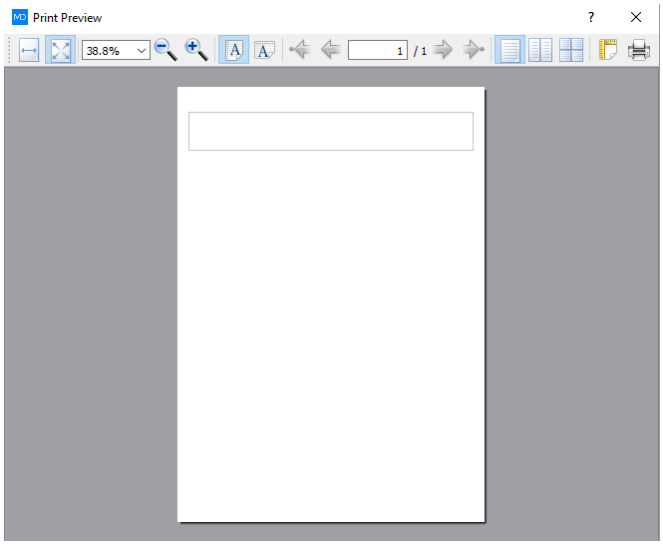
When document is open again, press *Preview* icon

and a new window will open from where we can see how the current document looks like before we print it (as shown on Picture 23). Now we will press *Print* icon

, the windows print dialog will open and now select your printer and press Print button to print the document.

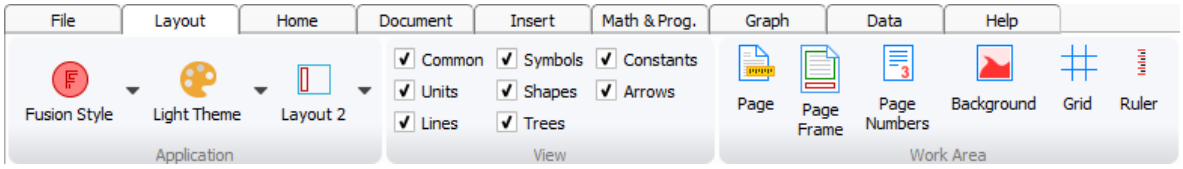
At the end we will save this document as PDF format file. To do so, press the *Export* icon

, choose the PDF option as the file format. Then select the location where the file will be saved and finally press the Save button.



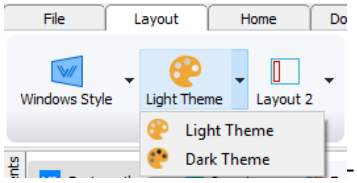
Picture 24: Preview of document

3.2 Layout Tab

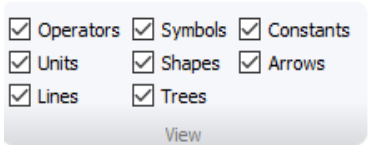


Picture 25: Layout tab

The layout thumb nail allows you to pick your preference in terms of the layout and view, it also allows you to change the page, frame, margins, header, footer, page numbers, background, grid, rulers and canvas properties.

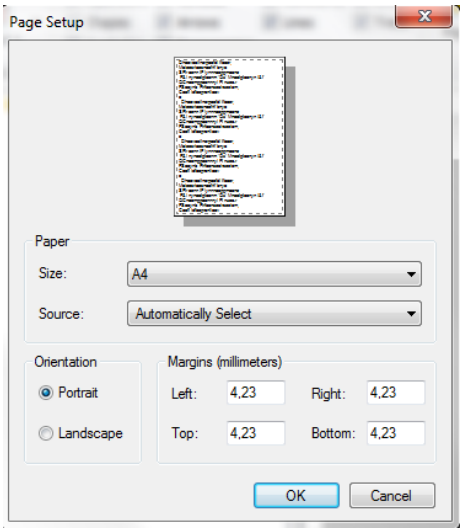


- To change the appearance of an application use the options available in the Application group which allow you to change the style, theme and layout of MatDeck by utilizing this group. To apply changes you have made to style and theme you will have to restart software



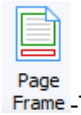
-To alter how you view the program click on the tick boxes

-To change the page setup press the ***Page*** icon and select the preferences you wish

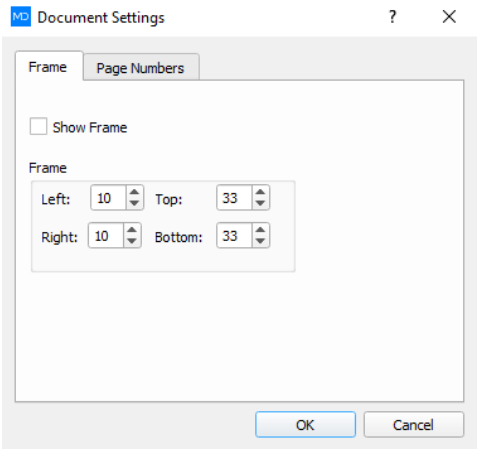


This allows you to choose the print size, source, orientation of paper and position of the margins.

Picture 26: Page Setup

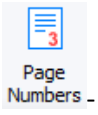


-To change the frame via the document settings press the *Page Frame* icon

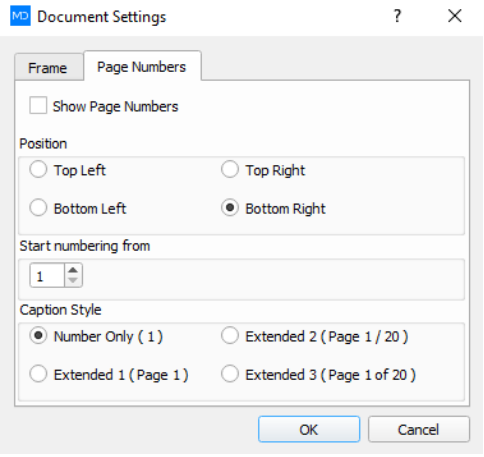


Here you can choose to show the frame or not, further more you can positions the frame where you want.

Picture 27: Document settings - frame

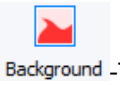


- To change the page numbers via the document settings press the *Page Number* icon

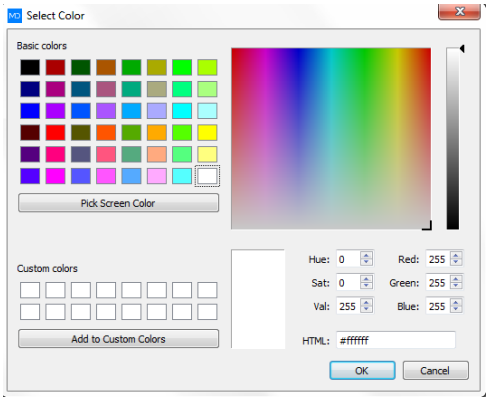


Choose if you want to show the page numbers and you can choose the position of the page numbers. You can also pick the caption style.

Picture 28: Document settings - page numbers



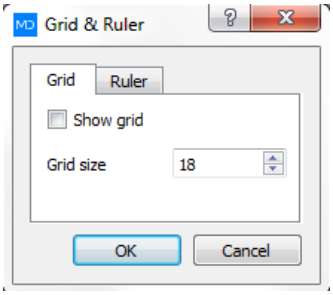
-To change the background colour press the *Background* icon



Select the colour you want your background to be by selecting either selecting a soil colour or making your own.

Picture 29: Select Colour

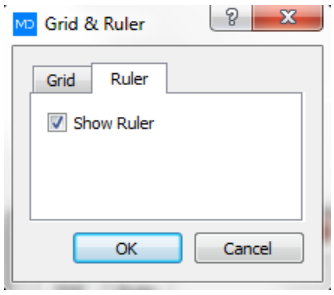
-To change the grid press the *Grid* icon



You can select if you want to show the grid and change the size of the grid. This grid affects the whole document and when it is turned off all grids on the canvas will automatically turn off. Also all individual settings of local canvas grids will be lost.

Picture 30: Grid tab

-To change the ruler press the ***Ruler*** icon

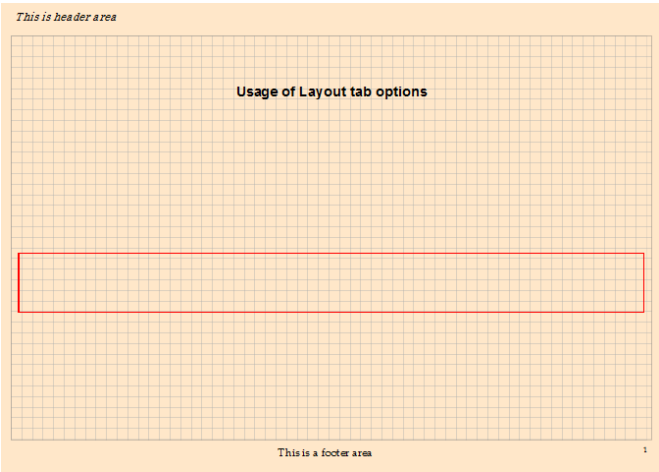


Click the tick box to select weather you want to show the ruler.

Picture 31: Ruler tab

3.2.1 Example: Document style setup

Let's create new document and set his style same as on Picture 32.



Solution:

From the File tab, press New icon to create a new document. From the Layout tab press Page icon and from the orientation section of window that just opened pick Landscape option. After we set orientation of document, press Frame icon and new Document settings window will open.

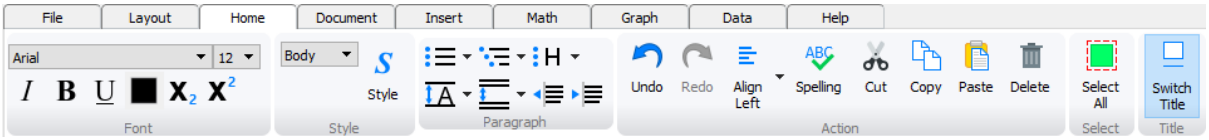
Picture 32: Example - Document style

Tick the option Show Frame and set left and right option of frame to **20**. Now go to Header tab of this window and from the drop down list of header font choose **Century**, size **14** and tick Italic option. Move to the Footer tab and for footer font choose **Palatino Linotype**, size **14**, from the Footer alignment drop down menu choose **Center**. On the last tab of the window *Page Numbers* tick Show Page Numbers option, position Bottom Right, caption style Number Only. Close the Document Settings window, press Background icon and from the new window that opened choose preferred colour of your document (pick same as on *Picture 32* if you want). Press the Grid icon , from window the *Grid & Ruler* tick Show grid option and keep the size of grid on **18**.

Now go to Place tab, press Canvas icon and click on the document to create new canvas object. Go to the Document tab, press Canvas Properties icon , on the Border tab of Canvas properties window tick Show border option and choose colour for the canvas border (we set it to red).

We just set all document style options that we have for our document to look like document on *Picture 34*.

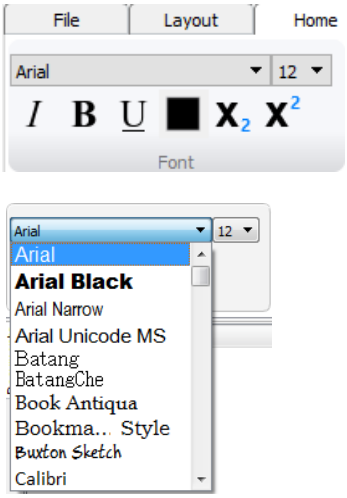
3.3 Home tab



Picture 33: Home tab

The home thumb nail allows you to do: editing and formatting of text, paragraph settings, style settings and clipboard actions. It also allows you to navigate through the document. In addition another feature is that it allows you to find, replace and create content.

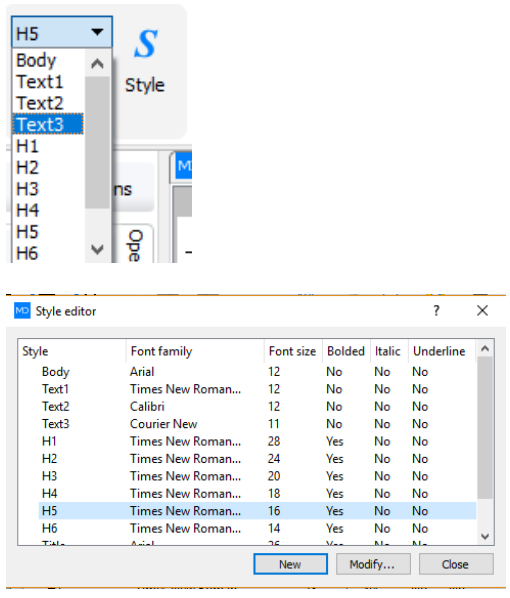
3.3.1 Font group



We can use settings from this group to change the font, letter size, colour and to make the font italic, bold or underlined. Also, we can set the subscript and superscript mode for the text.
Default font in MatDeck is **Arial**, size **12**.

Click the drop down menu to select the font you wish to write in and click the adjacent drop box to select the size of the font.

3.3.2 Style group



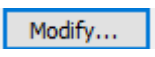
Picture 34: Style editor

Click the drop down box in order to choose the type of style you wish from any of the following choices.

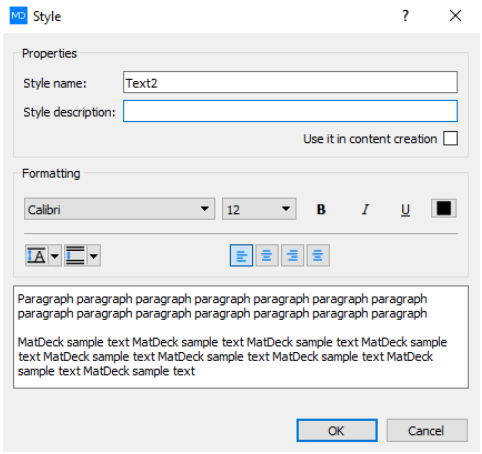
When you click on Style icon

the Style editor window will open from where we can modify and save any of the predefined styles (Picture 34).

If we press

or 

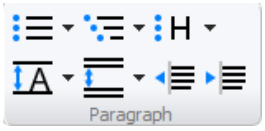
buttons the Style window shown on Picture 35 will open.



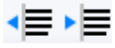
Picture 35: Style new /modify

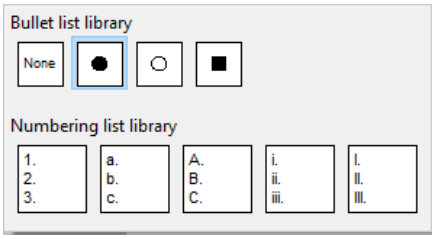
From this window we can define new or modify existing styles and adjust it to our needs.
We can define / change the name of the style and add a description. From the formatting part we can define / change the font, size, add Bold, Italic, Underline effect, define / change colour of the font, define / change the line and paragraph spacing and align the text.
Tick Use it in content creation option if you want to use these styles in the document Content styling, leave it if you don't plan to use it for document Content.

3.3.3 Paragraph group

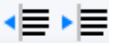


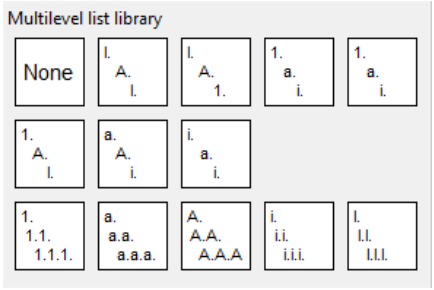
We can use the Paragraph group to change line and paragraph spacing, to create bullet points, multilevel and header lists and to change indent.

If you want to create bulleting list, select content from which we will create a list, press arrow to open the drop down menu, choose and press bulleting or numbering list from library. You can use the decrease and increase indent options  when one or more list items are selected, their list number or sign will change depending on indent level.

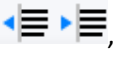


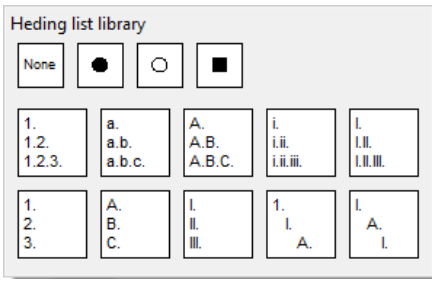
Picture 36: Bullet list library

If you want to create multilevel list, select content from which we will create a list, press arrow to open the drop down menu, choose and press the type of list you want to create. You can use the decrease and increase indent options  when one or more list items are selected, their list number will change depending on indent level and multilevel list type.



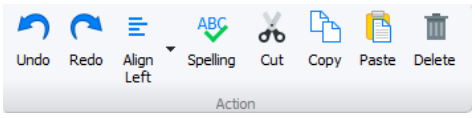
Picture 37: Multilevel list library

If you want to create a multilevel list of headings, choose arrow to open the drop down menu, choose and press the type of list you want to create and press icon in the end to activate the list type you have chosen.
Indent decrease and increase options  , in this case, will just move selected headings to the left or right without any change on list numbers.



Picture 38: Heading list library

3.3.4 Action group

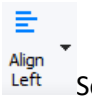


Picture 39:Action group

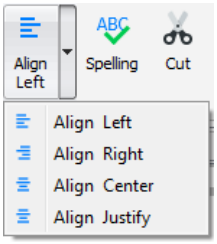
We can use the Action group to align items, check spelling, cut, copy, paste and delete items.
The following icons we can use to:

Undo an action.

To redo an action.



Set alignment of items, when the arrow on this icon is pressed a dropdown menu like the one in Picture 40 will appear.



Picture 40: Align menu

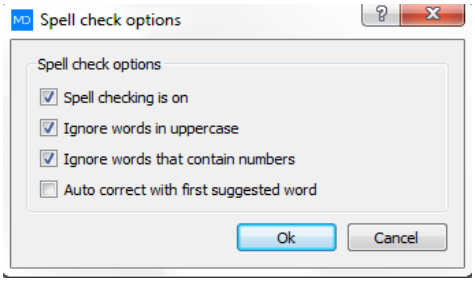
Check your spelling and punctuation. When it is pressed the window shown in Picture 41 will appear.

Copy selected content to clipboard and delete it;

Copy selected content to clipboard;

Paste content from clipboard;

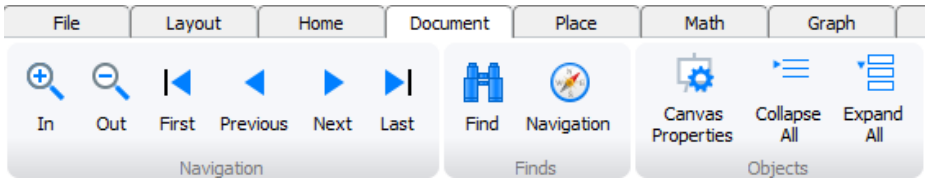
Delete selected content.



Picture 41: Spell check options

By clicking Spelling button it allows you to change the settings in spellings by selecting or unselecting tick boxes.
The settings we can choose in this window are: *Spell checking is on, Ignore words in uppercase, Ignore words that contain numbers, Auto correct with first suggested word.*

3.4 Document tab



Picture 42: Document tab

Purpose of this group is to help you navigate through the documents and make them easier to find. Following icons can be use to:

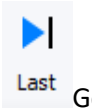
Zoom in on the file press, or use Ctrl + mouse scroll combination;

Zoom out of the file press, or use Ctrl + mouse scroll combination;

Go straight to the first page of the document;

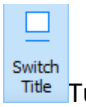
Go to the previous page of the document;

Go to the next page of the document;



Go straight to the last page of the document;

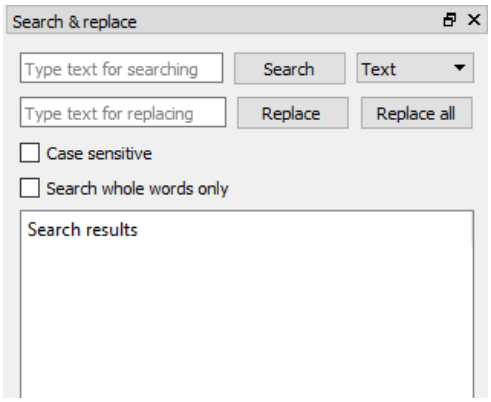
Select the entire current document;



Turn on/off title on menu icons (global setting).

The last two option icons belong to the Select group, but we can place them together in this user manual as they complement each other.

