

Knovel Equation Solver User Guide

Overview

The Equation Solver is a web application for desktop and tablet browsers that allows you to quickly make engineering calculations using online worksheets, which function similar to an engineering notebook.

- Open equation worksheets from Knovel's Interactive Equations and edit them directly in the browser. Use the worksheets as a starting point for your own calculations, to change the given variables or units, and to automatically calculate results without having to download and install anything.
- Create worksheets completely from scratch, enter equations, formulas, graphs, and descriptive text into a single worksheet and use built-in mathematical functions, engineering units, and mathematical symbols to create a comprehensive engineering solution.
- Equations display as they do in any engineering reference book; knowledge of programming language or complicated syntax is not required.
- Save worksheets as PDF, HTML, image, or Knovel proprietary format (.sm) files. Any worksheet can be printed out.
- No installation is required; the Solver is web-based. The following browsers are supported: Google Chrome 25 and above, Internet Explorer® 8.0 and above, Firefox 19 and above, Safari 5.1 and above, and Opera. The application uses cookies to store information about the current user's session. For example, worksheets are loaded in the current session. If cookies are disabled or if the browser is set to block storing your browser local data, the application will not work.
- The Solver is optimized for tablets, such as the iPad® and the Samsung Galaxy.


 [Watch](#) a brief introductory video tour of the Knovel Interactive Equation Solver.

Table of Contents

Equation Solver Interface Snapshots	2
How to Open the Equation Solver	5
Equation Solver Worksheets	8
Equation Solver Top Menu	11
Equation Solver Palettes	36
Known Issues	57
Equation Solver Cheat Sheet	

Equation Solver Interface Snapshots

The Solver interface consists of three main sections: 1) the **worksheet editing area**, in the center of the Solver, 2) the **top menu**, located above the worksheet editing area, which has tools for entering, editing and saving worksheets, and 3) the **palettes**, a menu of utilities for performing mathematical, programming, and plotting functions, located to the right of the worksheet area. The Solver can be displayed in two views: 1) embedded within the Interactive Equations pages, and 2) in a separate window or tab.

Top Menu: Create and save worksheets, insert text/ equations, edit and solve equations, and more

Show Solver in separate window

Hide Solver

Palettes: Insert operators and symbols, perform functions, and more

Worksheet editing area

Antoine Equation

An equation that describes the relation between the vapor pressure of pure components. The Antoine equation is defined by:

$$\ln P = A - \frac{B}{C + T}$$

where

pressure P Pa

A, B, C (dimensionless): component-specific constants

$A := 8$ $B := 2000$ $C := 300$ $T := 300$

$P = 46415.8883$

Arithmetic

Matrices

Boolean

Functions

Plot

Programming

Lowercase Greek

Uppercase Greek

Solver in Embedded view

↓ Top Menu: Create and save worksheets, insert text/equations, edit and solve equations, and more

Worksheet editing area

Palettes: Insert operators and symbols, perform functions, and more

Antoine Equation

An equation that describes the relation between vapor pressure and temperature for pure components. The Antoine equation is derived from the Clausius-Clapeyron relation.

$$P = 10^{\frac{A - \frac{B}{C+T}}{C+T}}$$

where

pressure P Pa

$A; B; C$ (dimensionless): component-specific empirical constant

$A=8$ $B=2000$ $C=300$ $T=300$

$P=46415.8893$

- Arithmetic
- Matrices
- Boolean
- Functions
- Plot
- Programming
- Lowercase Greek
- Uppercase Greek

Solver in separate window view


Click Show Solver button to open Solver in embedded view

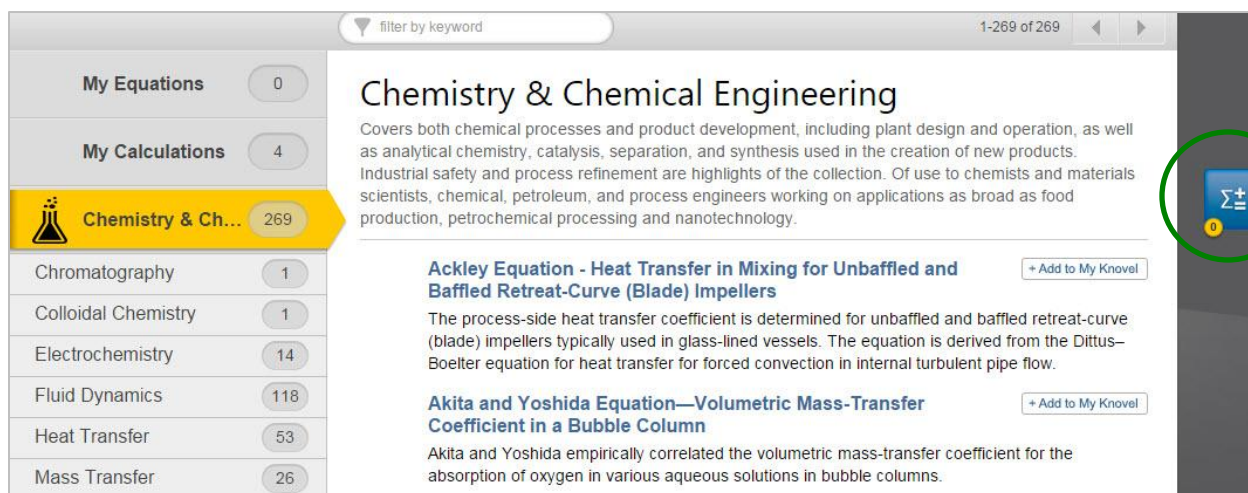
Show Solver button

How to Open the Equation Solver

The Equation Solver is part of Knovel Interactive Equations. There are a few ways to open the Equation Solver:

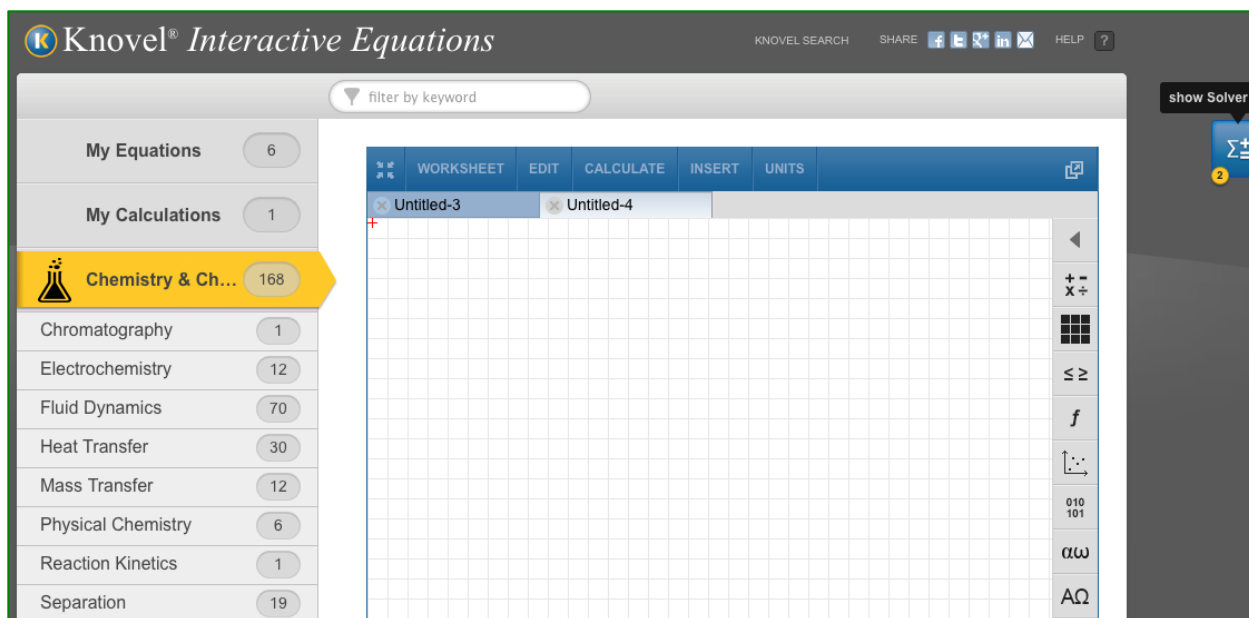
- From any page within Interactive Equations,

Click on the blue button located on the right side of the page  (a **Show Solver** tool tip will appear when you hover your mouse over the button). If you haven't yet opened a worksheet for this browser session, the Solver will open a blank worksheet. If you have already opened a worksheet(s), the number displayed in the left bottom corner of the button indicates the number of currently open worksheets. The Equation Solver will open in embedded view.



The screenshot shows the 'Interactive Equations' web interface. On the left is a sidebar with categories: 'My Equations' (0), 'My Calculations' (4), and 'Chemistry & Chemical Engineering' (269, highlighted in yellow). Below these are sub-categories like Chromatography (1), Colloidal Chemistry (1), Electrochemistry (14), Fluid Dynamics (118), Heat Transfer (53), and Mass Transfer (26). The main content area is titled 'Chemistry & Chemical Engineering' and contains a description of the collection. Below the description are two featured equations: 'Ackley Equation - Heat Transfer in Mixing for Unbaffled and Baffled Retreat-Curve (Blade) Impellers' and 'Akita and Yoshida Equation—Volumetric Mass-Transfer Coefficient in a Bubble Column'. On the right side of the page, there is a blue button with a calculator icon and a yellow circle with the number '0' in the bottom left corner, which is circled in green. This button is the 'Show Solver' button mentioned in the text.

Interactive Equations Browse page and Show Solver button



Open Equation Solver (embedded view)

- From any Equation detail page,

Move your cursor to the **open** button, then click **equation worksheet**.



Add equation worksheet to Solver

Knovel® Interactive Equations

Chemistry & Chemical Engineering > Thermodynamics > Gas Laws > Ideal Gas Law

Ideal Gas Law

Relates m, MW, P, V, and T for ideal gas.

Contributed by: Vadim Lvovich

References:
http://app.knovel.com/web/view/swf/show.v/cid:kt003BFBU4/root_slug:advanced-thermodynamics?cid=kt003BFBU4&page=1&b-group-by=true

Citations: Winterbone, Desmond E. (1997). Advanced Thermodynamics for Engineers. Elsevier. P. 121.

Worksheet:

Ideal Gas Law

Relates m, MW, P, V, and T for ideal gas.



$$P = \frac{m}{MW} \cdot R \cdot \frac{T}{V}$$


Legend with variables and units

Gas Pressure	P
Gas volume	V
gas temperature	T
gas weight	m
gas molecular weight	MW

Equation Detail Page, open Equation Worksheet

The Equation Solver will open in embedded view and will display the corresponding worksheet for this equation.

- To go back to the Interactive Equations page, click the **Hide Solver** button, , which is located in the upper left corner of the Solver in the embedded view.
- While in the embedded view, to open the Equation Solver in a separate window or tab, click the **Open Solver** button, , located in the upper right corner of the Top Menu.
- Note that your open worksheets remain intact and in sync across embedded and separate window views.

 Orange-colored elements of Knovel's Interactive Equations are static or read-only elements. Solver elements are blue, indicating interactivity.

Worksheets

There are two types of worksheets: (1) built-in worksheets authored by Knovel and (2) user-created worksheets. Though you can have multiple worksheets open at one time, for optimized performance it is recommended you work with a maximum of 10 worksheets simultaneously. Each worksheet may consist of one or more of the following “regions”, for inserting and working with equations (math), text, plot graphs, and images (see the **Top Menu/INSERT** section below for more information about regions). Every worksheet opens as a separate tab in the Solver interface.

