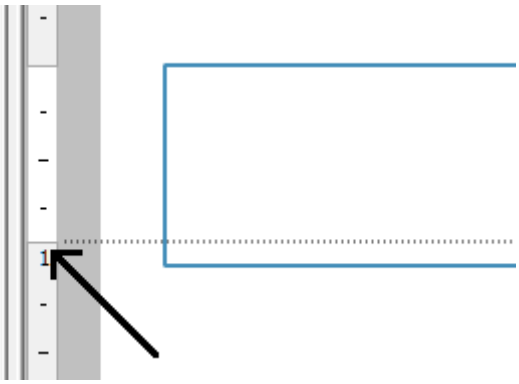
MatDeck Mathematics Manual

Contents

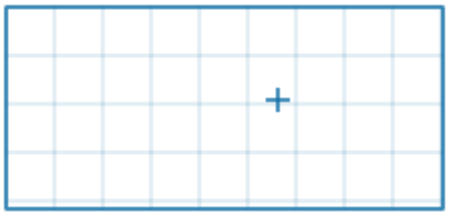
1.1 Variables

Formulas, functions and variables must be placed inside a canvas to be used. To do so, open the Insert Ribbon tab, then select the Canvas Icon and click on the document where you want to place the canvas. **To create a math object, double click on the canvas.**

If you need to resize you canvas place the mouse on the edge of the vertical ruler slider and move it towards either the top of the document or the bottom of the document, depending on whether you want to make the canvas smaller or bigger.



To turn the canvas grid off or on use Ctrl + G or right click the canvas, a menu will appear. Select Canvas properties from the menu and click on the Grid & Snap Ribbon, then tick the Show grid box.



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, click on canvas and 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.

MatDeck formulas, functions and variables 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. This means that the document will independently and automatically evaluate code, formulas and functions.

1.2 Getting Started in 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

$$a := b \cdot c$$

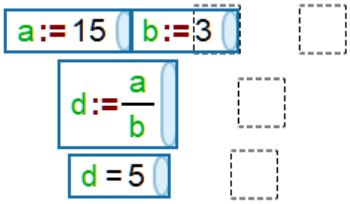
Shift + **6** (**^**) –to raise an object or element to a power in math objects

$$g := n^{0} \qquad g := n^{x}$$

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 unit, to make m as variable

$$F := m \cdot a$$

Select m and

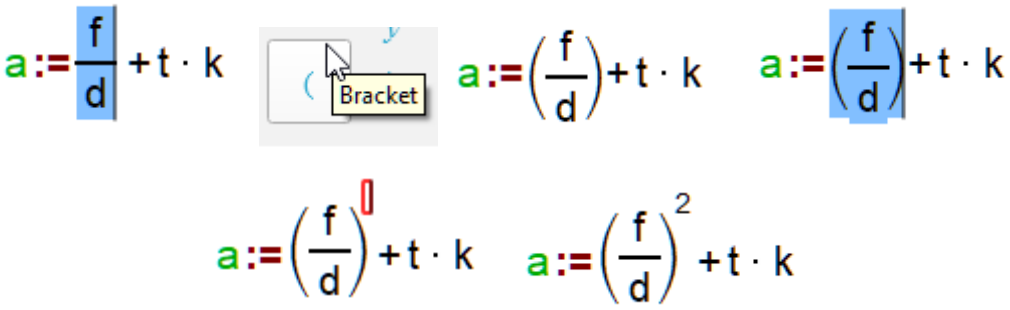
$$F := m \cdot a$$

Ctrl + U –changes units to variables and vice versa

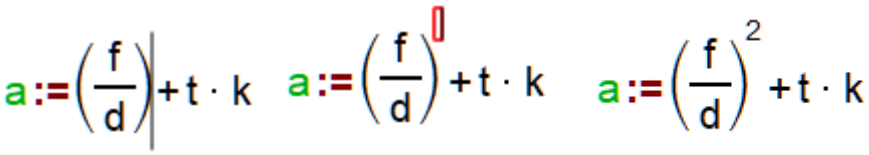
$$F := m \cdot a$$

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.