3.4.1 Search & replace



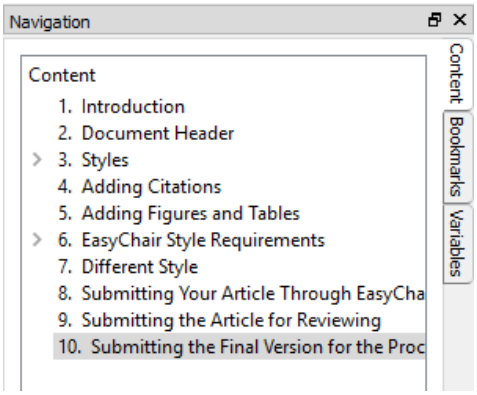
Picture 43: Search & replace

We can use the *Find* icon to open the menu from which we can search for text in the document or replace some part of it. Here we can type a text we wish to search and replace it with another text and we will be able to see all results in *Search results* form. We can choose if we want to search text, headings or bookmarks.
Available options are: *Replace all* search results, *Case sensitive* and *Search whole words only.*

In search results every line that matches the word or phrase that has been searched is a hyperlink to the place in document where it is found.

3.4.2 Navigation

3.4.2.1 Content tab

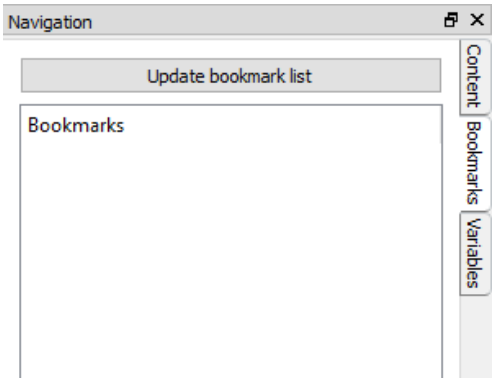


Picture 44: Content tab

We can use the Navigation icon to open the menu with three tabs in it, *Content tab*, *Bookmarks tab* and *Variables tabs*.

From the *Content* tab we can view content that we have created with the Content icon (section 3.5.12), with a list of all headings in the current document. The list is structured depending on heading style; every row in the list is linked to the heading position in the document.
For every document in the MatDeck program, the content tab will update and show the content state of the current document.

3.4.2.2 Bookmarks tab

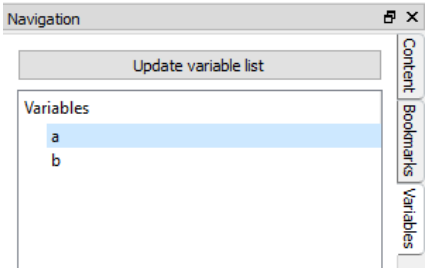


Picture 45: Bookmarks tab

Bookmarks tab contains list of all bookmarks in the current document. If we click *Update bookmarks list* we will see a list of all bookmarks in the current document. Every bookmark from this list is a link to the place in the document where the selected bookmark is placed.

Learn more about bookmarks from the Place tab section 3.5.3.

3.4.2.3 Variables tab

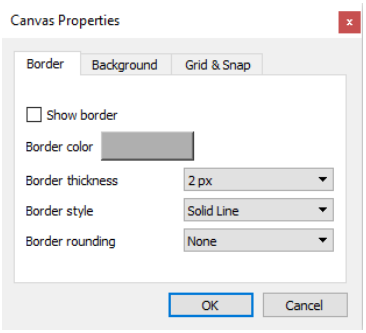


Picture 46: Variable tab

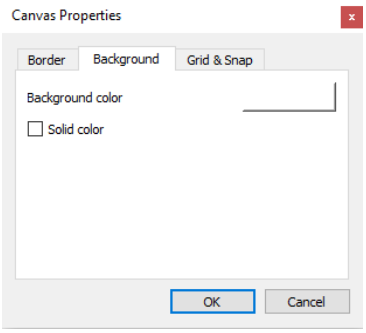
Variables tab contains a list of all variables defined in the current document. If we click *Update variable list* the list of variables will be displayed in Variable form.

3.4.2.4 Canvas properties

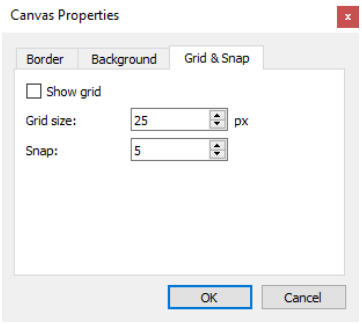
To open properties of the canvas press the *Canvas Properties* icon, this setting is global for all canvases on current document.



Picture 47: Canvas Properties- Border



Picture 48: Canvas Properties- Background



Picture 49: Canvas Properties – Grid & Snap

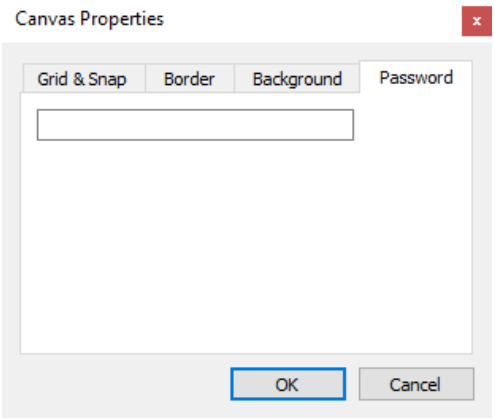
From the window shown on Picture 47 you can set the canvases auto size on or off, to have borders, their colour, thickness, style and rounding of that border. Setup of canvas borders from Document tab->Canvas properties->Border tab is a global setting and will refer to canvases in whole current document. The default state for this setting when we create a new document is **Show border on.**

From the window shown on Picture 48 you can set the canvases to have background colour. There is an option to set this colour to be transparent or solid.

From window shown on Picture 49 you can set the grid and snap of the canvas and also its border. If we already set these parameters for one or more canvases in document, settings opened from Canvas Properties icon will be applied to whole document ignoring the individual canvas settings. Grid size can be set in range 5 – 40 pixels, and snap setting represent how many parts we would like to divide one grid rectangle by. Snap size can be set from 1 to current grid size, if set to one this means that grid and snap are the same.
To see usage of canvas grid and snap view Example: Lines and snap.

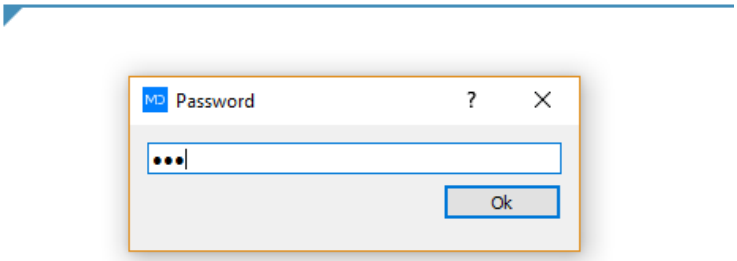
If you want the *Canvas Properties* settings to refer only to a single canvas, use the right mouse button Properties option on it.

If you enter the Canvas properties window from the right mouse button context menu, it will have a fourth tab called *Password*.



Picture 50: Password tab

From this tab you can set a password for your canvas, so when you collapse the canvas and you try to expand it a new Password window will appear as shown on Picture 51. The canvas will collapse into a horizontal line with a right angled triangle in the left corner. To reopen the canvas you must click on the triangle in the corner.



Picture 51: Password window

You will have to enter the correct password, the same as the one that you have set earlier in the Password tab, to make the canvas expand.

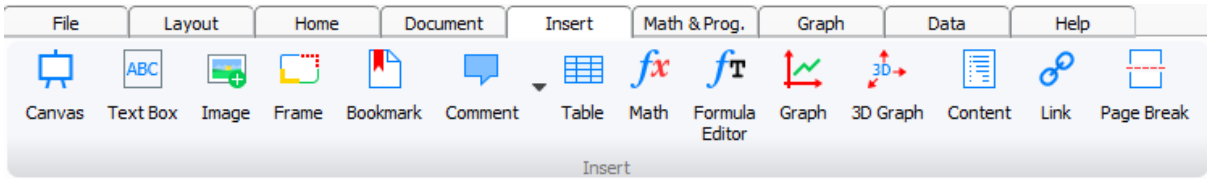
To remove the canvas password, go to the Password tab (Picture 50), remove the password from the text field and press OK.

3.4.2.5 Collapse All and Expand All

- To collapse all texts and canvases on the current document use Collapse All icon;

- To expand every collapsed text or canvas on the current document use Expand All icon.

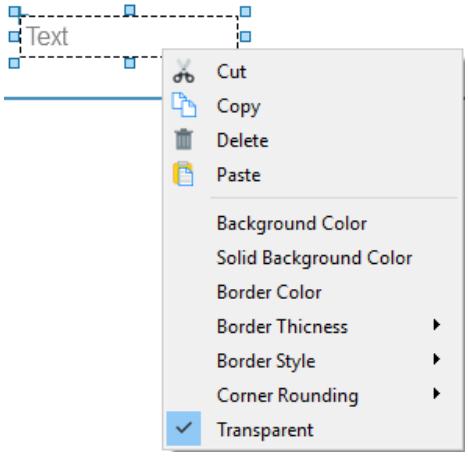
3.5 Insert tab



Picture 52: Insert tab

The insert thumb nail allows you to place text boxes, images, bookmarks, comments, content, links and page break. Furthermore you can also place tables, canvases, maths formulas, graphs and 3D graphs.

3.5.1 Text box



Picture 53: TextBox options

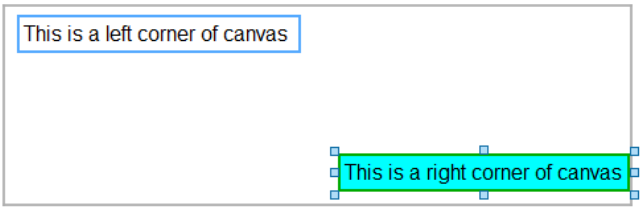
To insert a text box press the *Text Box* icon

and click on the canvas to position where you want it.

Text box can be placed only in the canvas object of the document. You can drag and drop it in the canvas object to position it. To resize it move the surrounding blue boxes.
Right clicking on the text box opens up a menu that is shown on Picture 53, from this menu we can set the background and border colour, border thickness and style, turn solid background colour on or off, set corner rounding, set transparency. The default setting for borders and background colour is white (no border).

3.5.1.1 Example: text box use

Create two text boxes, place them in canvas corners and set the style of your choice.



Picture 54: Text box example

Solution:

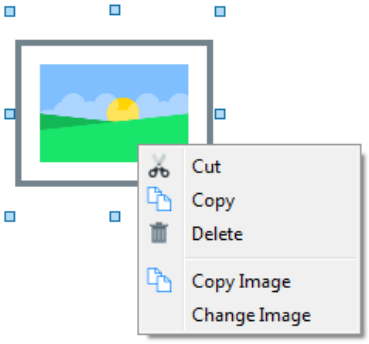
Create a new document by pressing the New icon

, press Text box icon

and select place on the document where you want to place it. New canvas object will be created with Text box inside it. Place the cursor inside the Text box object and type “This is a left corner of canvas”, resize text box by moving the surrounding rectangles so the text that we typed takes up only one line. We will change the place of the text box by the drag and drop technique and place it in the top left corner. With the right mouse click press, content menu (Picture 53) will open, choose Border colour option and set the preferred colour (we set it to blue). Now we will insert another text box, again press Text box icon

and select a place on the document where you want to place it. Type “This is a right corner of canvas”, resize the text box so it only takes up one line and move it to bottom right corner of the canvas (when you want to move Text box, place the cursor above the canvas and drag and drop it to the preferred place). Open the content menu of this text box and change its border colour (we set it to green), after that open the content menu again and choose Background colour option and change them (we set it to blue). On Picture 54 you can see the final look of document.

3.5.2 Image



Picture 55: Picture options

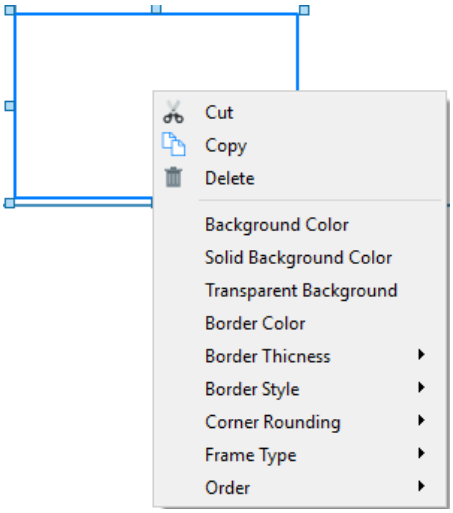
To insert an image object press the *Image* icon

and click on the canvas to the position where you want to place it.

An image can be placed only in the canvas object of the document. You can drag and drop it in the canvas object to position it. To resize it move the surrounding blue boxes.

To set the picture double click on image object and *Open Image* window will open you can choose a image. Right click on the text box and a menu opens that is shown on Picture 55, from which we can set/change image.

3.5.3 Frame



Picture 56: Frame options

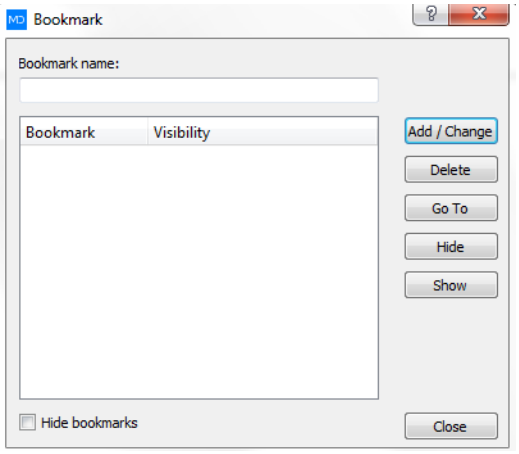
To insert a frame object press the *Frame* icon

and click on the canvas on the position where you want to place it.

A frame can be placed only in the canvas object of the document. You can drag and drop it in the canvas object and position it. To resize it move the surrounding blue boxes.

Right clicking on the frame opens up a menu that is shown on Picture 56, from which we can set background and border colour, border thickness and style, turn solid background colour on or off, set corner rounding and frame type. From this menu you can also move the frame in front or behind other canvas objects.

3.5.4 Bookmarks



Picture 57: Bookmark window

To insert a bookmark press the *Bookmark* icon

and click on the canvas to the position where you want to place it.

Bookmarks can be placed only in the canvas object of the document. You can drag and drop it in the canvas object to position it.
From the bookmark window that is shown on Picture 57 you can *Add* new or *Change* existing bookmarks, *Delete* bookmarks, *Hide* or *Show* them. Also there is an option *Hide bookmarks* that will hide all bookmarks in the document.
Bookmarks are linked so by clicking Go To you will be taken to the place in the document where the bookmark is. We can view the list of all bookmarks in the document from the Home tab->Navigation icon->Bookmarks tab described in section 3.4.2.2.

3.5.4.1 Example: Images and bookmarks

Create a new document with two canvases, in every canvas insert a picture with a caption.

Solution:

Create a new document by pressing the New icon

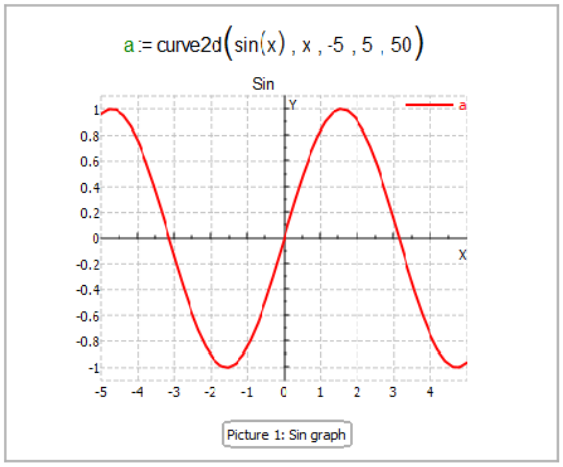
, press Canvas icon

and select the place on the document where you want to place it, press Image icon

and select the position on canvas where you want it to be placed. Double click on the image object, a new window will appear and from here you have to select the picture which you are placing into the document (we prepared the picture of function sin). After the picture is inserted resize it by moving the surrounding blue rectangles. Drag and drop the picture to place it in a central position on the canvas.

We will now insert a Bookmark item, press the Bookmark icon

, select and press the place under the picture to insert a bookmark. A new window will open, in the Bookmark name field type text “Picture 1: Sin function” and press Add/Change button. After we have finished this action the document will look like on Picture 58.



Picture 58: Image and bookmark example

Place the cursor under the canvas and press enter on the keyboard a few times, press the Canvas icon

and select a place on the document where you want to place it, press Image icon

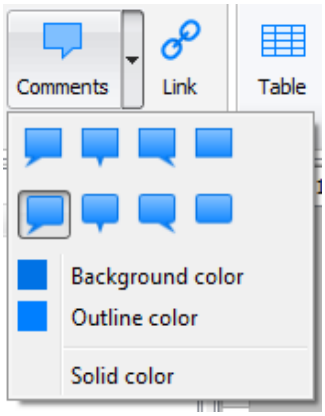
, select and press place on the canvas where it will be placed. Double click on the image object; a new window will appear from where you have to select the picture for placing into the document (we prepared the picture of function cos). After the picture is inserted, resize it by moving the surrounding blue rectangles and drag and drop the picture to place it in a central position of canvas.

Insert a new bookmark item, press Bookmark icon

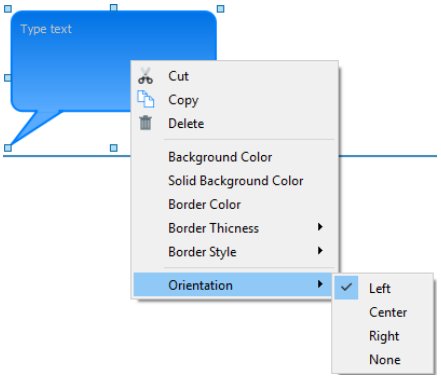
, select and press the place under the picture to insert a bookmark. A new window will open, in the Bookmark name field type text “Picture 2: Cos function” and press Add/Change button.

Now go to the Home tab->Navigation icon->Bookmarks tab, press Update bookmark list button to create a list of all bookmarks in the current document. A list will have two items, one for every bookmark we place in the document. Each item from the list is a link to the place in document where the bookmark is set.

3.5.5 Comments



Picture 59: Comment drop down menu



Picture 60: Comment options

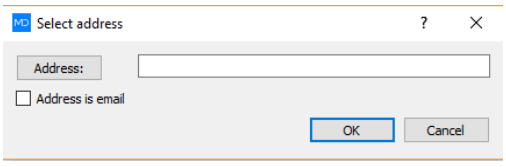
To insert a comment press the *Comments* icon

and click where you want to place it.

Comments can be placed only in a canvas object of the document. You can drag and drop them into a canvas object.
If you press the right arrow from the Comments icon a drop down menu will appear which allows you to pick the shape of the comments and change the background and outline colour (Picture 59).

Right clicking on the comments opens up a menu that is shown in Picture 60 from which you can also change the background and border style and colour, select the orientation of the comment...

3.5.6 Link



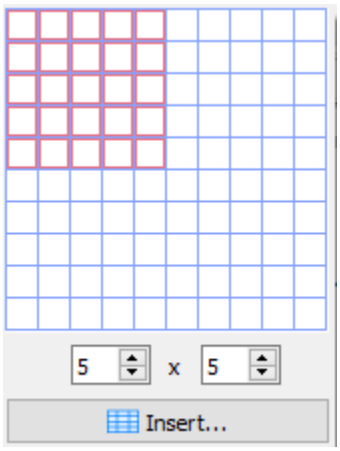
Picture 61: Linking

You can link the text in a document if you select it and click Link icon

. The Selected address window will open (Picture 61).
Only regular text could be linked, you cannot insert a hyperlink on text which is in the canvas.
If the text you are linking is an email address, tick the option Address is email and in the address field we will type mailto: prefix.

3.5.7 Table

Table is one of the objects that can be placed in a canvas. To insert a table press the *Table* icon, chose the preferred size of table and click in the canvas to the position where you want to place it.

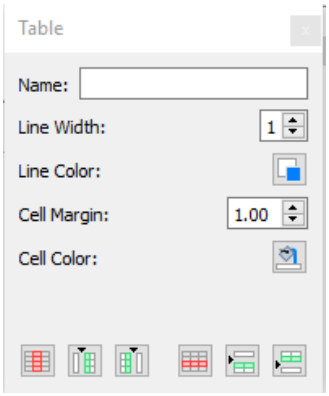


Picture 62: Insert table

You can insert a table in the canvas as an independent object. A table inserted in the canvas can be resized by moving the surrounding blue boxes which you can see when the table is selected.

The drop down menu allows you to create a table of whatever size you wish. Only tables in the canvas can have a name.

A whole table could be selected if you position the cursor arrow in the top left angle of the table, to select a table row position the cursor arrow left from the preferred row, if you position the cursor arrow above the column you can select that column.



