SHORT CUT GUIDE TO MATHCAD

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Adapted for Mathcad 2001 by Chris Gill

INTRODUCTION

This handout is intended to get you started on Mathcad, a mathematics software program that potentially will help you apply that mathematics you've learned. From this beginning your ability to use Mathcad will grow though use, seeing many more applications than this introduction touches. A "Help" function is available on screen to assist the learning process. Every Mathcad equaiton, text paragraph, and plot in a worksheet is a separate object called a "region". Soon you will see that you can "see" these regions by clicking in a blank area of the screen and dragging your mouse across equations and text.

Let's try it. First, you need to log on the computer and get Mathcad on the screen. This "guide" is being typed using Mathcad 2001. Notice at the top of the Mathcad screen is the "main menu" with name like File, Edit, Text, etc. Mathcad calls this your "gateway to math, graphics, symbolic functions and provides commands that handle the details of editing and managing your worksheets".

To the far right of the screen is the math toolbar Let your mouse "hover" over each button to see what each button is. You will find they are in turn: calculator toolbar, graph toolbar, vector and matrix toolbar, evaluation toolbar, calculus toolbar (important for engineers), boolean toolbar, programming toolbar, Greek symbol toolbar, and symbolic keyword toolbar. If you click on one of these buttons you bring up the toolbar for the associated operator. For example, click on the calculus toolbar to see the possibilities. Now click on the "X" to remove the calculus toobar.

Skipping to the bottom of the screen you will notice the "message line" which gives you status alerts, tips, and other helpful information.

Let's get deeper into Mathcad.

WORKING WITH MATHCAD REGIONS

Every mathcad eqation, text paragraph, and plot in a worksheet is a separate object called a "region". You can see these regions by clicking in a blank area and dragging your mouse across equations and text. Let's do this. Position your red crosshair in a blank area of the screen and type x:100. You should see x:=100. (This is the way Mathcad defines variables.) Now click in a blank area of screen and drag your mouse across the equation. Notice the dashed selection box that appears, distinguishing the region. After releasing the mouse, the region border will turn solid black. To summarize and expand:

*Drag-select the region so it appears in a dashed box
*Move the cursor inside one of the boxes and it becomes a black hand.
*Hold down your mouse button and drag it to move all of the selected region.
*Click on an empty part of the screen to deselect the region.

An important property of Mathcad is that it reads your document from left to right and top to bottom, just as we read a page. To show this, type "x:5" which will give you x:=5 on the screen. Again, as we said before, this is how Mathcad defines variables. Now move your red crosshair to the right of the x:=5 area and type "x*3 =" which will look as follows:

$$x := 5 \qquad\qquad x \cdot 3 = 15$$

You have done your first Mathcad calculation showing 5 times 3 is 15. Some of you made mistakes possibly. If so, do you have part of your equation with a blue selection box around it? Hit the "up arrow" to enlarge the selection arrow to enclose your entire expression. To remove errors, select Edit from the "Main Menu" and "Cut" from the submenu to remove the expression. Even if you didn't make a mistake you can try this.

The point of this exercise is to show the "left to right, top to bottom" flow. Get the x:=5 and X*3 = 15 back on the screen. Select the x*3 region and drag it above the x:=5 line. Notice that you lose the answer, showing the left to right, top to bottom character.

Let's look some more at the selection box. Click your mouse in a blank space so you see the red crosshair. Then type 2+ and you see:

$$2 + \blacksquare$$

After you type the + you see a little box surrounded by a blue selection rectangle. In Mathcad this black box is called a placeholder. If you continue typing, whatever you type will appear in the palaceholder. For example, type 2+2= and you will see your answer 4.

You can insert text regions into a Mathcad document simply by beginning to type. At the completion of your typing, click outside the text region delineated by the black box, the black box disappears, and you may go back to calculating. The text region is very helpful to explain to the reader (and yourself later) just what calculations were being made. Too often, calculations that seemed very clear when you are making them become almost unintelligible later when they are revisited. Other readers of your work face the same problem in trying to understand your work.