Adding Knovel built-in worksheets to the Equation Solver

- Click **open** in the upper right corner of the Equation Detail page, then click **equation worksheet** to add the equation to its own worksheet. Or

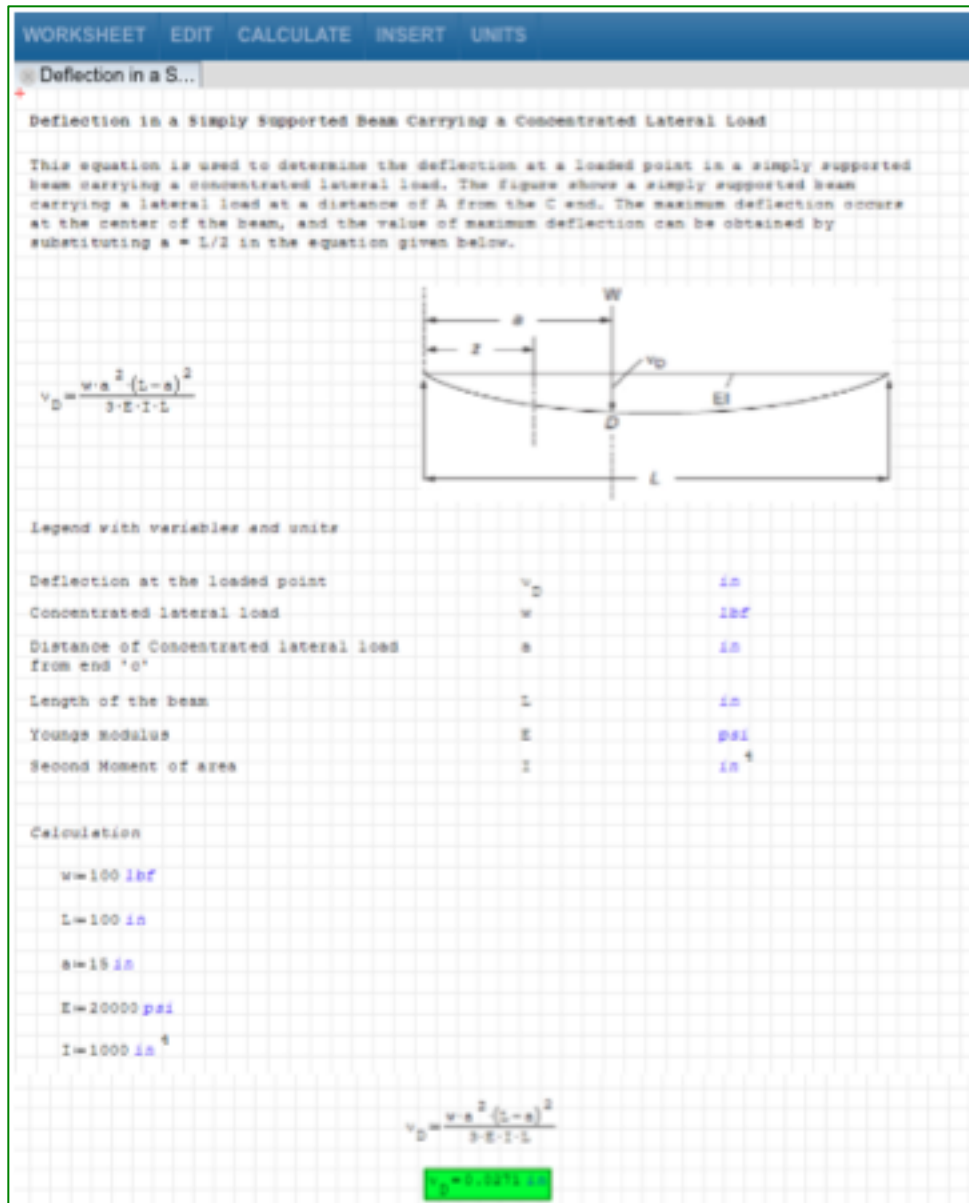
The screenshot shows the 'Equation' detail page in the Solver interface. The equation displayed is the Bernoulli Equation:
$$\Delta P := \rho g_e \left(\frac{u_2^2 - u_1^2}{2 g_e} + z_2 - z_1 \right)$$
 Below the equation, the following variables are defined:

- ΔP is pressure differential, Pa
- g_e is gravitational acceleration, m/s^2
- P_1 and P_2 is fluid pressures at two points in a pipe, Pa
- u_1 and u_2 is flow rates at the two points in a pipe, m/sec
- ρ is density of fluid, kg/m^3
- z_1 and z_2 is elevations of the two sections, m
- h is head loss due to friction, m

 In the top right corner, there is a button labeled 'Open Equation Solver' with a dropdown arrow. The dropdown menu is open, showing the option 'equation worksheet'. Below this option, it says 'Append to prior worksheet:' followed by 'Bernoulli Equation, First Equation'.

Add equation worksheet to Solver

- Click **open** and then click on the name of the equation(s) from the displayed list to append this equation to an already opened worksheet. The Solver opens and displays the built-in worksheet. See below for an example.



Built-in worksheet in separate window view

A built-in worksheet is prepopulated with the following information:

- Name of the equation
- Description of the equation

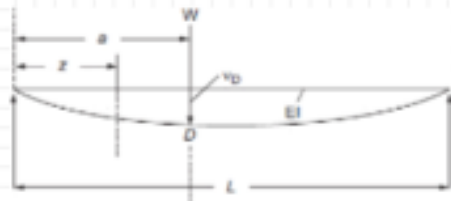
- Formula
- Legend that explains the variables by name, symbol and unit
- Interactive section for making your calculations; includes example values, units for correspondent variables, and results of your calculations
- Knovel citation
- Explanatory illustrations, if available

Equation/tab name →

Description →

Formula →

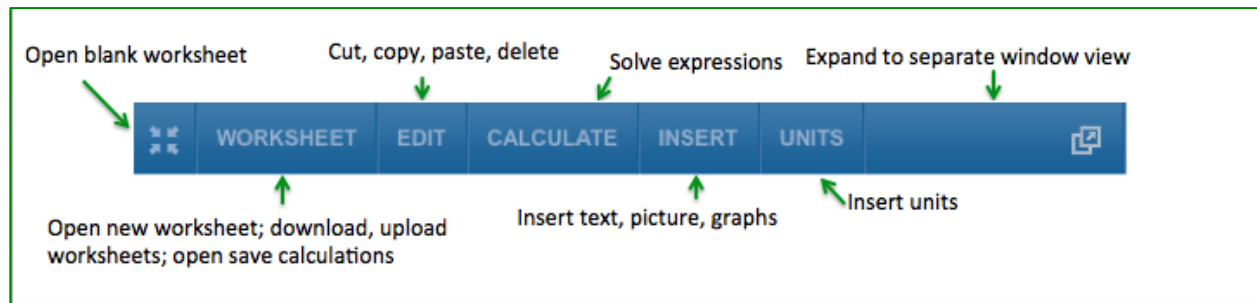
Legend →

WORKSHEET	EDIT	CALCULATE	INSERT	UNITS																		
Deflection in a S...																						
<p>Deflection in a Simply Supported Beam Carrying a Concentrated Lateral Load</p> <p>This equation is used to determine the deflection at a loaded point in a simply supported beam carrying a concentrated lateral load. The figure shows a simply supported beam carrying a lateral load at a distance of A from the C end. The maximum deflection occurs at the center of the beam, and the value of maximum deflection can be obtained by substituting a = L/2 in the equation given below.</p> <div style="display: flex; align-items: center; justify-content: center;"> <div style="margin-right: 20px;"> $v_D = \frac{w \cdot a^2 \cdot (L-a)^2}{3 \cdot E \cdot I \cdot L}$ </div>  </div> <p>Where ,</p> <table style="width: 100%;"> <tr> <td>Deflection at the loaded point</td> <td>v_D</td> <td>in</td> </tr> <tr> <td>Concentrated lateral load</td> <td>w</td> <td>lbf</td> </tr> <tr> <td>Distance of Concentrated lateral load from end 'c'</td> <td>a</td> <td>in</td> </tr> <tr> <td>Length of the beam</td> <td>L</td> <td>in</td> </tr> <tr> <td>Youngs modulus</td> <td>E</td> <td>psi</td> </tr> <tr> <td>Second Moment of area</td> <td>I</td> <td>in⁴</td> </tr> </table> <p> $w=100$ lbf $L=100$ in $a=15$ in $E=20000$ psi $I=1000$ in⁴ </p> <p style="text-align: center;">Calculation result</p> <div style="background-color: #00ff00; padding: 5px; text-align: center; margin: 10px auto; width: 100px;"> $v_D = 0.0275$ in </div> <p style="text-align: right;">Knovel citation</p> <p>Document downloaded from http://tools.knovel.com/EL. Original compilation copyright</p> <p>Use of this document is subject to the Knovel Terms and Conditions which can be found here, http://why.knovel.com/terms-a-conditions.html</p>					Deflection at the loaded point	v_D	in	Concentrated lateral load	w	lbf	Distance of Concentrated lateral load from end 'c'	a	in	Length of the beam	L	in	Youngs modulus	E	psi	Second Moment of area	I	in ⁴
Deflection at the loaded point	v_D	in																				
Concentrated lateral load	w	lbf																				
Distance of Concentrated lateral load from end 'c'	a	in																				
Length of the beam	L	in																				
Youngs modulus	E	psi																				
Second Moment of area	I	in ⁴																				

Open worksheet with elements identified

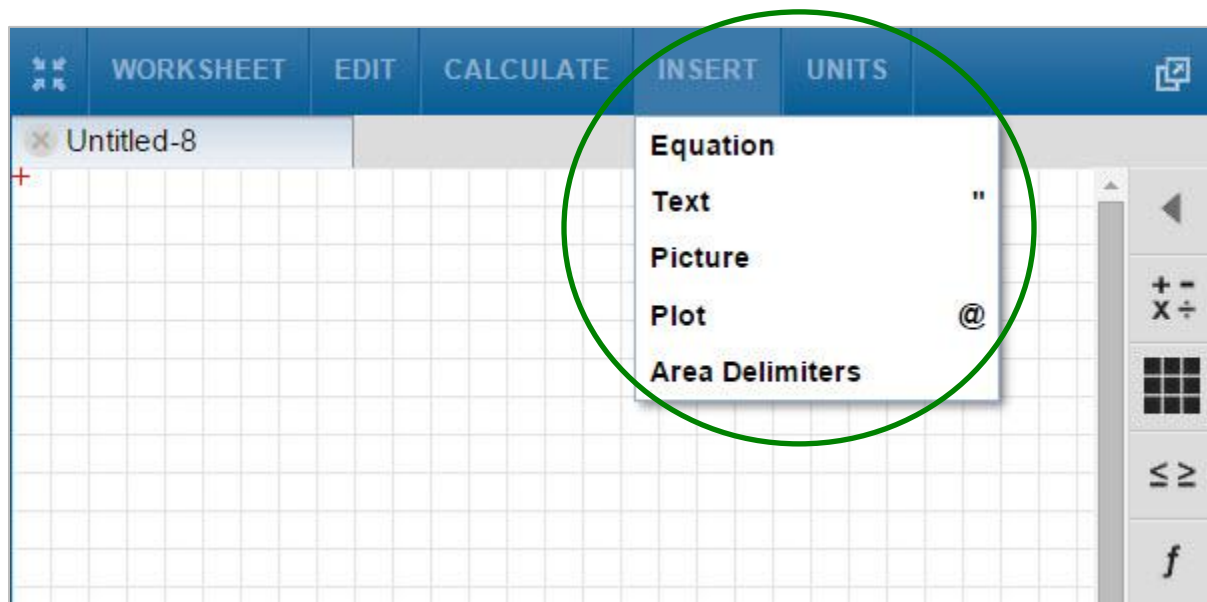
- Edit any part of the worksheet. Enter different values or units for variables and the result will be automatically re-calculated.
- To rename the worksheet, click the worksheet tab name twice to make it editable. Then, click your return key to save the name.

Top Menu




The top menu, located above the worksheet editing area, consists of buttons that allow you to create blank worksheets, upload worksheets from your local device, save worksheets in various formats, edit (cut, copy, paste and delete) within a worksheet, and includes various calculation functions as well as access to print and units menus. Hover your mouse over the buttons to read tips on how to use them.

A. INSERT



Open INSERT drop-down button in Top Menu

- Click the **INSERT** button to insert a “region” into a worksheet. A “region” is an independent part of the worksheet, which can be selected and edited. The following “regions” may be combined within a worksheet: **Equation, Text, Plot, Picture, and Area Delimiters**.
- Position your worksheet cursor  at the point in the worksheet where you want to insert a region, type data or text, or work with **palette** utilities (the cursor defaults to the upper left corner when you open a new worksheet).
- Click anywhere inside the worksheet to reposition your cursor.
- When you have finished working with a region, click on any point outside the region or use your device’s “Enter” or “Return” key.

In addition to the **INSERT** button, you can use the following shortcuts to insert regions into your worksheet (currently, there is no shortcut to insert an **Area Delimiters** region).

Region	Keyboard Shortcut
Equation (default region)	Start typing
Text	Double quotes
Plot	@

Equation region

- Equation is the default region of the Solver. It allows you to enter any mathematical expression or equation.
- To insert, place your cursor at the desired location in the worksheet. Then, click **INSERT**, then **Equation**; or just simply start typing.
- To insert symbols into an equation region, use the **palettes** positioned on the right side of the screen: Arithmetic, Matrices, Boolean, Functions, Programming and the palettes for Greek Symbols (see details on palettes later in this guide). Note that some symbols—such as digits from the **Arithmetic** palette—can be

inserted directly from your local device keyboard (see the Cheat Sheet at this end of this guide for details).

Working with variables in an equation region:

- Variable names can be any combination of letters (Latin or Greek symbols), numbers, the underscore symbol, or subscript symbol. However, they must start with a letter and are case-sensitive.
- Examples of valid variables names:
 - my_var
 - My_var1
 - length_of_the_beam
 - α_1 (type the word “dot” to display subscript; in this example: “ α dot 1”),

Subscripts only display within the Equation region. To use subscripts in other regions, you must switch to the Equation region. Also note that the Solver interprets literal subscripts and vector subscripts (indexes) differently.



[Watch](#) a brief video on using Functions, which explains the difference between literal and vector subscripts.

Defining a variable

- Variables do not need to be defined before their formula or function is typed into the worksheet. However, variables need to be assigned values for a formula or expression that uses them to be evaluated numerically. See example below:

```
// symbolic variables a and b do not need to be defined before using them in function f(x)
f(x):=a·x+b

// symbolic variables need to be assigned values in order to evaluate f(x)
// red indicates error
f(3)=
// symbolic variables are defined
a:=2
b:=2
f(3)=8
```

Numeric evaluation using variables

- A variable that has not been defined cannot be evaluated. The variable is displayed in red, indicating that it needs to be defined.