Picture 63: Table properties

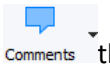
When you place the cursor inside the cell of the table or select any part of it, the *Table* window will open (Picture 63). From this Table window you can set*: Name* of table, *Line Width, Line Colour, Cell Margin, Cell Colour*, Delete column, Insert column to right, Insert column to left, Delete row, Insert row under and Insert row above.

3.5.7.1 Example: Comment, link and table

Insert two comments in the document; create a table with a description of the characteristics of each of the comments. Make the descriptions link to external pages with more information about them.

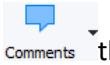
Solution:

Create a new document by pressing the New icon

, press Comments icon arrow 

then select and press the type of comment you prefer (we inserted comment), place and press on the document where you want to place the comment. A new canvas object will be created with the same comment you have choose to place inside it.

Place the cursor in the comment text area and type “This is first comment”. Press on the right mouse button when the cursor is above the comment and from the content menu select Background colour option, from the Select colour window pick a colour and press Ok. Open content menu again and choose Line colour option, select the colour of the line and press Ok. From content menu choose Solid colour option. Drag and drop the comment to the top left corner of the canvas. If you have made an error during the selection of the comment style .Use options from the content menu Orientation these will help you to switch comment tail to the preferred side.

We will now enter another comment, press the Comments icon arrow 

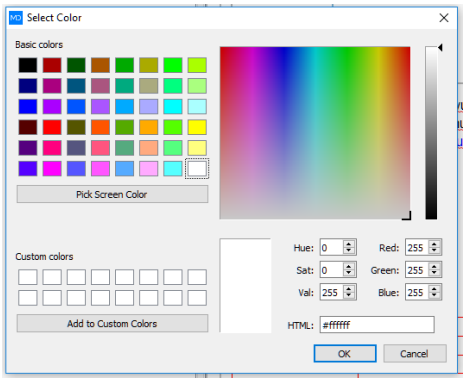
then select and press the type of comment you prefer (we inserted comment), place and press on the canvas where you want to place a comment. Place the cursor in the comment text area and type “This is second comment”. Do the background and line colour change with the same steps as we did for first comment.

	Background	Line colour	Solid colour
First comment	#00ffff	#aa00ff	Yes
Second comment	#aaaaff	#ff0000	No

Picture 64: Comments, link and table example

Press on the Table icon

and choose matrix 3x4 size. To insert it place the cursor in the document on the preferred place and click the left mouse button. An empty table will appear, in the top row enter the column names as shown on Picture 64. Insert the text to the first column and change the colour code of the text then change the background and line colours for each of them. You can view colour codes from the content menus options for every text individually.



Place the cursor in the cell with the colour code, hold Shift and press the left arrow keyboard key until the whole text in the cell is selected. Press on the Link icon

, in the Address field insert the url of the internet address which you want to link colour code for and press Ok. Repeat these steps for all of the colour codes from table.

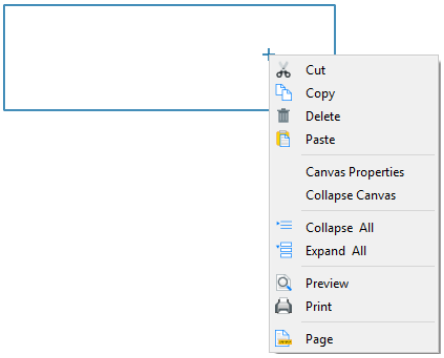
Place cursor on the top left corner of the table, the cursor will

change to a black arrow, press the left mouse button to select the whole table. From the Home tab, press the Align icon arrow

and choose Align center to align the whole table text. From Font group select icon and change the text font colour in the whole table (we set our font colour to orange).

3.5.8 Canvas

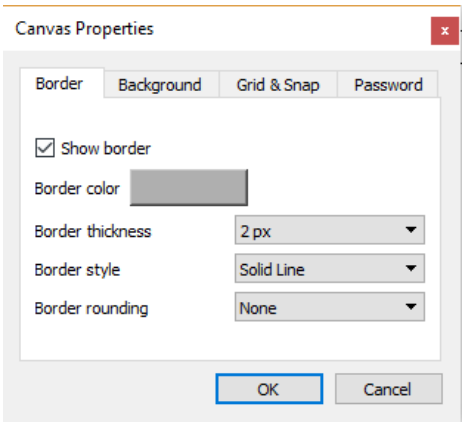
The canvas is a container object for several types of objects. In the canvas we can place: formulas, graphs, images, comments, text boxes, bookmarks, tables, data objects, shapes, arrows, lines and trees. To insert a canvas object press the Canvas icon and click on any unused part of the document in order to place the canvas.



Picture 65: Canvas

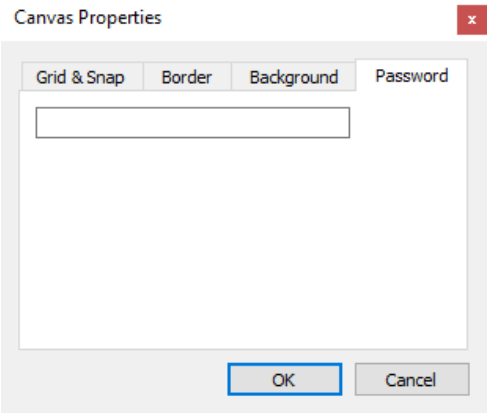
A Right mouse click will open the menu shown in Picture 65, from this menu you can Collapse Canvas and open canvas *Properties*.

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,*3.4.2.4*). 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 66). When you select the canvas its border colour is blue.



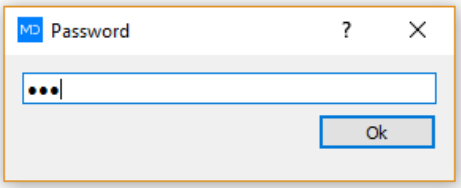
Picture 66: Canvas Properties – border

Canvas background colour can be set from Background tab. You can resize the canvas if you adjust indents using the ruler when the cursor is in the canvas.



Picture 67: Password tab

From the Password tab you can set a password for the canvas, so when the canvas is collapsed and you try to expand it, a new Password window will appear as shown on Picture 68. The canvas will collapse into a horizontal line with a right angled triangle in the left corner. To reopen the canvas you must click on the triangle in the corner.



Picture 68: Password window

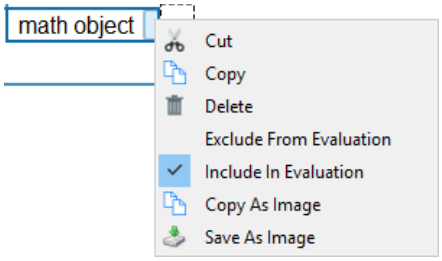
You will have to enter your password, the same as the one that you have set earlier in the Password tab, to make the canvas expand.

To remove the canvas password, go to the Password tab (Picture 67), remove the password from the text field and press OK.

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**.

3.5.9 Math

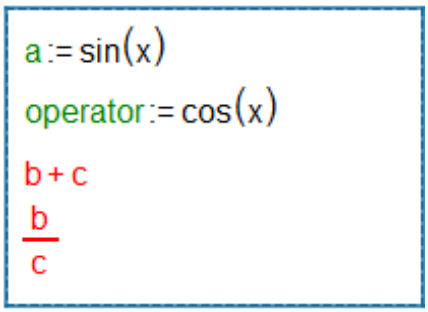
We can use a Math object when we want to insert functions, equations, to define variables or to do programming. There are the four ways to insert a Math object in the document: press the *Math* icon and click in canvas on the position where you want to place it; double left mouse click on the canvas to the position where you want to place it; single left mouse click in canvas to position where you want it (icon + will appear) and begin to type; press the *Math* icon and click in the document, a canvas will be placed and inside it there will be a Maths object.



Picture 69: Maths object

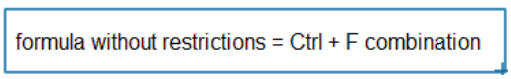
Math objects consist of a formula part which is bordered blue on Picture 69 and a formula caption bordered with dashed rectangle. Both the formula and caption part will resize depending on the content in them.

Use Include/Exclude from the Evaluation options to increase the evaluation speed of a document (excluded math objects won't be considered during evaluation of the document).
If you type *Enter* in a math object, a new one will be created in the line under the current line. Use the left arrow key to return to the first math object.



Picture 70: Variable declaration

Operators in the math object can be placed from the keyboard, from the Operators tab (described in section 2.3.1.1) or from Symbols tab (described in section 2.3.1.2).
There are some operators which have restriction when you want to use them:
a) := operator can be used only when we define a variable in one line (space included); fraction, expression, expression in borders can't be declared as a variable (Picture 70);
b) **{** operator can be used only when you want to construct a function body after *function name()* combination, in every other case you won't be able to use it.



Picture 71: Formula

If you want to create an equation that will be solely used for presentational purposes use combination of **CTRL** and **=** inside of a math object. After this an equal sign will appear inside the math object, after this you can type in the math object without an automatic calculation occurring. You can alternatively, use the **Ctrl** and **F** combination that transforms the mathematical node into a text node that can be used without restrictions. These are all one-sided operations because you can't switch to the math objects rules again.

3.5.9.1 Example: Canvas and Maths

Define function f(a, b, c) = $9\frac{abc}{a+b+c}$ *and calculate* $\frac{df}{dc}$*(a, b, c) at the points (a, b, c) = (1, -2, 4).*

Solution:

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

Type **f:=9*(a*b*c)/(a+b+c)** and a new variable will be created. Press the **Enter** key on the keyboard and a new Maths object will be created under the existing one with the cursor in it. We can calculate the derivative of function f using the function **derivative**. Type **derivative** and a new function will be created $\frac{d}{dx}\square$, place the cursor in an empty node (object with red border inside function), and type variable **f**, move the cursor to the denumerator position, replace letter x with letter **c** and type **=**. In this way we will calculate and display the first derivation of function f with respect to c.

Now let us create a new variable **x** and **use replace symbols** function to replace the symbol a with the value of 1 and store the result in variable x. To do so type **x:=replace symbols** or use auto suggestion that will appear after the second character has been typed. A new function will appear $x := \text{replace symbols}(\square, \square, \square)$. In the first empty node enter the derivative function again, and calculate the first derivative of function f with respect to c, in the second node type character **a**, and inside the third node type number **1**. The meaning of this function is that we are going to replace value a with number 1 in the first derivative of function f and store the result in variable x.

Now we will create variable y and store the result of the new replace symbols function. Type **y:=replace symbols**, in the first node enter variable **x**, in the second node enter value **b** and in third enter number **-2**. At the end create the variable **z:=replace symbols**, in the first node type **y**, in the second type the value **c** and in the third type the number **4**. We have now replaced values a, b and c with numbers 1, -2, 4 respectively, in the first derivative of function f with respect to value c. To see the value of first derivative at the point (1, -2, 4) type **z=**.

$$f := 9\,(a\,b\,c)/(a+b+c)$$

$$\frac{d}{dc}\,f = \frac{9\,a^2\,b + 9\,a\,b^2}{a^2 + 2\,a\,b + 2\,a\,c + b^2 + 2\,b\,c + c^2}$$

$$x := \text{replace symbols}\left(\frac{d}{dc}\,f\,,\,a\,,\,1\right)$$

$$y := \text{replace symbols}(x\,,\,b\,,\,-2)$$

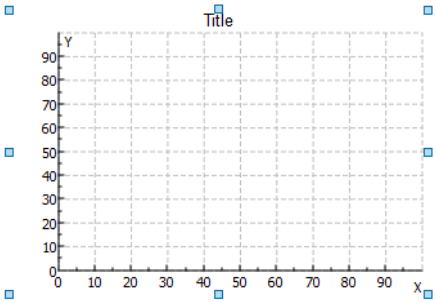
$$z := \text{replace symbols}(y\,,\,c\,,\,4)$$

$$z = 2$$

3.5.10 Graph

We can use graph object when we want to plot a 2D graph. This object can only be inserted in a canvas. We have 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 graph in it we press the *Graph* icon and click in the canvas to 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 second column are y-axis data in the graph. 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**.



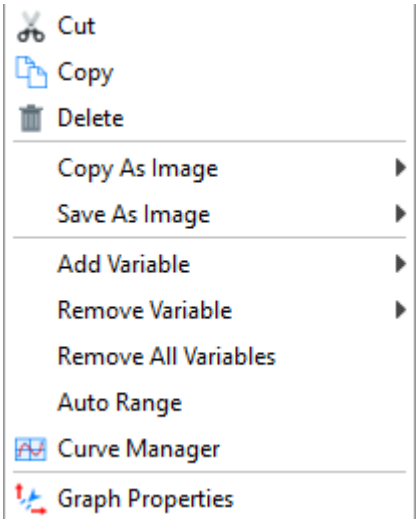
Picture 72: Graph object

This is what a default graph will look like once it has been inserted into the document (Picture 72). 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 73 will appear.



Picture 73: Graph dropdown menu

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

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

Remove Variable option will show a list of variables that we can plot on our current graph from which you could choose what variable you want to remove from the graph.

Use *Remove All Variables* option to remove all the plots from graph.

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* opens a new options windows, Graph properties and Display properties that have detailed described in Graph Tab section (Picture 142 and Picture 135).

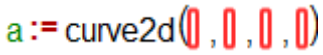
3.5.10.1 Example: Graph

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

Solution:

Create new document by pressing the New icon

, press 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 results of function **curve2d** in it. 

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. Simply put, 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

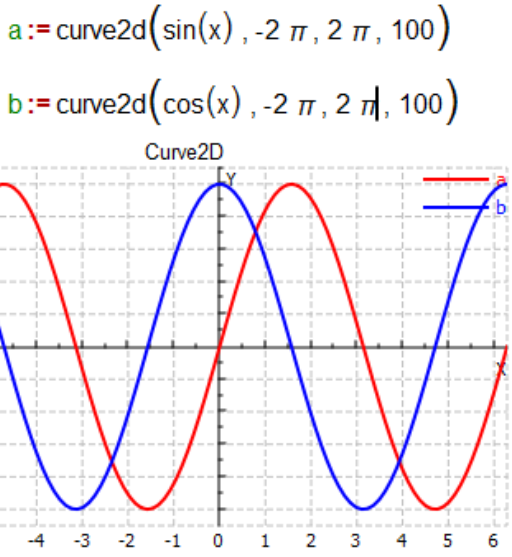
, then type symbol **x** as its argument. In the second node type type **-2*cpi** (this is a standard way of inserting constants π in to the document, every constant has a character c in front of it), in the next node type **2*cpi** and in the last node type 100 for example.

From the 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 select the content menu and press Add variable option, now choose 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

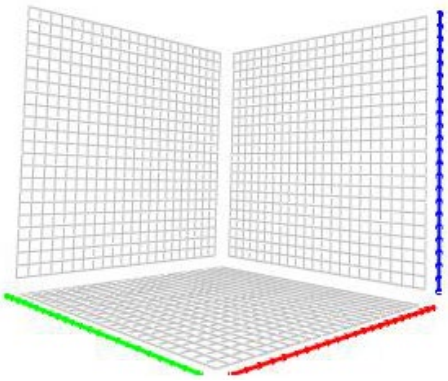
and type the symbol **x** as its argument. In the second node type **-2*cpi**, in the next node type **2*cpi** and in the last node type 100 for example. From the right mouse button click select the content menu and press Add variable option, now choose variable **b** that we have just created. A cosine function graph will appear.



3.5.11 3D Graph

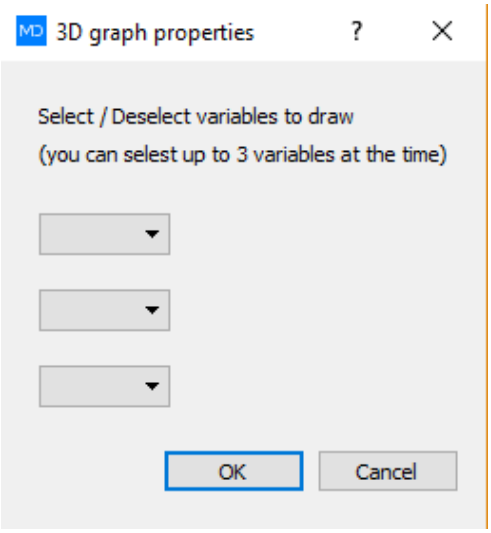
We can use 3D graph objects when we want to plot a 3D graph. This object can only be inserted in the canvas. We have two ways of inserting a graph object in the document: press the*3D Graph* icon and click in the document, a canvas will be placed and inside it there will be a 3D graph object; if we already have a canvas in the document and we want to insert a graph in it we will press the *3D Graph* icon and click in the canvas to the position where we want to place it.

To plot a 3D graph you have to define a variable and store data in it. Only data stored in matrix of vectors can be plotted, every vector represents one point in 3D space with x, y and z coordinates. The minimal number of points which can be plotted on a3D graph is four, so the minimal matrix size for plot is 2x2. Functions that place the data in such a matrix and thus prepare them to be drawn in the 3D graph are: **surface3d, curves3d**.

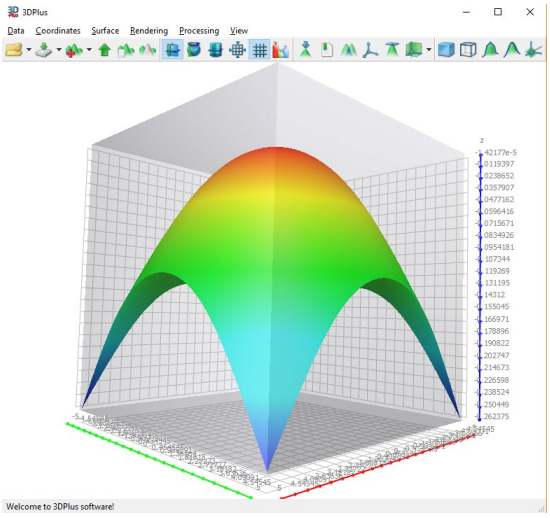


Picture 74: 3D graph object

This is what a default 3D graph will look like once it has been inserted into the document. Use the surrounding blue boxes to make the graph bigger or smaller.
If you right click on the 3D graph object a dropdown menu will appear with *Save As Image* and *Properties* options. Properties option will open a 3D graph properties window shown on Picture 75, from which you can select a maximum of three variables to be shown on the graph. After selecting a variable the 3D surface will open in 3D Plus. When you are done with the customization of your graph and it is positioned in the preferred way, close the 3D Plus window and graph will appear in your document. If you double left click on the 3D graph object a 3D Plus software window will open shown on Picture 76.



Picture 75: 3D graph properties



Picture 76: 3D plus

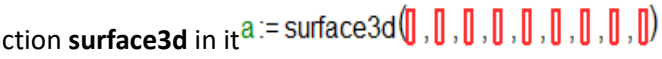
3.5.11.1 Example: 3D graph

Create a graph of trigonometric functions $\sin(x^2+y^2)$ on $[-2\pi, 2\pi]$ segment.

Solution:

Create a new document by pressing the New icon

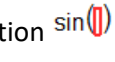
, press Maths icon

, 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 new variable **a:=surface3d,** this code will create a new variable **a** and store results of the function **surface3d** in it 

.

Function surface3d will be always used when we want to draw a 3D graph, it is a function that creates a matrix of vectors of the size 3x1, every vector is presents a point in space. The first argument is the function that we want to draw with preferred symbols or values as arguments, the second argument is the first symbol which we are going to change with numerical values, third and fourth arguments are numerical intervals of values that will the symbol from second argument will take, fifth argument is the number of samples for first symbol, sixth argument is the second symbol which we are going to change with numerical values, seventh and eighth arguments are numerical intervals of values that the symbol from the sixth argument will take and the ninth argument is the number of samples for the second symbol.

$$a := \text{surface3d}\left(\sin\left(x^2 + y^2\right), x, -2\,\pi, 2\,\pi, 50, y, -2\,\pi, 2\,\pi, 50\right)$$

In the first empty node type **sin** to create a new sine function 

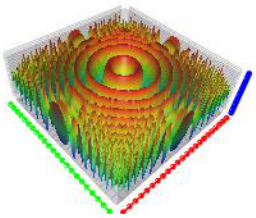
and type the symbol **x**, hold **Shift** on the keyboard and press key **6** as its argument (this combination will create

), place the cursor inside the power node and type **2**. With the right arrow key on the keyboard place the cursor next to x^2 and type **y**, use **Shift** + **6** combination again and insert the number **2**. Place the cursor in the second empty node and type symbol **x**, in the third node argument type **-2*cpi** (cpi is code to create constant π), type **2*cpi** in as fourth argument, type **50** as fifth argument, type symbol **y** as sixth argument, **-2*cpi** as seventh argument, type **2*cpi** as eighth argument and the number **50** as ninth argument.

