## 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 Solver is optimized for tablets, such as the $\mathrm{iPad} ®$ and the Samsung Galaxy.

Watch (hyperlink on "Play" icon) a brief introductory video tour of the Knovel Interactive Equation Solver.
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## 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.


[^0]
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## Separate window view

| $\Sigma^{ \pm}$ | Click Show Solver button to open Solver in <br> embedded view |
| :--- | :--- |

Show Solver button

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## 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,


#### Abstract

$\Sigma^{ \pm}$ Click on the blue button located on the right side of the page 0 (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.




Interactive Equations Browse page and Show Solver button


Equation Detail Page, open Equation Worksheet

The Equation Solver will open in embedded view or a new tab 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, 몬, 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.

## Equation Solver 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 anywhere on the equation grid space.


## Equation

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

$P$ is vapor pressure of liquid, atm
A is component-specific empirical constant
$B$ is component-specific empirical constant
C is component-specific empirical constant
T is temperature, C

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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


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- Interactive section for making your calculations; includes example values, units for correspondent variables, and results of your calculations
- Knovel citation
- Explanatory illustrations, if available


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Note: The variables in this equation may be subject to constraints on input vaiues that may not have been explicitly imposed by the author. These constraints may relate o the specific material or design for a given project, or may reflect limitations on the available data in the cited source. Users are expected to exercise professional
juggent when gelecting equations suitable for the tasx, and entering values for inputs in these equations.

Open worksheet with elements identified

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- 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.


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Equation Solver 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 (Note that some buttons may not be available in the tablet version of the Equation Solver). Hover your mouse over the buttons to read tips on how to use them.
A. INSERT

| ATE | IIISERT | UUIITS |
| :--- | :--- | :--- |
|  |  |  |
|  | Equation |  |
| Text |  |  |
| Picture |  |  |
| Plot | @ |  |
| Area Delimiters |  |  |
|  | Hyperlink | , |

[^1]
## Knovel Equation Solver User Guide

- 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, Area Delimeters, and Hyperlinks.
- 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 | "Shift" key + @ |
| Hyperlink | Ctrl + K |

## 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


## Knovel Equation Solver User Guide

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:
o my_var
o My_var1
o length_of_the_beam
o $\alpha_{1}$ (type the word "dot" to display subscript; in this example: " $\alpha$ 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 (hyperlink on "Watch" or the icon) 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:


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```
// symbolic variables a and b do not need to be defined before using them in funtion f(x)
f(x):=a\cdotx+b
// symbolic variables need to be asigned values in order to evaluate f(x)
// red indicates error
f(3)=1
// symbolic variables are defined
a:=2
b}=
f(3)=8
```


## Numeric evaluation using variables

- A variable that has not been defined cannot be evaluated. The variable is displayed in red to indicate a missing value and incomplete the assignment.


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.


## Knovel Equation Solver User Guide

Use the Boolean equal operator (=), 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 (=). The expression outlined in red indicates that $M$ has yet to be defined and cannot be evaluated.

```
// using the Boolean equal operator
M=\frac{1}{2}\cdot\mp@subsup{w}{}{2}
w:= 78
// expression cannot be evaluated,
M:= I
```

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

- 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.


# Knovel Equation Solver User Guide 

$$
\begin{aligned}
& f(x):=x^{2}+45 \cdot x-67 \\
& / / \text { symbolic evaluation } \\
& f(x)=-67+x \cdot(45+x) \\
& / / \text { numerical evaluation } \\
& f(3)=77
\end{aligned}
$$

## 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 (->) produces a symbolic result, in fraction or radicals.


Numerical vs symbolic evaluation

- Note that the spacebar and arrow keys within an equation region allow you to broaden your selection.
o Place your cursor anywhere inside an expression and press the spacebar until you make your desired selection. This is particularly helpful when


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applying an operator such as a radical or a fraction to a selection of the math expression. Or,
o 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.

$$
f(x, y)
$$

## 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 ${ }^{\boxed{ }}$ 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.

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```
// 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
```

```
    2
```

    2
    2\cdotx}+7\cdotx-78 +\sqrt{}{45
2\cdotx}+7\cdotx-78 +\sqrt{}{45
3

```
    3
```

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.


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.


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- 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.

```
Bernoulli Equation
For inviscid and adiabatic flow, an increase in the speed of the fluid occurs
simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.
\(\Delta \mathrm{P}:=0 \cdot\left(\frac{u_{2}{ }^{2}-\mathrm{u}_{1}{ }^{2}}{2 \cdot \mathrm{~g}}+\mathrm{z}_{2}-\mathrm{z}_{1}-\mathrm{h}\right) \mathrm{Cl}\)
```

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, $\xrightarrow{\leftrightarrow}$.


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- 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 \{:


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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,


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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 $\ddagger$ 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.