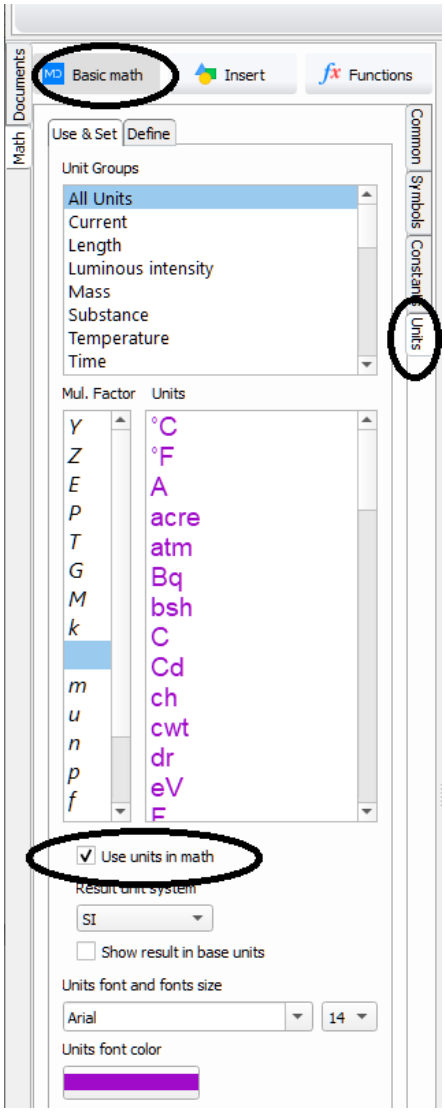
The click on the mathematical element in the Basic Math Tab e.g. the bracket sign or the cos sign. The mathematical element will appear on the outside of the selected variable/elements, meaning that the mathematical element is applied to the variable/element.



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.

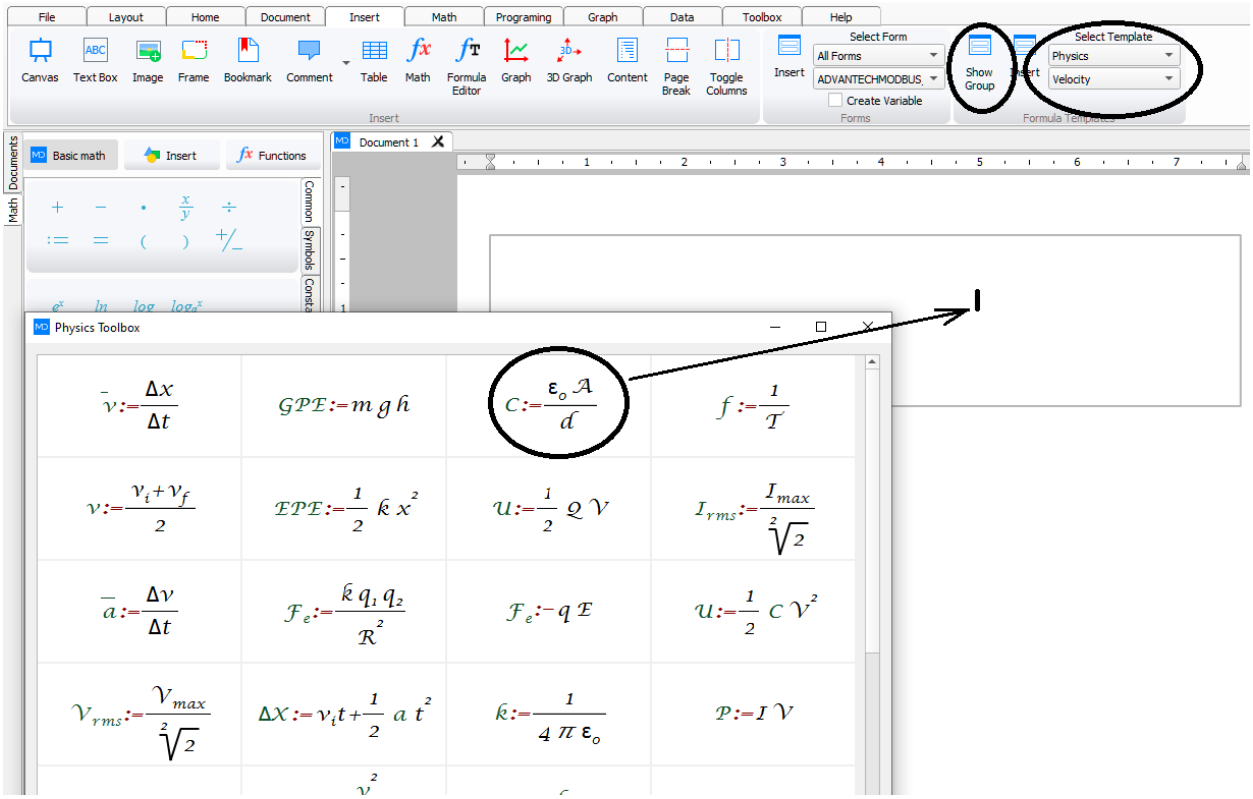
Switching units ON and OFF

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.