From the Place tab select 3D Graph icon

, select the place on the canvas where you want to place it. A new 3D graph object will appear. From the right mouse button, click on the content menu and select Properties option now from the dropdown menu of the window shown on Picture 75 choose variable **a** that we created earlier. A new window will appear with a sine function on a 3D graph. Press icon and move the z axis ratio slider to -60, we will "shrink" the height of the graph this way. Close the 3D Plus window at the end.

$$a := \text{surface3d}\left(\sin\left(x^2 + y^2\right), x, -2\,\pi, 2\,\pi, 50, y, -2\,\pi, 2\,\pi, 50\right)$$

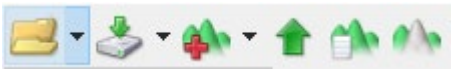


3.5.11.2 3D Plus

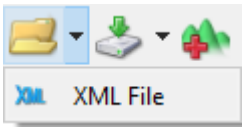
3D Plus is an additional plug in software in MatDeck which is intended for plotting and managing of 3D graphs. It has a large variety of options and tools for setting and modifying any part of the 3D charts. This makes it an excellent medium for advance use of these graphs.

We will start with a detailed description of each of the menu items, as well as methods on how to use them as effectively as possible.

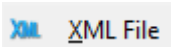
3.5.11.2.1 Data tab



From this tab we can open and save files, create curves, update current surface and manage all imported surfaces.



Picture 77: 3D Plus open

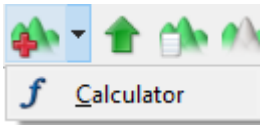
From this icon we can open 3D graph files, 

option will open a new window from which we should choose an xml file we want to open (.xml is file format that is default for 3D Plus software, and the only supported file format).

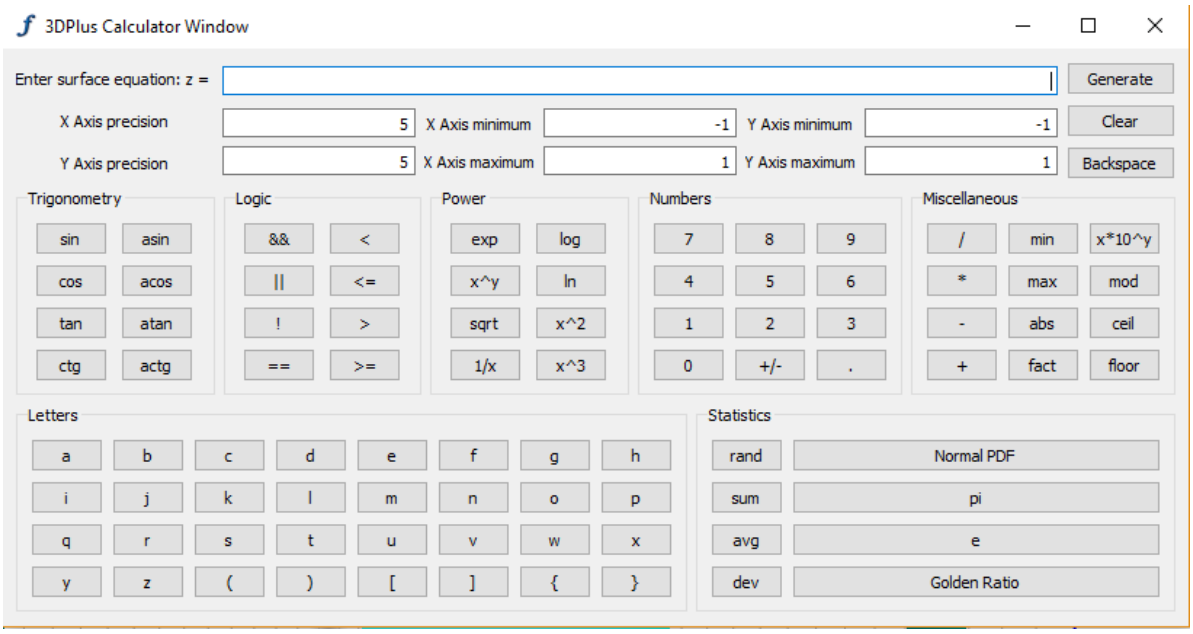
From this icon we can save our graph/ file. The format is .xml .

Picture 78: 3D Plus save

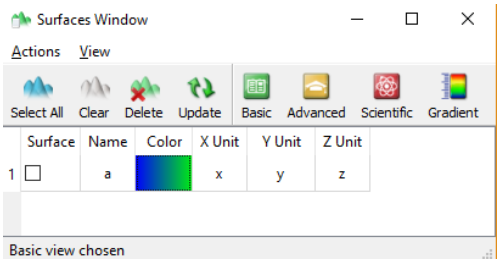
From this icon we can create a new graph independently from the graph that is currently drawn, pressing the icon will open a new window shown on Picture 80. From this window you have a wide range of functions, operators and their predefined combinations that can be used. Consider this calculator as a keyboard from which you type function to draw, you also need to set the x and y axes minimum and maximum values and precision. Precision is the number of pieces on which intervals (axis minimal value, axis maximal value) will be divided.



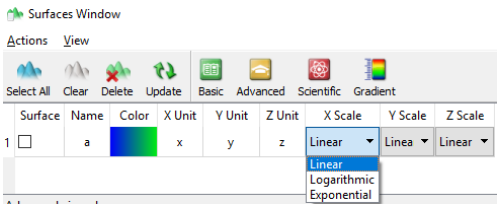
Picture 79: 3D Plus create



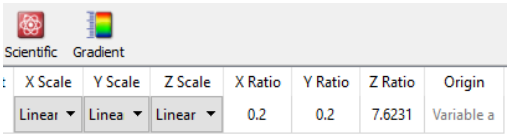
Picture 80: 3D Plus Calculator window



Picture 81:3D Plus Surfaces



Picture 82: 3D Plus - Advance view



Picture 83: 3D Plus - Scientific view

The range for precision is 1-1000, and it is the number of samples for selected axis. After we created the preferred equation, draw the graph by pressing *Generate* button. There is also a *Clear* button for discarding the current equation.

Update icon , where we can update graphs and apply all changes that we have made.

If we press Surfaces icon the window shown on Picture 81 will open. From this window we can manage all created graphs , the options we have available are:

Select All select all surfaces;

Clear clear all surfaces;

Delete delete selected surfaces;

Update update selected surfaces;

Basic basic view Picture 81;

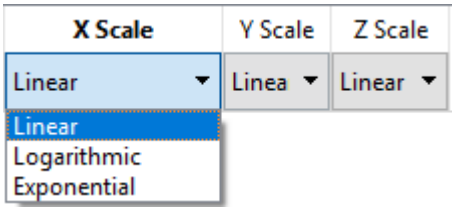
Advanced advance view Picture 82;

Scientific scientific view Picture 83;

Gradient gradient, how the surface gradient is changing that's how the colour is changing

Picture 84: Surface - Basic view

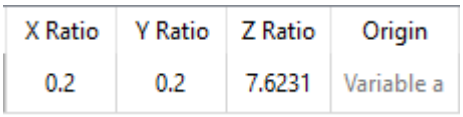
In *Basic view* like in Picture 84, for every surface following data is displayed: *Name* – name derived from the data source, *Colour* – colour for displaying surface (one colour or gradient), *X Unit*– name for x axis (changeable from the table), *Y Unit* – name for y axis (changeable from the table), *Z Unit* – name for z axis (changeable from the table).



Picture 85: Surface - Advance view

In *Advance view* except data from Basic view we can set ratio for every axis. Scale options are Linear which is default, Logarithmic and Exponential.

Scientific view except data from previous views, displays scale for every axis (changeable from the table) and data origin.



Picture 86: Surface - Scientific view

Manager icon will open the window shown on Picture 87. From this window we can display or remove surfaces from the graph, update them or set them to automatic updating. Options we have available are:

Select all surfaces;

clear all surfaces;

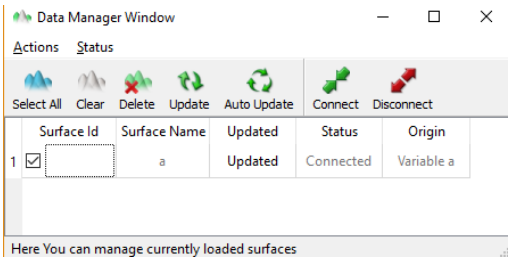
delete selected surfaces;

update selected surfaces;

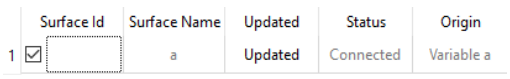
turn automatic updating on or off;

pressing this icon will display all selected surfaces on the graph;

pressing this icon will remove all selected surfaces from the graph.

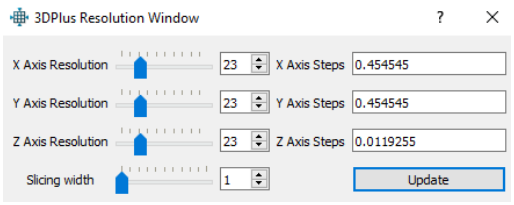


Picture 87:3D Plus – Manager



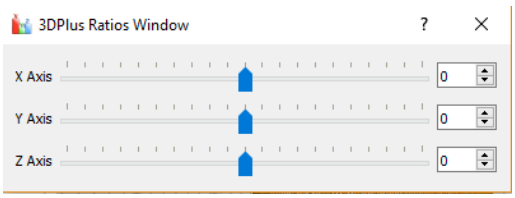
For every surface the following data is displayed in Manager window: *Surface Id* - shown if data source is channel, *Surface name, Updated* – state of the surface at the moment (updated or modified), *Status* – is selected surface displayed on graph (Connected) or not (Disconnected) and *Origin* – which is the data source for selected surface.

3.5.11.2.2 Coordinates tab



Picture 88: 3D Plus - Resolution

The three icons from the left side of this group refer to the choice of the coordinate system. So if we press icon the surface will be plotted in the Cartesian coordinate system, pressing of icon will plot the surface in the spherical coordinate system and pressing of icon will plot it in the cylindrical coordinate system.



Picture 89: 3D Plus - Ratios

Pressing of will open a window shown on Picture 88, from this window we can set a resolution or step size for every axis. Column with values on the right side of Picture 88 are actual values of steps for every axis.

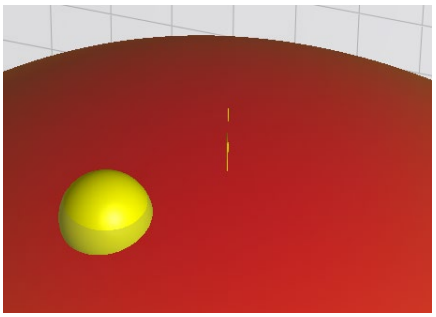
Icon turns on or off displaying of grid on graph, default state is grid on.

Pressing of icon will open the window shown on Picture 89 from which we can set a ratio for every axis. If we for example draw a surface with the values of the z axis is divided from the values of the other two axes, we will change the setting of z axis ration and set it to lower state.

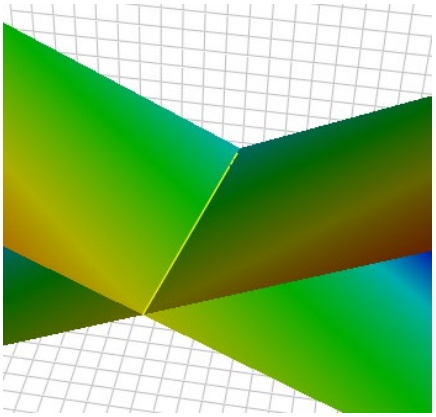
3.5.11.2.3 Surface tab

Options from this group are additional drawing and calculating tools which will help you in demonstration of surface features and finding of characteristic.

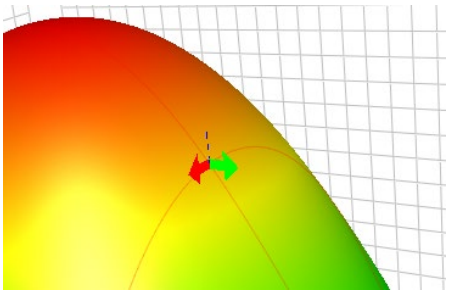
When we press Show Peaks icon, on the surface will appear a thin yellow line that will mark the place of the highest peak on the graph.
If we press the right mouse button anywhere on the surface of the graph, the content menu will appear with options *Add Bookmark* and *Reset View point*. Bookmarks are represented as yellow semi balls on the surface of graphs, as shown on Picture 90. We add them using the right mouse click content menu.



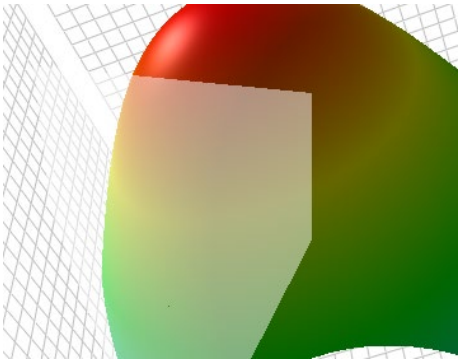
Picture 90: Surface peak and bookmark



Picture 91: Intersection of surfaces



Picture 92: Trihedron on surface



Picture 93: Surface tangent planes

To remove a bookmark, press the right mouse button while the cursor is on the preferred bookmark, and choose *Remove Bookmark* option.

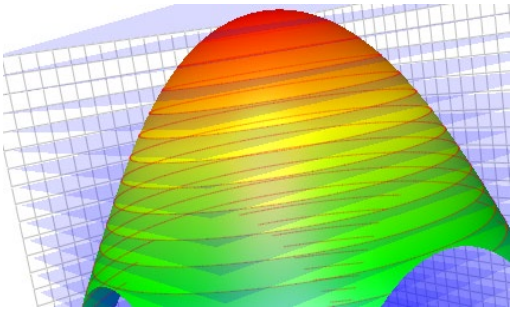
Show Bookmarks icon will display all bookmarks on graph if it is turned on, and if we press this icon again it will turn off and stop displaying the bookmarks.

Intersections icon will find the intersections of surfaces (option works only if two or more surfaces are displayed) and mark them yellow as shown on Picture 91.

Trihedron icon , if pressed will show intersections of surfaces and the coordinate planes from the selected place on the surface. We place this item by pressing of trihedron icon, after that we have to select a place on the graph from which we want this intersections to start. There is no limit of the number of placed trihedrons, so we can place them as many as we want as long as icon is turned on.

When *Tangent Planes* icon is turned on, we have to select points on the surface where we want the tangent plane to be displayed, as shown on Picture 96. Number of tangent planes that can be drawn is one per graph, and if a tangent plane is displayed and we select another place on the surface, first plane will disappear and the new one will appear.

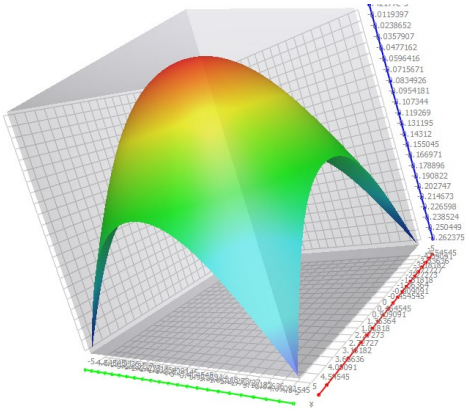
When we press *Coordinates plane* icon the graph will be filed with planes whose density depends on resolution of the axes. There are three options under this icon: XY coordinate planes, XZ coordinate planes and YZ coordinate planes. These options are independent from one another and can be turn on or off separately.



Picture94: Surface coordinates planes

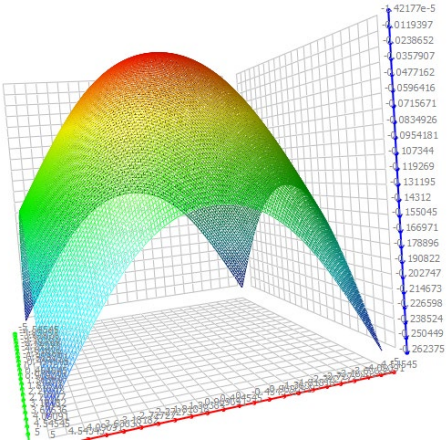
3.5.11.2.4 Rendering tab

We select the graph with the left mouse click while the cursor is on the graph, when selected the graph surrounding will change colour to grey and cubes around the graph will become visible as on Picture 98.



Picture 95: 3D graph when selected

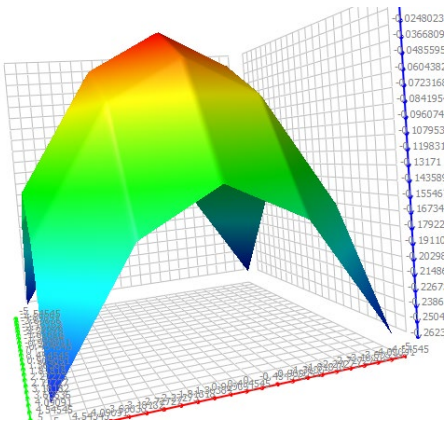
Icons Solid and Wireframe refers to the way of displaying surfaces of graph. Solid state, shown on Picture 95, is the default way of displaying graphs but we can change it to wireframe state, shown on Picture 96, with simple click on icon.



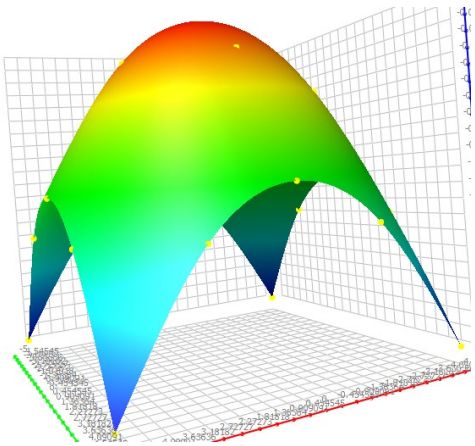
Picture 96: 3D graph – Wireframe

Icons Linear and Cubic spline refers to the way of interpolation between the input points. Default option is Cubic spline interpolation, as shown on Picture 95, and when Linear interpolation option is chosen the graph will look like Picture 98.

The last icon from this group is Origin points icon and when it is turned on, the graph will display the input points based on which the graph is drawn.
They are presented as small yellow spheres on the surface of graph.

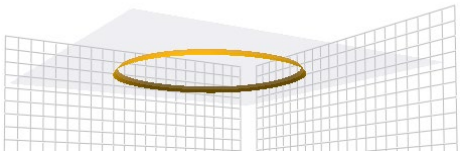


Picture 98: 3D graph - Linear interpolation



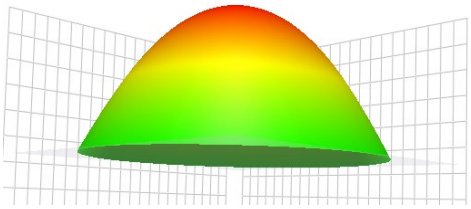
Picture 97: 3D graph - Origin points

3.5.11.2.5 Processing tab



Picture 99: Surface slicing

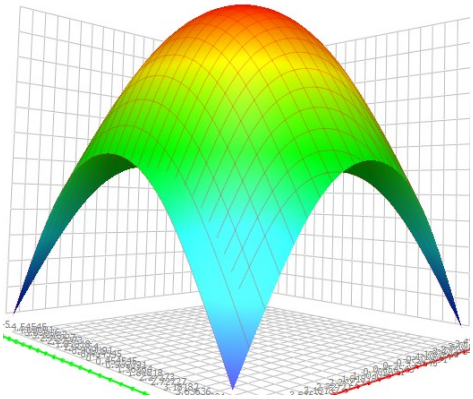
If we press Slicing icon a new window will open in which the current graph will be separated into slices like on Picture 99. The heights are predefined values on z axis. Use Ctrl + mouse scroll combination to move up and down the slicing plane.



Picture 100: Surface clipping

If we press Clipping icon a new window will open in which the current graph will be clipped and shown like on Picture 100. Use Ctrl + mouse scroll combination to translate clipping plane.

If we press First gradient icon and Second gradient icon a new window will open in which the surface of the current graph will be painted in colours depending on the first and second gradient vector respectively.