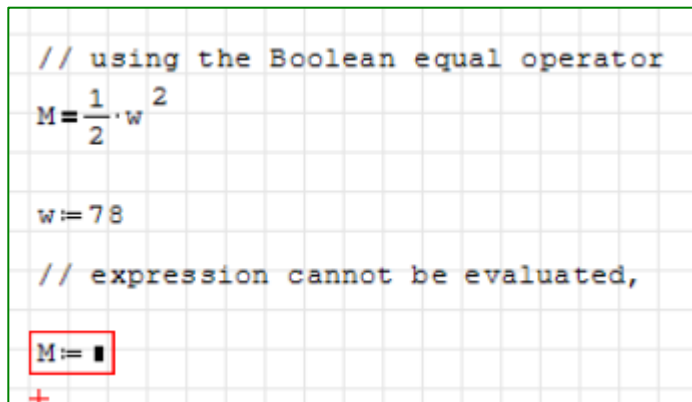
```
// variable new_variable has not been defined
new_variable:=
```

Indication of an undefined variable

- If you inadvertently enter numbers and symbols incorrectly, the Solver will display the error with a red border.
- If you try to use the numerical evaluator with an undefined variable the Solver will switch automatically to the **Definition** operator (**:=**). To insert the **Definition** operator: 1) open the **Arithmetic** palette and click the **Definition** button, or 2) type

(:) and the Solver will automatically insert the operator. Use the **Definition** operator if you intend your expression to be numerically evaluated.

! Use the Boolean equal operator (\Rightarrow), located in the Boolean palette to the right of your worksheet if you intend to document the expression or formula (see more details in the **Palettes** section). In the example below, the first line is documenting the formula for variable M using Boolean equal operator (\Rightarrow). The expression outlined in red indicates that M has yet to be defined and cannot be evaluated.



```
// using the Boolean equal operator
M  $\Rightarrow$   $\frac{1}{2} \cdot w^2$ 

w := 78

// expression cannot be evaluated,
M  $\Rightarrow$  ■
```

Using the Boolean equal operator to document an expression

Using the numerical evaluation operator ($=$)

- To insert: 1) click the ($=$) sign on your device's keyboard, or 2) open the **Arithmetic** palette and select the ($=$) option (see details in the **Palettes** section). The Solver will display the value of the variable or expression.

! The Solver displays a maximum of 15 decimal places.

Using the symbolic evaluation operator \rightarrow

- Use the symbolic evaluation symbol \rightarrow to display symbolic expressions and results. The example below illustrates both a numerical and a symbolic evaluation of expression using symbolic variables.

```
f(x):=x2+45·x-67
// symbolic evaluation
f(x)=-67+x·(45+x)
// numerical evaluation
f(3)=77
```

Numerical/symbolic evaluations

The example below illustrates the difference in how a result is displayed depending on the operator you use. Using the numerical evaluation operator (=) produces a numerical, floating-point result. Using the symbolic evaluation operator (\rightarrow) produces a symbolic result, in fraction or radicals.

```
//numerical evaluation

$$\frac{\frac{78}{5} + 57}{7} = 10.3714$$

//symbolic evaluation

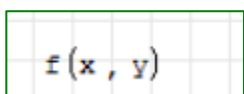
$$\frac{\frac{78}{5} + 57}{7} = \frac{363}{35}$$

```

Numerical vs. symbolic evaluation


- **Note** that the spacebar and arrow keys within an equation region allow you to broaden your selection.

- Place your cursor anywhere inside an expression and press the spacebar until you make your desired selection. This is particularly helpful when applying an operator such as a radical or a fraction to a selection of the math expression. Or,
- Use left and right arrow keys to move within a complex expression.
- Insert a comma within an equation region to separate arguments, such as function arguments.



Using a comma to separate arguments

How to correct typographical errors

- To delete either one character or one character at a time, use the backspace key on your keyboard or the  button located on the **Arithmetic** palette (see the **Palettes** section for more information on how to use palettes).
- To make corrections within an equation or expression (for example, if you are typing a more complex solution and you would like to select just a part of the expression for replacement):
 1. Place your cursor inside the expression.
 2. Press the spacebar as many times as you need until you've made the desired selection.
 3. Press the backspace key on your keyboard once to mark the selection in blue.
 4. Press the backspace key to delete, or simply start typing to replace the selection.

// use spacebar to select, once selected use backspace once to mark the selection , press backspace again to delete or just start typing and replace the selection

$$\frac{2 \cdot x^2 + 7 \cdot x - 78}{3} + \sqrt{45}$$

Selection within an expression (marked by dark blue color)

- To correct/delete entire regions within a worksheet, select by dragging and dropping your mouse (your selection is marked in light blue), then select the **Delete** option from the **EDIT** button in the Top Menu to delete everything that is selected.

inhibitor dissolved in each phase.

Partitioning Coefficient:

$$P := \frac{CI_{oil}}{CI_{water}}$$

P: Partitioning coefficient, unit less

CI.oil: Concentration of the corrosion inhibitor in the oil, ppm

$$CI_{oil} := 10 \text{ ppm}$$

CI.water: Concentration of the corrosion inhibitor in the water, ppm

$$CI_{water} := 100 \text{ ppm}$$

Selection within a worksheet (marked by light blue color)

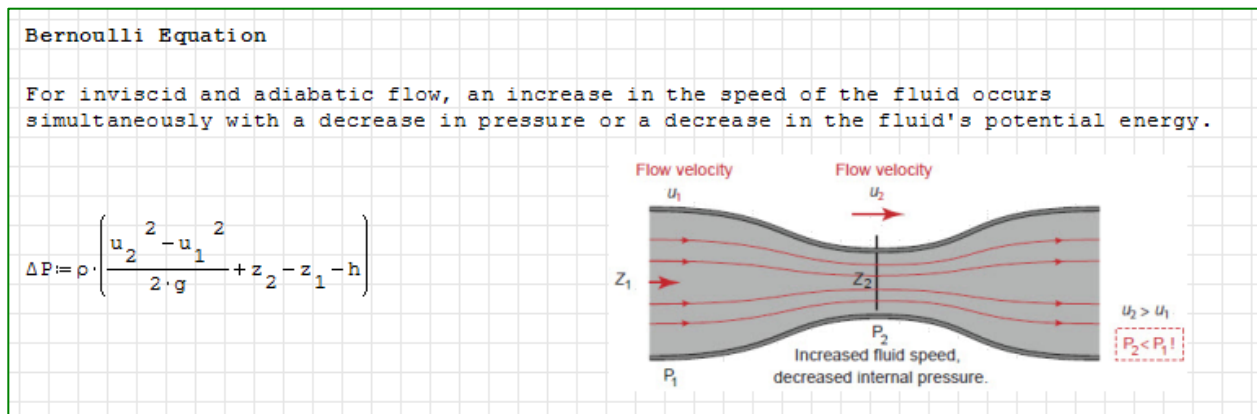
Text region

- Insert a text region to make notes or other documentation for your equations and calculations.

- To insert, click **INSERT** in the top menu, then **TEXT**. Or type double quotes in the desired location of the worksheet.
- Note that Courier New (Generic Monospace) is the only font used in the Equation Solver.

Picture region

- Insert a picture from your local device for documentation purposes.
- Some Knovel built-in worksheets include illustrations. See below for an example.




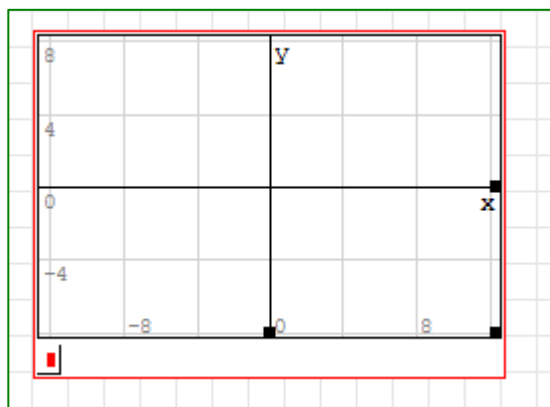
Worksheet with illustration

- To insert a picture, place your cursor at the point in the worksheet where you wish to position the picture, click **INSERT** in the top menu, then **Picture**.
- Supported formats: jpg, jpeg, gif, png and bmp.


Plot region

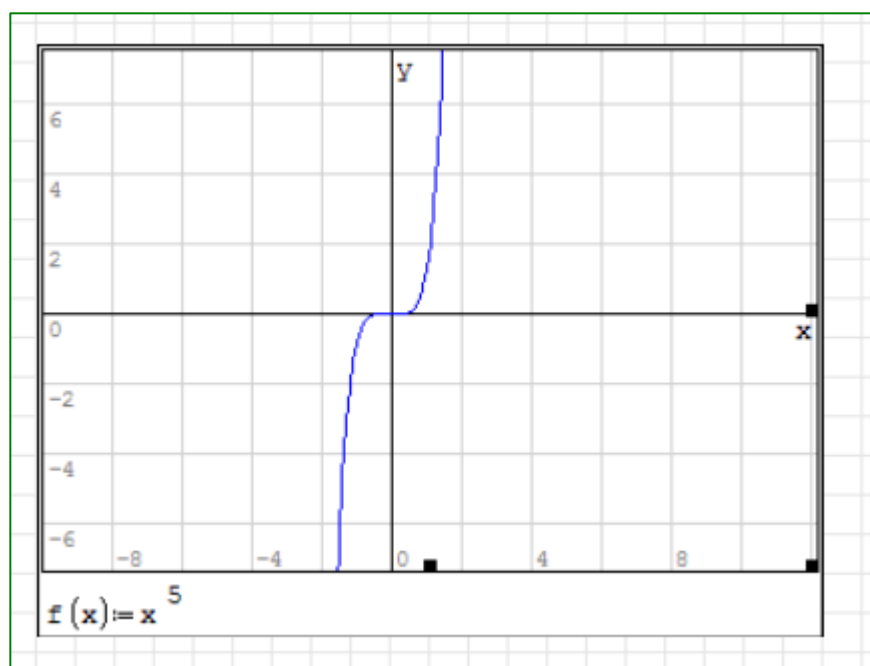
- Insert a plot region to plot functions using a graph.
- To insert; place your cursor at the point in the worksheet where you wish to position the upper left corner of your plot, click **INSERT** in the top menu, then **Plot**. Or Type "SHIFT @".

- You can also insert an empty graph by clicking on the first button on the **Plot** palette,  .
- The red cursor displayed in the lower left corner of the graph indicates that it is ready for input.

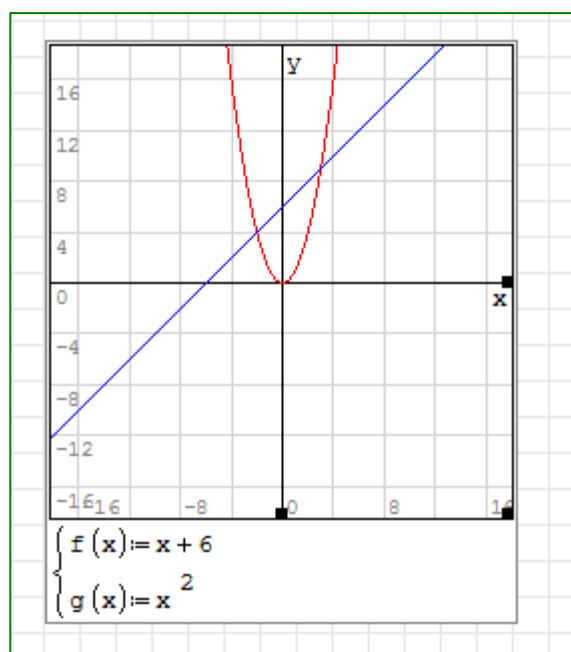


Empty graph

- To plot functions, type the formula at the red cursor and hit the “Enter” or “Return” key on your device (you can plot one or more functions on the same graph). To plot two or more functions, open **Functions** in the Palettes menu, located to the right of the worksheet, and click the **System of values and equations** button  .




Graph displaying one function



Plotting more than one function in the same graph

- Open the **Plot** palette—located in the palettes menu to the right of the worksheet—to edit and manipulate the graph using the following buttons: **Scale**, **Move**, **Graph by points**, **Graph by lines** and **Refresh**. Hover your mouse over each button for tool tips.

Example: to preview part of the graph not displayed in the plot region, click the **Move**  button, then click inside the plot and drag your mouse to the desired position.



