A Simple Tutorial for Mathcad 2000

Entering and Editing Equations

Calculations in Mathcad are performed much the same as when you work on a sheet of paper. Using the mouse, you may click anywhere and begin typing assignment statements, equations, functions, etc. Mathcad performs multiple calculations on a page from left to right and from top to bottom. Entering and editing equations may seem a bit awkward at first, but becomes easier with practice. As a very simple example, suppose you wish to calculate (6+2)/3; in Mathcad, you can simply enter this equation exactly as shown and press the equals sign to evaluate. Mathcad automatically rearranges the equation and also prints the result:

keystrokes: (6 + 2) / 3 = result: $\frac{(6+2)}{3} = 2.667$ ▌

The solid rectangle (▌) is called a "placeholder" and can be used to supply units (e.g. kg, m, s, lb, hr, etc.) for a number, if necessary. Including units will be discussed more later. A more efficient way to do this same calculation is to use the space bar (↑):

keystrokes: 6 + 2 ↑ / 3 = result: $\frac{6+2}{3} = 2.667$ ▌

The space bar the the left and right arrow keys are used to move the blue vertical and horizontal lines that indicate what part of the expression is selected. Everything contained by these selection lines is treated as a single entity, which (as in the example above) can eliminate the need to use parentheses.

Now suppose you wish calculate (6/2 + 4); observe the results for the following entries:

keystrokes: 6 / 2 + 4 = result: $\frac{6}{2+4} = 1$ (this is not what we wanted)

keystrokes: 6 / 2 ↑ + 4 = result: $\frac{6}{2} + 4 = 7$ (this is what we wanted)

Understanding how the space bar and left/right arrow keys work is important when editing equations in Mathcad. Consider the following example:

keystrokes: 6 / 2 ↑ + 4 ↑ / 2 ↑^3 = result: $\left(\frac{\frac{6}{2}+4}{2}\right)^3 = 42.875$

Assigning and Using Algebraic Variables

Usually, you want to store values as algebraic variable for use in subsequent calculations. Just like Maple, the assignment operator in Mathcad is a colon followed by an equal sign (:=); however, when entering an equation, you only need to type the colon and Mathcad automatically supplies the equal sign. For example, to assign a value of 3 to a variable named **x**:

keystrokes: x : 3 result: x := 3

Once a variable has been assigned, you can view its value using the equal sign:

keystrokes: x = result: x = 3

In other words, "x := " is used to assign a value to variable x, while "x = " is used to display the value of **x**; if you try to enter "x = " in a Mathcad document without having previously performed an assignment statement (using "x := "), then Mathcad automatically assumes you meant to type "x:=" so it changes you "=" to a ":=". Algebraic variables can be combined in equations using all the basic mathematical operations (+, -, *, /, ^, !, etc.)

There are three kinds of equal signs in Mathcad. Examples of the uses will be discussed in the following sections.

Functions

Mathcad has a large number of built-in (intrinsic) math functions, including trigonometric (sin, cos, tan, etc.), logarithmic, and exponential functions. You need to only click on the function icon for a selection or just type the function name if you know it. The symbol π is in the Greek letter palette and the calculator palette.

keystrokes:sin(2*π)= result: 0

You can also define your own functions to simplify repetitive calculations. For example, suppose you wish to evaluate the following equation at various values of x and y: ($x^3 - 4x^2y$). In Mathcad, this function could be defined by:

keystrokes: f(x,y) : x^3↑↑-4*x^2↑↑*y result: $f(x,y) := x^3 - 4x^2y$

Now you can use this function just as you would any intrinsic function, by supplying numbers for the arguments (x and y) and pressing the equal sign to display the function value:

f(3,0) = 27
f(1,4) = -15

Units and Dimensions

A very useful feature of Mathcad is its ability to perform calculations with units included. Mathcad automatically takes care of conversions for you. Consider the following example:

keystrokes	result
mass : 4 * kg	mass := 4 kg
g : 9.8 * m / s ^ 2	$g := 9.8\ m/s^2$
force : mass * g	force := mass * g
force =	force = 39.2 N