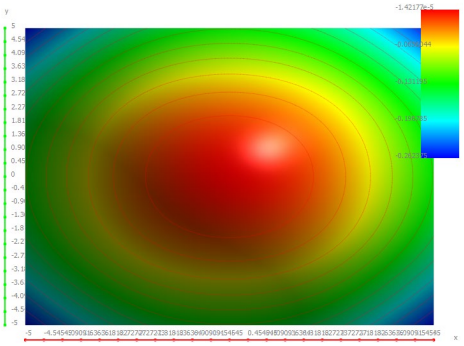


Picture 101: 3D graph - Isocurves

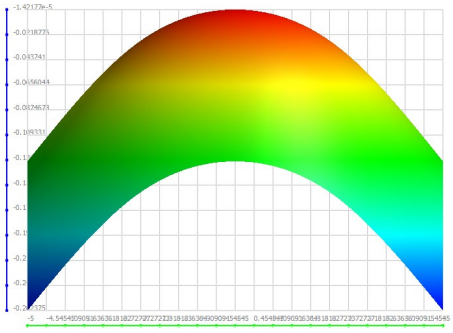
When we press Isocurves icon a new window will open in which the current graph will be displayed with isocurves on it. There are three options under this icon: X axis isocurves, Y axis isocurves and Z axis isocurves. On Picture 101 the X axis isocurves are shown.

If we press Isocurve map icon a new window will open with the isocurve map shown on Picture 106.

The last icon from this group is the Projection icon with three options: Oxy projection, Oxz projection and Oyz projection. On Picture 102 we presented projection of current graph with Oyz projection.



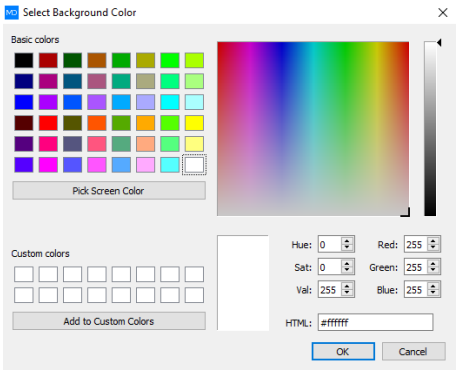
Picture 103: 3D graph - Isocurve map



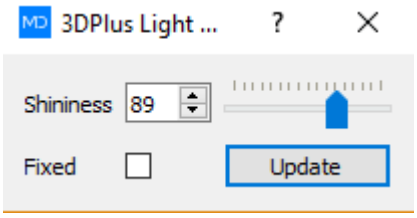
Picture 102: 3D graph - Projection

3.5.11.2.6 View tab

From this tab, we can use tools to customize the background colour of the graph, axes display style, brightness of graph surface and we can walk through the graph.



Picture 104: 3D graph - Background colour



Picture 105: 3D graph – Lights

If we press *Walking* icon a new window will open in which we can use the keyboard arrows to view the graph.

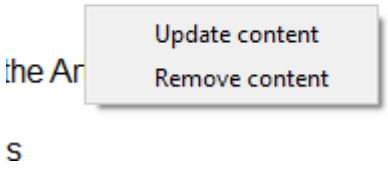
Background icon opens a window shown on Picture 107 from where we can set the background colour for the graph.

Font icon opens a window from where we can set the style of axes text, font, font style and size, effects and writing system.

Lights icon

will open a window shown on Picture 105 where we can set the brightness of graphs surface.

3.5.12 Content



Picture 106: Content

In MatDeck you have an option to generate content and place it in the document. To do so press the Content icon

and click in the document to the position where you want to place the content.

Content is a list of all the headings in the document sorted by the heading type.

Using the right mouse content menu you have the options Update content and Remove content as shown on Picture 106.

There is an option to view and use content list that you have generated, from Home tab->Navigation icon->Content tab as we already explained in section 3.4.2.1.

3.5.12.1 Example: Content

Create document content for "Document example.mdd" and add a new heading in it then update content.

Solution:

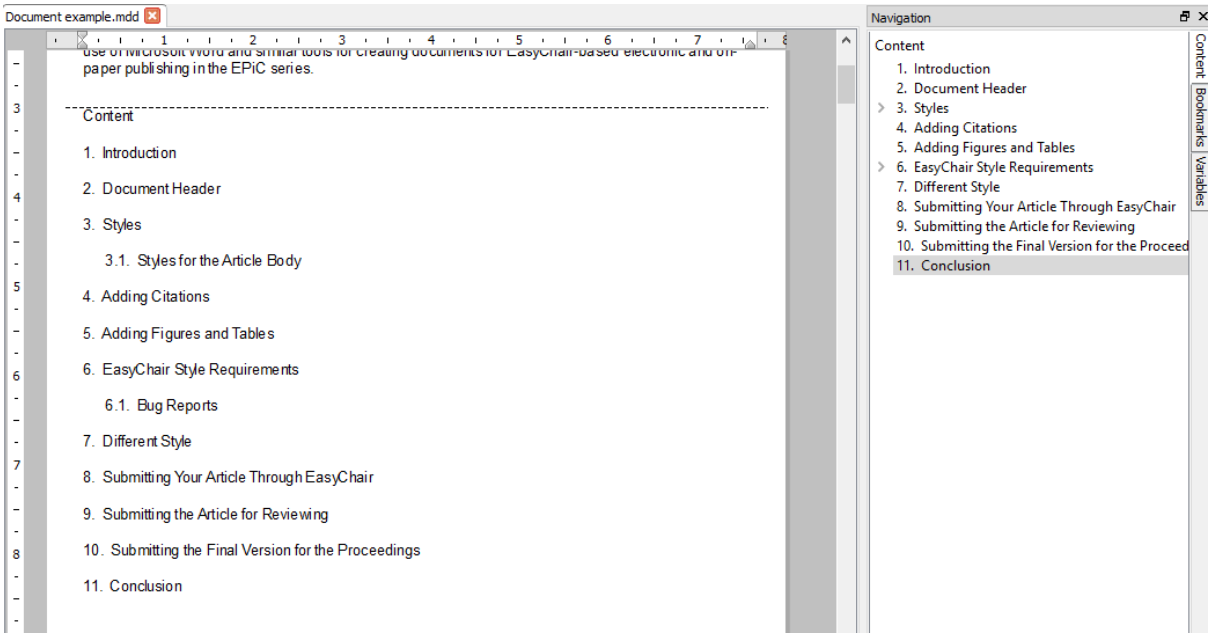
We have already created ''Document example.mdd" with ten chapters and we want to place a content within that document. To do so, open up the document and from the place tab press icon

, select a place in the document where you want to place the content. List of all document headings, arranged in content will be created in the document. Every row of this list is a link to the place in document where the selected heading was placed. We activate links with a single left mouse button click on it.

Now, inside a document create a new chapter title by creating a heading. Type the chapter title, in this example we entered chapter **Conclusion** at the end of the document, go back to the document content and place the cursor on the content and then press the right mouse button. A menu will appear, as shown on Picture 106 from which we will choose the option *Update content*.

Next go to Home tab and press the Navigation icon

. The tab on the right side of Picture 107 will open, from where you can also view the content. Every item from this list is also a link and by pressing it you will be redirected to the place in document where this chapter begins.



Picture 107: Content example

3.5.13 Page Break

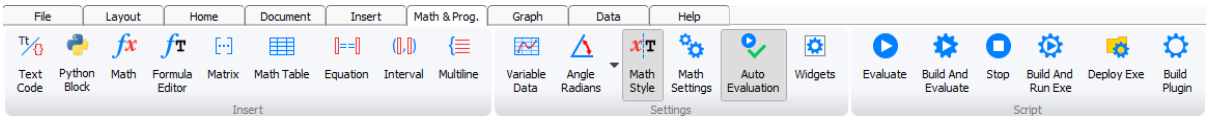
To insert a Page Break and move the following document content onto a new page, place the cursor in the document and press the Page Break icon

.

From the selected area in the document till the end of current page, there will not be any content. All the document content that follows the line in which we have placed the Page Break will be moved to the next page of the document.

To delete the inserted Page Break, place the cursor in front of the content on the page that follows the page with Page Break and press the Backspace keyboard button.

3.6 Math & Programming tab



Picture 108: Math tab

The Math thumb nail allows you to place Math objects, to view variable data, to change measured units, to insert matrix, table, equation and interval, to define a Maths settings, to build code as well as run it in the console and to deploy document as exe file, to create and edit the script code.

3.6.1 Getting started with Mathematics

Double left mouse click- when used in a canvas it creates an empty Math object.
type a name and := - to assign a value to a variable; or assign a value to an already created a variable;

$$a := 3$$
$$a = 3$$

= - this displays the variable value or the value of a mathematical object/equation;

$$1 + 2 = 3$$

/ - used for division

$$a := b / c$$

Alt + **/** -create a fraction;

$$a := \frac{b}{c}$$

* used for multiplication

$$a := b \cdot c$$

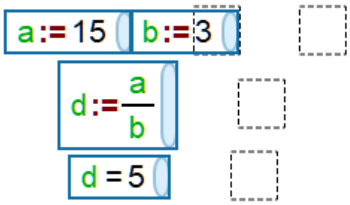
Shift + **6** (**^**) –to raise an object or element to a power in math objects

$$g := n^{\square} \qquad g := n^{x}$$

Press * twice, * + ***** - this combination creates a multiplying operation without a visible multiplication sign;

$$g := L \cdot M \qquad k := L\,M$$

Ctrl + R – selects all formals, math objects and variables in a canvas (you can change fonts and other features in one step click)



Change units to variable and opposite

If units are on, for example typing m will be meter, to make m as variable

$$F := m \cdot a$$

Select m and

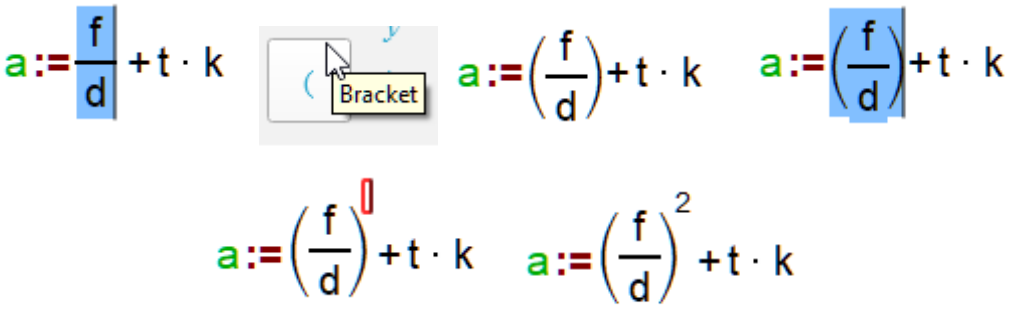
$$F := m \cdot a$$

Ctrl + **U** –changes units to variables and vice versa

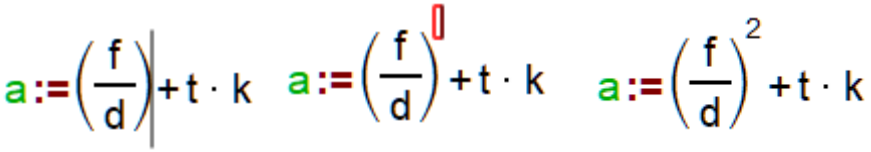
$$F := m \cdot a$$

Selecting multiple objects

To add an element or mathematical object to a group of variables/elements, highlight them by double clicking the variables themselves or clicking their main element e.g. the line in a fraction or the brackets themselves.



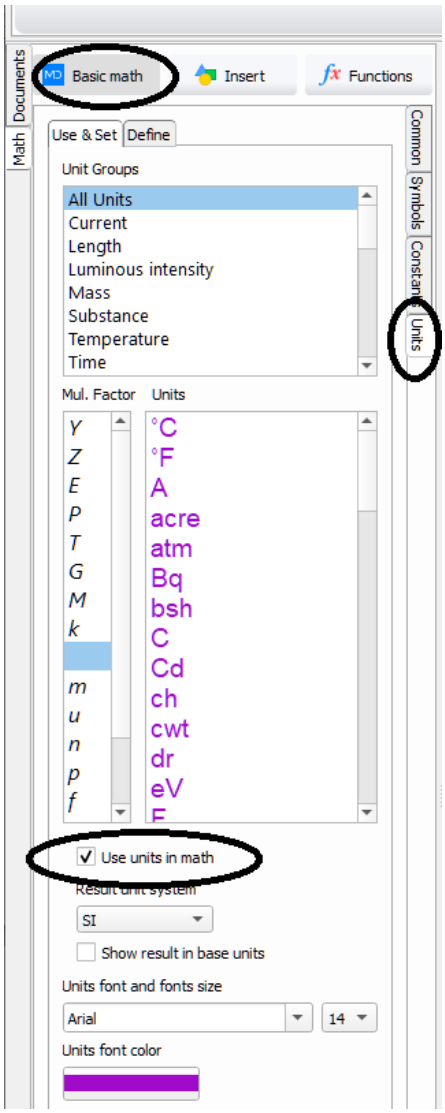
The click on the mathematical element in the Basic Math Tab e.g. the bracket sign or the cos sign. The mathematical element will appear on the outside of the selected variable/elements, meaning that the mathematical element is applied to the variable/element.



If you are adding mathematical elements using keyboard shortcuts or other method, and then highlighting the object will not work, you will have to place you your vertical slash just at the end of the element and then add the mathematical element e.g. Shift + 6 to add indices.

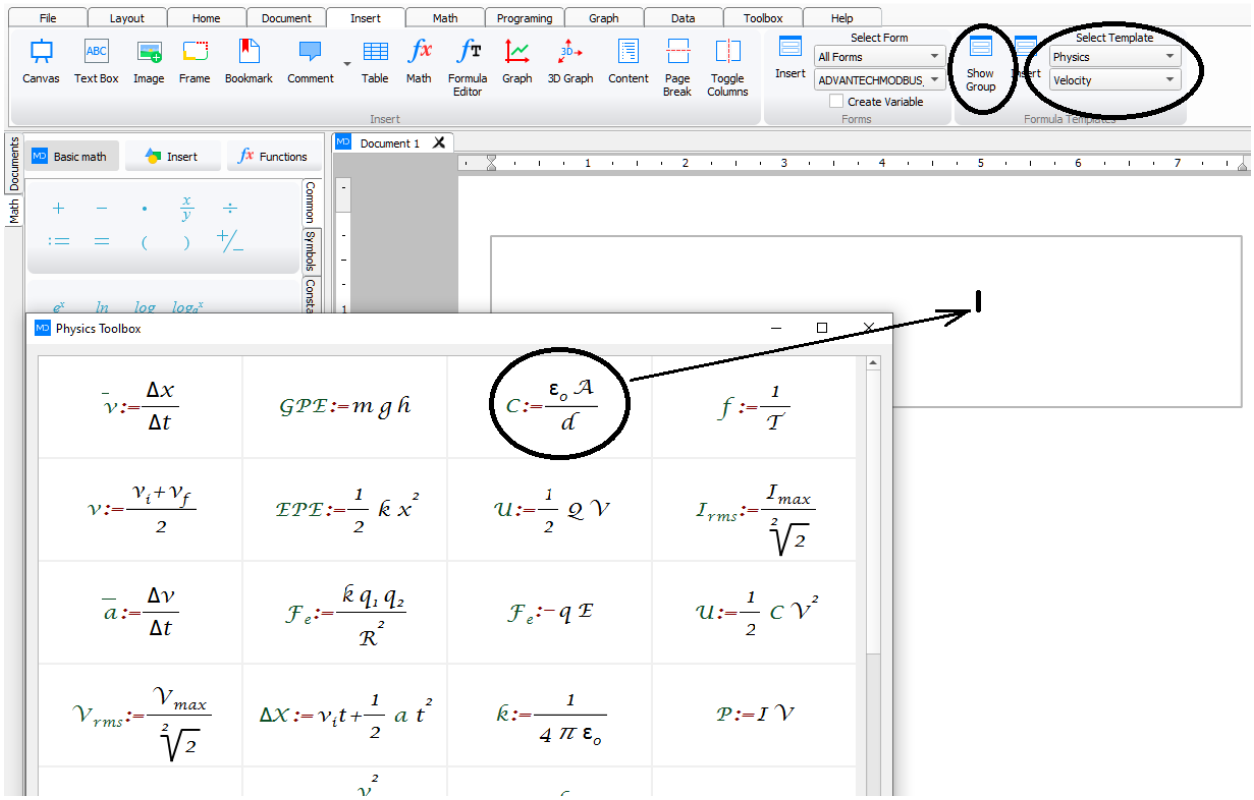
Switching units ON and OFF

To do this, go to **Basic math tab** and select the **Unit subtab**. In the unit tab, select or deselect the **Use Units in Math** checkbox, depending on whether you want to use units or not.

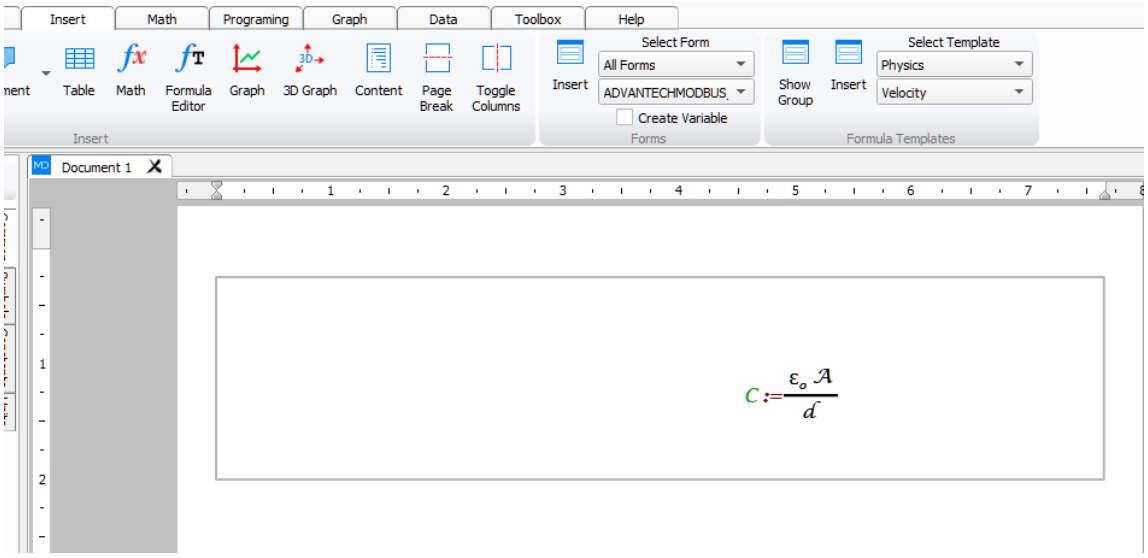


Formula Templates

To insert a formula from a Formula Template, you will need to go to the Insert tab and then the far most left corner. From there, you can select the Group of the Formula Template and the Formula Template itself using the two drop down menus. To get the Formula Template GUI shown below, click the Show Group button.



To then add the formula template to the canvas, double click on the canvas, when the vertical slash appears, click on the formula you would like to insert into the canvas.



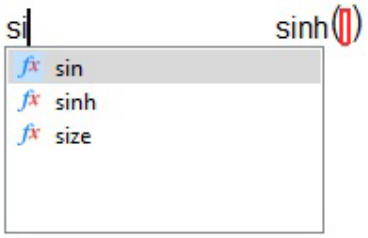
Alt + **-** -value or expression to become negative; the negative of existing expression or variable value, when the cursor is in front of the variable or expression use Alt – combination to change the sign of it;

a 5

-a -5

Alt – continue writing the function name; use Alt to insert multi character commands or to skip auto suggestion and continue with typing; while you type in the canvas auto suggestion will display all

functions that contain the inserted combination of characters, to skip it just use Alt and continue with typing;



Subscript and superscript

Ctrl + **M** – to turn superscript mode on or off; O^2

Ctrl + **B** – to turn subscript mode on or off; O_2

Shift + **6** (**^**) – if Math Style button is down enter a power node in math objects, otherwise XOR operator.

Superscripts and subscripts can be added before or after the pivot letter, just place the cursor on the preferred side and use above key combination.

$$\overset{1}{\underset{2}{O}}\overset{3}{\underset{4}{}}$$

Function help

F1 –place the cursor in the function object and press F1 to open help for the selected function on the default internet browser for your computer;

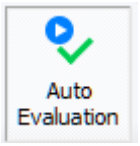
Zoom

Ctrl + **mouse scroll**–zoom in, zoom out;

Formulas and Equations

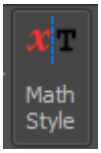
Formulas themselves must be placed inside a canvas. To open or insert a canvas, open the **Insert ribbon** tab, then select the **Canvas icon** and **left click** where on the document you want to place it.

MatDeck formulas will be calculated when they are evaluated. For formulas to be evaluated in real time and while you're typing, select the **Auto Evaluate Icon** in the **Math Tab** ribbon.



Double left click *–when used in a canvas, it creates an empty Math object.*

To use real formula which can be **evaluated** with operators, switch on the **Math Style Icon** within the **Math Tab ribbon;** or switch it off for a demonstration **Text Formula**.



$$H := \sqrt[2]{P} \qquad H := \text{root}(P, 2)$$

Ctrl +**F** excludes math objects (formula) from mathematical rules; use this key combination when you want to type full formulas or part of formula for demonstrational purposes, without applying any mathematical rules (there are no operators, variables, fractions, functions, …).