Plot Palette

Area Delimiters region

- Create a collapsible region within the worksheet to separate, group, or hide equations or mathematical or text expressions. Within the designated area you can insert equation, text, and plot regions.
- To insert an **Area Delimiters** region, place your cursor at the point in the worksheet where you want the top demarcation line of your delimiter to appear, click the **INSERT** button, then **Area Delimiters**. In addition to the top demarcation line, a line will automatically display below the equation or text.
- To extend or reduce the height of your **Area Delimiters** region, click any point along either of the demarcation lines and drag and drop the line vertically to the desirable height.
- In the example below, **Area Delimiters** regions are used to delimit validation area for an equation.

```

Validation:
if (m_dot > 0) ^ (s_out >= s_in > 0) ^ (s_out > 0) ^ (Q_evap > 0)
    msg = "VALID Solution"
else
    msg = "INVALID Solution, mass flows, entropies, and added heat must be positive as depicted"

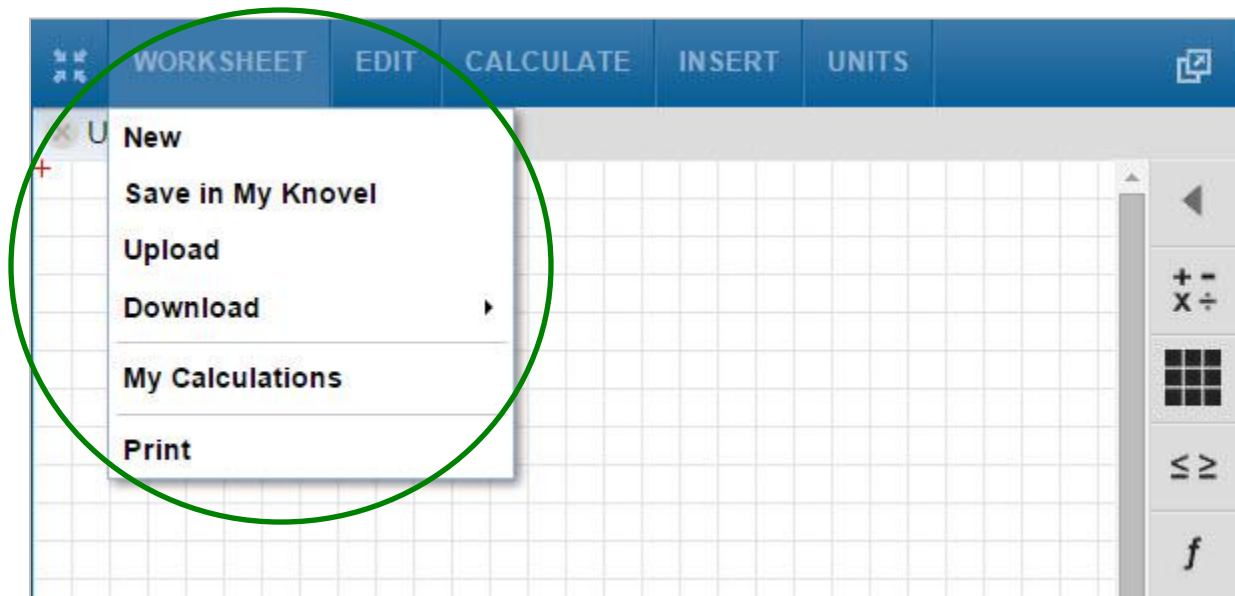
msg = "VALID Solution"

Irreversibility rate for the evaporator
I_evap = 1.41  $\frac{\text{BTU}}{\text{hr} \cdot \text{R}_a}$ 

```

Area Delimiters

B. WORKSHEET

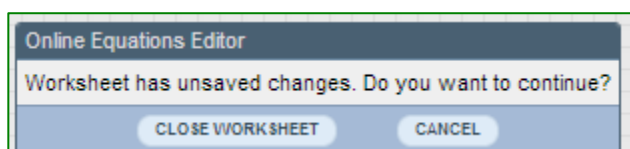


WORKSHEET tab in Top Menu

- To open a blank, untitled worksheet, select **NEW**; the worksheet will be labeled "Untitled".
 - To rename a worksheet, click the label twice, then click your "Enter" or "Return" key to save.
 - To close a worksheet, click the x button to the left of the title, then the **CLOSE WORKSHEET** button in the following window. You will lose any changes to the worksheet that you haven't saved.

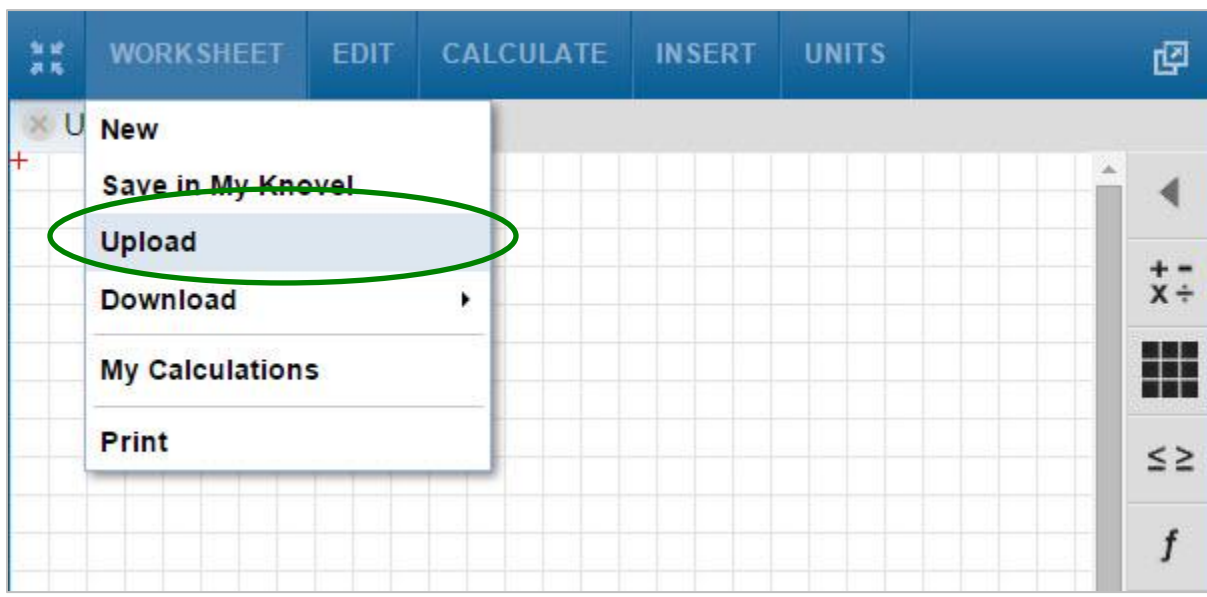
Note:

For users who have already logged in using their username, the Equation Solver automatically saves worksheets every 5 seconds (click **MY CALCULATIONS** or go to My Knovel to manage your saved worksheets). Users who have not logged in with a username will see the following warning message and should click **CLOSE WORKSHEET** to save. To save to your computer, select the **DOWNLOAD>Knovel Worksheet** option from the **WORKSHEET** tab.



Warning message should you attempt to close a worksheet with unsaved changes

Upload

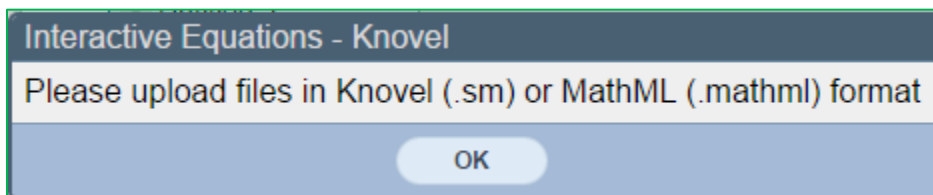


- Click to upload previously saved worksheets in Knovel's proprietary .sm format from your computer or device.

- Equation Solver is MathML compatible. Via Upload you can upload files in MathML format.

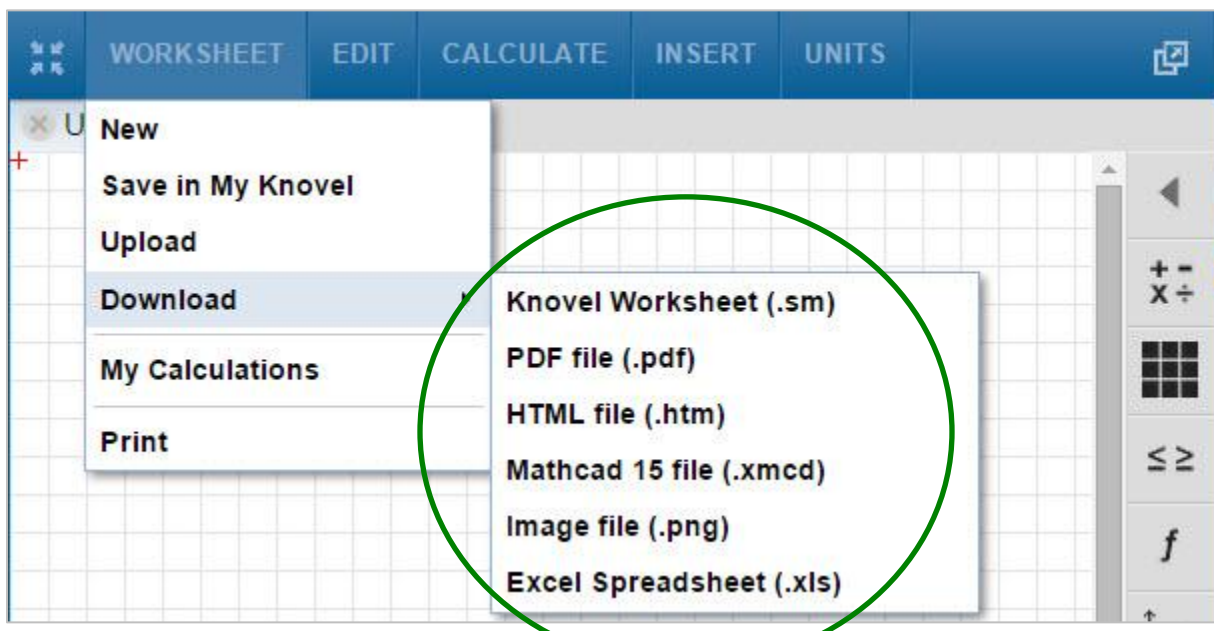
[Watch](#) a brief video on using Upload MathML file

- If you try to upload any other format file (non-.sm files or.mathml), the following error message will appear.




Upload error message


Download



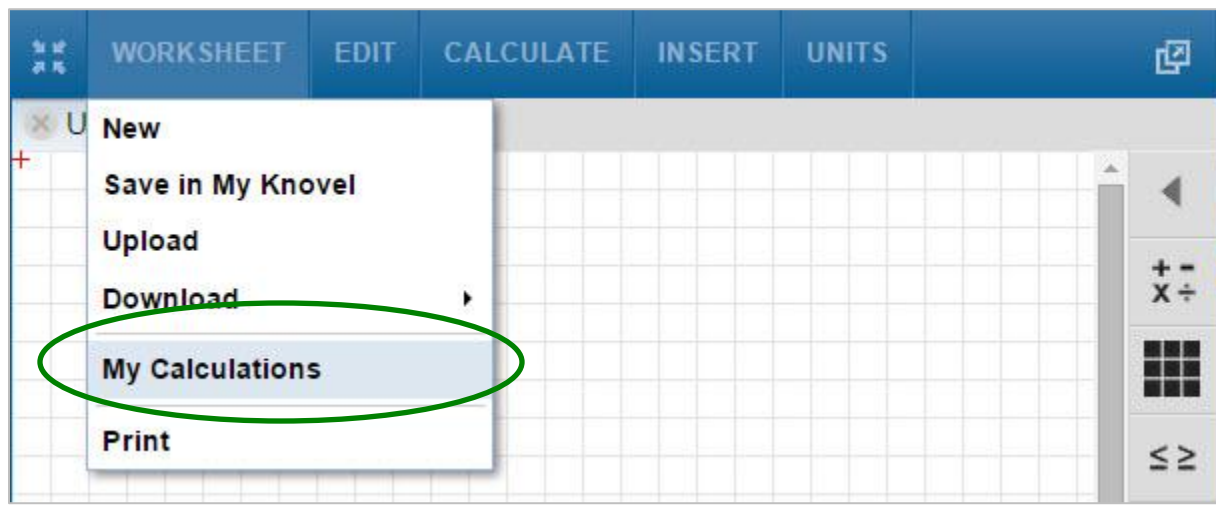
Opened DOWNLOAD drop-down button

- Click to save a worksheet onto your computer in the following formats. The downloaded file is automatically placed on your computer's clipboard (Windows) or in the Downloads folder (Macintosh).
 - Knovel proprietary .sm format
 - Adobe PDF
 - HTML
 - Mathcad 15, .xmcd
 - .png
 - .xls

 Since Mathcad requires that variables be defined before you insert them into a formula—and the Solver does not—when you save your worksheet in Mathcad, you need to manually reposition the formula below the legend.

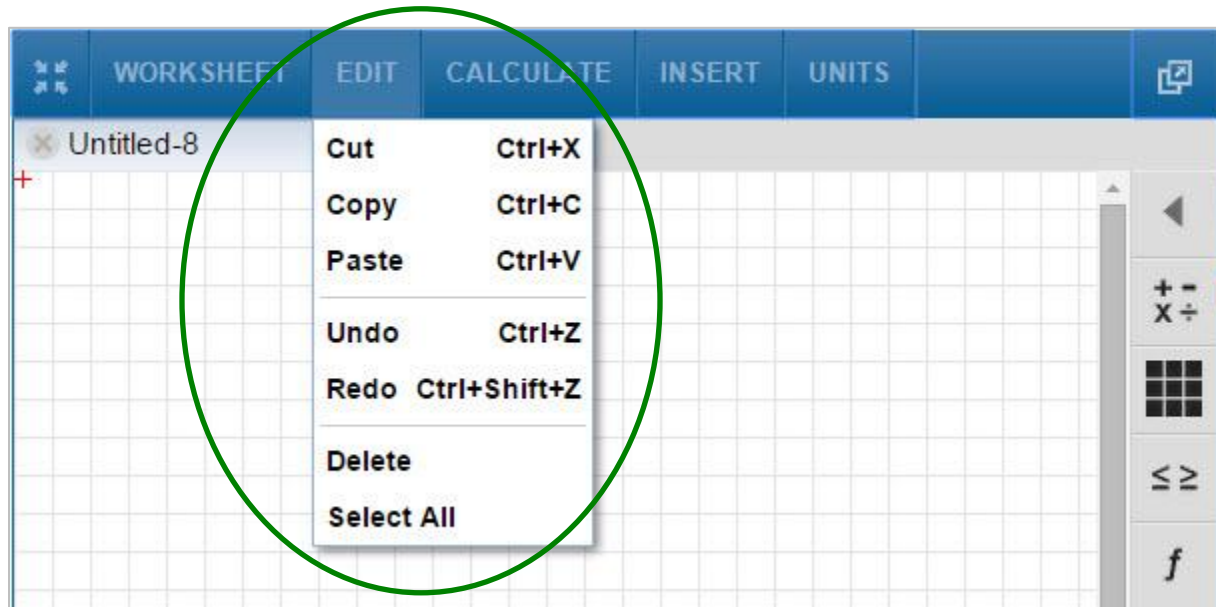
 [Watch](#) a brief video of how to use the **UPLOAD/DOWNLOAD** buttons.

