Chapter 1
The Basics

This chapter describes everything you need to get started working with Mathcad. The following sections make up this chapter:

First principles

Mathcad's design and interface.

What you can do with Mathcad

Starting Mathcad.

Working with windows

How to scroll a window, how to move and resize windows, and how to open several worksheets at once.

A simple calculation

Calculating with Mathcad.

Definitions and variables

Creating simple Mathcad equations.

Entering text

Adding notes and labels to a worksheet.

Regions and menus

How equations, text, and plots make up a worksheet; Mathcad's menu commands.

Iterative calculations

Using range variables to repeat an equation for several values.

Graphs

Building a simple two-dimensional plot.

Saving, printing, and quitting

The Save, Print, and Exit commands from the File menu.

First principles

Mathcad looks simple, and it is. It was created according to basic design principles to make it powerful, flexible, and easy to use. In Mathcad:

- **Everything appears in familiar math notation.** If there's a standard mathematical way to show an equation, operation, or graph, Mathcad uses it.
- **What you see is what you get.** There is no hidden information; everything appears on the screen. When you print, the output looks just like the screen display.
- **To create simple expressions, just type them.** Mathcad uses the standard keys for standard mathematical operations.
- **Typing aids make equations easier to enter.** There are palettes for most mathematical operators and symbols.
- **Fill in the blanks.** Mathcad guides you through the creation of plots, integrals, and other mathematical expressions by laying down the framework and letting you fill in the blanks.
- **Calculation features are modular.** If you don't want to use a feature—like complex numbers, units, or matrices—you can just pretend it isn't there.
- **The numerical algorithms are robust, standard, and predictable**. Mathcad's numerical algorithms for features like integrals, matrix inversion, and equation solving are reliable, standard methods.
- **OLE support**. Mathcad is an OLE2 application, providing drag and drop support of Mathcad objects into applications like Microsoft Word, in-place activation of Mathcad objects in client applications, and enhanced support for embedded OLE objects in Mathcad worksheets.
- **Exchange data with other applications.** Mathcad gives you easy-to-use tools to exchange data with spreadsheets, graphing packages, and other calculation applications.
- **On-line help.** Pressing [**F1**] brings up an extensive on-line help system. Click on error messages, operators and functions and press [**F1**] to display the relevant help screen. There's no need to search for the topic you're interested in. The *User's Guide* includes more detail on all the features, with step-by-step instructions and illustrative examples. At the back of the *User's Guide* is a complete cross-referenced index.
- **Collaboration features.** If you're connected to an electronic mail system compatible with Microsoft Mail, mail worksheets to colleagues from right within Mathcad. And you have access to MathSoft's Collaboratory server, a unique Web-based resource where you can exchange text messages, upload and download Mathcad files, and connect to a community of Mathcad users.
- **Resource Center.** A collection of Mathcad worksheets in an interactive, searchable Electronic Book, with links to resources on the World Wide Web. The Resource

Center includes an Overview, Tutorial, Reference Tables, QuickSheets—prefab working templates for completing common mathematical tasks, ready for customization and dragging into your own worksheets—and Practical Statistics, an overview of hypothesis testing and data analysis in Mathcad. Mathcad Professional includes in-depth sections on Solving and Programming drawn from *The Mathcad Treasury*, our best-selling Electronic Book. Visit MathSoft's home page (**www.mathsoft.com**) directly from the Resource Center, or browse to any other resources on the World Wide Web.

This chapter provides a quick introduction to Mathcad and demonstrates a few more advanced features like iterative calculation and plotting. After you read this chapter, you'll have enough information to begin to solve your own problems in Mathcad. The rest of this *User's Guide* describes all the features in detail, so you can learn more about any selected topic. For more information about on-line resources like the Collaboratory, Resource Center, and on-line Help system, see Chapter 2, "On-line Resources."

What you can do with Mathcad

Mathcad combines the live document interface of a spreadsheet with the WYSIWYG interface of a word processor. With Mathcad, you can typeset equations on the screen exactly the way you see them in a book. But Mathcad equations do more than look good on the screen. You can use them to actually do math.