Note how Mathcad automatically uses the units and does the conversions to obtain a value in units of Newtons (N). The default unit system to be used in all calculations can be specified by clicking *Math…Options…Units System* in the menu bar. If you want the result in different units simply click on the equation to activate the unit placeholder (▌):

force = 39.2 N ▌

Now use the mouse to click on the placeholder; when you see a selection box surrounding the placeholder, simply type the desired units. In the above example, if you type "lbf" in the placeholder, then Mathcad responds with:

force = 8.813 lbf

Mathcad automatically does the required conversion. Click *"Insert…Unit"* on the menu bar to see a list of all the units Mathcad "knows". When working with units you need to be careful about choosing your variables; for example, Mathcad uses "m" for meters. You can define m as something else in your worksheet, but just remember if you do so that m no longer is a unit for length.

Ranges, Arrays, Vectors, and Matrices

A range variable can be thought of as a one-dimensional array (i.e., a vector). If we wish to define **x** as a range variable, the semicolon (;) is used to create range variables in Mathcad, as shown below:

keystrokes: x : - 2 * π ; 2 * π result: x := -2*π .. 2*π

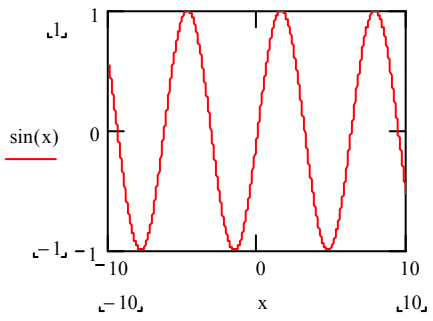
Note that the semicolon results in the ellipsis (..), which denotes a range variable. (π is entered by clicking the appropriate symbol from the palette left of the Mathcad screen.) Thus, we have created a one-dimensional array named **x** that contains a range of values between the desired endpoints.

A matrix is a two-dimensional array of data structure. If we want to define a 3 x 2 (three by two) matrix, click on the *vectors-and matrices-palette*, select the *matrices or vectors* icon, type number of rows (3) and columns (2) , and then select **create**. A 3 x 2 matrix form will appear on the worksheet; enter values by moving the selections box with the tab key.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Graphics: Two-Dimensional Plots

Suppose you wish to plot the function sin(x) for **x** values between -2π and +2π. In Mathcad 2000, it is easy to quicly create such a plot. Click *"Insert…Graph…X-Y Plot"* to place blank graph on the page; there are two placeholders – one on the x-axis, one on the y-axis. Click on the x-axis place holder and enter "x", then click on the y-axis placeholder and enter "sin(x)". This creates the graph shown below.



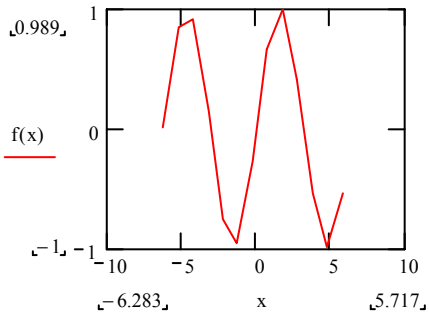
By default Mathcad decided to plot this for a range of x-values from –10 to +10; to change these limits, click on these numbers and change them. Once created, you can double-click a graph and adjust various display options.

We can also create a graph by explicitly calculating the values we want to plot (similar to how a plot is made in Excel, in which you first created columns of the numbers you want to plot). For example:

keystrokes: x : - 2 * π ; 2 * π result: x := -2*π .. 2*π

keystrokes: f (x) : sin (x) result: f(x) := sin(x)

As before, now click *"Insert…Graph…X-Y Plot"* to place blank graph on the page. Click on the x-axis place holder and enter "x", then click on the y-axis placeholder and enter "f(x)". This creates the graph shown below.



