Mathcad Lecture #1 In-class Worksheet
Mathcad Basics

At the end of this lecture, you will be able to:

- Evaluate mathematical expression numerically
- Assign variable and use them in subsequent calculations
- Distinguish between the different types of Mathcad "equal signs" and use each appropriately
- Construct complex mathematical equations involving ()'s, exponents, square roots, etc.
- Perform symbolic algebraic manipulations using both the menu-based method and toolbar method.
- Format Mathcad sheets for readability by highlighting regions, changing answer precision, and aligning regions.

1. Evaluating Expressions Numerically

Explanation

- The red crosshair indicates the insertion point on the worksheet.
- You can begin typing numbers and mathematical symbols
- + is for addition
- - is for subtraction
- / is for division
- * is for multiplication

Demonstration

Try typing 15-8/104.5=

$$15 - \frac{8}{104.5} = 14.923$$

Try typing 15-8<space>/104.5=

$$\frac{15 - 8}{104.5} = 0.067$$

Key Points

- The blue horizontal line indicates what is currently selected
- The blue vertical line indicates the insertion point
- Change the selection portion by pressing <space>
- Toggle the insertion point between one end of the selection to the other by pressing <insert>
- Left and right arrow keys can be used to move the insertion point.

2. Assigning and Using Variables

Explanation

- Variables can be created to store values
- A variable can be given almost any name, from single letters to words

- Assign a variable by typing the desired name followed by : followed by a numerical value.
- Once a variable is assigned, it can be used in subsequent calculations.

Demonstration

a := 5

b := 10

a + b = 15

Key Points
- Notice that the result of typing : is :=
- Colon (:) is called the *assignment operator*.

Caution: The order of variable assignment is important.

x + y = ▮

x := 5

y := 10

x + y = 15

Key Points
- Mathcad evaluates expressions from **Left to Right** and **Up to Down**
- *Consequence*: Variables must be assigned before they are used.

3 Different Types of Equal Signs

Explanation

- Up to this point, we have seen two types of equal signs; **=** and **:=**
- There are actually four types of equal signs in Mathcad

1. Assignment Operator (discussed above)

   f := 3 Keystroke is :

2. Display Value (seen above)

   f = 3 Keystroke is =

3. Global Assignment Operator

   h ≡ 2 Keystroke is ~ h is defined everywhere "above" and "below"

4. Symbolic Assignment

   PV = nRT Keystroke is <ctrl>= We will use this more later.

Key Points
- Notice the keystroke and associated symbol of each type of equal sign
- Usually don't want to use global variables except for such things as Avogadro's

number or the gas constant.

Cautions

- Mathcad has several predefined variables. (Help => Built-in Constants)

$e = 2.718$ $g = 9.807 \frac{m}{s^2}$ $c = 2.998 \times 10^8 \frac{m}{s}$ $\pi = 3.142$ $\infty = 1 \times 10^{307}$

- You can reassign variables. Be sure you don't do so inadvertently.

$g := 100$ $g = 100$

Notice the green underlining on g. This means you reassigned the variable. (You can turn off this warning in the Tools/Preferences menu.)

4. Common Mathematical Operations

Explanation

- Mathcad has almost any mathematical operator you need.
- These are found on *Tool Palettes* or can be inserted with various *keystrokes*
- The table below has a list of common operations and the associated keystrokes
- The main Tool Palette can be accessed by selecting View/Toolbars/Math. Several other palettes can then be accessed by clicking on the icons. The calculator icon has several common operations.

Keystroke	Description
+	Add
-	Subtract
*	Multiply
/	Divide
<Shift>6	Power x^y
|	Absolute Value $\|\blacksquare\|$
\	Square root $\sqrt{\blacksquare}$
<Ctrl>\	Nth root $\sqrt[\blacksquare]{\blacksquare}$
<Space Bar>	Enlarges the selected part of an expression. Space within a variable name turns it into text
<Ctrl><Enter>	Addition with a line break (To place long expression on two lines)
<Insert>	Toggles the insertion point between the front and back of the expression.
“	Creates a text box.
.	**Text** subscript as part of a variable name.
[	**Vector/Matrix** subscript
<Ctrl>g	Changes the preceding character to the corresponding Greek letter.