When "Ctrl + F" is active, the text of the Math Object will be **highlighted in grey**. "Ctrl + F" mode can be used in any node, however in order to enter graphical math elements "Ctrl + F" must first be deactivated. The image below shows a graphical demonstration formula.

$$f(x) = \sum_{n=-\infty}^{\infty} x(n)$$

To stop the evaluation of **:=**, use **Ctrl** + **=** - when used inside a Math object, it stops the selected object from calculating; use this combination when you want to create a presentational formula that is excluded from calculation; In order to use "Ctrl + =", "Ctrl + F" mode must first be deactivated. After "Ctrl + =" is used, "Ctrl + F" mode can be activated again.

*** +*** - to create multiplying operators whose sign is not visible; when the cursor is behind the value or variable use the * + * combination to create a multiplying operation without a multiplying sign.

$$2x$$

Alt + **/**- create a fraction;

$$\frac{x}{y}$$

Shift + **6** – enter a power node in math objects;

Ctrl + **M** – to turn superscript mode on or off;

Ctrl + **B** – to turn subscript mode on or off;

Alt + **-** - selected value or expression to become negative; the negative of an existing expression or variable value, when the cursor is in front of the variable or expression use the Alt – combination to change the sign of it;

Use the **Left** and **Right Arrows** to move from node to node.

Right mouse click on a Math/Equation object, then select **Exclude** from evaluation.

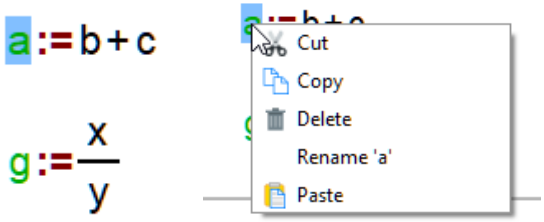
$$\int_{-\infty}^{\infty} e^{-x^2}\,dx = \sqrt[2]{\pi}$$

Set style, colour, and size of letters in equations independently by using the font editing tools present.

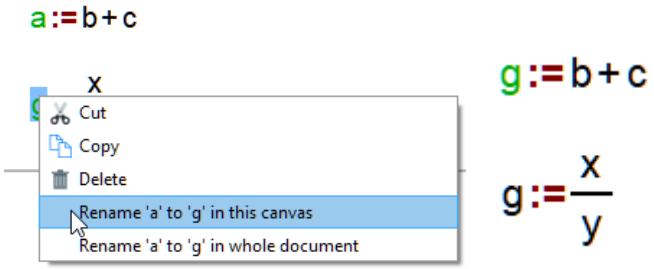
$$f(x) = \sqrt[2]{\left| \sum_{n=-\infty}^{\infty} \frac{y(n)}{x(n)} \right|}$$

Rename variable

To rename a variable, select the variable by double clicking it, then right click on it and choose the Rename option. This is seen in the pictures below.



Then select the variable you would like to rename it to and right click it, now the rename option will give you the choice of renaming the variable in the canvas or the whole document, click on your preferred choice.



Now the variable a will have been changed to the variable g.

3.6.2 Formula Editor

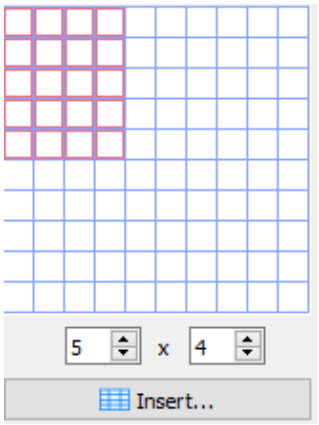
Use this option to create a formulas that will be excluded from calculations. The formula editor must be selected before being used with any formulas. These kinds of formulas can be used to create various expressions for presentational purpose, without limitations and rules that are used in standard MatDeck mathematical formulas. When inserted, the field for editing will become grey.

$$\sum_{n=|}^{|} = \lim_{x \to |} \int x^{5} \cdot \cos(x)\, dx$$

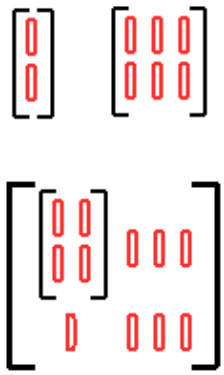
3.6.3 Math

A detailed explanation and example of how to use Math can be found at 3.5.9

3.6.4 Matrix



Picture 109: Insert matrix



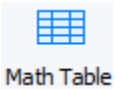
Picture 110: Vector, matrix

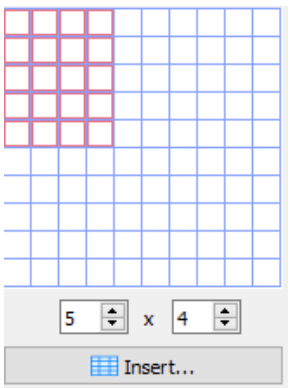
Matrix or vectors can only be placed in a math object of the canvas.

There are three ways of inserting them in the document:
1) Once the matrix icon is pressed you are able to choose the dimensions of your preference with the mouse movement.
2) By selecting a number of rows and columns and click on Insert.
3) Typing vector /**matrix** functions in a math object in the canvas. They will create an empty vector of 2x1 size/matrix of 2x2 size. To add another column on the right of the current cursor position use the **Space** key, to add another row use the **Enter** key on keyboard. To delete a column in which the cursor is in, use **Ctrl** + **Space** combination, to delete a row use **Ctrl** + **Enter** key combination.

You can place the matrices and vectors one inside the other, as shown on Picture 110.

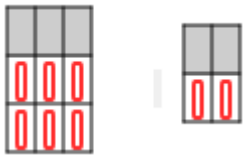
3.6.5 Math Table





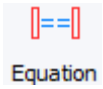
Picture 111: Insert Mat Table

Math Table can only be placed in canvas.
There are three ways of inserting them in the document:
1) Once the table icon is pressed you are able to choose the dimensions of your preference with the mouse movement.
2) By selecting a number of rows and columns and clicking on Insert.
3) Typing **table** function in a math object in the canvas. It will create an empty table of 1x2 size. To add another column on the right of the current cursor position use the **Space** key, to add another row use the **Enter** key on keyboard. To delete a column in which the cursor is in, use **Ctrl** + **Space** combination, to delete a row use **Ctrl** + **Enter** key combination.



Picture 112: Empty tables

3.6.6 Equation

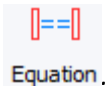


$$\square == \square$$

$$y^2 == x^2 - 2x + 3$$

$$y <= x - 7$$

Picture 113: Equations and inequalities

To insert an equation empty node use *Equation icon* 

. Equation can only be placed in a Maths object. Another way to create an equation is to type ***equation*** while the cursor is in the Maths object.

To create an inequality just replace one or both of the equal signs with < or > sign (both forms <= or =< are valid).

3.6.7 Interval

$$(\square,\square)$$
$$(a,b)$$
$$[a,b)$$
$$(a,b]$$
$$[a,b]$$

Picture 114: Intervals

To insert an interval empty node use *Interval icon*

. Interval can only be placed in a Maths object. Another way to create an interval is to type ***interval*** while the cursor is in the Maths object.

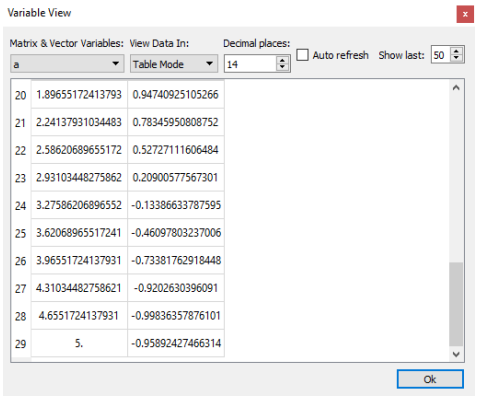
You can simply delete interval round brackets (,) and replace them with square brackets [,] to create interval of your choice.

3.6.8 Variable data

If we want to view vector or matrix data stored in a particular variable we can do that in two ways: by typing variable name and + =combination in the canvas; or by using the *Variable data* option. The second way is better for larger sets of data because it is much easier to view them when presented in this way.

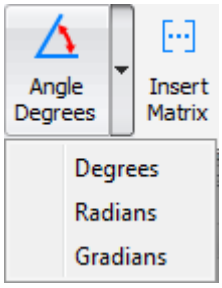
To use this option click on the *Variable Data* icon and the window shown in Picture 115 will open.

The dropdown menu, *Matrix & Vector Variables*, contains a list of all the variables in the current document that are defined as a matrix or vector. If there is no variable with any vector or matrix data defined in it, this list will be empty.
From the second menu, *View Data In*, you can choose how your data will be shown; it can be in a table or a graphic mode.
The Decimal places option defines the number of decimal places that will be shown in a variable data window.
With Auto refresh option ticked the variable data will refresh on every data change.



Picture 115: Variable data

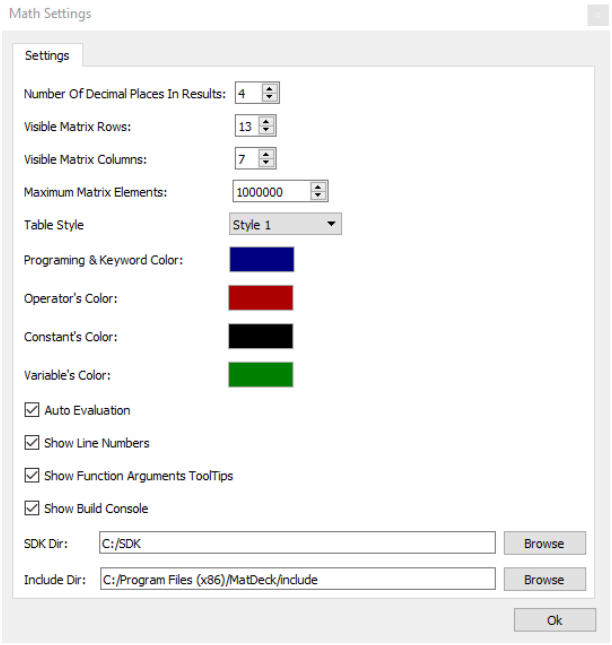
3.6.9 Angle units



Picture 116: Angle degrees

This setting refers to the current document and represents the measurement units for data displaying.
Default unit for displaying data is radians.

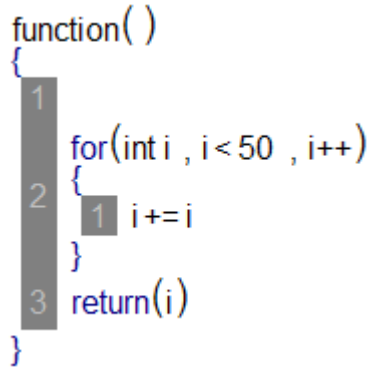
3.6.10 Maths settings



Picture 117: Math settings

Once the *Math Settings* icon is pressed the window shown in Picture 117 will open. From this window you can choose basic maths and programming settings. These settings are global and refer to all documents.

Number of decimal places in results: 0 – 14
Visible/table matrix rows: 1 - 15
Visible/table matrix column: 1 -15
(if vector, matrix or table size is greater that selected in the previous two options, the object will shrink to selected size and place ··· symbol in the corner; if you click on the symbol the vector / matrix will expand to full size)
Maximum Matrix Elements: define maximal allowed size of vectors and matrix
Table style: Choose one of available styles
Programing & keyword color, Operator's color, Constant's color and Variables color are color settings for displaying selected object in the document.

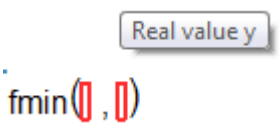


Picture 118: Show line numbers

Auto Evaluation: unselecting this option can make a program run faster because the calculations inside math objects will only start after we Evaluate the document, no calculations will be performed while we type or change the formula.
You can also control this setting by using the Auto Evaluation button

.

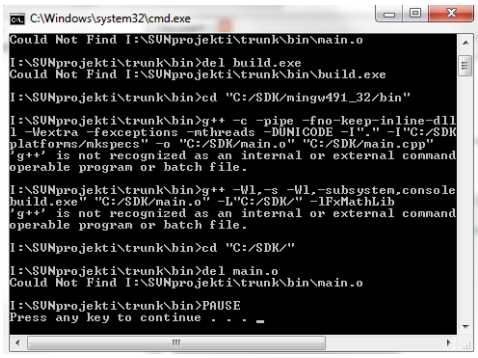
This option is automated and it will turn itself off if calculations last more than 1 second, it will turn on if the operations lasts less than 1 second.



Picture 119: Tooltip in formula

Show line numbers: this option refers to programming and whether or not you want to display line numbers, as shown on Picture 118.

Show function arguments tooltips: this option shows tooltips for the function arguments, as shown on Picture 119.

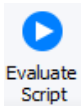


Picture 120: Build console

SDK Dir: from this option you can change the destination folder for SDK (software development kit) installation. The default folder for installation of this software kit is root of partition, where you can install windows.

Include Dir: from this option you can change the default destination folder for the included function (function that includes code from other files)

3.6.11 Evaluate




```
fnMin(v)
{
1  n:=inf
   if("vector"!=type(v))
2  {
     1 return(void)
   }
   for(i:=0 , i<size(v) , i+=1)
   {
3    if(v[i]<n)
     {
       1 n=v[i]
     }
   }
4  return(n)
}
```

Picture 121: Script example

When the programming script is entered it will be calculated automatically But if you change any part of the code, it won't affect the results because the script will calculate automatically just for the first time. To initiate a calculation and run modified script use Evaluate icon. Just press it and the calculation will start.

Evaluate Script refers specifically only to the current document and it will recalculate the whole document (all math and script objects).

3.6.12 Build And Evaluate

```
fnMin(v)
{
1  n:=inf
   if("vector"!=type(v))
2  {
     1 return(void)
   }
   for(i:=0 , i<size(v) , i+=1)
   {
3    if(v[i]<n)
     {
       1 n=v[i]
     }
   }
4  return(n)
}
```

Build And Evaluate recalculates the whole document (same as the Evaluate option), but it differs from the Evaluate option in the fact that the calculation will start in a separate thread resulting in higher execution speed. The same document can be evaluated much faster by utilizing this option. To initiate a calculation use the Build And Evaluate icon. Just press it and the calculation will start.

Evaluate script refers only to the current document.

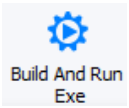
3.6.13 Stop script

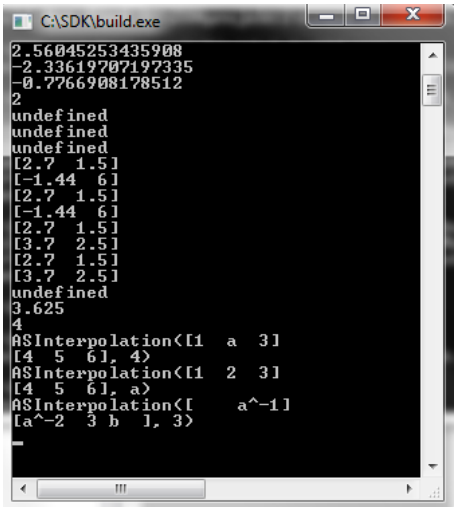
```
class Person
{
    fnm:=""
    lnm:=""
    Person(firstName , lastName)
    {
        fnm=firstName
        lnm=lastName
    }
    getName( )
    {
        return(fnm+" "+lnm )
    }
}
```

There is also an option to stop script calculations. To use it just press Stop script icon. Use this feature when the script enters infinite loops or when you want to stop calculations in order to correct a mistake.

When we press it the calculations will stop in current document.

3.6.14 Build and run exe



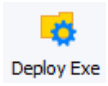


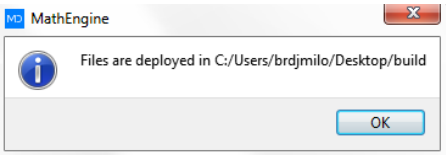
Picture 122: Application run from console

One of MatDeck's many options is to build your document and run it from the console window. This option refers to the current document only.

To use this option simply create a document you would like to run through the console and click on *Build and Run Exe* icon. If you enable build console in the Math settings window, the build console window will show the progress of your build process. When the build finishes a new console window will open and run code from the document.
By using this option you can reach speeds which are comparable to the execution speed of high level programming language code.

3.6.15 Deploy exe



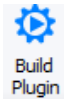


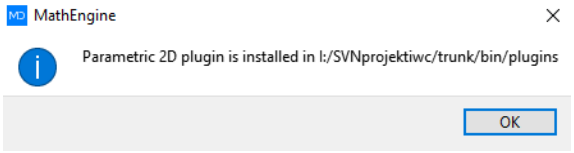
Picture 123: Successful deploy message

Another useful option is to deploy the document you create so it can run independently from the program's installation as an EXE standalone application. It's also refers only on current document.

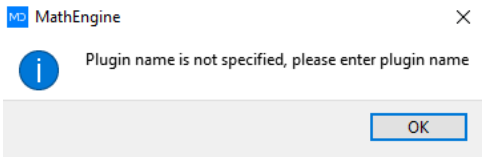
To use this option simply click on the *Deploy Exe* icon, you will be prompted to select the location where your deployed EXE will be saved. A successfully created deploy will finish with a message as shown on Picture 126.

3.6.16 Build plugin





Picture 124: Successfully installed plugin message



Picture 125: Failed to install plugin

With the Build plugin icon you can build predefined or custom plugins and create new groups of functions with compiled coded functions in the

tab.

The successful installation of the plugin will conclude with the message shown on Picture 127. On the contrary unsuccessful installation will conclude with the Picture 128.
To learn more about plugin creation and usage open **Plugin user manual** in the form of

.

3.6.17 Multiline

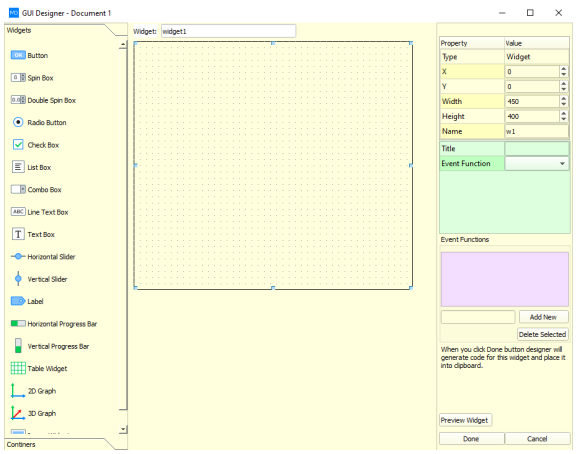
$$f(x)=\begin{cases} \frac{1}{e^{x-1}}, x<1 \\ 0, x=1 \\ \arctan\left(\frac{1}{x-1}\right)-\frac{\pi}{2}, x>1 \end{cases}$$

Picture 126: Usage of multiline

Use this option to define noncontinuous functions or other multiline objects. It can only be used in formula objects

meaning that it will be excluded from calculations and its purpose is to be used in documents for presentations and documentation.

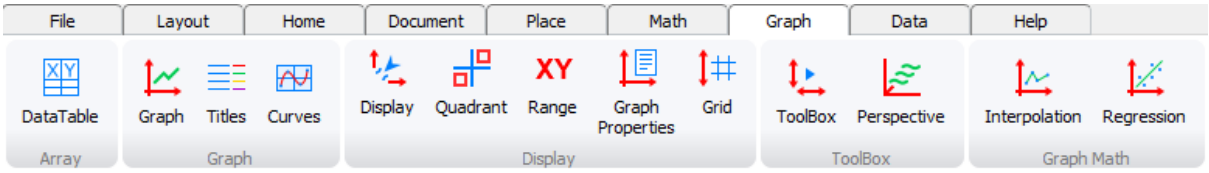
3.6.18 Widgets



You can create or edit widgets from this option using implemented MatDeck GUI editor. Widgets are document oriented objects and this option controls only forms and widgets created in the current document.

Read more about widgets and how to create, edit and place widgets in a document, with the Widgets User Manual from our documentation page.