Like a spreadsheet, as soon as you make a change anywhere in your worksheet, Mathcad goes straight to work, updating results and redrawing graphs. With Mathcad, you can easily read data from a file and do mathematical chores ranging from adding up a column of numbers to evaluating integrals and derivatives, inverting matrices and more. In fact, just about anything you can think of doing with math, you can do with Mathcad.

Like a word processor, Mathcad comes with a WYSIWYG interface, multiple fonts, and the ability to print whatever you see on the screen. This, combined with Mathcad's live document interface, makes it easy to produce up-to-date, publication quality reports.

Starting Mathcad

For information on system requirements and how to install Mathcad on your computer, see the instructions that accompanied your installation media.

When you start Mathcad, you'll see the window shown in Figure 1-1. You can view or hide the Math Palette, the Toolbar, and the Format Bar by choosing corresponding commands from the **View** menu.

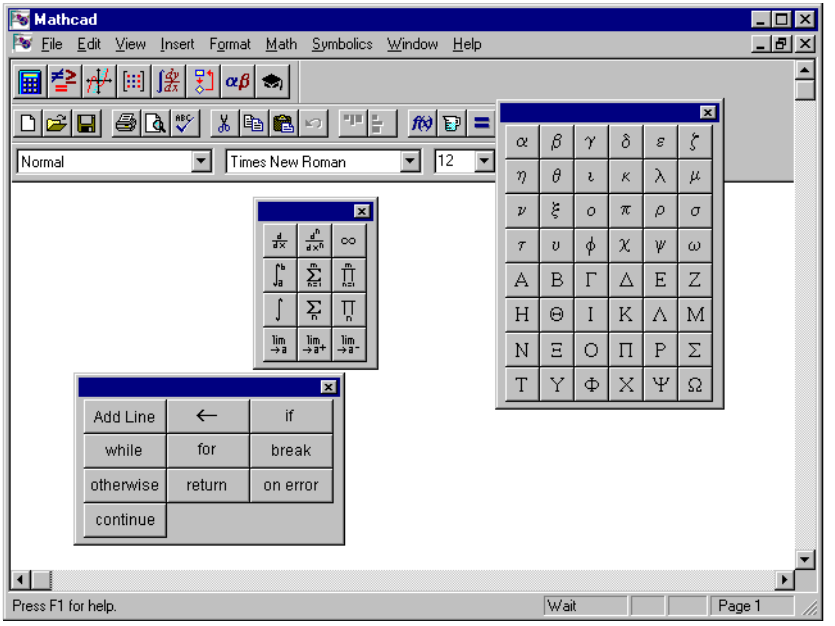


Figure 1-1: Mathcad Professional window with some math palettes displayed.

You can place equations anywhere in the Mathcad worksheet. To get to places not visible in the window, use the scroll bars as you would in any Windows application.

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

Button	Opens palette...
	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.
	Programming constructs (*Mathcad Professional only*).
	Greek letters.
	Symbolic keywords.

The Toolbar is the strip of buttons shown just below the Math Palette in Figure 1-1. Many menu commands can be accessed more quickly by clicking a button on the Toolbar. To learn what a button does, click on the button and read the message line. If you don't want to activate the button, move the pointer away without releasing the mouse button. If you just want to know what the button does, let the pointer rest on the button momentarily. You'll see some text beside the pointer telling you what that button does.

The Format Bar is shown immediately under the Toolbar in Figure 1-1. This contains scrolling lists and buttons used to specify font characteristics in equations and text.

To conserve screen space, you can show or hide each of these elements individually by choosing the appropriate command from the **View** menu. Throughout the figures in this *User's Guide*, the symbol palette, the toolbar, and the format bar have all been hidden to allow more space for examples.

You can also detach each of these window elements and drag them around your window. To do so, place the mouse pointer anywhere other than on a button or a text box. Then press and hold down the mouse button and drag. You'll find that the toolbar and the symbol palette will rearrange themselves appropriately depending on where you drag them. The format bar, on the other hand, will retain its shape no matter where you drag it. And Mathcad remembers where you left your palettes the next time you open the application.