My Calculations




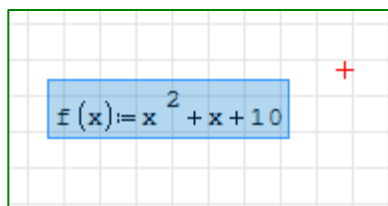
- Click to access all saved worksheets, which are located in **My Knovel**.

C. EDIT



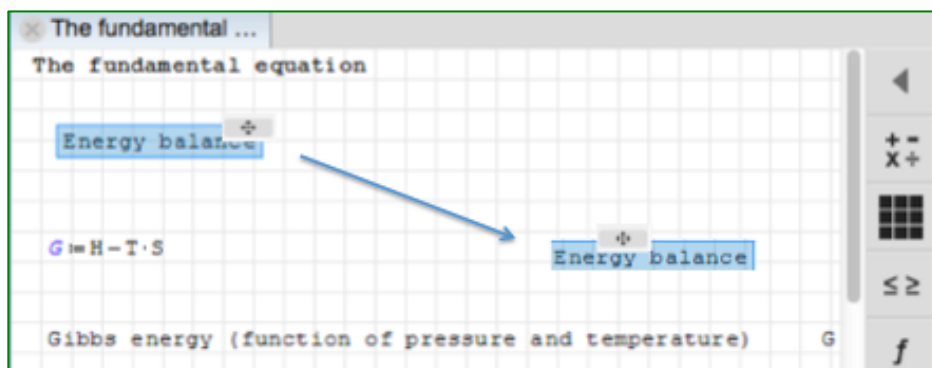
Opened EDIT drop-down button

- Click to: **Cut/Copy & Paste**; **Delete** equations, text or an entire worksheet; **Select All** of the elements on a worksheet; or **Print** an entire worksheet (parts of a worksheet cannot be printed separately).
- First select the part you wish to cut or copy by clicking somewhere above and to the left and drag your cursor across your selection. The selection will display in light blue and your cursor will change to the following symbol: . To select all elements on a worksheet, click **Select All**.



Selected equation

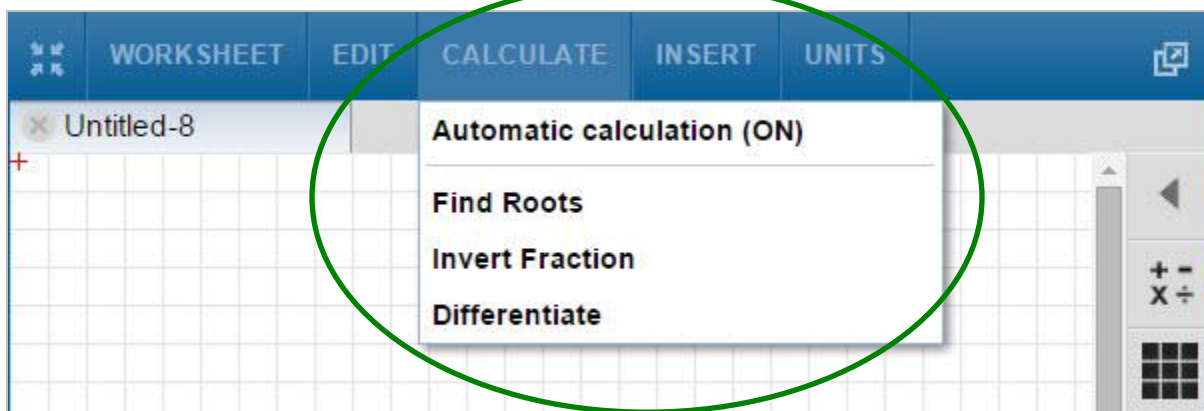
- Once you've made your selection, click **Cut** or **Copy**, click the area in the worksheet, then click **Paste**.
- You can also move a selection by using your mouse to drag and drop it into any other location within the worksheet.



Dragging and dropping a selection

- UNDO/REDO work with all the regions.

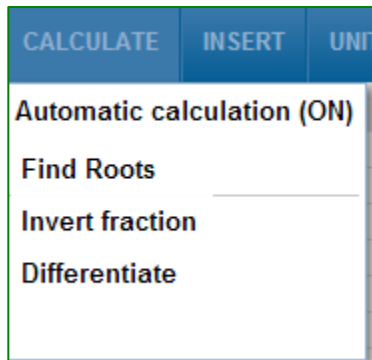
D. CALCULATE



Opened CALCULATE drop-down button

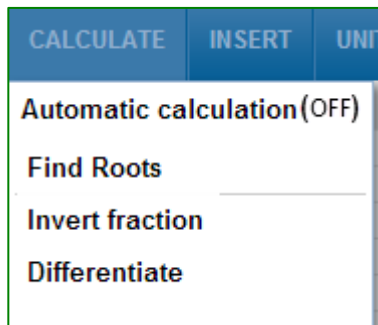
- Click to: 1) switch between automatic and manual calculation, 2) find the root of an expression, 3) invert a fraction or 4) differentiate a part of the expression. The Solver defaults to *automatically* calculating expressions; each time you change a

value or a unit the Equations Solver re-calculates automatically the worksheet and displays the result.



Automatic calculation function ON (default mode)

- Click **Automatic calculation (ON)** to switch to manual calculation. The submenu will change to display **Automatic calculation (OFF)**. Note that the worksheet will not recalculate expressions automatically if changes are made on dependent (previously entered) expressions.

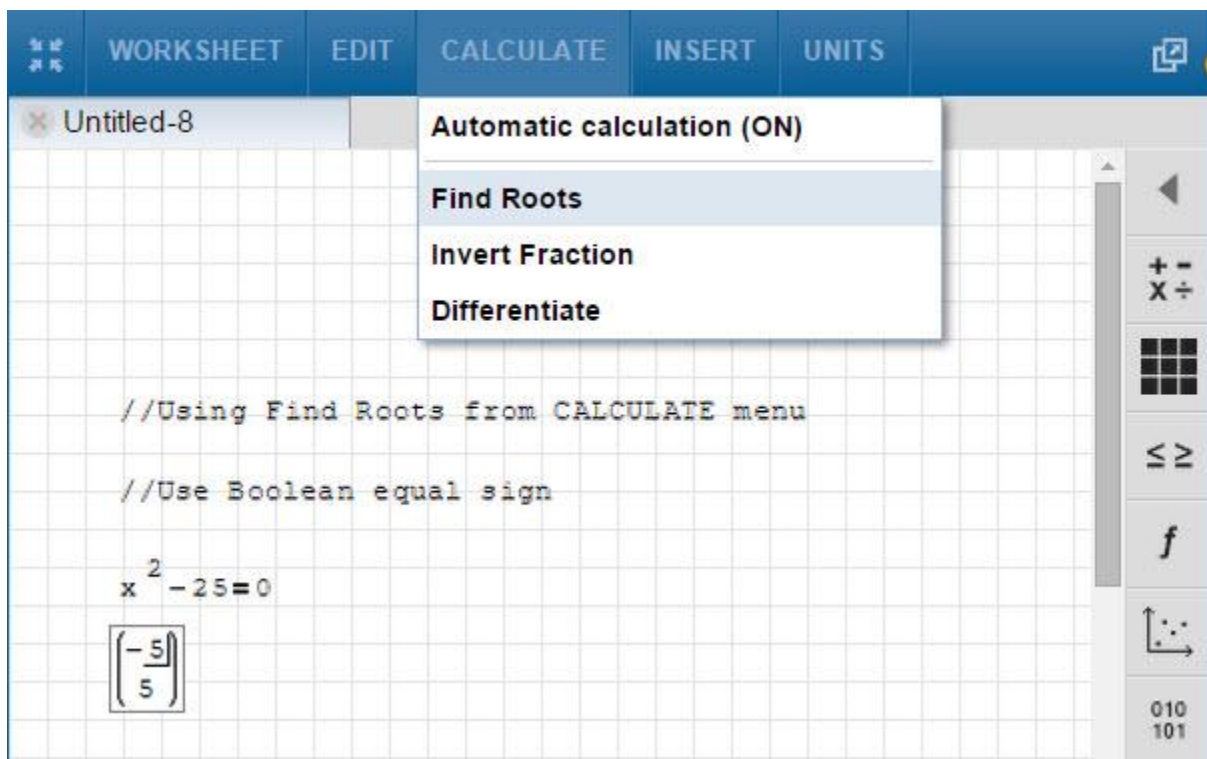


Automatic calculation (OFF)

- To change back to automatic calculation click on the submenu **Automatic calculation (OFF)**.

Find Roots

- Click to find the value for a variable that satisfies an expression, such as variable x in the expression $f(x)=0$. Use the Boolean equivalence symbol ($=$) (bolded) found in the **Boolean** palette to the right of the worksheet area. First, select the variable by clicking within the expression and using the spacebar then the backspace button to highlight your selection in dark blue. Click **CALCULATE**, then **Find Roots**. The root(s) will display on the line underneath.

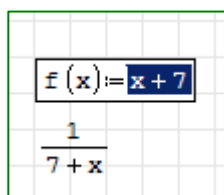


Find Roots for an equation result displays below the expression

Invert

- Select the fraction you wish to invert by clicking within the expression, using the spacebar then the backspace button to highlight your selection in dark blue. Click

Invert and the result of the inversion operation will be displayed on the line below the expression.

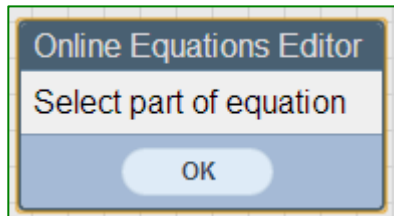


$$f(x) := x + 7$$

$$\frac{1}{7 + x}$$

Invert result display below expression

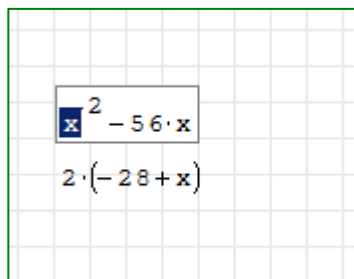
- If you do not make a selection prior to clicking **Invert**, the following window will open. Click **OK** to close the window, then make your selection for inversion.



Message displayed if no selection is made before using Calculate options

Differentiate

- Select the variable you wish to differentiate for by clicking within the expression, using the spacebar then the backspace button to highlight the variable. Click **Differentiate** to display the result below the selected expression.