Demonstration

$x^2 = 25$ $\sqrt{2} = 1.414$

Practice

Evaluate the following when x = 11 and y = -3

xy, x/y, x^y, $x^{|y|}$, $\sqrt{x}$, $\sqrt[-y]{x}$ $(x+3)^{-y}$

$x := 11$ $y := -3$

$x \cdot y = -33$ $\frac{x}{y} = -3.667$ $x^y = 7.513 \times 10^{-4}$ $x^{|y|} = 1.331 \times 10^3$

$\sqrt{x} = 3.317$ $\sqrt[-y]{x} = 2.224$ $(x + 3)^{-y} = 2.744 \times 10^3$

Demonstration: Label vs. vector subscripts

- A variable label may contain subscripts.
- Two types of subscripts are found in Mathcad. Each does something different.
- Typing a period (.) will give you a "label" subscript.
- Typing a bracket ([) will give you a vector subscript.

Label Subscripts Using the Period Key

$T_{in} := 80$ $T_{out} := 100$

Vector Subscripts Using the Bracket Key

$T_0 := 1$ $T_1 := 2$ $T = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$ We will learn more about this type of subscript later.

Key Points

- Using the wrong subscript is a common mistake that brings long hours of debugging.
- Note that each type looks identical when not selected.
- When a variable with a "label" subscript is selected, a small period appears in the subscript to remind you how the subscript was made.

5. Editing Expressions

Editing is often frustrating in Mathcad because as you delete or add numbers or variables Mathcad might add ()'s when they are not wanted. In general, the best way to do it is to place the insertion bar before the variable and number to be deleted and press the delete key. If you try to go behind the variable to be selected and press the backspace key, you have more problems. More specific tips are now discussed.

Change a value

Place the insertion point where the error is and either delete or backspace.

$R_g := 8.214$ Should be 8.314

Change an operator

Place the insertion point where the error is and either delete or backspace.

$r := 2$

$A = \pi \cdot r^2$ Should have :=

Add a minus sign

Placing the insertion point to the right of the open place holder will add a minus sign, not a subtraction operator. Placing the insertion point to the left of the operator will yield a subtraction sign.

$r := 2$

$B = 18 \cdot x^2 + 3 \cdot y^{-2}$

left of placeholder	right of placeholder
$B = 18 \cdot x^2 - 3 \cdot y^{-2}$	$B = 18 \cdot x^2 \square -3 \cdot y^{-2}$

6. Symbolic Manipulations

- Essentially two methods are available to perform symbolic manipulations.
- You can use either the Symbolics **menu** or the Symbolic tool **palette.**
- The difference between the two is in *recalculation.*
- If you use the tool palette, all previous calculations and variable assignments are honored and the symbolic operation is recalculated whenever a change is made.
- If you use the pull-down menu, previous calculations are not honored and symbolic operation is only done once (is not recalculated when changes are made).
- The output of the pull-down menu can be made more readable by changing the Evaluation Style.

Demonstration

$z := 3$

Tool palette $(z - 1)^2 + 2 \cdot z^2 + 4 \cdot z - 1 + w \text{ simplify } \rightarrow w + 33$

Pull down menu $(z - 1)^2 + 2 \cdot z^2 + 4 \cdot z - 1 + w$ simplifies to $3 \cdot z^2 + 2 \cdot z + w$

Key Points

- Notice that if the value of z is changed, the answer to the first symbolic operation changes but not the second.
- Notice that if the z is deleted, the answer to the first symbolic operation second are the same.
- Remember to select the entire expression to be simplified when using the pull-down menu.