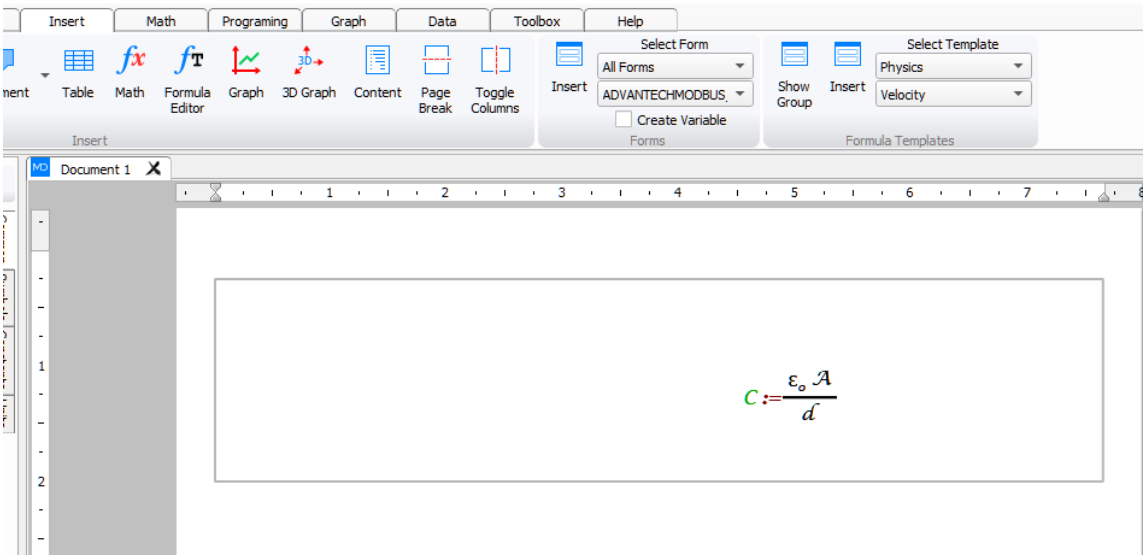


Formula Templates

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.



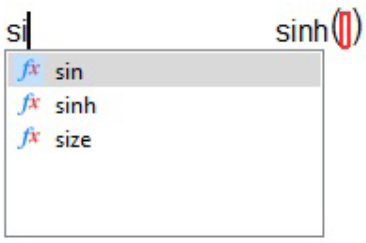
To then add the formula template to the canvas, double click on the canvas, when the vertical slash appears, click on the formula you would like to insert into the canvas.



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.

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

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;

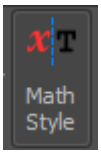
Formulas and Equations

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.

$$2\,x$$

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.

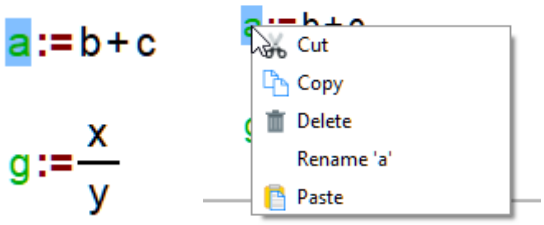
$$\int_{-\infty}^{\infty} e^{-x^2}\,dx = \sqrt[2]{\pi}$$

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

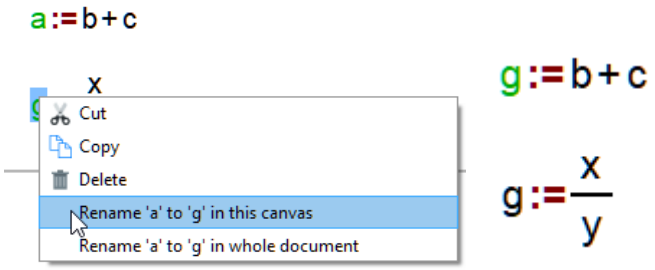
$$f(x) = \sqrt[2]{\left|\sum_{n=-\infty}^{\infty} \frac{y(n)}{x(n)}\right|}$$

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.

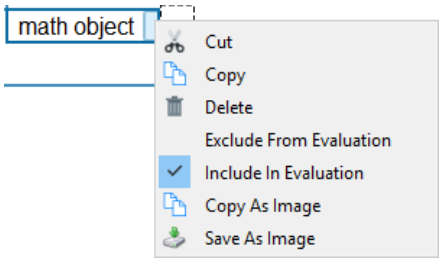
1.3 Formula Editor

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.

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

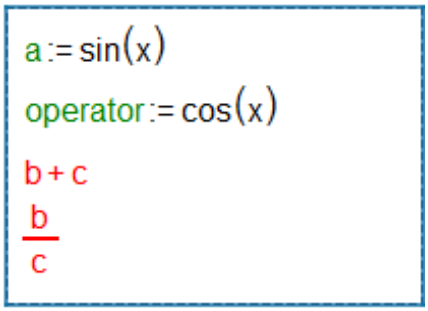
1.4 Math

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 1: Maths object

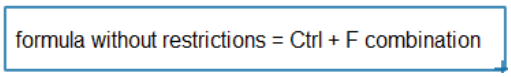
Math objects consist of a formula part which is bordered blue on Picture 1 and a formula caption bordered with dashed rectangle. Both the formula and caption part will resize depending on the content in them.



Picture 2: Variable declaration

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.

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 2);
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 3: 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.

