EE230 - Lab 1 An Introduction to Mathcad

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Mathcad is a very valuable tool for all engineers. In many ways it is a "number crunching" word processor. This document will explain and demonstrate some of the basic features of Mathcad.

Starting a new Mathcad document:

When you start a new document, do the following:

1. Click on File\New
2. Click on Blank Worksheet
3. Click on Format\Number
   A window is displayed. Set the following:
   "Displayed Precision" = 4
   "Exponential Threshold" = 15
   Click on j under "Imaginary"
4. Click OK
5. Click on File\Page Setup
   Set right margin = 0.5 in
6. Click OK

Adding text to a Mathcad document:

Text can be added to a Mathcad document; put the curser where you want it and just start typing.

In all documents turned in, you must type in your name at the top of the document.

The Basics

All of the usual math symbols are used in Mathcad, the only notation that might seem strange is the symbol used for the equal sign when a **variable is defined**. The symbol is the usual equal sign with a colon in front of the equal sign as demonstrated below:

$A := 5$ $B := 4$

This defining equal sign is achieved by pressing Shift and : at the same time. After typing in the value of the variable, hit Tab. In general, anytime that want to go on to the next step and need to get out of the box, hit Tab until the box disappears.

The usual equal sign is used to display the present value of a variable:

$A = 5$ $B = 4$

The normal math symbols are used as:

Addition:	$C := A + B$	$C = 9$
Subtraction:	$C := A - B$	$C = 1$
Division:	$C := \frac{A}{B}$	$C = 1.25$
Multiplication:	$C := A \cdot B$	$C = 20$

Rasing to a power: $C := A^B$ $C = 625$

A variable is raised to a power by typing the variable and then using the up arrow (carot key ^) above the number 6. Hold shift and 6 at the same time.

Square Root: $C := \sqrt{A}$ $C = 2.2361$

The square root symbol above is achieved by pressing the back slash key \.

Complex Numbers:

Variables in Mathcad can be real or complex. Complex numbers are defined using the operator j. Some care has to be taken in defining the complex number in that the imaginary part of the complex number is pre-multiplied by 1 j as demonstraded below (type 1j and then the * and then the number..

$D := 4 + j \cdot 5$ $D = 4 + 5j$ $E := 5 - j \cdot 7$ $E = 5 - 7j$

Note - the default for Mathcad is to use the operator i as the imaginary instead of j. To change the default to j, click on Format - Number and then click on the j.

Note that when the value of D is displayed the mathematician's notation of putting the operator j after the imaginary part is used rather than in front as we do in electrical engineering.

All the typical mathematical operations can be carried out.

Addition: $F := D + E$ $F = 9 - 2j$

Subtraction: $F := D - E$ $F = -1 + 12j$

Division: $F := \frac{D}{E}$ $F = -0.2027 + 0.7162j$

Multiplication: $F := D \cdot E$ $F = 55 - 3j$

Rasing to a power: $F := D^2$ $F = -9 + 40j$

Square Root: $F := \sqrt{D} \cdot E$ $F = 19.0766 - 10.4841j$

Note that in computing the square root above that when you type the \ key you get the square root symbol. Now type in the letter D. Note that the blue line stays just to the right of the letter D. If you continue to type the square root symbol will be carried over everything that you type. In the example above what you must do is after typing in the letter D, hit the space bar until the blue line is outside of the equare root symbol, now type the * and the letter E.

As demonstrated, all complex computations are carried out in rectangular form. To convert from rectangular to polar form the following can be done:

Magnitude of a complex number: $Dmag := |D|$ $Dmag = 6.4031$

The absolute magnitude brackets are achieved by pressing the | above the slash key (hold down the shift key and the slash \ at the same time).

Angle of a complex number: $\arg(D) = 51.3402 \cdot deg$

Note that a Mathcad defined constant "deg" is used to determine the angle in degrees. The "arg" function computes the angle in radians. Type in arg(D)= and then hit the tab key and type in deg

All of the usual trig functions are used as follows. The angle must be specified in radians.

$F := |E| \cdot \sin(\arg(D))$ $\quad F = 6.7173$

In the above after typing the E := hit shift and \ at the same time to get the brackets. Now type in the letter E. Once again you will need to hit the space bar to get the blue line outside of the brackets.