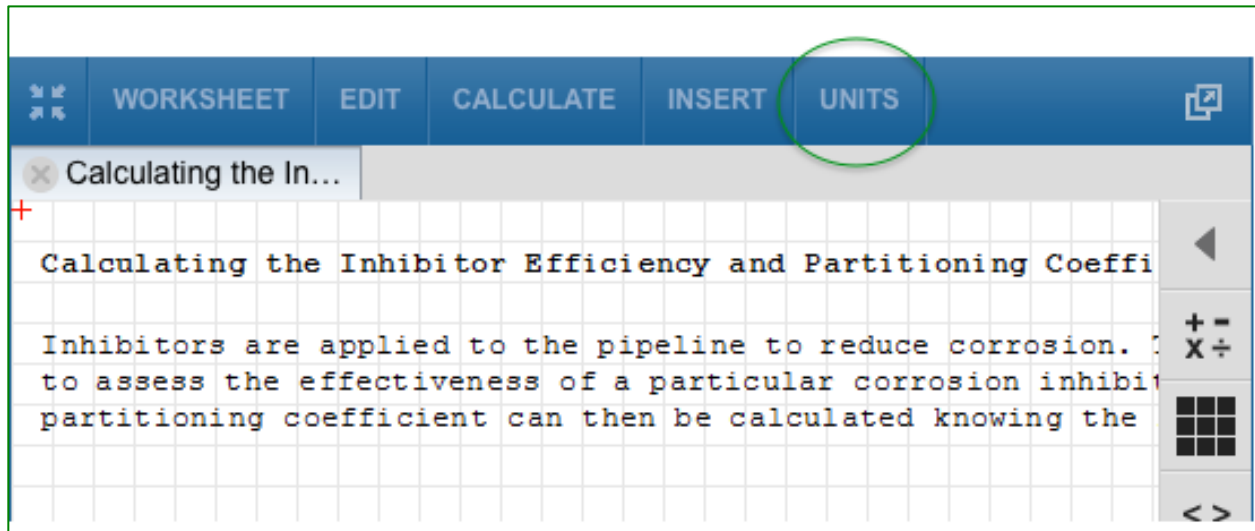


$$x^2 - 56 \cdot x$$

$$2 \cdot (-28 + x)$$

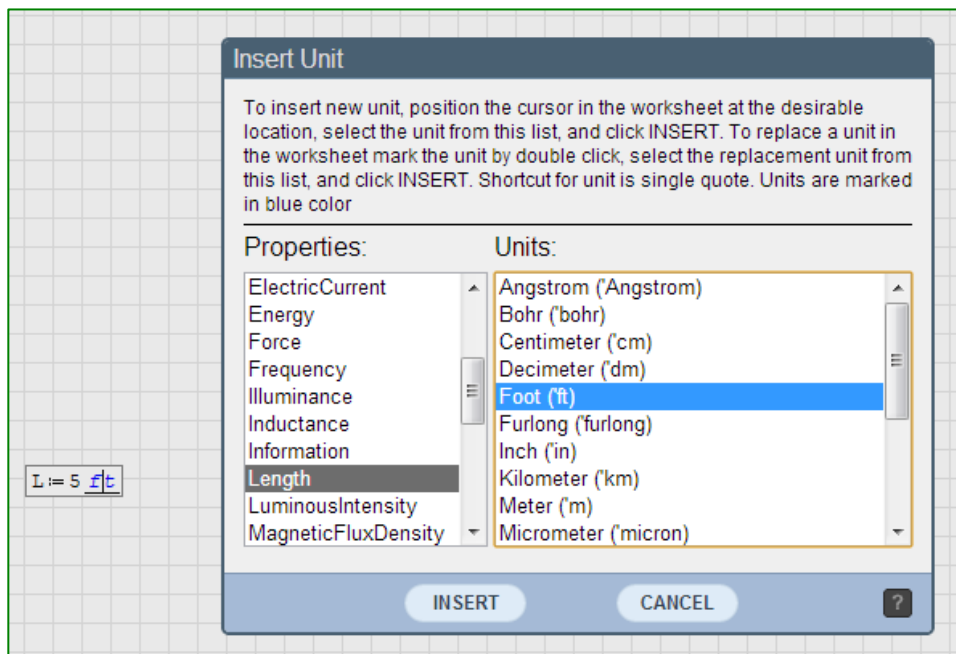
Differentiate result displays below the expression

E. UNITS



Units button

- To insert a unit into an equation or expression, type the desired numerical value, click **UNITS**, select your unit from the **Insert Unit** pop-up window, and click **Insert**. Units are organized alphabetically by name and can be quickly identified by first selecting a specific property.



Insert Unit pop-up window

- Unit symbols are displayed in blue in the worksheet.



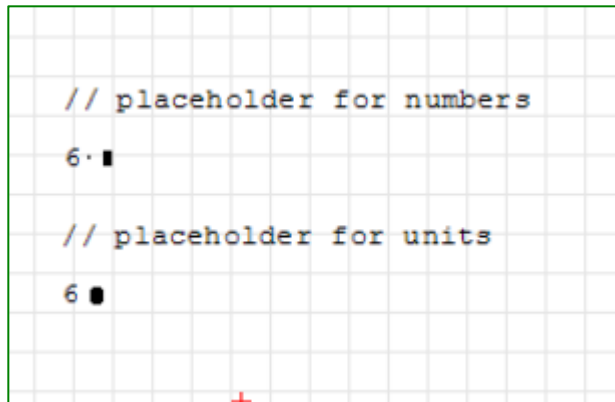
Display of unit placeholder and unit symbol in a worksheet

- Since the Equation Solver includes a finite list of default units, you can create your own. For example, a dekameter(dam) does not exist in the list of units related to a meter. Define a dekameter as 1dam = 10 m right in the worksheet.

```
// define unit dekameter
dam:=10 m
// usage of user-created unit (dam) in the worksheet
70 dam = 700 m
are:=dam2
78 are = 7800 m2
```

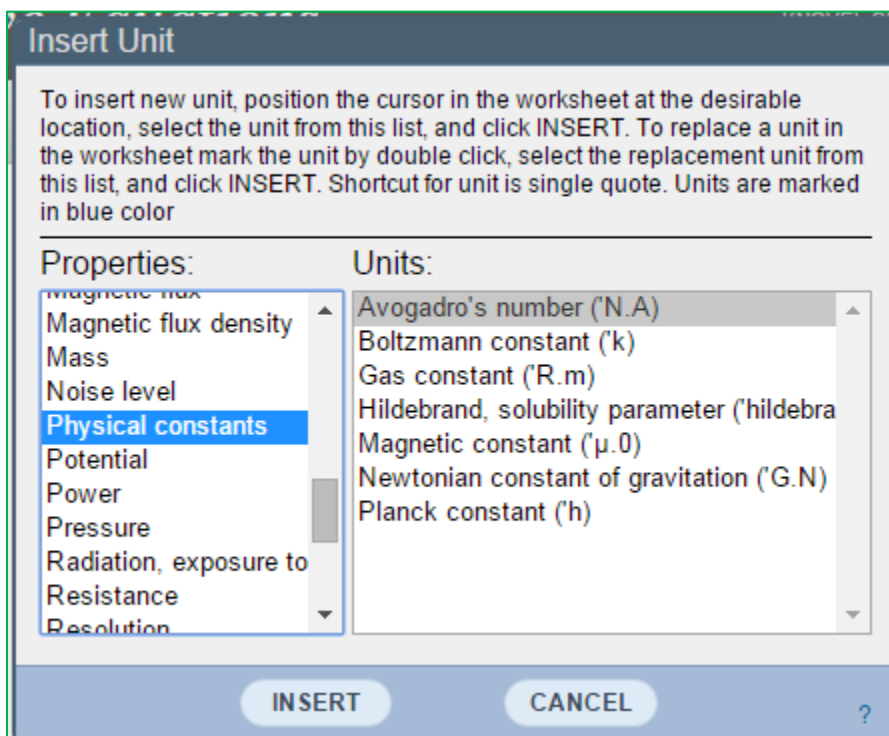
Creating your own unit

- If you already know a unit symbol, bypass the **Insert Unit** pop-up window and type a single quote, then the symbol. **Note** that when you type a single quote, the placeholder changes. A unit's placeholder is thicker than a number's placeholder.



Difference between placeholder for number and unit


- Note that the Solver defaults to the SI system (International System of Units)—not the U.S. system—of unit symbols.

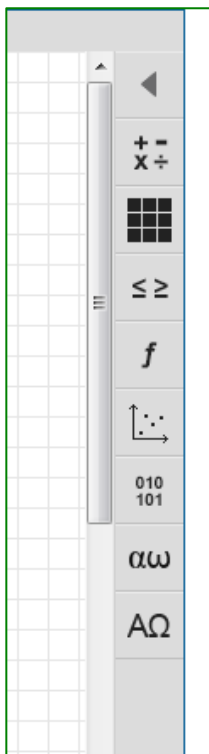


Units menu with Physical constants

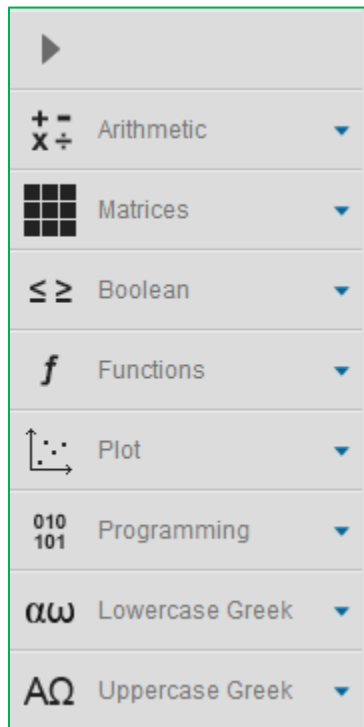
Palettes

Palettes are utilities such as mathematical symbols and functions, as well as graphical and programming functions that help you edit your calculations. The Equation Solver features **Arithmetic**, **Matrices**, **Boolean**, **Functions**, **Plot**, **Programming**, **Uppercase Greek**, and **Lowercase Greek palettes**. They are accessible via a series of tabs in the **Palettes** menu, which is located to the right of the worksheet area.

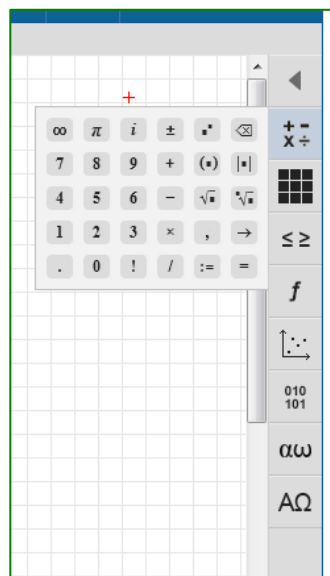
- For quick-reference information on a palette, hover your mouse over a palette label, and click on the following icon .
- To expand the **Palettes** menu, click on the left arrow.
- To open an individual palette and utilize its functions, click the label. While the menu is expanded, you can open one or more palettes simultaneously.
- To collapse the **Palette** menu, click the right arrow. While the menu is collapsed, you can only open one palette at a time



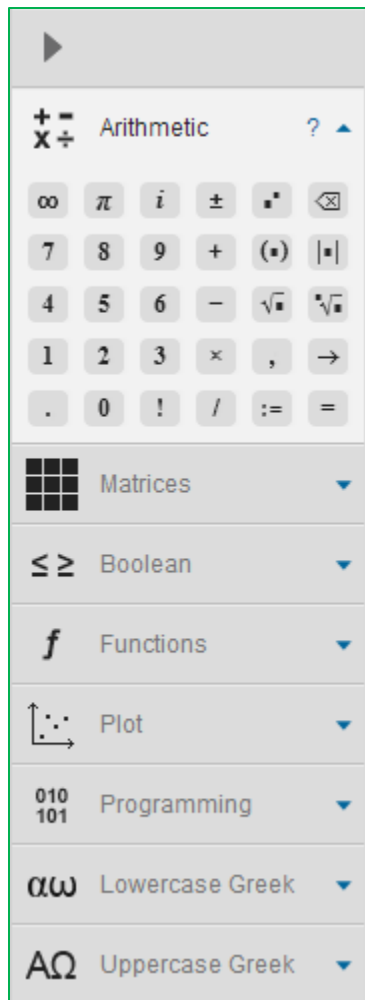
Collapsed Palettes menu (click the left arrow to expand)



Expanded Palettes menu (click the right arrow to collapse)

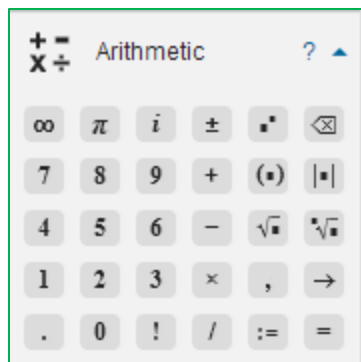


Collapsed Palettes menu with expanded Arithmetic palette

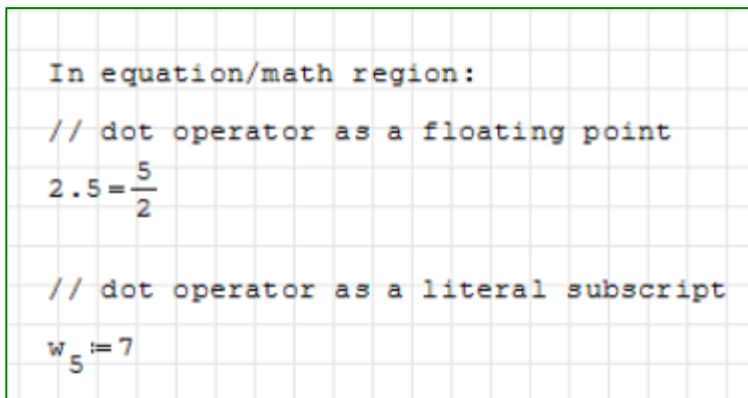


Expanded Palettes menu with expanded Arithmetic palette

A. Arithmetic palette



- Open to insert basic math operators (addition [+], multiplication [*], subtraction [-], division [/], power [^], root power of 2 [√], root power of n, absolute value [|]), and factorial [!]), as well as symbols such as the digits 0-9 (you can also enter digits directly from your keyboard).
- Note that the multiplication operator (*) displays as a middle dot in the worksheet.
- A dot entered immediately after a digit is interpreted as a digital point, while a dot entered after a letter is interpreted as a literal subscript.



Dot as digital point vs. literal subscript

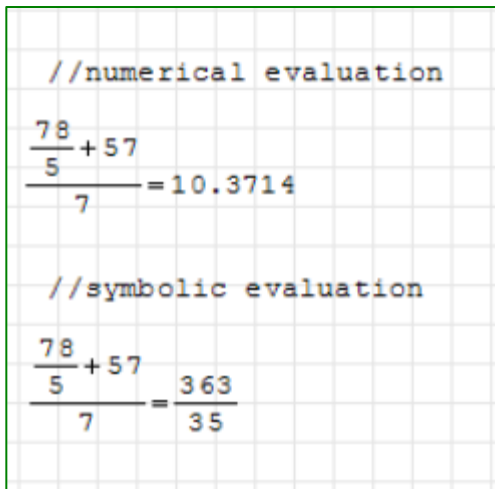
- Other symbols include:
 - Infinity, constant pi, and imaginary unit.
 - Plus/minus operator, designed to produce a list of two values.

$$\pm 6 = \begin{cases} 6 \\ -6 \end{cases}$$

Plus/minus operator

- Assignment/definition operator (:=), used to assign values to variables or to define functions or formulas/equations.
- Numerical evaluation symbol (=) and the symbolic evaluation symbol (->). Inserting a numerical evaluation symbol (=) produces a

numerical (floating-point) result; a symbolic evaluation (->) produces a symbolic result, fraction or radicals (see the earlier section in this guide on the Equation Region for more details on the assignment, symbolic, and numerical evaluation symbols, as well as on working with variables).