1.3.1 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 $\frac{d}{dx}$ [], 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 := replace symbols([], [], []). 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=**.

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

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

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

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

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

$$z = 2$$

1.5 Using 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 1.8 .

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 canvas and the double click the preferred function from *Functions*.

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.

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

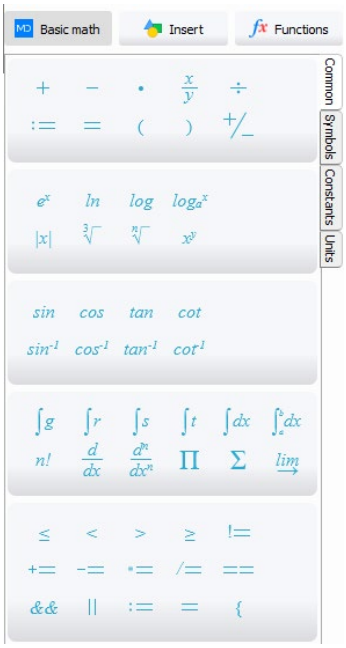
Depending on the functions and arguments, result can be single value (real or complex number), vector or matrix.

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

1.6 The Insert area

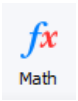
Insert area is divided in three groups: **Basic Maths**, **Insert** and **Functions.**
We will walk through each group and all the tabs inside of them.

1.7 The Common tab



Picture 4: 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.



1.6.1 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:

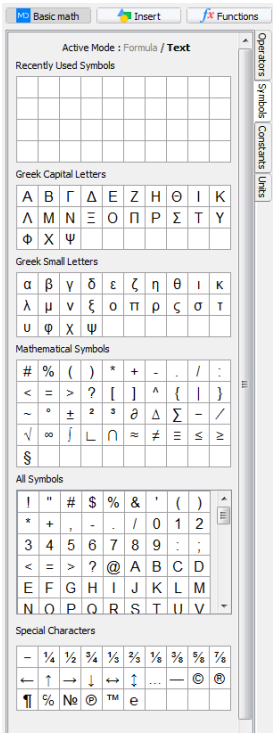
At the beginning we will create variable x and grant it value 2 with command **x := 2**, this variable will be used to check the results . Creating variable **a** allows us to store a formula expression, with command **a :=**, press Σ icon to create sum, press $\frac{x}{y}$ to create fraction. In the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

$$x := 2$$

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

$$a = 0.909$$

1.8 The Symbols tab



Picture 5: 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 *5* you can see a table of all the symbols that can be placed in the document.

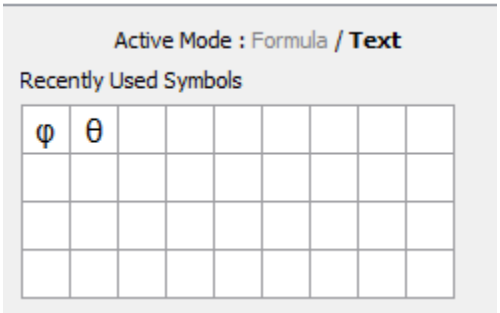
Symbols in this tab are divided in several groups: *Greek Capital Letters, Greek Small Letters, Mathematical Symbols, All Symbols* and *Special Characters*. Above them all is *Recently Used Symbols* group.

1.7.1 Example: Symbols

Create a table of trigonometric identities for product to sum.

Solution:

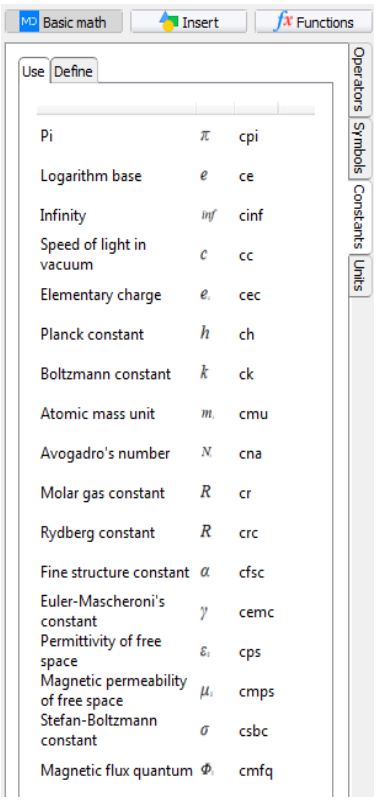
First, let's insert an empty table into the document. In the Place tab, press Table icon and choose a table of five rows and one column, click on the document and an empty table will appear in it. Place the cursor into the first row and type **Product to sum**, place it into the second row, type **2 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

