

# Introduction to Mathcad

*Mathcad is as versatile and powerful as programming languages, yet it is as easy to learn as a spreadsheet!*

This text will introduce you to:

- ***Fundamental functions of Mathcad, including simple calculations,***
- ***Defining variables,***
- ***Entering text,***
- ***Defining function,***
- ***Graphs***
- ***Equation Solving, both Numerically and Symbolically***

## Part 1 Introduction

Mathcad is well suited for technical calculations. It turns your computer screen into an interactive math scratchpad. Simply enter the mathematical equations and Mathcad does the rest. Mathcad provides hundreds of operators and built-in functions for solving technical problems from the simple to the very complex. It can be used to perform numeric calculations or to find more general symbolic solutions. In short, this software is an indispensable aid to the scientist, engineer or student since it allows him/her to concentrate on the solution to a problem rather than on the process.

## Part 2 Fundamentals

In Windows, click Start icon, choose program, Mathsoft Apps, and click Mathcad professional. When you start Mathcad, you will see a window similar to that shown in Figure 1 (appearances vary according to versions of the Software). You can view or hide the Math palette, the toolbar, and the Format Bar by choosing corresponding commands from the View Menu.

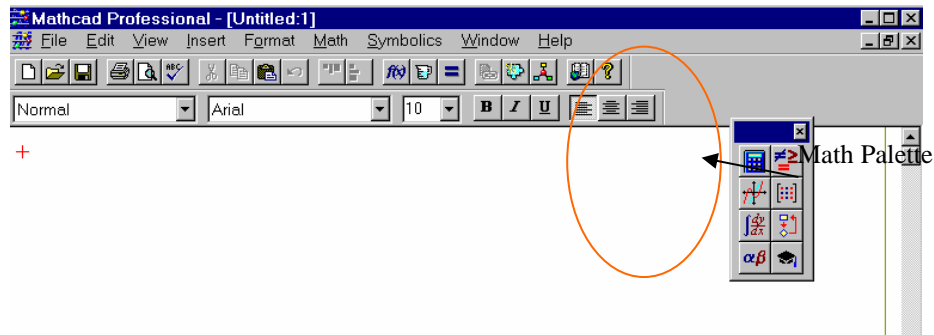


Figure 1 Mathcad window

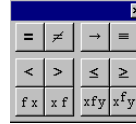
Each button in the Math Palette opens a palette of operators or symbols. You can insert operators, Greek letters, and plot regions by clicking on the buttons found on these palettes. There are eight buttons generating secondary palettes. From left to right, these are:



Common arithmetic operators.



Equal signs for evaluation and definition. Boolean expressions.



Various two and three dimensional plot types.



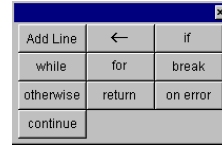
Matrix and vector operators.



Derivatives, integrals, limits and iterated sums and products.



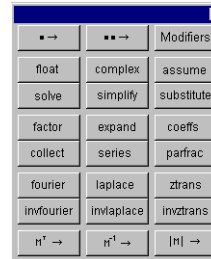
Pro Programming constructs (Mathcad Professional only)



Greek letters.



Symbolic keywords



You can place equations anywhere in the Mathcad worksheet. Click somewhere in the worksheet, you see a small crosshair. Anything you type appears at the crosshair.

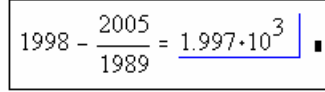
### Part 3 Basic Operations in Mathcad:

In this part, we learn/review the basic operations in Mathcad.

#### 1. Simple calculation

Although Mathcad can perform sophisticated mathematics, you can just as easily use it as a simple calculator. To perform your first calculation, follow these steps:

- Click anywhere in the worksheet. You see a small crosshair. Anything you type appears at the crosshair.
- Type 1998-2005/1989[space]= . When you press the equals (=) sign, Mathcad computes the numerical problem and shows the result.


$$1998 - \frac{2005}{1989} = 1.997 \cdot 10^3$$

This calculation demonstrates the way Mathcad works:

- Mathcad shows equations as you might see them in a book or on a blackboard, expanded fully in two dimensions. Mathcad sizes fraction bars, brackets, and other symbols to display equations the same way you would write them on paper.
- Mathcad understands which operation to perform first. In this example, Mathcad knew how to perform the division before the subtraction and displayed the equation accordingly.
- As soon as you type the equal sign, Mathcad returns the result. Unless you specify otherwise, Mathcad processes each equation as you enter it.

**Question 1:** Please type  $\int_1^{10} 5 \cdot x^{-3} dx =$ , and copy this equation and the result into your report.

Note: Click the integral button on palette



and



#### 2. Defining variables

Mathcad's power and versatility quickly becomes apparent once you begin to use variables and functions. To define a variable  $t$ , follow these steps:

- Type **t**: (the letter  $t$ , followed by a colon). Mathcad shows the colon as the definition symbol **:=**  $t := 10$
- Type 10 in the empty placeholder to complete the definition for  $t$ .