DEFINING VARIABLES

In math we very frequently need to define variables. For example, click to position the red crosshair in an empty space on the page and type "Name:60".

$$\text{Name} := 60$$

After you click outside the region you see "Name:=60". To see what Name equals, you just type "Name" followed by the equals sign:

$$\text{Name} = 60$$ (Mathcad gave you the 60)

Notice that when you typed the colon (:) key, Mathcad displays ":=". The assignment operator (colon equals) in Mathcad is used for definitions. If you want to assign a different value to Name, just click to the right of the 60 on the right-hand side of the difinition of Name, backspace over it to delete the 60, and enter the value you choose. Notice that as soon as you press the [Enter] key, Name= changes as well.

You can now use a Mathcad variable in an equaiton. For example, if we type some operation to the right or below the Name:=60, we get the answer:

$$\mathrm{Name} := 60$$

$$\mathrm{Name}\cdot 2 = 120$$ (Mathcad gave you the 120)

DEFINING FUNCTIONS

The syntax used for defining functions in Mathcad is the same as you see in textbooks. For example, click in a blank area to position the red arrow and type:

f(x):x^2 You should see:

$$f(x) := x^2$$

Notice that you use the assignment operator to define functions, just as was done to define variables in Mathcad. Once you've defined a function f(x) you can use it like a number. In the following we've continued after the difinition of f(x) as done above to define x:=4 and y:=13+f(x). These lines are inputted below, and Mathcad gave us the answer for y.

$$f(x) := x^2$$

$$x := 4$$

$$y := 13 + f(x)$$

$$y = 29$$

Troubles? Did you forget to use the assignment operator (:=)? Do you need to erase something? There are several ways to edit. One way is to get a selection box around whatever you want to remove, click Edit in the title bar and then select "Cut" to remove content of the selection box. To get the selection box around everything, click on the area you wish to remove, then hit the up arrow key to enlarge the selection box, and then Edit/Cut. More about this later.

You can create a function using expressions you build yourself from the keyboard, the math operator toolbar, or Mathcad's built-in functions. To see a list of built-in function along with brief descriptions, click on the calculator icon to open the calculator toolbar. Clicking on any of the buttons will allow you to insert a function directly into your worksheet. You can also type the name of any built-in function directly from the keyboard. For example, we might type "ln(26)=":

$$\ln(26) = 3.258$$

BUILDING MATHEMATICAL EXPRESSIONS

Click to position the red crosshair in an empty space and type the following. Pay attention to what happens when you press the spacebar.

f(x):x+6 [spacebar] * (x^3 [spacebar] -1)   You should see:

$$f(x) := (x + 6)\cdot\left(x^3 - 1\right)$$

The first time you pressed spacebar, you selected x+6 so when you typed the multiplication sign, you were multiplying by the expression that followed. If you hadn't pressed spacebar the first time you would have seen:

$$f(x) := x + 6\cdot\left(x^3 - 1\right)$$

The exponent operator is called a sticky operator because your keystrokes will "stick" to the exponent until you specifically ask to get out by pressing spacebar. This stickiness applies to exponents, square roots, subscripts, and division.

Another example, type the following

x^2 [spacebar]	Now x squared is in the selection box
+3 [spacebar]	Now the entire equation is in the selection box
/3 [enter]	You should get the following:

$$\frac{x^2 + 3}{3}$$

Now try typing x^1/t^2 [spacebar][spacebar][spacebar]/3. You should get:

$$\frac{x^{\frac{1}{t^2}}}{3}$$

Chances are some of you got something else?
Play with this to correct using Edit/Cut.

EDITING EXPRESSIONS

We have already looked some at editing with Edit/Cut. Mathcad's tutorial has an interesting exercise that shows sweveral features about editing.

Insert the following expression:

$$f(x) := \sqrt{\frac{x^2 + 5}{8} - x^3}$$

by typing the tsteps listed below:

f(x):	Defines the function
square root symbol	Click on the button from the Calculator toolbar
x^2 [spacebar] +5 [spacebar] /8	Enters the square root portion of the equation
[spacebar][spacebar] - x^2	Exits the square root and finishes the equation

Do you have the expression above? Manipulate the expression until you do. Now, let's work with the expression.