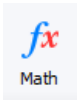
Product to sum
$2 \cos\theta \cos\varphi = \cos(\theta - \varphi) + \cos(\theta + \varphi)$
$2 \sin\theta \sin\varphi = \cos(\theta - \varphi) - \cos(\theta + \varphi)$
$2 \sin\theta \cos\varphi = \sin(\theta + \varphi) + \sin(\theta - \varphi)$
$2 \cos\theta \sin\varphi = \sin(\theta + \varphi) - \sin(\theta - \varphi)$

1.9 The Constants tab



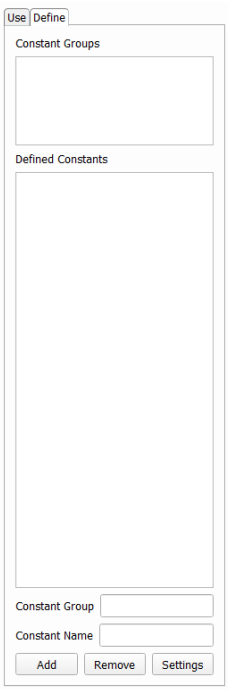
Picture 6: Constants – Use tab

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.

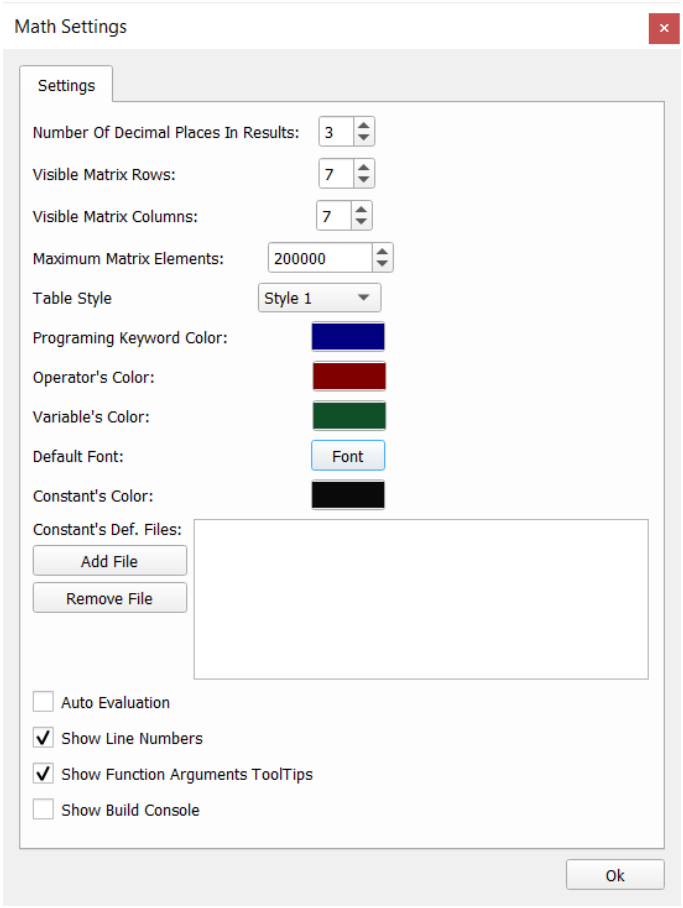
On the ***Use*** tab we can find predefined constants. Second column on Picture 6 shows us how constants will look like when we insert them into the document. The Third column is keywords for inserting constant through formulas. Every keyword begins with the letter **c**. For example, if we want to insert Euler's number *e* we will type **ce** in the Math object.



Picture 7: 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.

To import multiple constants via a MatDeck file, first press the "Settings" button located at the bottom of the constants tab. Once pressed, a new "Math Settings" window will appear. Here, you are greeted with several different customisable features applicable to your constants.

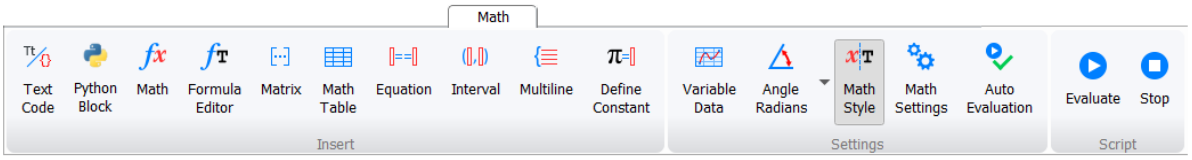


The Math Settings window will appear as such above. The settings available are:

- **Number of decimal places in results** – degree of decimal places results from calculations will reach
- **Visible matrix rows/columns** – number of rows/columns displayed in matrices
- **Maximum matrix elements**
- **Table style** – 3 available styles that can be used on math tables
- **Programming Keyword/Operator/Variable/Constant colour** – change colour to your preference
- **Default Font** – select your preferred font for numbers and letters in MD canvases
- **Constant's Def. Files** – here, you can add MatDeck files which contain your defined constants in canvases. All constants present in the MatDeck file will be auto added to the constants list and can be used anytime on any file. To remove constants, click on the file and press "Remove File"

1.8.1 Example: Constants defined in MD files

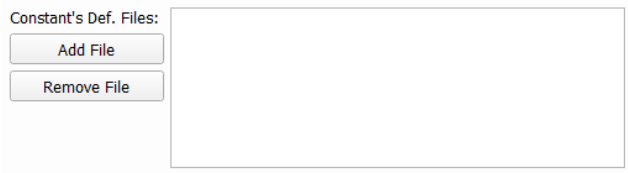
To defined new constants directly into a MatDeck file you must first create a math object within a MatDeck canvas. Users can create math objects by doubling clicking on the canvas and a math object will be created directly where the user double clicked.