$F := |E| \cdot \cos(\arg(D))$ $\quad F = 5.3738$

$F := |E| \cdot \tan(\arg(D))$ $\quad F = 10.7529$

$PF := \cos(\arg(D))$ $\quad PF = 0.6247$

To define a complex number in polar form, the true mathematical expression for a complex number is used.

$G := 10 \cdot e^{j \cdot 30 \cdot \deg}$ $\quad G = 8.6603 + 5j$

The complex number defined above has a magnitude of 10 at an angle of 30 degrees. Once again the constant "deg" is used to convert the angle from degrees to radians.

The only symbol used for complex numbers that is different from normal engineering notation is that of the conjugate. The conjugate of a complex number is defined by using a bar over the complex number.

$H := \overline{G}$ $\quad H = 8.6603 - 5j$

To get the bar over G, type G and then shift " at the same time:

The real part of a complex number is determined by:

$I := \mathrm{Re}(H)$ $\quad I = 8.6603$

The imaginary part of a complex number is determined by:

$J := \mathrm{Im}(H)$ $\quad J = -5$

Subscripts

Two types of subscript notation are used. The first type is when a subscript is used for notation purposes only. The second type is when the subscript is a variable itself.

Subscript used for notation: $V_{ab} := 480 \cdot e^{j \cdot 30 \cdot deg}$

Subscript used as a variable: $i := 1 \quad V_i := 100 \cdot e^{-j \cdot 45}$

You really have to look closely to see the difference between the two. The notation subscript is achieved by pressing the period key and then the subscript(s). The variable subscript is achieved by pressing the left bracket key [and then the subscript(s) .

To solve a system of equations

Consider problem 3.52 there are four nodes and two dependent sources so six unknowns.

First define the variables using an initial guess

$V1 := 1 \qquad V2 := 2 \qquad V3 := 0 \qquad V4 := 0 \qquad Ix := 9 \qquad Vx := 6$

Next tell Mathcad that you are solving a set of equations using the Given statement. The Given statement is a command and not text

Given Command statement Given as a text statement

Now define the equations using the Boolean toolbar bold equals sign or Ctrl=

$0 = V1 - V2 + 3 \cdot Ix$ Super node

$$0 = -2 + 2 \cdot Vx + \frac{V1 - 0}{5} + \frac{V2 - V4}{6} + \frac{V2 - V3}{8} + \frac{V2 - 0}{3}$$

$0 = V3 - 0 - 12$

$$0 = \frac{V4 - V3}{4} + \frac{V4 - V2}{6} + 4$$

$$Ix = -\frac{V2 - V4}{6}$$

$$Vx := \frac{V2 - 0}{3} \cdot 3$$

$$Sol := Find(V1, V2, V3, V4, Ix, Vx) \qquad Sol = \begin{pmatrix} 1 \\ -0.1538 \\ 12 \\ -2.4615 \\ -0.3846 \\ 1.4929 \end{pmatrix}$$

You can pull out the various values using the fact that Mathcad has the first row and column in a matrix as zero instead of the usual 1. To change the matrix column and row to 1 select Tools then select Worksheet Options and change Array Origin to 1. The use the subcsript use the [key

$V1 := Sol_{1,1}$ $\quad V1 = 1$

$V2 := Sol_{2,1}$ $\quad V2 = -0.1538$

$V3 := Sol_{3,1}$ $\quad V3 = 12$

$V4 := Sol_{4,1}$ $\quad V4 = -2.4615$

$Ix := Sol_{5,1}$ $\quad Ix = -0.3846$

$Vx := Sol_{6,1}$ $\quad Vx = 1.4929$

Say that you want to calculate the current coming out of the V2 node and going to the V3 node

$$I23 := \frac{V2 - V3}{8} \qquad I23 = -1.5192$$

Assignment for Lab 1

1. Input the above document into Mathcad. Do not input the text of the document.

2. Use the Given command to solve the node equations for Problem 3.52. Assign a variable for all of the node voltages and solve for the voltage (voltage being a positive number) across the 6 ohm resistor.

2.Use the Given command to solve the loop equations for Problem 3.100. Assign a variable for all of the loop currents and solve for the voltage (voltage being a positive number) across the 4 ohm resistor.