Working with windows

When you start Mathcad you'll open up a window on a Mathcad *worksheet*. There are times when a Mathcad worksheet cannot be displayed in its entirety because the window is too small. To bring unseen portions of a worksheet into view, you can:

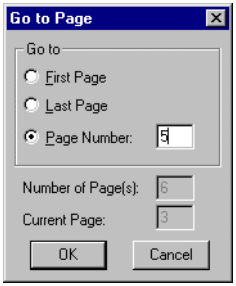
- Use the scroll bars and arrow keys to move around the worksheet.
- Make the window larger.
- Choose **Zoom** from the **View** menu and choose a number smaller than 100%.

Mathcad windows work very much like those of most Windows applications. If you've worked with Windows applications before, much of the material in this section will already be familiar to you.

There are several ways to move the window from one part of a worksheet to another:

- Move the mouse pointer and click the mouse button. The cursor jumps from wherever it was to wherever you clicked.
- Use the arrow keys [↑], [↓], [→], and [←] to move the crosshair up, down, right and left respectively. Mathcad scrolls the window whenever necessary.
- Click in the scroll bar to position the scroll box.

- With the mouse pointer on the scroll box, press and hold down the mouse button and move the mouse to drag the scroll box to another part of the scroll bar.
- Click on the arrows at the ends of the scroll bars to nudge the scroll box in the directions indicated by the arrows.
- Press [**PgUp**] and [**PgDn**] to move the cursor up and down by about one fourth the height of the window. You can also use [**Ctrl**][**PgUp**] and [**Ctrl**][**PgDn**] to move the cursor up and down by about 80% of the height of the window.
- Press [**Ctrl**][**Home**] to go to the first region of the worksheet, and [**Ctrl**][**End**] to go to the last region of a worksheet.
- Press [**Shift**][**PgUp**] and [**Shift**][**PgDn**] to position the preceding or following pagebreak at the top of the window.
- Choose **Go to Page** from the **Edit** menu and enter the page number you want to go to in the dialog box below. When you click "OK," Mathcad places the top of the page you specify at the top edge of the window.



The position of the scroll box within the scroll bar serves as a rough guide to the position of the window relative to the rest of the worksheet. If the top of the window is a third of the way down from the top of the worksheet, the scroll box will be about a third of the way down the vertical scroll bar. The page number for whatever page is visible in the window is shown on the message line at the bottom of the window.

Multiple windows

You can have as many windows open as your available system resources will allow. This allows you to work on several worksheets at once by simply clicking the mouse in whatever document window you want to work in. If the worksheet you want to work in is buried behind many other windows, pull down the **Window** menu and choose its name.

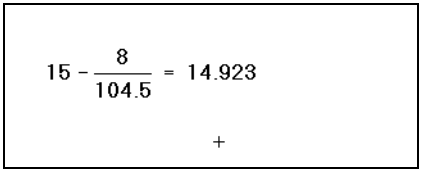
To open a new document window, choose **New** from the **File** menu. To open a window into a previously saved worksheet, choose **Open** from the **File** menu. For more information about opening new worksheets and templates, see Chapter 4, "Worksheet Management."

A simple calculation

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

- Click anywhere in the worksheet. You see a small crosshair. Anything you type appears at the crosshair.

- Type **15-8/104.5=** . When you press the equals sign, Mathcad computes and shows the result.



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 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. See the section "Controlling calculations" in Chapter 7 to learn how to change this.
- As you type each operator (in this case, – and **/**), Mathcad shows a small rectangle called a *placeholder*. Placeholders hold spaces open for numbers or expressions not yet typed. As soon as you type a number, it replaces the placeholder in the equation. The placeholder that appears at the end of the equation is used for unit conversions. Its use is discussed in the section "Displaying units of results" in Chapter 9.

Once an equation is on the screen, you can edit it by clicking in the appropriate spot and typing new letters, digits, or operators. You can type many operators and Greek letters by clicking in the symbol palette located just below the menu bar. Chapter 3, "Editing Equations," explains in detail how to edit Mathcad equations.