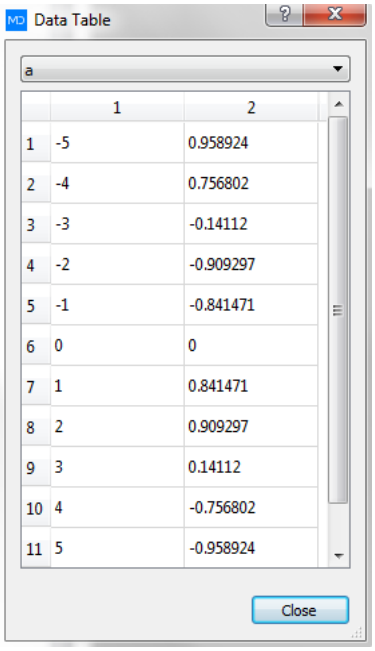
3.7 Graph tab



Picture 127: Graph tab

This tab refers to work done with 2D graph and its settings. Options from this tab can only be used if a graph object is inserted in the document and already selected. Option *Graph* from this tab is same as the Graph option from the Place tab that we described in section 3.5.10, so we won't further explain it.

3.7.1 Data table



Picture 128: Data table

When you press *Data table* icon, the window shown on Picture 132 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.
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.

3.7.2 Graph

This option is the same as the Graph option from Place tab, which is described in detail in section 3.5.10 so we won't write more about it.

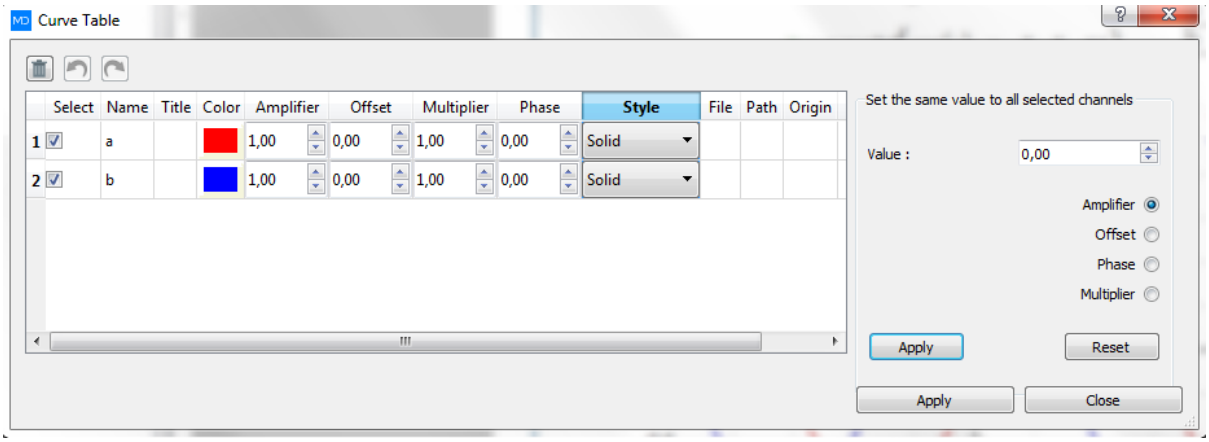
3.7.3 Titles

Name	Title	Color	Origin
a			
b			

Picture 129: Titles table

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 auto update any changes.

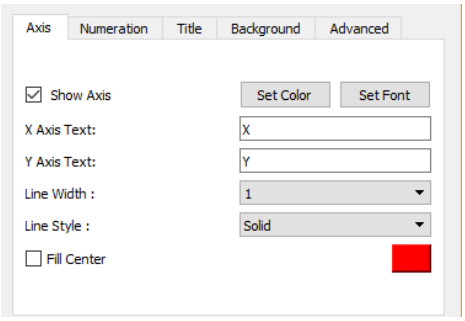
3.7.4 Curves



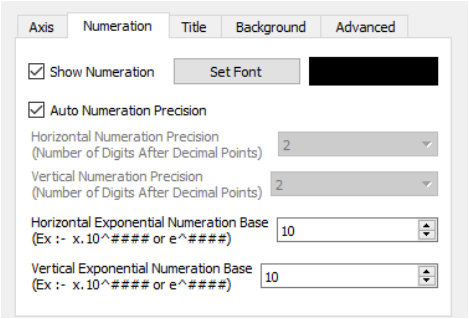
Picture 130: Curve table

When you press *Curves* icon the window from Picture 134 will open. From this window we can see and manage curves plotted in a graph. Every cell of the table is editable (double click, drop down menu, arrow change,…) and you can change: will curves 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 by setting up the value and pressing apply. Also there is a reset button to return values to default state.

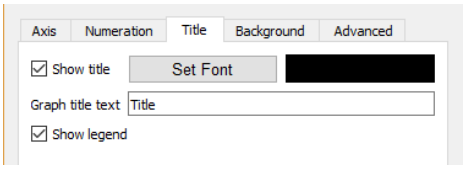
3.7.5 Graph properties



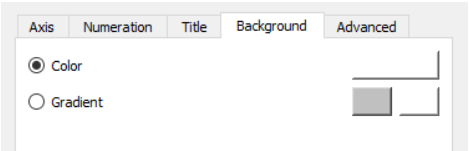
Picture 131: Display - Axis tab



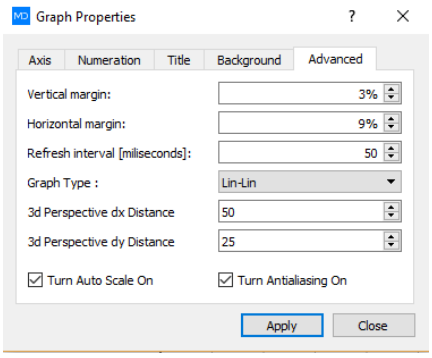
Picture 132: Display - Numeration tab



Picture 133: Display - Title tab



Picture 134: Display - Background tab



Picture 135: Display - Advanced tab

Pressing *Graph Properties* icon will open a window as shown on Picture 135, the same as from right click content option *Graph Properties,* from which you can configure graph axis and numeration, graph title, background colour, margins, perspective distance, refresh interval, etc. As we already said all this options refer only to the current graph and they are not global settings.

From *Axis tab*(Picture 135) 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.

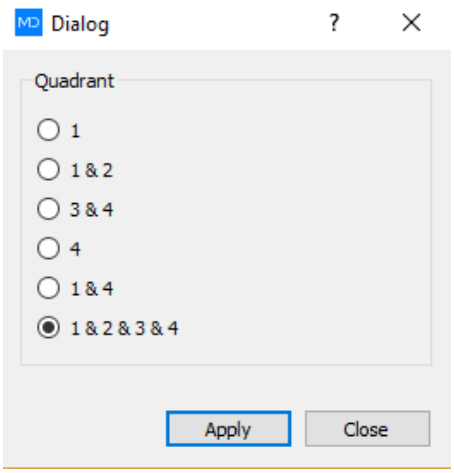
From *Numeration* tab *(*Picture 136)you can choose if axes numeration are going to be displayed or not, set their font, colour, will it be calculated automatically or manually (if you choose manually you will have to set a number of decimal places for each axis) and set exponential numeration base for each axis.

From *Title tab*(Picture 137) you can set title, choose if it will be displayed or not, set the font and colour. You can also choose to show Legend on the graph or not. If you plot a large amount of curves, the best practice is not to display legend but to use Titles table (section 3.7.3) instead.

From *Background tab*(Picture 138) you can change the background colour of the graph.

From *Advanced tab*(Picture 139) you can change margins, refresh interval and distance for 3D perspective. You can change axes base from decimal to logarithmic for both axes 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. *Turn Antialiasing On* option will remove "jaggies" and the staircase effect from plotted curves when it is on.

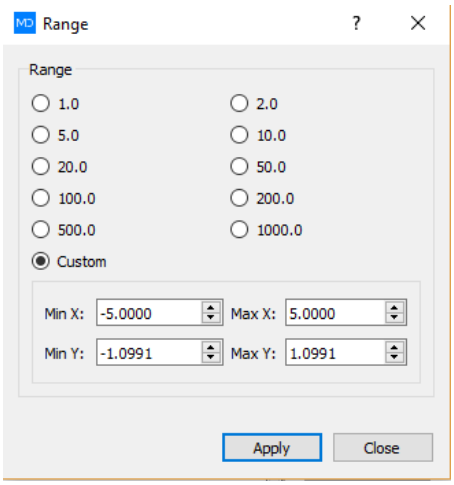
3.7.6 Quadrant



Picture 136: Quadrant window

Press *Quadrant* icon and window shown in Picture 140 will open. This option allows you to pick which quadrants of graph you wish to be seen.

3.7.7 Range

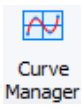


Picture 137: Range window

From this window you can change the range of selected graph to any of the present values or you can click custom to use your own. To use this option press *Range* icon and the window shown in Picture 141 will open.

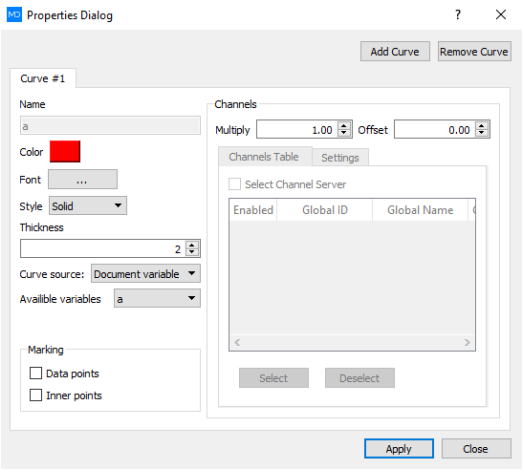
Four fields, in the bottom of the picture on the left, are editable only if the custom option is selected.

3.7.8 Curve manager



To change the curve properties press the *Curve Manager* icon and the window shown in Picture 141will open. This is the same as from right click content 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 on top of it. For every curve, the setting is dependent on their features:

Name field: depending on the source of data for curve this field can be editable or not, if source is *Device channel* name field is editable, if 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 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 contain following options: Device channel, Document variable and Database table.

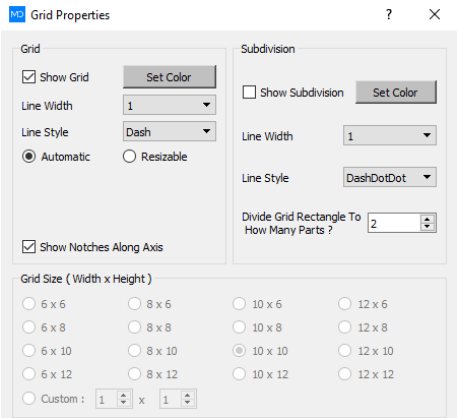
Picture 138: Graph Properties

If *Device channel* is selected, Channels group of settings on the right side of the window will become editable. You can set the curve *Multiply* and *Offset box.* From *Channel Table* tab you can establish channel connection which will be the source of data for the curve. Mark *Select Channel Server,* insert Server IP address and Server port and press Connect button, the connection will appear in table below. From *Settings* tab you can set which columns will be visible in 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. You can find out more about channels in section 3.8.6.

If *Document variable* is selected as curve source, *Available variables* drop down menu will appear from which 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 channel group will not be editable in this case. To learn more about variables go to section 2.2.

If *Database table* was selected as the curve source, *Database tables* drop down menu will appear from which you can choose which curves from the database will be displayed on a graph. In add it on the drop down menu contains the list of options where we established a connection to the database from Data tab of software (section 3.8.1). That selected database contains the data for at least one of the curves.

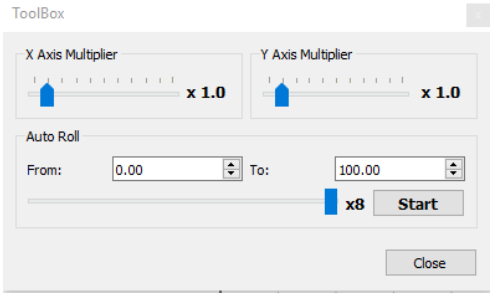
3.7.9 Grid



From the window shown in Picture 143 you can change the graph grid properties: you can show or hide grid, set line width, style, colour, make grid resizable, choose it size, show or hide notches along axis. Also you can show or hide subdivision, choose it size by selecting on how many parts you would like to divide the grid rectangle, set subdivision line width, style and colour.

Picture 139: Graph grid properties

3.7.10 Toolbox

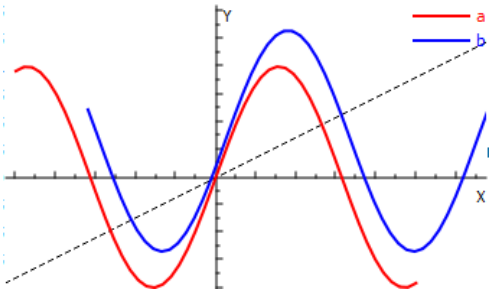


Picture 140: Graph toolbox window

From the *Toolbox* option the window shown in Picture 143will 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 *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.

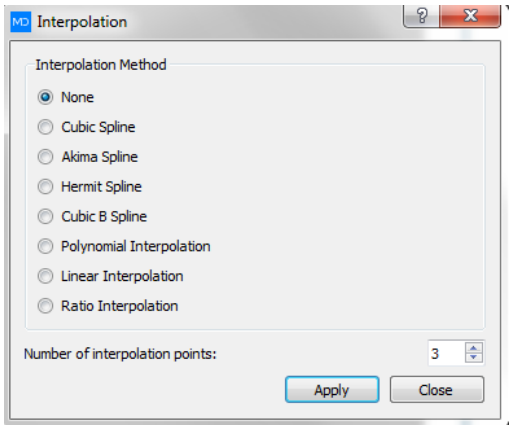
3.7.11 Perspective



Picture 141: 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 dashed line in Picture 145.

3.7.12 Interpolation

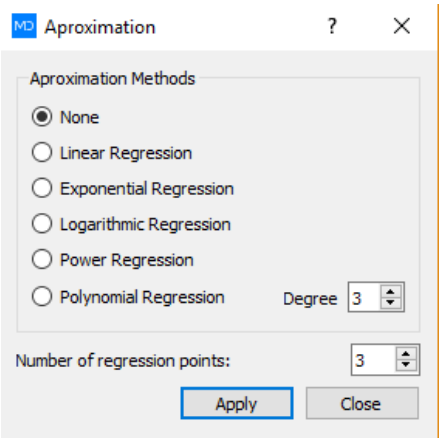


Picture 142: Interpolation

To use interpolations press the *Interpolation* icon and the window shown in Picture 146 will open. These settings refer only to the currently selected graph.

If 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 number of interpolation points and press Apply button. Number of interpolation points is a number in the range of 1-99 and represents number of points that will be placed between two source nodes.

3.7.13 Regression



Picture 143: Regression

To use regressions press *Regression* icon and the window shown in Picture 147 will open. These settings refer only to the currently selected graph.

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

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.

3.7.14 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.

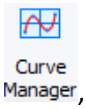
Solution:

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 $a := curve2d(\square, \square, \square, \square)$. In the first argument node type **(x-1)**, hold **Shift** and type **6**, that will create a power function node $(x-1)^{\square}$ 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**.

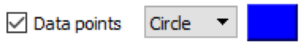
$$a := curve2d\left((x-1)^3 - 1, -1, 3, 20\right)$$

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.

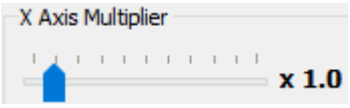
Press Curve Manager icon 

, press the red quadrant

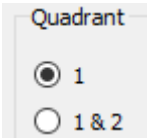
and the Select colour window will appear, set colour to orange and press OK. Tick on Data point's option, select the Circle from the drop down menu and set colour to blue 

. 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

, 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

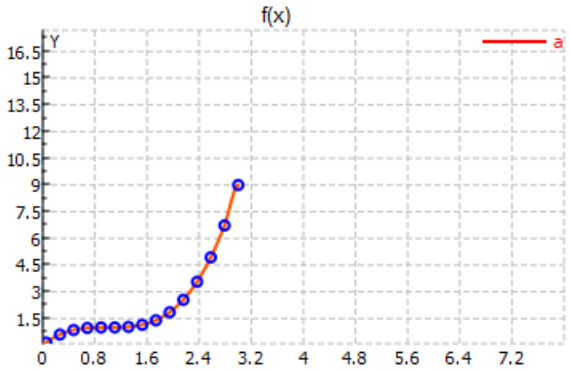
, a table will appear in the canvas. Place the cursor in the title column and type **f(x)**, now place the cursor in the top left corner of the table (cursor arrow will change to black arrow), open Home tab and from the Align icon drop down menu

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 147.

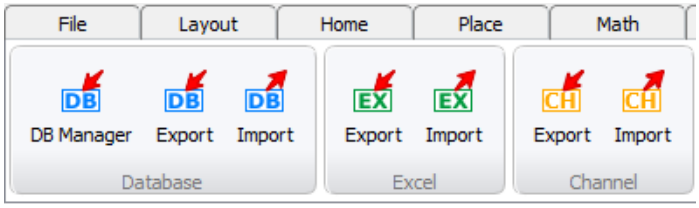
$$a := \text{curve2d}\left((x-1)^3 + 1 \, , x \, , -1 \, , 3 \, , 20 \right)$$

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



Picture 144: Graph tab example

3.8 Data tab



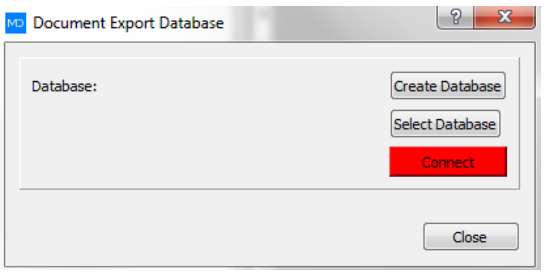
Picture 145: Data tab

From this tab you can connect your document with SQLite database or excel document to import and export your data, so they can be saved in other extensions. Also you can make a connection through TCP protocol with other computers or any other device that supports TCP IP protocol connection. This option allows you to transfer and display data in real time and opens up a wide range of ways to import, process, display and store data.

To use any of connecting options from this tab a document must to be created and every connection refers only to the current document.

3.8.1 DB Manager

MatDeck uses SQLite database management system to store and import data. If you would like to edit .db files created from MatDeck application you will have to install some SQLite viewers or tools, such as: DB Browser, SQLite studio, SQLite Manager for Firefox, …



Picture 146: DB Manager

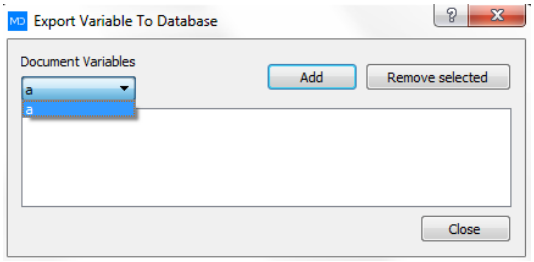
Use *DB Manager* Option to create a connection with the database. To create a new database press *Create Database* button, a new window will open from which you should create a database file with a name and location you prefer and then press Connect button. If you want to connect to an existing database use *Select Database* button, choose database file and press Connect button.

When you make a connection with a database the *Connect* button will change to *Disconnect* and it will appear like this Disconnect. To disconnect from a database just press this button.

3.8.2 Export to database

To create an Export database object press *Export* icon and click on a position in the canvas where you would like to place it. This is how Export database object looks like

.



Picture 147: DB export properties

Right mouse click opens up the content menu from which you should choose *Properties* option that will open a window shown in Picture 151.
From the drop down menu of this window you can choose the data of variable which you would like to be exported to database. List of variables contains all variables created in the current document. After you selected a variable press the *Add* button, variable will appear in the table of variables to be exported. To remove a variable from this table, select it and press the *Remove button.*

3.8.2.1 Example: Export to database

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

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. Now create a variable with code **a:=curve2d** and a new variable with the function inside it will appear $a := \text{curve2d}(\square, \square, \square, \square, \square)$. In the first argument node type **sin** and insert the symbol **x** inthe sine function. In the second argument node type **-2**, in the third argument node type **2** and in the fourth type **50**. $a := \text{curve2d}(\sin(x), -2, 2, 50)$

Press the DB Manager icon

then choose the Create database button. A new window will open, create a new database file *base.db* on the Desktop of yourcomputer. Type **base** in the File name field, choose Desktop from the list and then press the Save button. Press

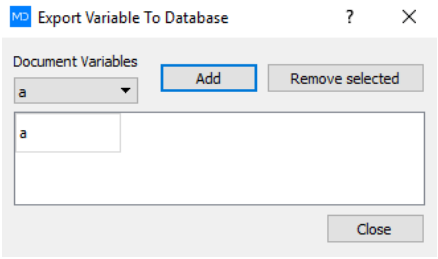
buttom,the connection to the database is established. The connect button will change to

button. Press Close to exit this window.

Press the Export icon

and select a place on the canvas where you want to place it, a new Database export object will appear

. Place the cursor above this object and using the right mouse click content menu choose Properties and the *Export Variable To Database* window will



open. In the Document Variables menu, variable **a** is selected as 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 database export data object will now looks like this

meaning that we exported data from variable a to our database.