Once a math object has been created, press on the define constant in the Math tab. By doing so, a constant form will be created with four empty argument fields. A empty constant form looks as such below.

The first argument is the symbol which represents your constant. Second is the actual value of the constant with units included. Units can be added using the units tab which is explained further in the manual. The group field is to which group does this constant belong to (Physics, Bio, …). The name filed is the full or abbreviated name of the constant u have entered.

Constant defined this way can be imported into MatDeck's constants by adding the file in the constant settings.



To do so, open the math settings by pressing the settings button placed at the bottom right corner of the constant tab.

1.9.1 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:

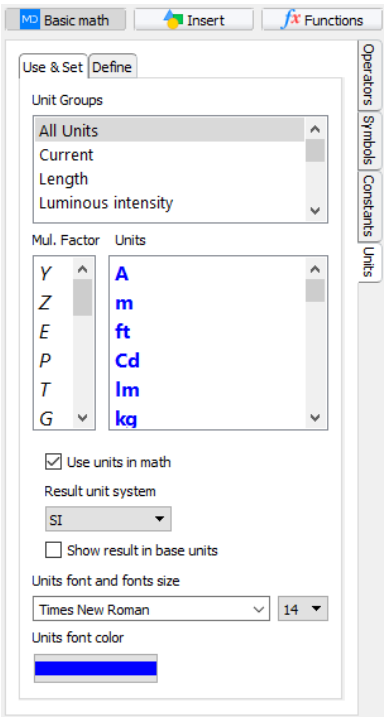
Go to the *Define* tab, enter constant name and constant symbol and press *Add Constant* button. After constant will appear in constant list, select it and enter value. For this example we defined constant
xyz = 4.72 m/s^2. As you can see, we can define constant with or without units.

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.

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

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

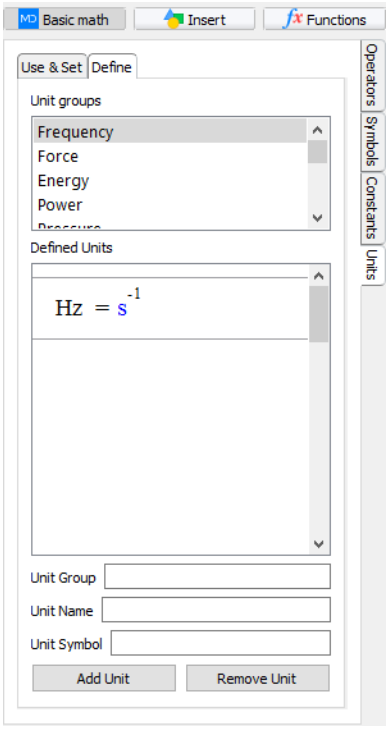
1.10 The Units tab



Picture 8: 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 9: 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.

1.10.1Example: Units

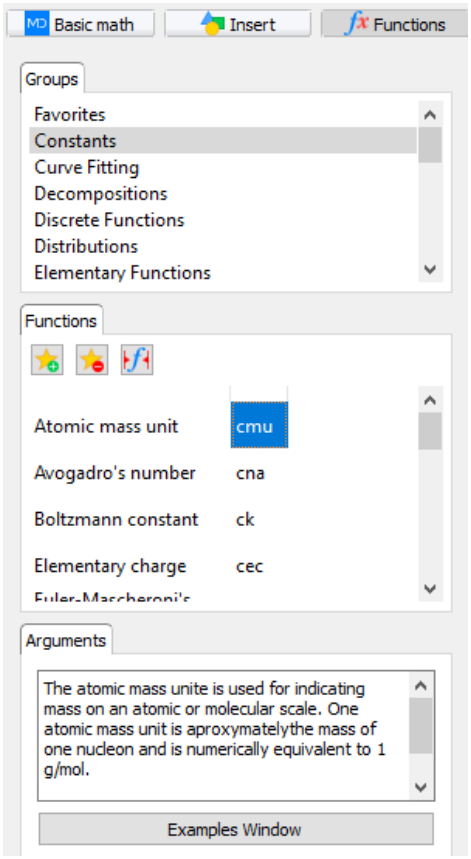
If a base of rectangle is b = 83 meters and a height h = 45 feet, calculate the area of rectangle in square feet.

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.