- Remember to select the entire expression to be simplified when using the pull-down menu.

Practice

Use both the symbolics pull-down menu and the symbolic tool palette to perform the following operations.

1. **Simplify** $\frac{x^2-3x-4}{x-4}+2x-5$
2. **Expand** $(x+y)^2$
3. **Factor** $x^2+8x+16$

$\frac{x^2-3\cdot x-4}{x-4}+2\cdot x-5 \text{ simplify } \rightarrow 29$

$\frac{x^2-3\cdot x-4}{x-4}+2\cdot x-5$ simplifies to $3\cdot x-4$

$(x+y)^2 \text{ expand } \rightarrow 64$

$(x+y)^2$ expands to $x^2+2\cdot x\cdot y+y^2$

$x^2+8\cdot x+16 \text{ factor } \rightarrow 3^2\cdot 5^2$

$x^2+8\cdot x+16$ by factoring, yields $(x+4)^2$

7. Formatting Mathcad

You can do several things to make Mathcad easier to read.

Demonstration

Change the margins to 0.5 or 1.0 in instead of the 1.2 inches

Highlight results $a := 1$ $b := 2$ $a+b=3$

Align regions

$b := 2$

$a := 1$

$a + b = 3$

$a - b = -1$

Change precision

You can change the number of significant digits shown by first clicking on the equation or answer of interest and then go to Format then Results and then type in the number significant digits.

Greek Letters

Greek letters can be obtained using the Greek Tool Palette or by typing the corresponding Roman letter and hitting <ctrl>g.

8. Mathcad Help

The Mathcad Help menu is actually very good. Often, the help menu has Quick Sheets which are actual Mathcad documents that you can copy and paste into your worksheet. if you have a problem with Mathcad, or don't know how to do something, check the help menu.

9. More Practice

A. Entering/Editing Equations

Input the following equations into Mathcad.

$$ans = \frac{\left(b + \frac{c}{a}\right)d}{a}$$

$$\text{ans} = \frac{\left(\text{b} + \frac{\text{c}}{\text{a}}\right)\cdot\text{d}}{\text{a}}$$

$$k_{dl} e^{(6\xi x_{ri})^2 k_{dt}^2 / \pi} \left[erf\left(\frac{(6\xi x_{ri}) k_{dt}}{\sqrt{\pi}} \right) + 1 \right] = 1$$

$$k_{dl} \cdot e^{\left(6\xi \cdot x_{ri}\right)^2 \cdot \frac{k_{dt}^2}{\pi}} \cdot \left[\operatorname{erf}\left[\frac{\left(6 \cdot \xi \cdot x_{ri}\right) \cdot k_{dt}}{\sqrt{\pi}} \right] + 1 \right] = 1$$

B. Trig Functions

Answer the following and explain how you determined your answer.
When using trigonometric functions, what are the units on the angle?

$\tan(45) = 1.62$ $\tan\left(\frac{\pi}{4}\right) = 1$

At what angle will the cosine be equal to 0.5?

$\operatorname{acos}(0.5) = 1 \cdot \frac{\pi}{3}$

C. The pressure of an Ideal Gas

In an industrial process, you are compressing 2 lbmol of nitrogen. The temperature and volume before the compression are 500 R and 600 ft^3 respectively. After the compression, the temperature and volume are 600 R and 400 ft^3 respectively. What is the change in pressure if nitrogen can be assumed to be an ideal gas. Note: Rg = 10.73 ft^3 psia $lbmol^{-1}$ R^{-1}.

$n := 2$ $v_1 := 600$ $v_2 := 400$ $T_1 := 500$ $T_2 := 600$ $Rg := 10.73$

$P_1 := \frac{n \cdot R_g \cdot T_1}{v_1}$ $P_2 := \frac{n \cdot R_g \cdot T_2}{v_2}$

$\Delta P := P_2 - P_1$ $\Delta P = 10.952$ psia