Click on the square root symbol. Notice how the square root and its contents are selected in a half blue selection box. To learn more, click on the 5 and start pressing [spacebar] to select more of the equation with the blue selection box. Press the up or down arrow keys to deselect the equation. Selecting parts of the equation with this technique allows one to add to the expression or remove parts of it.

- If you want to replace the 5 with a 6, click to the right of the 5 (you'll see the blue insertion bar), press the [backspace] key, and type 6.
- If you want to replace the division with multiplication, click on the division bar, press [delete], hit the right arrow key once, and type *.
- If you want to multiply the entire right side of the equation by 3, click between the equals sign and the square root and type 3.

The tutorial recommends if you are editing an expression and make a mistake you do not know how to resolve, either delete the expression and start over or select Undo from the Edit menu. If you recently saved your worksheet, close it without saving changes and reopen it.

So, incorporating everything you've learned, try to reproduce the following equaitons yourself:

$$\text{score} := 3 \qquad \text{result} := \frac{\sqrt{\text{score} + 6} + \frac{1}{2}}{\text{score}^2 \quad 3} \qquad \text{result} = 0.583$$

Try working with this until you begin to understand the ideas.

DEFINING RANGE VARIABLES

We often wish to use a range of values of a variable; for example, let's have an x variable that ranges from 0 to 10. To do this, type "a=0;10". You should see:

$$a := 0 .. 10$$

The semicolon (;) caused the two dots to appear on the screen followed by a placeholder. This is Mathcad's "range variable". Another way to put the range variable operator in your worksheet is using the proper button on the Vectors and Matrices Toolbar. Mathcad creates an output table, a vertical series of boxes, as shown below:

$c := 0..10$

$g(c) := 24 \cdot c + 6$

c =	g(c)
0	6
1	30
2	54
3	78
4	102
5	126
6	150
7	174
8	198
9	222
10	246

Note: "c=" and "g(c)" were typed to view the matrices.

If you want increments to be other than 1, enter the next value in the range after the first one
For example, to create a range variabel d that goes from 1 to 8 in increments of 0.5, type:

$d := \ \ ,1.5..8$

d =
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8

Notice a comma was used before the second value of d and then a semicolon.

VECTORS AND MATRICES

Mathcad deals with vectors and matrices by creating a vector or matrix by choosing the dimensions of the array and filling in the placeholders. To create a vector x, click to position the red crosshair in an open space and:

- Type "x:"
- Click on the Vector and Matrix Toolbar
- Click on "Vector or Matrix" or hit Ctrl+M
- Choose the number of rows and columns and click OK
- Fill in the placeholders with values. Hit [Tab] to move from to the next placeholder.

Create the following

$$:= \begin{pmatrix} 5 \\ 4 \\ -3 \end{pmatrix}$$

To access a certain element of a vector, use the subscript operator which you create by typing a left square bracket ([ ). For example, typing "e[1=" yields the value 4. The index for a vector starts with 0. Any values not defined by you will be defined 0 by Mathcad. You can define the index as a range variable to access all of the elements at one time as shown below. Again, we have created the vector x, defined the range variable, and accessed all elements at once.

$$e = \begin{pmatrix} 5 \\ 4 \\ -3 \end{pmatrix} \qquad i := 0..2 \qquad e_i =$$

5
4
-3

We can use vector elements as arguments of functions. For example, we will define y to be 10 and x to be 2.5. The example function is shown below:

$$y := 10 \qquad x := 2.5 \qquad f(r) := \frac{\sqrt{r + x}}{y} \cdot r$$

Any need to Edit and Cut? Let's assume you have defined the above. Now define the vector e and use its elements to evaluate f(e).

$$e = \begin{pmatrix} 5 \\ 4 \\ -3 \end{pmatrix} \qquad i := 0..2 \qquad f\left(e_i\right) =$$

1.369
1.02
-0.212i

Most vector and matrix operators are in the Vector and Matrices toolbar. A wide variety of built-in functions are available for manipulating vectors and matrices.