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

1.11 Functions



Picture 10: 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;

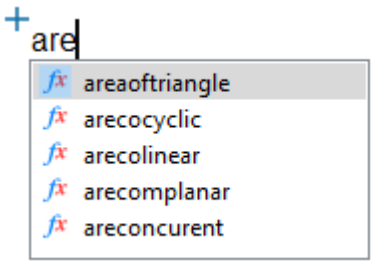
 Delete selected function from Favorites group;

 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.

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 11.
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.



Picture 11: Functions autosuggestion

1.11.1Example: Using 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.

We will use **replace symbols** function, after we type it it'll look like this replace symbols(▯ , ▯ , ▯) .

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

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

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

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

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

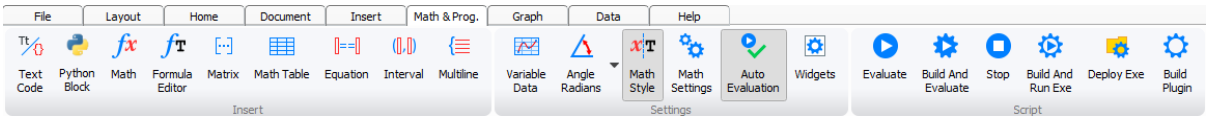
$$\text{replace symbols}(a , x , -3) = -18$$

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

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.

1.12 The Math tab



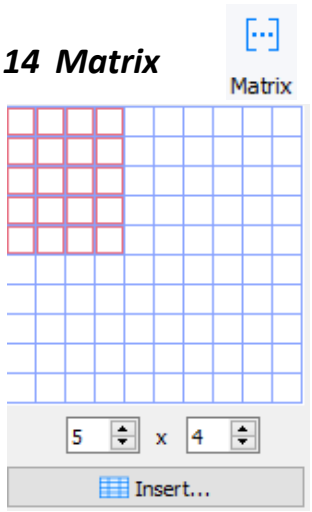
Picture 12: Math tab

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.

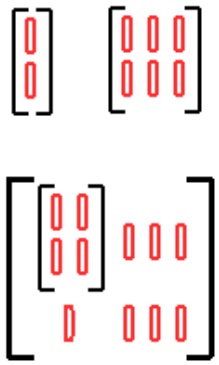
1.13 Auto Evaluation

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. This means that the document will independently and automatically evaluate code, formulas and functions.

1.14 Matrix



Picture 13: Insert matrix



Picture 14: 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 14.

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

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

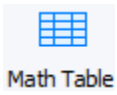
In MatDeck there is a group of functions called Matrix and Vector in which you can find a whole range of functions for data manipulation on vectors and matrix's. For example,

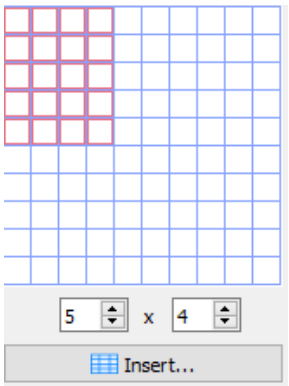
$$\text{rank}(a) = 2 \qquad \text{positivedefinite}(a) = \text{false}$$

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,

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

1.15 Math Table





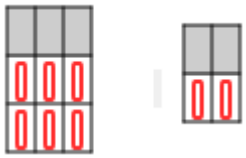
Picture 15: Insert Mat Table

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.

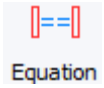
2) By selecting a number of rows and columns and clicking on Insert.

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 16: Empty tables

1.16 Equation

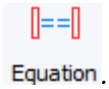


$$\square == \square$$

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

$$y <= x - 7$$

Picture 17: 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).

1.17 Interval

$$(\square,\square)$$

$$(a,b)$$

$$[a,b)$$

$$(a,b]$$

$$[a,b]$$

Picture 18: Intervals

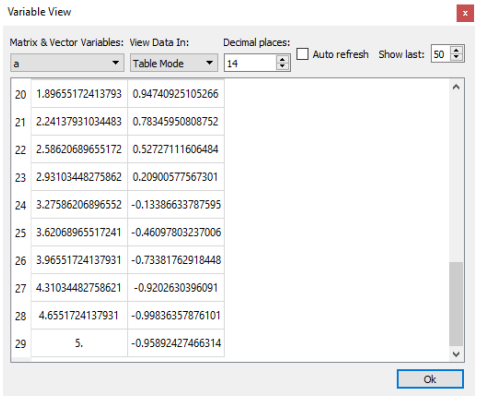
To insert an interval empty node use *Interval icon* 

. 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.

1.18 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.

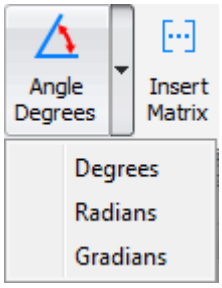


Picture 19: Variable data

To use this option click on the *Variable Data* icon and the window shown in Picture 19 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.