//numerical evaluation

$$\frac{\frac{78}{5} + 57}{7} = 10.3714$$

//symbolic evaluation

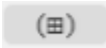
$$\frac{\frac{78}{5} + 57}{7} = \frac{363}{35}$$

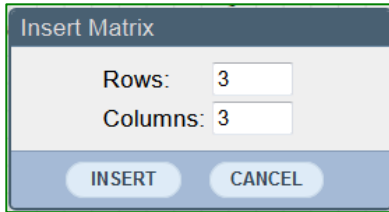
Numerical and symbolic evaluation of the same expression

 [Watch](#) a brief video on how to use the **Arithmetic** palette.

B. Matrices Palette

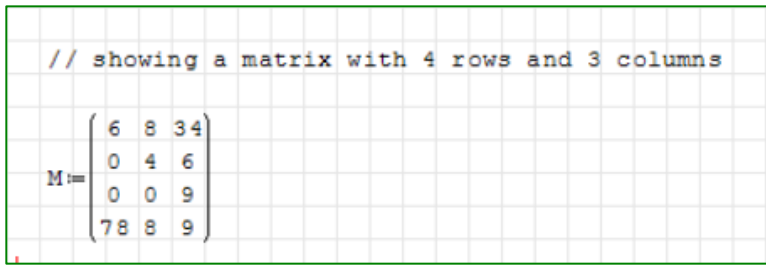


- To insert a Matrix into the worksheet click the first button on the palette, . A pop-up window allows you to select the number of rows and columns for the matrix.



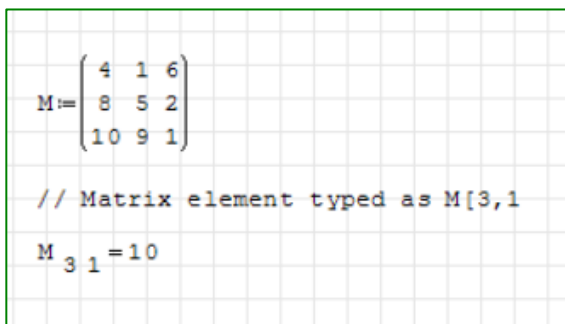
Insert Matrix window

- In the window, click **INSERT**. An empty matrix will be inserted into the worksheet at the point you've selected with your cursor.
- To enter values for matrix elements, click on the placeholders. Use the right arrow key to move to the next placeholder.




Inserted matrix with values for each element

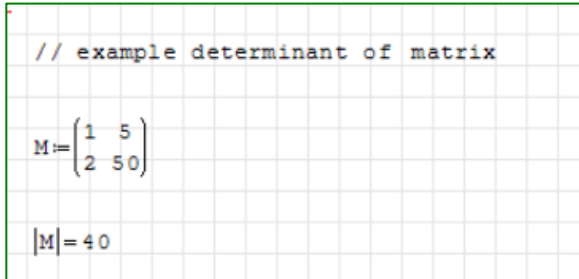
- To reference a matrix element, type the values at the intersection of a specific row and column. In the example below, type M[3,1 to reference the element at M_{31} (the intersection of row 3 and column 2). The Solver will remove the comma between the two values.



Referencing a matrix element

- Additional matrix utilities include:

-  - **Determinant**: Define your matrix, type the name of the matrix, click the **Determinant** button, then type the arithmetic equal sign (=) to calculate the value.




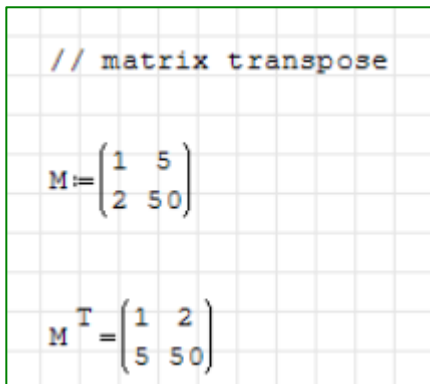
```
// example determinant of matrix

M:= $\begin{pmatrix} 1 & 5 \\ 2 & 50 \end{pmatrix}$ 

|M|=40
```

Calculating the determinant of a matrix

-  - **Transpose**: Define your matrix, type the name of the matrix, click the **Transpose** button, then type the arithmetic equal sign (=) to transpose the matrix.




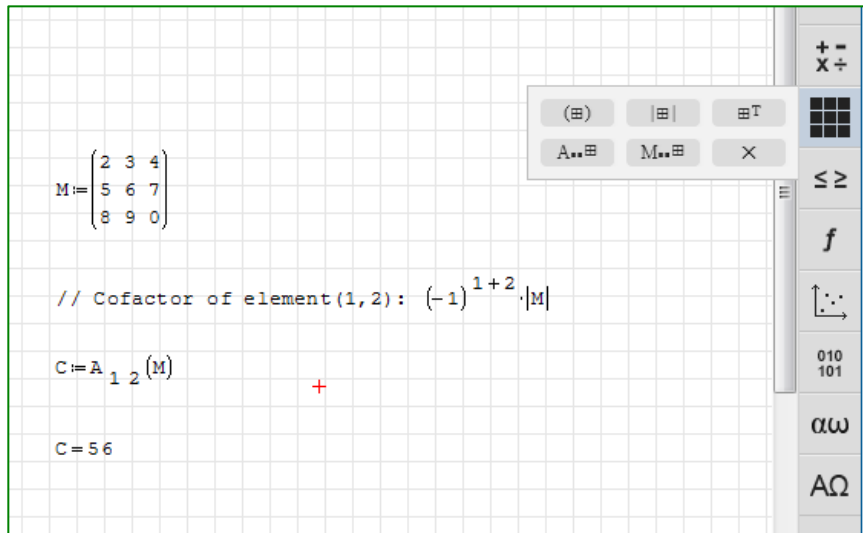
```
// matrix transpose

M:= $\begin{pmatrix} 1 & 5 \\ 2 & 50 \end{pmatrix}$ 

MT= $\begin{pmatrix} 1 & 2 \\ 5 & 50 \end{pmatrix}$ 
```

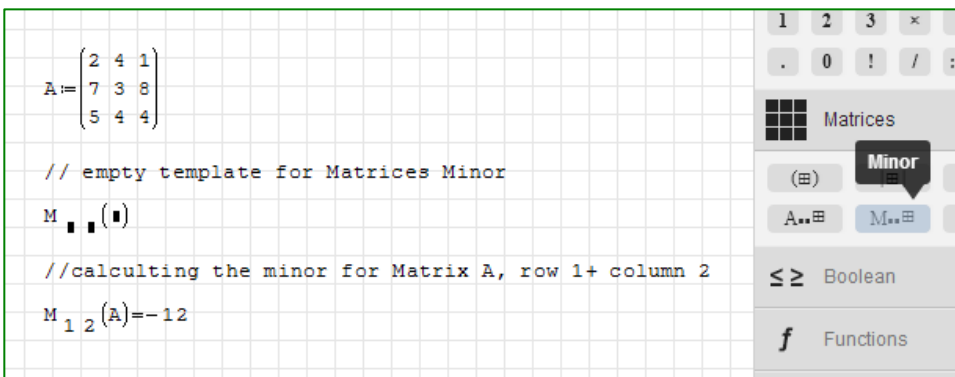
Transposing a matrix

-  - **Cofactor**: Define your matrix, click the **Cofactor** button, fill in the placeholders, then type the equal sign (=) to calculate the Cofactor.



Calculating the Cofactor of a matrix

- **M..** - **Minor** – Define your matrix, click the Minor button. An empty template will display (see the example below). The first placeholder indicates the row number, the second placeholder indicates the column number and the third placeholder indicates the matrix.



Calculating the Minor for a Matrix

- **×** - **Cross product** – Define your vectors and click the Cross product button. An empty template will display with two placeholders, one for each vector (see the example below). This function works only with vectors that have 3 elements.

```
//define vectors
```

$$V_1 := \begin{pmatrix} 3 \\ 5 \\ 3 \end{pmatrix} \quad V_2 := \begin{pmatrix} 4 \\ 2 \\ 8 \end{pmatrix}$$

```
// cross product empty template
```

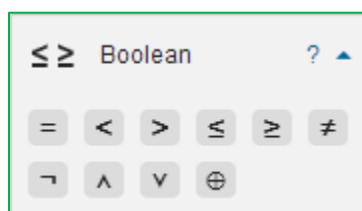
$$\blacksquare \times \blacksquare$$

```
//calculating cross product for V1 and V2
```

$$V_1 \times V_2 = \begin{pmatrix} 34 \\ -12 \\ -14 \end{pmatrix}$$

Calculating the cross product of vectors

C. Boolean Palette



- Use Boolean symbols primarily in a programming structure such as “if-then” equations and expressions.
- When inserted into a worksheet, Boolean symbols display bolded to differentiate them from basic arithmetic symbols.

```

a:=79

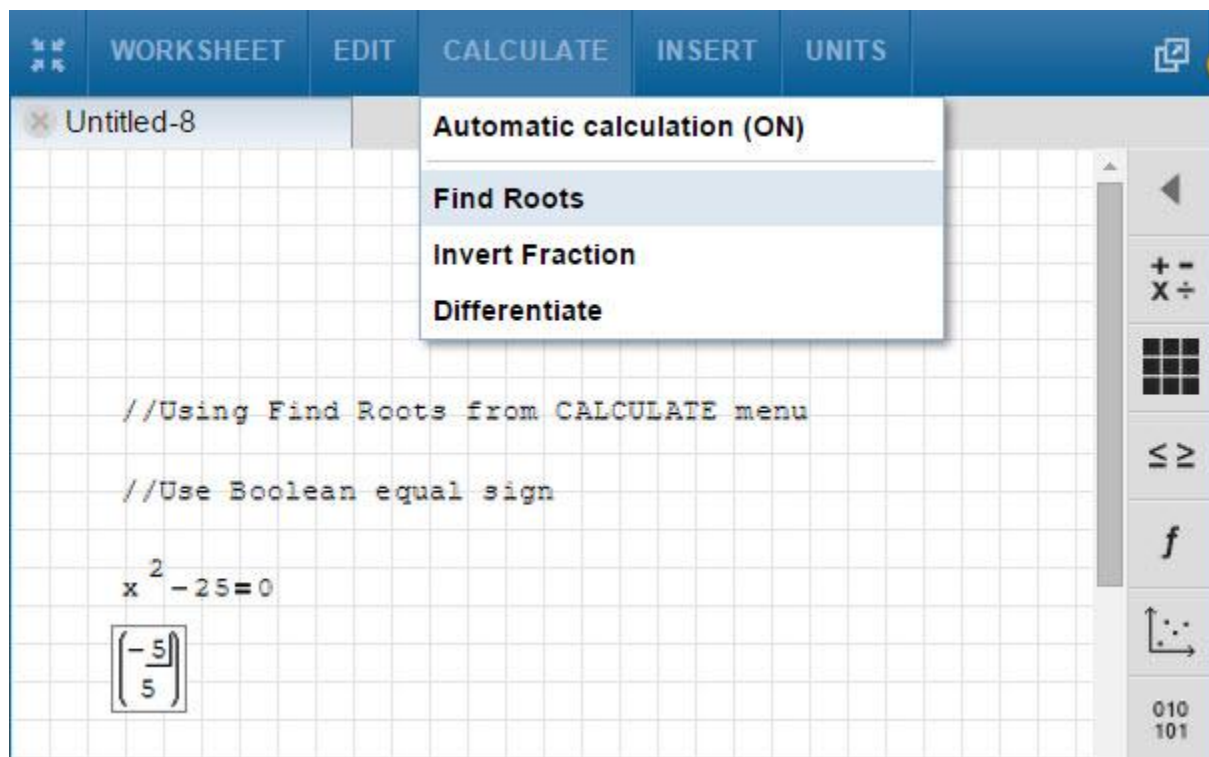
if a=78      // using Boolean equal within the conditional structure
  f(x):=x+5
else
  f(x):=x-5

f(3)=-2

```

Using the Boolean equal symbol (=)

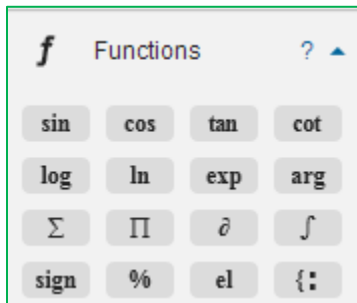
- Use the Boolean equal symbol (=) with the **Find Roots** function, accessible from the **CALCULATE** button in the Top Menu.



Using of the Boolean equal (=) symbol with the Find Roots function

- Use the Boolean equal (=) symbol when you write a formula for documentation purposes only.