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Area Delimiters

## B. NEW



NEW tab in Top Menu

- Click the NEW tab to open a blank, untitled worksheet, which is then automatically 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 $\mathbf{x}$ button to the left of the title, then the CLOSE WORKSHEET button in the following window. Note that you will lose any changes to the worksheet that you haven't saved (to save a worksheet, click CANCEL then use the DOWNLOAD button; see below for instructions on using the UPLOAD/DOWNLOAD buttons).


## Online Equations Editor <br> Worksheet has unsaved changes. Do you want to continue?

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

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## C. UPLOAD



## UPLOAD button

- Click to upload previously saved worksheets in Knovel's proprietary .sm format from your computer or device. If you try to upload any other format file (non-.sm files), the following error message will appear.


## Knovel Interactive Equations

Please upload Knovel (.sm) format files.

## OK

Upload error message

## D. DOWNLOAD



[^2]
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- 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).
o Knovel proprietary .sm format
o Adobe PDF
o HTML
o Mathcad 15, .xmcd
0 .png
o .xls (currently in beta)
!
Since Mathcad requires that variables are defined before you insert them into a formula—and the Solver does not-if you save your worksheet in Mathcad, the formula will be repositioned below the legend.

$\nabla^{*}$Watch (hyperlink on "Watch" or the icon) a brief video of how to use the UPLOAD/DOWNLOAD buttons.

## E. EDIT

| Y* | NEW | UPLOAD | DOWNLD | EDIT | CALCuLATE | INSERT | UNITS | 눈 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| U Untitled-1 |  |  |  |  |  |  |  |  |
| $+$ |  |  |  |  |  |  |  | 4 |
|  |  |  |  | Paste |  |  |  |  |
|  |  |  |  |  |  |  |  | $\stackrel{+}{\mathbf{x}} \div$ |
|  |  |  |  | Delete |  |  |  |  |
|  |  |  |  |  |  |  |  | 퓸 |
|  |  |  |  | Select All |  |  |  |  |
|  |  |  |  | Print |  |  |  |  |
|  |  |  |  |  | - |  |  | $\leq \geq$ |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | $f$ |
|  |  |  |  |  |  |  |  | f |

[^3]
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- 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: $\ddagger$. 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.


[^4]
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## F. CALCULATE

| ** | NEW | UPLOAD | DOWNLD | EDIT | CALCULATE | INSERT | UNITS | 匃 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| * Untitled-1 |  |  |  |  | Automatic calculation (ON) |  |  |  |
| + |  |  |  |  | Find Roots |  |  | 4 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Invert fraction |  |  | $\pm$ |
|  |  |  |  |  | Differentiate |  |  | $\mathrm{x} \div$ |
|  |  |  |  |  |  |  |  | 파N |
|  |  |  |  |  |  |  |  | H |

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.

| CALCULATE | INSERT |
| :--- | :--- |
| Automatic calculation (ON) |  |
| Find Roots |  |
|  |  |
| Invert fraction |  |
| Differentiate |  |

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.

| CALCULATE | INSERT |
| :--- | :--- |
| Automatic calculation(OFF) |  |
| Find Roots <br>  |  |
| Invert fraction |  |
| Differentiate |  |

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.



## 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.

| Online Equations Editor |
| :---: |
| Select part of equation |
| OK |

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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.


[^5]
## G. 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.


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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 1 dam $=10 \mathrm{~m}$ right in the worksheet.


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```
// define unit dekameter
dam:=10m
// usage of user-created unit (dam) in the worksheet
70 dam =700m
are:=dam}\mp@subsup{}{}{2
78 are = 7800 m
```

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. Therefore, some unit symbols may not be as intuitive as you may think. For example, the Solver displays the symbol for gram as "gm".


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Units menu

## Equation Solver 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)

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Expanded Palettes menu (click the right arrow to collapse)


Collapsed Palettes menu with expanded Arithmetic palette

| $+=$ |  | me |  |  | $?$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\infty$ | $\pi$ | $i$ | $\pm$ | * | 区 |
| 7 | 8 | 9 | $+$ | (.) | \| 1 |
| 4 | 5 | 6 | - | $\sqrt{1}$ | $\sqrt[3]{1}$ |
| 1 | 2 | 3 | $\times$ | , | $\rightarrow$ |
| - | 0 | $!$ | 1 | := | $=$ |
|  | Matrices |  |  |  | $?$ |
| $\leq \geq$ | Boolean |  |  |  | $?$ |
| $f$ | Functions |  |  |  | $?$ |
| $\because$ | Plot |  |  |  | $?$ |
| $\begin{aligned} & 010 \\ & 101 \end{aligned}$ | Programming |  |  |  | $?$ |
| $\alpha \omega$ | Lowercase Greek |  |  |  | $?$ |
| $\mathrm{A} \Omega$ | Uppercase Greek |  |  |  | $?$ |

## Expanded Palettes menu with expanded Arithmetic palette

## A. Arithmetic palette

| $\stackrel{+}{\mathrm{X}} \div$ | Arithmetic |  |  | ? |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\infty$ | $\pi$ | $i$ | $\pm$ | * | 区 |
| 7 | 8 | 9 | + | (1) | \| 1 |
| 4 | 5 | 6 | - | $\sqrt{1}$ | $\sqrt{1}$ |
| 1 | 2 | 3 | $\times$ | , | $\rightarrow$ |
| - | 0 | $!$ | 1 | := | $=$ |

- 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.


## Knovel Equation Solver User Guide

- 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.