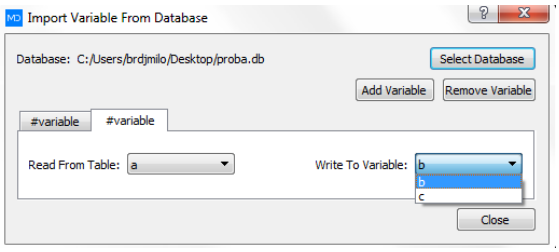
Now we have a SQLite file base.db on the Desktop of our computer in which we have saved a matrix with two rows, in the first row we have placed data for the x axis and in the second we have placed the corresponding y axis data.

$$a := \text{curve2d}\left(\sin(x)\ ,\ x\ ,\ -2\ ,\ 2\ ,\ 50\right)$$

3.8.3 Import from database

To create an Import database object press the *Import* icon and click on a position in the canvas where you would like to place it. This is how the Import database object looks like

.



Picture 148: DB import properties

The right mouse button click opens up the content menu from which you should choose the *Properties* option that will open the window shown in Picture 152.
Press *Select Database* button to choose a db file from which you would like to import data from. Press *Add Variable* button and a *#variable* tab will appear, if you want to insert data from more variables press Add variable again and for each variable you will have one tab.
From *Read table* in the drop down menu, select the variable for which data you would like to insert. From *Write table in the* drop down menu select the variable from the document you would like to store the data in.
To remove a variable which data you have imported, select the tab from where you inserted the variable data and press *Remove variable button.*

3.8.3.1 Example: Import from database

Import data we exported in example 3.8.2.1 and draw 2D graph with them.

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 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

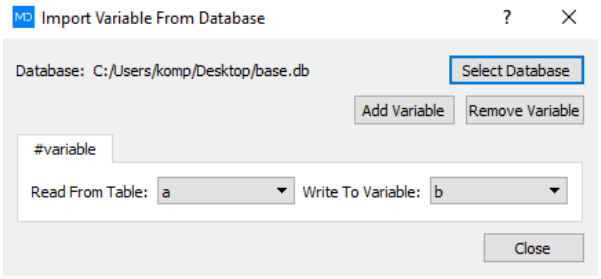
and then press the Select database button. A new window will open, select the Desktop of your computer, selected the base.db file and press Open button. Press the

button and now the connection to the database is established. The connect button now has changed to

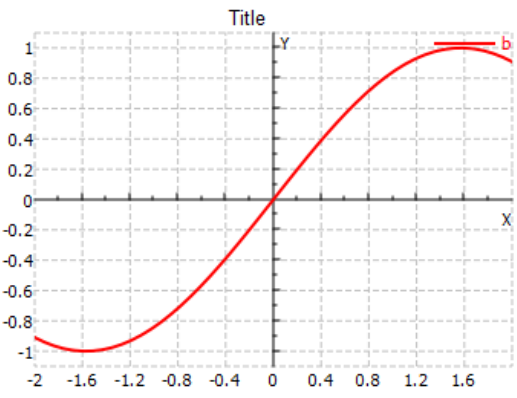
button. Press Close to exit this window.

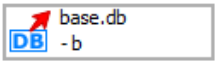
Press the Import icon

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.



b := 0



The database import data object will now looks like this 

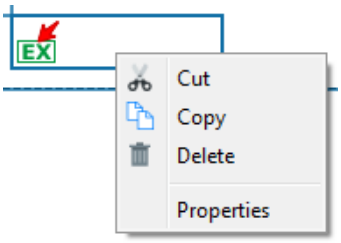
meaning that we have imported data from the database to variable b. Now we shall draw the graph with this data.

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.

3.8.4 Export to excel

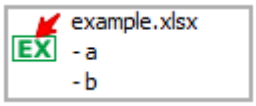


Picture 149: Excel export content menu

To create the Excel export object press the *Export* icon and click on the position on the canvas where you would like to place it. This is how the excel export object looks like

.

Pressing the right mouse button opens the content menu from which you should choose the *Properties* option that will open the window shown on Picture 153.



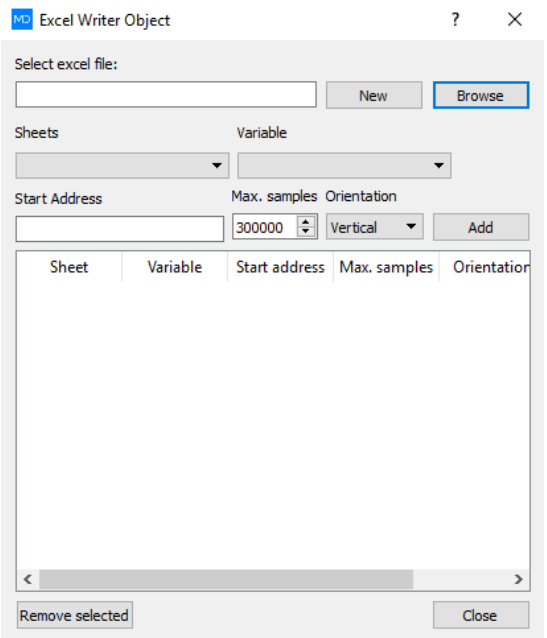
Picture 150: Excel export object

Press New and select a folder where you want to create a new excel file or press *Browse* to select existing excel document in which you want to export data. Select a Sheet from the drop down menu and the variable which data you are exporting (a list of variables will contain all variables created in current document), in *Starting Address* type number of an excel cell from which the data will be written and select *Max. Samples* value. We suggest leaving this value to a default.

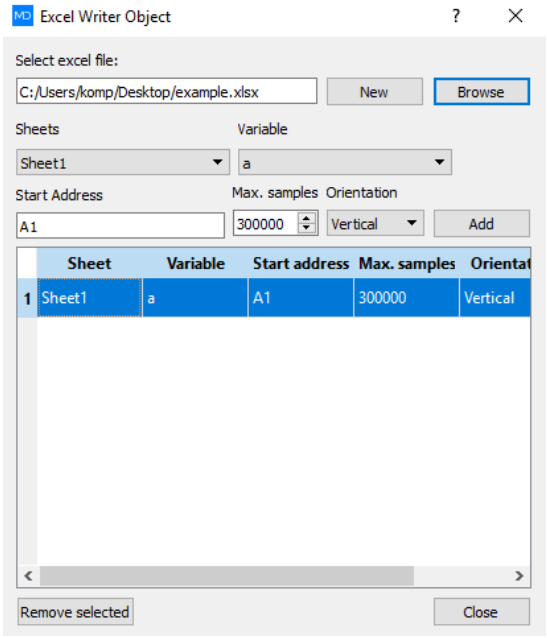
Select *Orientation* and press *Add* button.

A new row will appear in the table of connected variables where you can view all parameters set in this window.

To remove a variable connection from table, select the row you want to remove and press *Remove selected* button.



Picture 151: Excel export



Picture 152: Excel export remove variable

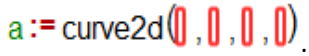
3.8.4.1 Example: Export to excel

Export values of the sine function on the interval [-2, 2] to excel file.

Solution:

Create a new document by pressing the New icon

, 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 **a:=curve2d** and a new variable with functions inside it will appear 

. At the first argument node type **sin** and insert the symbol **x** in the sine function. In the second argument node type **-2**, in the third argument node type **2** and in the fourth type **20**.

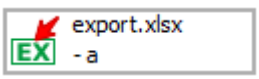
$$a := curve2d(sin(x), -2, 2, 50)$$

Press the Export icon

, select a place on canvas where you want to place it, a new Excel export object will appear
. Place the cursor above this object, from the right mouse click content menu choose Properties and an *Excel Writer Object* window will open.

Before we continue, we have to create an excel file in which we are going to export data. Therefore we created export.xlsx file on the Desktop. Press the Browse button and a new window open, choose export.xlsx file from your Desktop. In the Sheets field choose the excel sheet where the data will be placed, a Variable field will automatically display variable a (because it is the only variable in current document). In the Start address box, type the excel cell position as a starting cell for data export, (we inserted A1 in this field), choose Max. Samples value (always insert a larger number than your current data size, because of a possible change the size of variable a), choose Orientation of exported data (we left Vertical option) and press Add button. A table of export will add one row with variable a, that we have just selected to export data from. Press the Close button to exit this window.

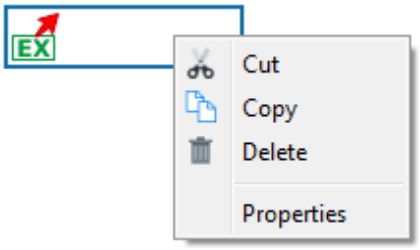
Excel file export.xlsx is locked for read/edit during the export process. We can't open it until the current MatDeck document is opened. After we close this document, we can open a excel file and see the exported data.

After the closing of the Excel Writer Object window, the Excel export object will look like this 

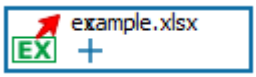
.

$$a := curve2d(sin(x), x, -2, 2, 50)$$

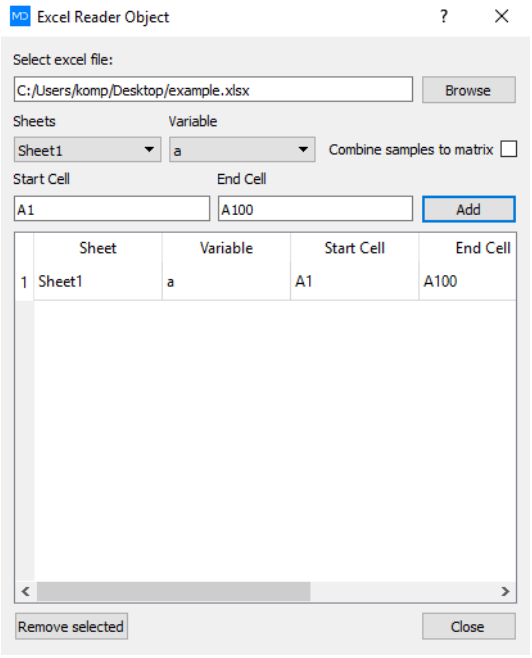
3.8.5 Import from excel



Picture 153: Excel import content menu



Picture 154: Excel import object



Picture 155: Excel import

To create an Excel import object press the *Import* icon and click on the position in the canvas where you would like to place it. This is how excel import objects looks like.

Right mouse click will open the content menu from which you should choose the *Properties* option that will open a window shown on Picture 157.

Open *the* drop down menu. Press *Browse* and select the excel document from which you want to import data. From the drop down menu *Sheets* select the one that will contain the data you want to import, select a variable in which the data will be placed (list of variables will contain all variables created in current document).Insert range where data is placed in excel document (*Start* and *End Cell*), this range specifies the size of the variable after insertion of data and press the *Add* button.
A new row will appear in the table of connected variables where you can view all parameters set in this window.

If you want to insert several rows/columns from an excel document to a variable, select the option *Combine samples to single matrix*. *You* will have to specify the range for every row/column of data you are inserting and add it in the table of connections. Don't forget to choose the same destination variable when you add connections.

To remove a variable connection from a table, select the row you want to remove and press the *Remove selected* button.

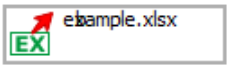
3.8.5.1 Example: Import from excel

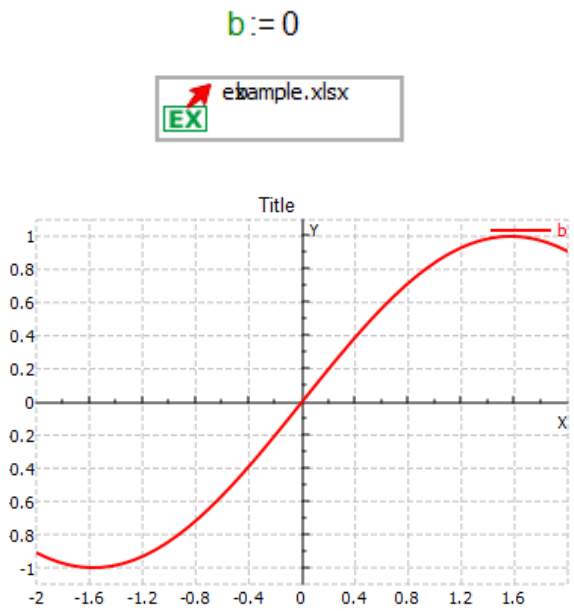
Import data we exported in example 3.8.4.1 and draw 2D graph with them.

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. PresstheImport 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.

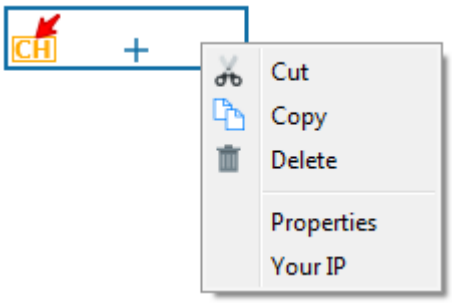
Press the Browse button and from the new windows that you have just opened choose export.xlsx file from your Desktop (file where data was exported). In the Sheets field, choose the excel sheet where your data is saved, the Variable field will automatically display variable b (because it is the only variable 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.



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.

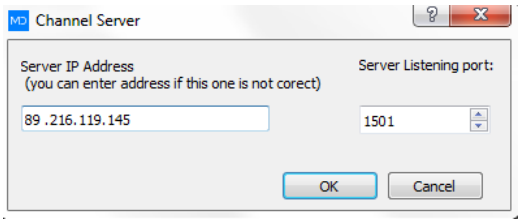
3.8.6 Export to channel



Picture 156: Channel export content menu

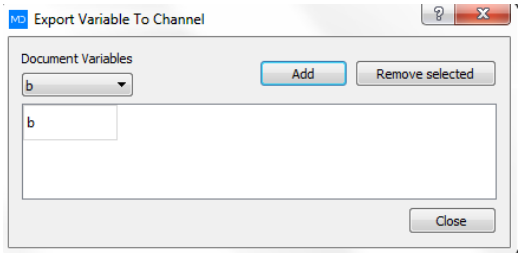
To create a channel export object, press the *Export* icon and click on the position in the canvas where you would like to place it. This is how the channel export object looks like.

The right mouse click opens a content menu shown on Picture 160 from which you can choose *Properties* and *Your IP* options.



Picture 157: Your IP option window

Your IP option opens a window also shown on Picture 160, where the Server IP address and Server listening port fields are already filled. Both fields refer to your computer (named server in their descriptions). The *Server IP Address* field contains public IP address of your rooter (if your computer is connected to internet) or your default localhost IP address 127.0.0.1 (if your computer is offline). Server listening port is by default set to 1501.



Picture 158: Properties option window

The *Properties* option opens a window shown on Picture 162 from which you can choose the variable you would like to export. A list of variables in the drop down menu consists of all the variables created in the current document. After you choose a variable press the *Add* button and a variable will appear in the table meaning that you exported its data through the channel. To remove it from the table of exported variables select the row within the table and press the *Remove selected* button.

3.8.6.1 Example: Export to channel

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

Solution:

Create a new document by pressing the New icon

, 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 **a:=curve2d**anda new variable with functions inside it

will appear $a := curve2d(\square, \square, \square, \square, \square)$. For function first argument type **sin** and insert the symbol **x** inthesine function. For the second argument type **-2**, in the third argument type **2** and in the fourth type **30**.

$$a := curve2d(sin(x), -2, 2, 30)$$

Press the Export icon

, 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 looks like this

meaning that we have exported data from variable a to channel.

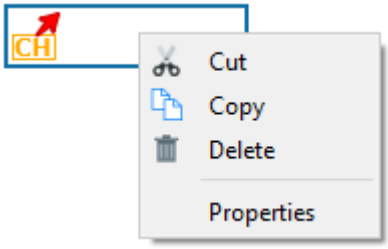
Now we have opened the channel from which we are sending the data via variable a as a matrix with two rows, in the first row we have placed data for the x axis and in the second, y axis data.

At the end we will save the file by pressing the Save icon

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.

$$a := curve2d(sin(x), x, -2, 2, 30)$$

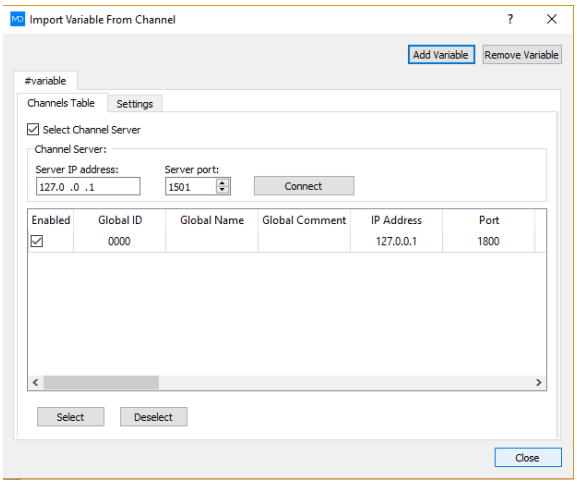
3.8.7 Import from channel



Picture 159: Channel import content menu

To create a channel import object press the *Import* icon and click on its position in the canvas where you would like to place it. This is how the channel export object looks like

.
Right mouse click opens a content menu shown on Picture 162 from which you can choose the *Properties* option.



Picture 160: Channel import variable – Channel Table tab

The *Properties* option opens a window shown on Picture 163 from which you can import and remove variables by pressing the buttons *Add Variable* and *Remove Variable* from the top of the window.

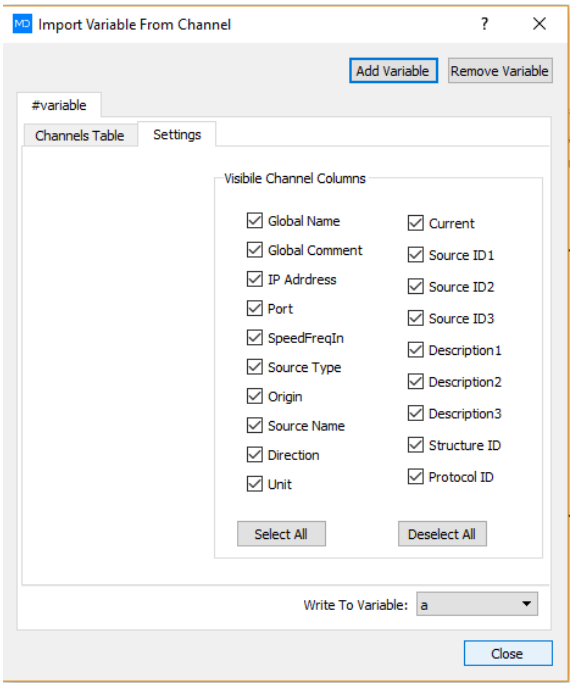
The *Add Variable* button will create a new tab with the name *#variable*. Every tab refers to one variable, so you can establish multiple imports by creating several tabs. There are two sub tabs inside the variable tab: The *Channel table* tab is where you can manage the channel connection and the *Settings* tab is where you can set visibility of the columns for the first tab.

Select the *Select Channel Server* option to connect to the preferred server (insert server IP address and port) by pressing the Connect button. After connection has been established, the table will be filled in with available variables that were exported through channel from the server that you have chosen.

Select row from the table that contains data you want to import, from drop down menu in bottom right corner of this window, choose the variable in which you want to import that data and press *Select* button. The table will change colour and enter to non-editable mode.

Write to variable drop down menu contains all variables created in current document.

To disconnect between the connected channel table row and variable, press *Deselect* button and the table will become editable again. To remove one of the tabs that contains channel – variable connections, select that tab and press *Remove variable* button.



Picture 161: Channel import variable – Setting tab

From the *Settings tab*, shown on Picture 164, you can choose which columns will be displayed in the Channel table tab when we establish connection to server. These settings refer to current variable tab; it is not a global setting for all variable tabs.

3.8.7.1 Example: Import to channel

Import data we exported in example 3.8.6.1 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 3.8.6.1.

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.

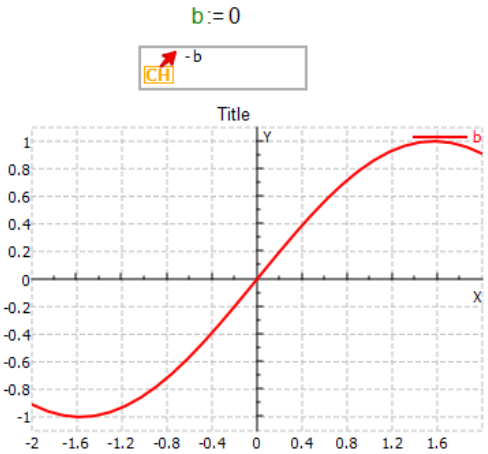
Press the Import icon

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.