D. Functions Palette



Knovel built-in functions

- Use the **Functions** palette to quickly insert built-in trigonometric and calculus functions.
- Trigonometric functions include:
 - Sine (sin)
 - Cosine (cos)
 - Tangent (tan)
 - Cotangent (cot)



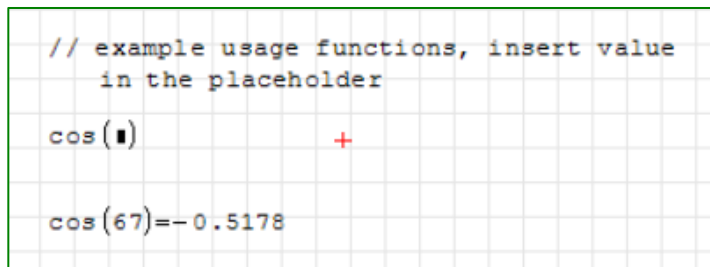
Since all trigonometric functions arguments default to radians, you must specify degrees by inserting a numerical value, then 'deg'.

```
// sine of 56 radians  
sin(56)=-0.5216  
  
// sine of 56 degree  
sin(56 deg)=0.829
```

Using trigonometric functions with degrees

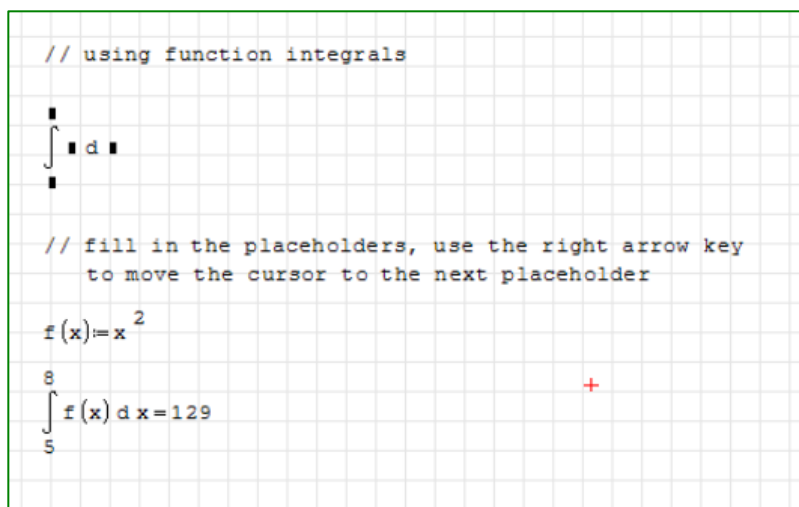
- Logarithmic functions include:

- Logarithm base 10 (log)
- Natural logarithm (ln)
- Calculus functions include:
 - Exponent (exp)
 - Angle for a complex number (arg)
 - Series such as Summation (Σ) and Iterated product (Π)
 - Derivative (∂) and Integral (\int)
 - Algebraic Sign (sign)
- To insert a function from this palette, place your cursor in the worksheet and click on the desired function button. The symbol for the function will display, along with a placeholder (or placeholders) for the arguments value.



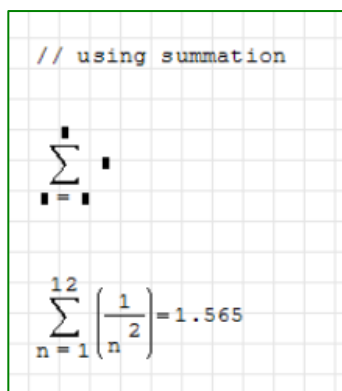
Blank and filled in template for a trigonometric function

- When inserted, functions requiring multiple arguments will display multiple placeholders. Use your right-arrow key to move your cursor between placeholders as you enter values.



Display of inserted functions requiring multiple arguments

- To enter a summation, place your cursor at the desired point in the worksheet then click Σ . The summation symbol, along with 4 placeholders, will display. Enter values in the placeholders and move between them using your right-arrow key—or simply click inside each placeholder.



Example summation with placeholders, values, and result

- To enter a product, place your cursor at the desired point in the worksheet and click Π . The symbol, along with 4 placeholders, will display. Enter values in the placeholders and move between them using your right-arrow key—or simply click directly inside each placeholder.

The screenshot shows a worksheet with a grid background. At the top, the text "// using product" is visible. Below it, a product formula is entered using placeholders: $\prod_{i=1}^n$. The result of the calculation is displayed as $\prod_{n=1}^{12} \left(\frac{1}{n^2} \right) = 4.3584 \cdot 10^{-18}$.

Example Product with placeholders, values, and result

- To define the element of a vector, place your cursor at the desired point in the worksheet and click **el**. Two placeholders will display, representing: 1) the name of the vector, and 2) a subindex containing a numerical value representing the order of the element in the vector. See an example below of how to define the value for the fourth element of a vector.

The screenshot shows a worksheet with a grid background. The text "//assign value to element subindex 4 of a vector labeled 'my_vector'" is at the top. Below it, the formula $\text{my_vector}_4 := 45$ is entered. Further down, the text "// list vector" is visible. At the bottom, the vector my_vector is displayed as a column vector: $\begin{pmatrix} 0 \\ 0 \\ 0 \\ 45 \end{pmatrix}$.

Defining the element of a vector

- You can also use a shortcut to enter the element of a vector. For example, to enter v_4 , type $v[4]$ and the Solver will insert a vector subscript.



Please see below the difference between how the Solver displays the element of a vector (subindex) and a subscript.

```

//assign value to element subindex 4 of a vector labeled "my_vector"
my_vector_4:=45

// list vector
my_vector=


$$\begin{pmatrix} 0 \\ 0 \\ 0 \\ 45 \end{pmatrix}$$

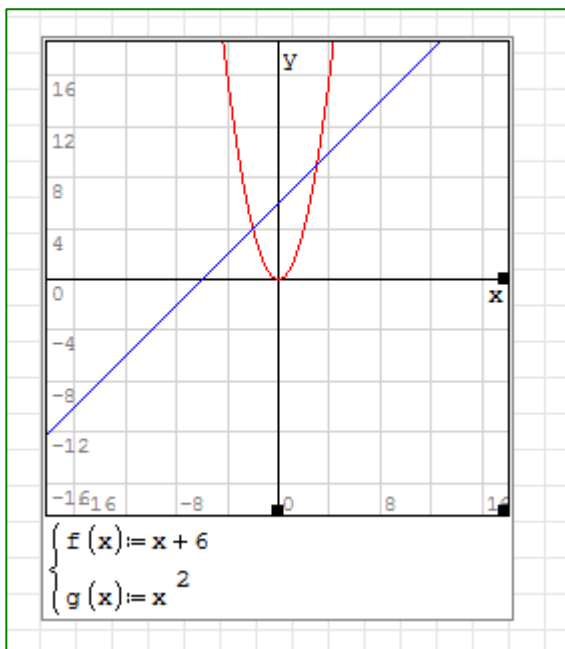

// create variable my_vector_4 by using dot notation to subscript
my_vector_4:=100

// both element 4 of my_vector and variable my_vector_4 looks the same
but they are different mathematical objects

```

Difference between subindex and subscript

- Use the values or equations button () to plot more than one function on the same graph, as illustrated in the example below.



Plotting more than one function on the same graph



[Watch](#) a brief video on how to use built-in functions.

User-defined functions

- Each user-defined function has the following syntax: <function name>
(parameter(s))= <function expression using parameter(s)>

```
// example user-defined function with one parameter
f(x):=x2+56·x-7


// numeric evaluation
f(3)=170

// evaluate using a variable previously defined, ξ
ξ:=2.1
f(ξ)=115.01

// example user-defined function with two parameters
g(x, y):=√x3+67-y

g(23, 45)=65.6074
```

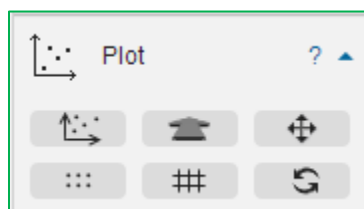
Examples of user-defined functions

- To separate parameters use the comma key or click the  button, located on the **Arithmetic** palette.










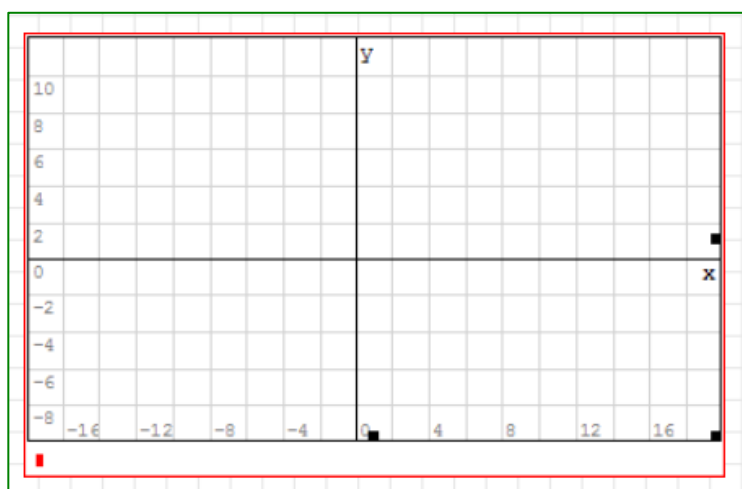
[Watch](#) a brief video on how to create your own functions, as well as using the derivative and integral **Function** utilities.

E. Plot Palette








Plot utilities include the following (hover over a button to read a quick description of how the button works):

- Insert Graph- 
- Scale - 
- Move - 
- Graph by points - 
- Graph by lines - 
- Refresh - 
- To insert a plot, place your cursor at a point in the worksheet where you want the position of upper left corner of the graph then click . Or, click the **INSERT** button in the Top Menu, then **Plot**. Or, simply type the @ sign on your keyboard. An empty graph will be inserted into the worksheet.

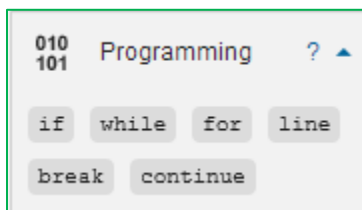



Empty plot

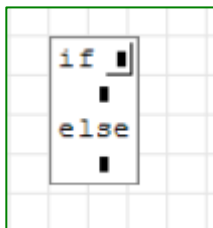
- To resize the plot area, click on any of the three solid black dots (bottom center, bottom right corner, and right center) then drag to the desired size.
- Enter the function to plot at the red cursor in the left bottom corner. **Note** that you can plot more than one function on the same graph.

- To use the Move () and Scale () buttons, first click inside the plot area to activate it. Click on the button (Move or Scale), then click on the plot and drag accordingly.
- The default display for graphs is lines. To switch to a dotted display, click on the plot area to activate it, then click the Graph by points button (). Click the Graph by lines button () to switch back to lines display.
- To restore the graph to its original size, scale, and orientation: click inside the plot area to activate it, then click the Refresh button, ().

F. Programming Palette

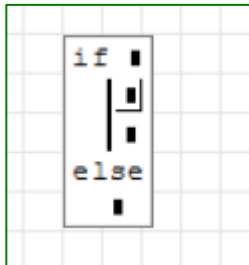


- Use the **Programming** palette to insert conditional expressions for decision (“if/else”) and looping (“while and for”).
- Within a programming structure, use Boolean symbols from the **Boolean** palette.
- To insert an “if” structure, place the cursor in the desired location in the worksheet and click the () button. A blank structure will be displayed in the worksheet, along with multiple placeholders.



Inserted blank structure

- The first placeholder is where the condition is entered. Use the Boolean operators from the **Boolean** palette for the condition expression. If more than one line is needed for the second placeholder, click on the placeholder, then the (`line`) button. The Solver will insert a new line.



Inserted second line for a placeholder

- All placeholders must be filled, but there may be cases when you may need an “if” without an “else”. In such cases, just type a zero or a text string into the last placeholder.
- Programming structures are used in the Knovel built-in worksheets mostly to validate that values for variables falls into a valid range and display a message to the user otherwise. This is illustrated in the example below.

Coefficient of Performance

Performance of a refrigeration cycle is described by its coefficient of performance (COP), which is defined as the benefit of the cycle (amount of heat removed) divided by the required energy input to operate the cycle. For an ideal Carnot refrigeration cycle, the COP may be expressed in the terms of the refrigerated space temperature and the ambient air temperature.

$$\text{COP} = \frac{T_R}{T_O - T_R}$$

COP is the coefficient of performance

T_R is the refrigerated space temperature $T_R := 479.67 \text{ } ^\circ\text{Ra}$

T_O is the ambient air temperature $T_O := 550 \text{ } ^\circ\text{Ra}$

Validation:

```

if (T_O - T_R > T_R)
  msg := "NOT VALID"
else
  msg := "VALID Solution"

```

msg = "VALID Solution"

Coefficient of Performance **COP = 6.82**

Example of an "if/else" structure

G, H. Lowercase & Uppercase Greek

αω Lowercase Greek ? ▲

α	β	γ	δ	ε	ζ
η	θ	ι	κ	λ	μ
ν	ξ	ο	π	ρ	σ
τ	υ	φ	χ	ψ	ω

ΑΩ Uppercase Greek ? ▲

A	B	Γ	Δ	E	Z
H	Θ	I	K	Λ	M
N	Ξ	O	Π	P	Σ
T	Υ	Φ	X	Ψ	Ω

- To insert a Greek symbol, place your cursor at the desired location in the worksheet and click the appropriate button.
- Note that Greek symbols can be used in all the Solver regions: Equation, Text, Plot, and Area Delimiters.

Known Issues

Welcome to Knovel's Interactive Equations Solver. Please bookmark this site for future use. We are interested in your first impression of the Solver, and how quickly you were able to get going without formal training or help from Support Center.

Download to Mathcad format is not working if the worksheet contains a plot.

Programming structures do not convert well in Mathcad format.