```
In equation/math region:
// dot operator as a floating point
2. 5 = 5
// dot operator as a literal subscript
w
```


## Dot as digital point vs literal subscript

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

$$
\pm 6=\left\{\begin{array}{l}
6 \\
-6
\end{array}\right.
$$

Plus/minus operator
o Assignment/definition operator (:= ), used to assign values to variables or to define functions or formulas/equations.
o 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).

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| $/ /$ numerical evaluation |  |
| :--- | :--- |
| $\frac{78}{5}+57$ |  |
| $\frac{7}{7}=10.3714$ |  |
| $1 /$ yymbolic evaluation |  |
| $\frac{78}{5}+57$ |  |
| $\frac{7}{7}=\frac{363}{35}$ |  |

Numerical and symbolic evaluation of the same expression

Watch (hyperlink on "Watch" or the icon) 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 |  |  |  |
| :--- | :--- | :---: | :---: |
|   <br> Rows: 3 <br> Columns: 3 <br>  INSERT |  |  | CANCEL |

[^6]
## Knovel Equation Solver User Guide

- 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.
// showing a matrix with 4 rows and 3 columns

$$
M=\left(\begin{array}{ccc}
6 & 8 & 34 \\
0 & 4 & 6 \\
0 & 0 & 9 \\
78 & 8 & 9
\end{array}\right)
$$

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 $\mathrm{M}[3,1$ 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.

```
M:=(\begin{array}{ccc}{4}&{1}&{6}\\{8}&{5}&{2}\\{10}&{9}&{1}\end{array})
// Matrix element typed as M[3,1
M M 1 = 10
```

Referencing a matrix element

- Additional matrix utilities include:

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

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```
// example determinant of matrix
M:=(\begin{array}{ll}{1}&{5}\\{2}&{50}\end{array})
|M|=40
```

Calculating the determinant of a matrix

- $\boxplus^{\mathrm{T}}$ - 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
$M:=\left(\begin{array}{ll}1 & 5 \\ 2 & 50\end{array}\right)$

$$
M^{T}=\left(\begin{array}{ll}
1 & 2 \\
5 & 50
\end{array}\right)
$$

Transposing a matrix

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


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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

- $\quad \times$ - 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.


## Knovel Equation Solver User Guide



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.


## Knovel Equation Solver User Guide

```
a}:=7
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.


## Knovel Equation Solver User Guide

## D. Functions Palette

| $\boldsymbol{f}$ | Functions |  |  |
| :---: | :---: | :---: | :---: |
| $\boldsymbol{\operatorname { s i n }}$ | $\cos$ | $\tan$ | cot |
| $\log$ | $\ln$ | exp | arg |
| $\Sigma$ | $\Pi$ | $\partial$ | $\delta$ |
| sign | $\%$ | el | $\{:$ |

## Knovel built-in functions

- Use the Functions palette to quickly insert built-in trigonometric and calculus functions.
- Trigonometric functions include:
o Sine (sin)
o Cosine (cos)
o Tangent (tan)
o Cotangent (cot)
Since all trigonometric functions arguments default to radians, you must specify degrees by inserting a numerical value, then 'deg).


Using trigonometric functions with degrees

- Logarithmic functions include:
o Logarithm base 10 (log)


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o Natural logarithm (In)

- Calculus functions include:
o Exponent (exp)
o Angle for a complex number (arg)
o Series such as Summation ( $\Sigma$ ) and Iterated product ( $\Pi$ )
o Derivative ( $\delta$ ) and Integral ( $\delta$ )
o 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.

```
// example usage functions, insert value
    in the placeholder
cos(1)
cos(67)=-0.5178
```

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.


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```
// using function integrals
< 1
// fill in the placeholders, use the right arrow key
    to move the cursor to the next placeholder
f(x):= x 2
\mp@subsup{\int}{5}{8}f(x)dx=129
```


## Display of inserted functions requiring multiple arguments

- To enter a summation, place your cursor at the desired point in the worksheet then click $\Sigma$. 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.

```
// using summation
\sumi=n
\sum 
```

Example summation with placeholders, values, and result

- To enter a product, place your cursor at the desired point in the worksheet and click $\Pi$. 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.