This graph looks pretty rough because by default increments variables by 1 when creating range variables. So in this example, the assignment statement above for x results in the following vector of x-values: [-6.28 -5.28 -4.28 … 5.28 6.28]. How can we increase the number of points plotted? The procedure outlined below shows one method of controlling the number of points to be plotted:

keystrokes	**result**
N : 50	N := 50
x_min : – 2 * π	x_min := –2*π
x_max : 2 * π	x_max := 2*π
dx : x_max - x_min ↑ / N - 1	$dx := \frac{x\_max - x\_min}{N - 1}$
i : 0 ; N – 1	i := 0 .. N–1
x [i : x_min + i * dx	x_i := x_min + i*dx
f(x) : sin (x)	f(x) := sin(x)

In this example, **N** is the number of points to be plotted. We also have defined variables for the endpoints (**x_min** and **x_max**) so that these can also be easily varied. **dx** is the distance between successive x-values, and is calculated as shown above. Both **i** and **x** are range variables, the difference being that **i** is an array of integers (0, 1, 2, 3, ... N - 1), while **x** is an array of values that depend on **i**. We show that **x** depends on **i** by using a subscript, $\mathbf{x_i}$. Subscripts can be created either by using the left bracket ([), as shown above, or from the *vectors-aand matrices-palette*.

Now create a graph to plot $\mathbf{x_i}$ versus **f(x)**. Using 50 points, you'll observe that the curve is much smoother. You can then change any of the values for **N**, **x_min**, or **x_max**, and Mathcad will immediately update the graph to reflect the changes. This process is logically equivalent to manual graphing on a graph paper. You may want to save this particular process so that you can recall it later.

Symbolic Calculations

Mathcad is capable of performing symbolic calculations, meaning that algebraic equations can be manipulated such that the answer for a given calculation can itself be expressed algebraically. Mathcad's symbolic routines are based on Maple, which is a larger, more powerful symbolic math package. See the

Differentiation. Suppose you need to find the partial derivative of x^3-4x^2y with respect to **x**. First type the equation:

$$x^3-4x^2y$$

Now, using the mouse and/or arrow keys, to one of the **x**'s in the equation. Then click **Symbolics…Variable…Differentiate**. Mathcad differentiates this equation with respect to the selected variable to give:

$$3x^2-8xy$$

If instead you wish to differentiate with respect to **y**, then select **y** in the original equation, click **Symbolics…Variable…Differentiate**. This should give:

$$-4x^2$$

Indefinite Integration. Integration is performed much the same as differentiation; type in the equation, select the variable of integration, then click **Symbolics…Variable…Integrate** from the **Symbolics** menu. Using the same equation as above (x^3-4x^2y), integrating on **x** yields:

$$\frac{x^4}{4}-\frac{4x^3y}{3}$$

As you no doubt remember from calculus, there is not a unique solution for an indefinite integral, since any equation of the form shown below is a valid answer:

$$\frac{x^4}{4}-\frac{4x^3y}{3}+\text{constant}$$

If instead you wish to integrate with respect to **y**, then select **y** in the original equation, click **Symbolics…Variable…Integrate**. This should give:

$$x^3y-2x^2y^2$$

Definite Integration. Suppose you need to evaluate the integral of (x^2+4x-1/x) between x = 1 and x = 8. Again, you start by typing the equation of interest onto the Mathcad screen:

$$x^2+4x-1/x$$

Then select the equation by clicking on any term inside it and pressing space bar (↑) until the entire equation is selected. Then click the integral sign button on the calculus tool palette. Mathcad creates a definite integral equation with three placeholders: two for the desired limits on the variable and the other for the variable integration.

Other Resources for Learning How to Use Mathcad

This tutorial is very basic and only introduces you to a small fraction of the many features available in Mathcad. For much more extensive information, click **Help…Resource Center**. The Mathcad Resource Center contains a huge amount of useful information, including a variety of online tutorials and numerous "quicksheets" showing examples of how to use Mathcad to solve a wide variety of problems. As with most software, the best way to learn Mathcad is to use it. Don't worry about hitting the wrong key or entering an illegal command – there is nothing you can do that will cause any harm to the computer you are using. Mathcad does have a tendance to freeze up (or "hang") every now and then, but that's Mathcad's problem, not yours. If it stops working, you can always reboot the computer and start again. You should always be sure to save your work often, since if it does hang you will lose anything you've done since the previous file save operation.