Mathcad worksheets read from top to bottom and left to right. Once you have defined a variable like  $t$ , you can compute with it anywhere below and to the right of the equation that defines it.

Mathcad can do repeated or iterative calculations as easily as individual calculations. Mathcad uses a special variable called **range variable** to perform iteration. **Range variable** takes on a range of values, such as all the integers from 10 to 20. Whenever a **range variable** appears in a Mathcad equation, Mathcad calculates the equation not just once, but once for each value of the **range variable**.

For previous example, we can compute results for a range of values of  $t$  from 10 to 20 in steps of 1. To do so, follow these steps:

- First, change  $t$  into a **range variable** by editing its definition. Click on the 10 in the equation **t:=10**.
- Type **, 11**. This tells Mathcad that the next number in the range will be 11.
- Type **;20**. This tells Mathcad that the last number in the range will be 20. Mathcad shows the semicolon as a pair of dots (another way to do this is to select **m..n** from the Arithmetic palette)  $t := 10, 11.. 20$
- Click somewhere below the equation, and type **t =**. Mathcad will list all the values of  $t$ . Mathcad uses  $t$  as a **range variable**.

**Question 2:** Follow the previous procedure, and define another variable  $acc$  as  $-9.8$ , and type  $acc/2[space]*t^2[space]=$ , copy the result to your report

### 3. Entering text

To begin typing text, click at an empty space and do any one of the following: Choose **Text Region** from the **Insert** menu, or press the double-quote key (“), or click on the text region button (a capital **A**) on the toolbar.

For instance:

- Click at the blank space to the right of the equations you entered. You will see a small crosshair.
- Press “ to tell Mathcad that you are about to enter some text. Mathcad changes the crosshair into a vertical line called the **insertion point**. Characters you typed appear behind this line.
- Type **Equations of motion**

To change font sizes, check spelling, cut, copy, or paste any entity in Mathcad, follow the same procedure as in MS Word.

### 4. Defining functions

In Mathcad, you can gain additional flexibility by defining functions. Here is how to define your own functions.

- Define the function  $d(t)$  by typing **d(t):**
- Complete the definition by typing this expression: **1600+acc/2[space]\*t^2**

The definition you just typed defines a function. The function name is  $d$ , and the argument consists of values of  $t$ . To evaluate the function once for each value of  $t$  we defined earlier, click below the other equation and type **d(t)=**.

Mathcad shows a table of values as shown on the right.

Note: You can change the value of  $t$  or  $acc$ , the value of  $d(t)$  will change accordingly after you put the cursor inside of box of  $d(t)$ .

$t := 10, 11.. 20$

$acc := -9.8$

$d(t) := 1600 + \frac{acc}{2} \cdot t^2$

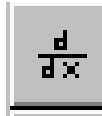
**Question 3:** Define  $t=1,2; 10$ , and  $f(t) = \frac{d}{dt} 5 \cdot t^2 + 6 \cdot t + 7$ ,

then copy the values of  $f(t)$  in your report.

Note: The symbol  $\frac{d}{dt}$  can be found by clicking:



and then:



d(t)
$1.11 \cdot 10^3$
$1.007 \cdot 10^3$
894.4
771.9
639.6
497.5
345.6
183.9
12.4
-168.9
-360

### 5. Graphs

Mathcad can show both two-dimensional Cartesian and polar graphs, contour plots, surface plots and a variety of other plots.

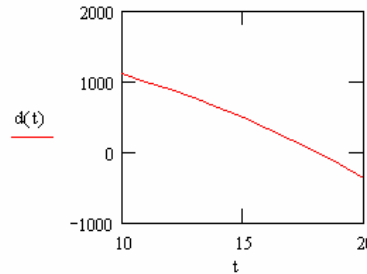
To create a graph in Mathcad, click in blank space where you want the graph to appear and choose **Insert, Graph and X-Y Plot**. An empty graph appears with placeholders on the x-axis and y-axis for the expressions to be graphed. X-Y and polar plots are ordinarily driven by **range variables** you define. In most cases, you will enter the **range variable**, or an expression depending on the range variable, on the x-axis of the plot.

**Shortcut:** The **QuickPlot** feature in Mathcad lets you plot expressions even when you don't specify the range variable directly in the plot. Here is an example:

- Position the crosshair and type  $d(t)$ . Make sure the editing lines remain displayed on the expression as shown in the left picture



- Choose **Graph-X-Y Plot** from the **Insert** menu, or click the **X-Y Plot** button on the Graphing palette. Mathcad displays the frame of the graph.

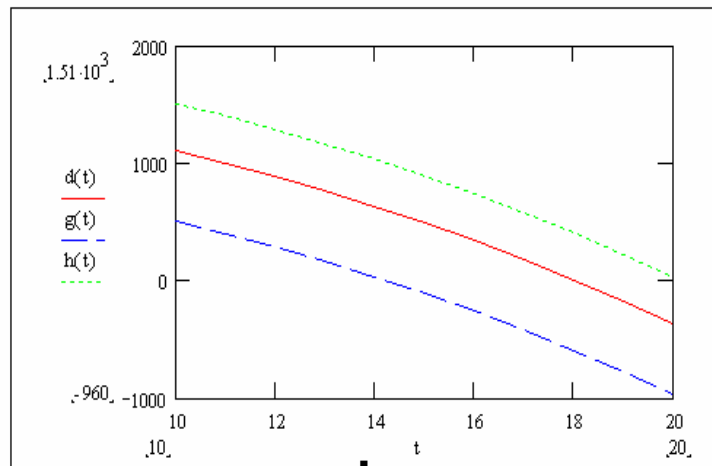


- Click anywhere outside the graph. Mathcad calculates and graphs the points as shown in the following picture.