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.

```
//assign value to element subindex 4 of a vector labeled "my_vector"
mY_vector }4:=4
// list vector
my_vector =( c}
```


## Defining the element of a vector

- You can also use a shortcut to enter the element of a vector. For example, to enter $\mathrm{v}_{4}$, type $\mathrm{v}[4$ 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.


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```
//assign value to element subindex 4 of a vector labeled "my_vector"
my_vector }\mp@subsup{4}{}{:=45
// list vector
my_vector }=(\begin{array}{c}{0}\\{0}\\{0}\\{45}\end{array}
// create variable my_vector 4}\mathrm{ by using dot notation to subscript
my_vector 4}:=10
// both element 4 of my_vector and variable my_vector }4\mathrm{ looks the same
    but they are dfferent mathematical objects
```

Difference between subindex and subscript

- Use the values or equations button (i:) 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 (hyperlink on "Watch" or the icon) a brief video on how to use built-in functions.

## Knovel Equation Solver User Guide

## 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):=\mp@subsup{x}{}{2}+56\cdotx-7
// numeric evaluation
f(3)=170
// evaluate using a variable previously defined, \xi
\xi:=2.1
f(\xi)=115.01
// example user-defined function with two parameters
g(x,y)=\sqrt{}{\mp@subsup{x}{}{3}+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 (hyperlink on "Watch" or the icon) a brief video on how to create your own functions, as well as using the derivative and integral Function utilities.

## E. Plot Palette



## Knovel Equation Solver User Guide

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

- Insert Graph-
- Scale -
- Move - $\ddagger$
- Graph by points ::
- Graph by lines - \#
- Refresh G
- 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 $\stackrel{\leftrightarrow}{\longleftrightarrow}$. 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.


## Knovel Equation Solver User Guide

- To use the Move ( $\ddagger$ ) and Scale ( ${ }^{(1)}$ ) 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 ( $\quad$ ). 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, ( $\checkmark$ ).


## F. Programming Palette

| 010 | Programming |  |
| :--- | :--- | :--- |
| 101 |  |  |
| if while for line |  |  |
| break continue |  |  |

- 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 ( ${ }^{\text {if }}$ ) button. A blank structure will be displayed in the worksheet, along with multiple placeholders.


Inserted blank structure

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- 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 ( $\left.{ }^{\text {ine }}\right)$ 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.


## Knovel Equation Solver User Guide



Example of an "if/else" structure

## G, H. Lowercase \& Uppercase Greek

| $\alpha \omega$ | Lowercase Greek |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\alpha$ | $\beta$ | $\gamma$ | $\delta$ | $\varepsilon$ | $\zeta$ |
| $\eta$ | $\theta$ | $i$ | $\kappa$ | $\lambda$ | $\mu$ |
| $v$ | $\zeta$ | 0 | $\pi$ | $\rho$ | $\sigma$ |
| $\tau$ | $v$ | $\varphi$ | $\chi$ | $\psi$ | $\omega$ |


| $\mathrm{A} \Omega$ | Uppercase Greek |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| A | B | I | $\Delta$ | E | Z |
| H | $\Theta$ | I | K | $\Lambda$ | M |
| N | $\Xi$ | O | $\Pi$ | P | $\Sigma$ |
| T | Y | $\Phi$ | X | $\Psi$ | $\Omega$ |

- 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.


## Knovel Equation Solver User Guide

## Equation Solver Cheat Sheet

| Task | Keyboard Shortcut |
| :--- | :--- |
| To enter UNITS | SHIFT + single quote (text will <br> become blue) |
| To enter TEXT region | SHIFT + double quote |
| To enter PLOT region | SHIFT + @ |
| To enter MATH region | Start typing |
| Assignment for a variable | $:$ |
| Numerical evaluation | $=$ |
| Symbolic evaluation | CTRL + . |
| Square root | I |
| N-th root | CTRL + ! |
| Factorial | ^ |
| Power | log(10,2) |
| Log 10 of base 2 | Dot ( .) |
| Literal subscript | [ |
| Vector subscript (index) | Soubht/left arrow keys |
| To select within complex | Spacebar |
| math expressions |  |
| To move cursor within |  |
| stroke remove the last key | Backspace |
| To select any element |  |


[^0]:    Embedded view with Hide Solver and Show Solver in a separate window buttons

[^1]:    Open INSERT drop-down button in Top Menu

[^2]:    Opened DOWNLOAD drop-down button

[^3]:    Opened EDIT drop-down button

[^4]:    Dragging and dropping a selection

[^5]:    Differentiate result displays below the expression

[^6]:    Insert Matrix window