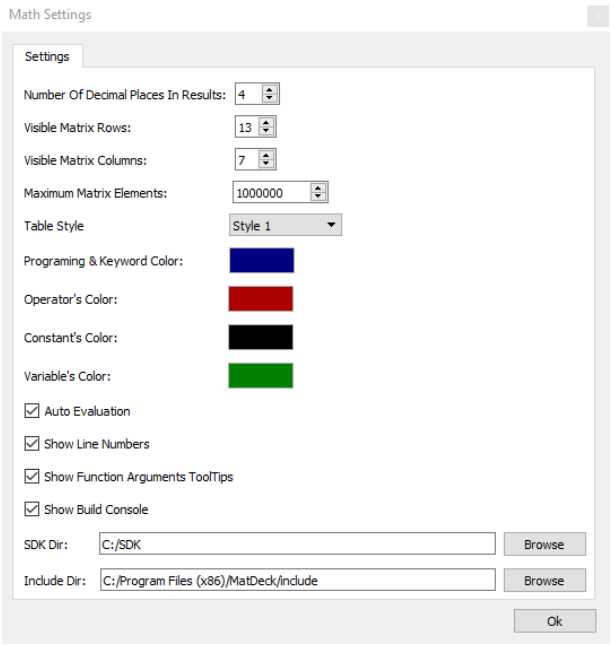
1.19 Angle units



Picture 20: Angle degrees

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

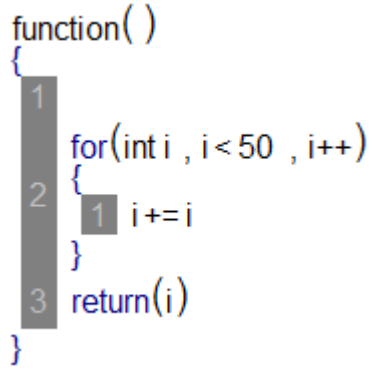
1.20 Maths settings



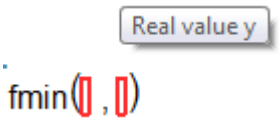
Picture 21: Math settings

Once the *Math Settings* icon is pressed the window shown in Picture 21 will open. From this window you can choose basic maths and programming settings. These settings are global and refer to all documents.

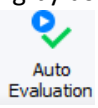
Number of decimal places in results: 0 – 14
Visible/table matrix rows: 1 - 15
Visible/table matrix column: 1 -15
(if vector, matrix or table size is greater that selected in the previous two options, the object will shrink to selected size and place ··· symbol in the corner; if you click on the symbol 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 22: Show line numbers



Picture 23: Tooltip in formula

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 

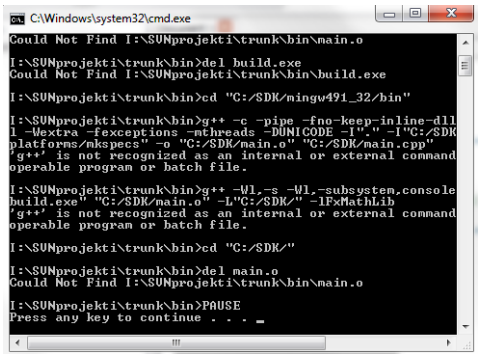
.

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.

Show line numbers: this option refers to programming and whether or not you want to display line numbers, as shown on Picture 22.

Show function arguments tooltips: this option shows tooltips for the function arguments, as shown on Picture 23.

Show build console: is an option from which you can choose if the console will be visible when *Build and run exe* option is in use, Picture 24

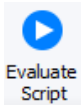


Picture 24: Build console

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)

1.21 Evaluate




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

Picture 25: 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).

1.22 Build And Evaluate


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

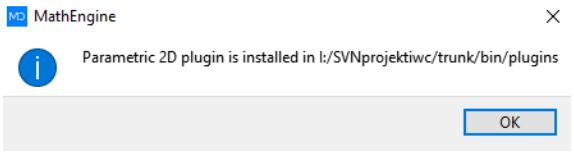
1.23 Stop script


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

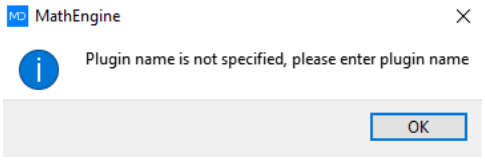
There is also an option to stop script calculations. To use it just press Stop script icon. Use this feature when the script enters infinite loops or when you want to stop calculations in order to correct a mistake.

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

1.24 Build plugins



Picture 1: Successfully installed plugin message



Picture 27: 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 Functions 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 Docs.

1.25 Multiline

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

Picture 28: Usage of multiline

Use this option to define noncontinuous functions or other multiline objects. It can only be used in formula objects Formula Editor meaning that it will be excluded from calculations and its purpose is to be used in documents for presentations and documentation.