Note: you can resize, move or format the graph. Also you can plot several functions in the same graph. Here is an example:

- Define  $g(t) = 1000 + \frac{acc}{2} \cdot t^2$  and  $h(t) = 2000 + \frac{acc}{2} \cdot t^2$

- Type  $d(t)$ ,  $g(t)$ ,  $h(t)$ . Make sure the editing lines remain displayed on the expression
- Choose Graph-X-Y Plot from the Insert menu, or click the X-Y Plot button on the Graphing palette. Mathcad displays the frame of the graph.



- Click anywhere outside the graph. Mathcad calculates and graphs the points as shown in the following picture

The three functions will be plotted in the same graph.  $d(t)$  is solid line,  $g(t)$  is dot line and  $h(t)$  is dash line. By double clicking the graph, you can change or edit each trace representing a function.

**Question 4:** After defining  $t$  and  $f(t)$  as shown in Question (3), you can define two more functions as  $g(t) = 5 \cdot t^2 + 6 \cdot t + 7$  and  $f(t) = \int_0^1 (5 \cdot t^2 + 6 \cdot t + 7) dt$ . Plot the three functions in one graph and copy the result in your report.

#### **Part 4: Solving Equations Numerically and Symbolically**

Let's begin by typing the quadratic equation given below. Please **note** that the equal sign is not an ordinary equal sign. This sign, which is accessed by pressing the **control key** and the = **sign** is used to define an equation. The := **sign** is used to define a function and the plain = **sign** is used to calculate a result. The control-equal sign is displayed in **boldface**.

**Again:** Hold down the **control key** and hit the **= key** on the keyboard.

$$A \cdot x^2 + B \cdot x + C = 0$$

To solve symbolically for x, first position the crosshair next to x, then click **Symbolics** on the menu bar at the top of the screen, select **variable**, and **solve**. The result, i.e. the two roots of the quadratic equation, is shown on the worksheet (see at left)

$$A \cdot x^2 + B \cdot x + c = 0$$

$$\frac{1}{(2 \cdot A)} \cdot \left( -B + \sqrt{B^2 - 4 \cdot A \cdot C} \right)$$
$$\frac{1}{(2 \cdot A)} \cdot \left( -B - \sqrt{B^2 - 4 \cdot A \cdot C} \right)$$

Suppose that you wish to **solve a system of equations numerically**. First, make an initial guess for the variable, i.e., define the variables. Next type **“Given”** and then type the equations below "Given". After you type in the equations, then type **“Find”** below the equation (entering the unknowns as arguments). The Example below illustrates the procedure.

A := 1  
B := 1  
C := 1  
D := 1

Given

$$3 \cdot A + 4 \cdot B + 5 \cdot C + 8 \cdot D = 10$$

$$5 \cdot A + 9 \cdot B + 1 \cdot C + 4 \cdot D = 24$$

$$2 \cdot A + 16 \cdot B + 3 \cdot C + 2 \cdot D = 30$$

$$8 \cdot A + 2 \cdot B + 7 \cdot C + 3 \cdot D = 12$$

In the result vector returned by Mathcad,

$$\text{Find}(A, B, C, D) = \begin{bmatrix} 1.576 \\ 1.781 \\ -0.678 \\ 0.192 \end{bmatrix}$$

The first number is A  
The second number is B  
The third number is C  
The fourth number is D

Note: **Given** is a function, not text, and should be treated as a variable.

**Question 5:** Use the symbolic method to solve equations  $x^3 + 6x^2 + 11x + 6 = 0$  and  $1998 \cdot \tan(\theta)^2 - 20000 \tan(\theta) + 3188 = 0$ .

Note: Mathcad requires that all angles used in trigonometric functions be in **radians**. As a result, the solution to the second equation will automatically be given in radians. In your report, please state the result in degrees. Conversion:  $x$  (in radians) =  $x$  (in degrees) \*  $\pi/180$ . Example: 90 degrees =  $90 * \pi/180 = \pi/2$  radians. Perform the conversion to degrees in your Mathcad spreadsheet wherever necessary!

**Question 6:** Use the numerical method to solve the following equations: (hint: define A, B, C, D, and E as 1 and use **Given** and **Find**)

$$2A + 4B + 6C + 7D + 2E = 15$$

$$7A + 9B + 2C + D + 9E = 30$$

$$3A + B + 13C + 20D + 5E = 18$$

$$8A + 11B + 4C + 2D + E = 8$$

$$9A + 10B + 9C + 13D + 5E = 12$$

**Reference:** Mathcad User's Guide