CREATING GRAPHS

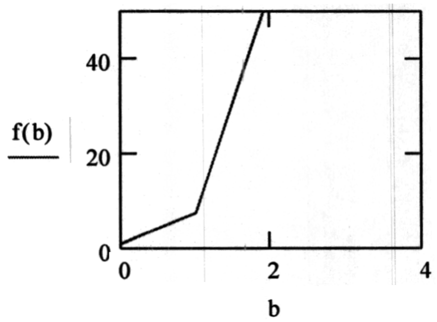
Making a graph is a very necessary task for engineers. To make a simple x-y graph you click in a blank space and select X-Y Plot from the Graph toolbar. A large box with placeholders should appear with one placeholder on each axis to be filled in.

Let's graph f(b)=exp(2*b). First define the function f(b) and the range of values for b. Click on the Graph toolbar, and then select X-Y plot. Fill in the placeholders on the x-axis with "b" to label the x-axis and a range of values from 0 to 4. Fill in the placeholders of the y-axis with f(b) and a range from 0 to 50.

$$f(b) := \exp(2 \cdot b)$$

$$b := 0..4$$

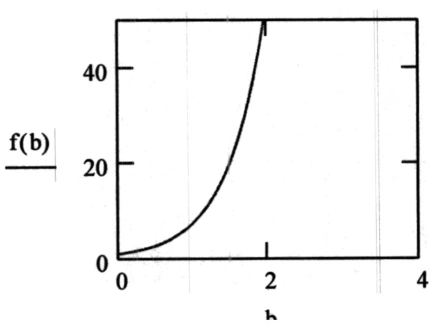
Now click X-Y Plot on the Graph toolbar.



Notice the jagged appearance of the graph. We can smooth the graph by changing the definition of b to smaller steps, i.e. 0.1. Try this by changing your definition of b as shown below:

$$f(b) := \exp(2 \cdot b)$$

$$b := 0, 0.1..4$$



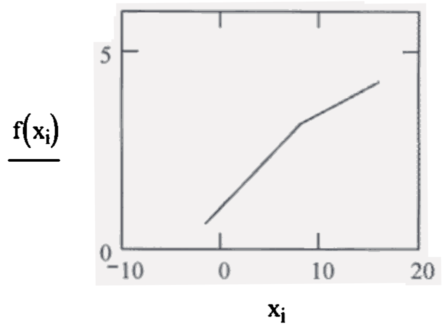
To format an x-y plot, just double-click on it to bring up a formatting dialog box. The tabbed dialog box allows you to change options. Experiment with your plot.

You can plot a function over a domain that does not have evenly spaced values. For example, your domain could consist of a vector of values. Plotting a function of vector elements requires defining a function, defining a vector which will be the domain of the function, and plotting.

Below we define the function f(x), the vector elements of x, the index variable i, and plot.

$$f(x) := \sqrt{x+2} \qquad x := \begin{pmatrix} -4.3 \\ -1.6 \\ 8 \\ 16 \end{pmatrix}$$

$$:= 0..4$$

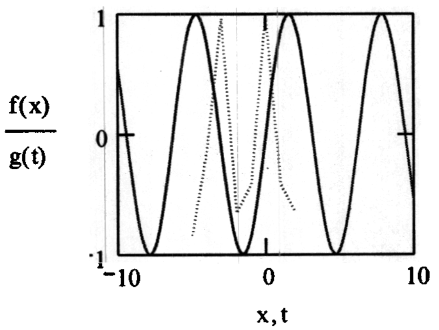


Notice the subscripted axes labels and that the horizontal axis does not need to be in even increments.

Two or more functions may be plotted on a single graph. For example, define f(x) and g(x) as done below, define the ranges of the variables, and plot.

$$f(x) := \sin(x) \qquad x := -10, -9.8..10$$

$$g(t) := \cos(2 \cdot t) \qquad t := -5, -4..2$$



Good luck!