Definitions and variables

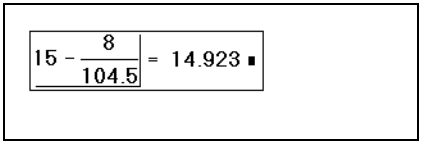
Mathcad's power and versatility quickly become apparent once you begin to use *variables* and *functions*. By defining variables and functions, you can link equations together and use intermediate results in further calculations.

The following examples show how to define and use several variables.

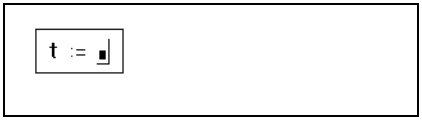
Defining variables

To clear the previous equation and define a variable *t*, follow these steps:

- Click in the equation you just typed and press [**Space**] until the entire expression is held between the two editing lines. Then choose **Cut** from the **Edit** menu.



- Now begin defining *t*. Type **t:** (the letter *t*, followed by a colon). Mathcad shows the colon as the definition symbol **:=**.



- Type **10** in the empty placeholder to complete the definition for *t*.

If you make a mistake, click on the equation and press [**Space**] until the entire expression is between the two editing lines, just as you did earlier. Then delete it by choosing **Cut** from the **Edit** menu.

These steps show the form for typing any definition:

- Type the variable name to be defined.
- Type the colon key to insert the definition symbol.
- Type the value to be assigned to the variable. The value can be a single number, as in the example shown here, or a more complicated combination of numbers and previously defined variables.

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.

Now enter another definition.

- Press [↵]. This moves the crosshair below the first equation.

■ To define *acc* as –9.8, type: **acc:-9.8**. Then press [↵] again.

Figure 1-2 shows the two definitions you just entered.

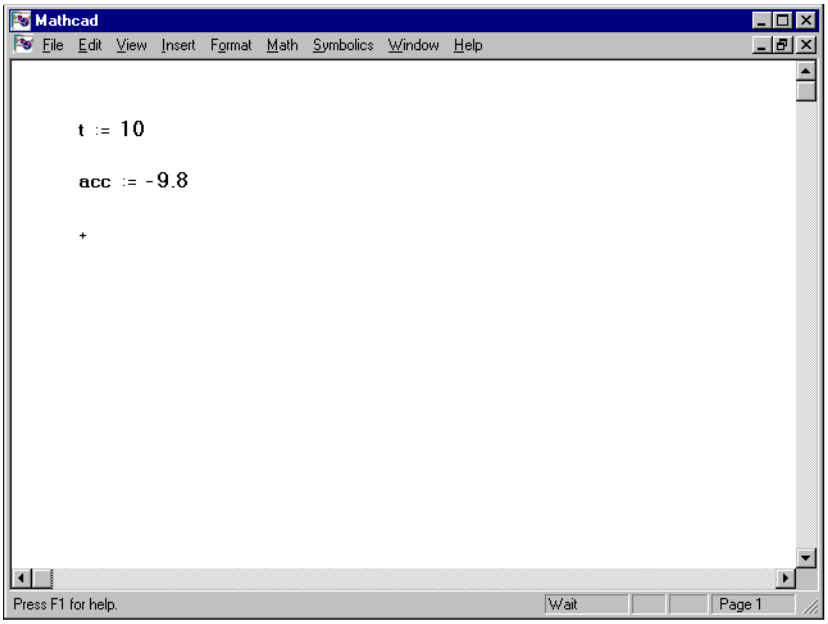


Figure 1-2: Equations to define acc and t.

Calculating results

Now that the variables *acc* and *t* are defined, you can use them in other expressions.

■ Click the mouse a few lines below the two definitions (see Figure 1-2).

■ Type **acc/2**[**Space**]***t^2**. The caret symbol (**^**) represents raising to a power, the asterisk (*****) is multiplication, and the slash (**/**) represents division.

■ Press the equal sign (=).

This equation calculates the distance traveled by a falling body in time *t* with acceleration *acc*. When you enter the equation, Mathcad returns the result as shown in Figure 1-3. The window now contains two *definitions*, which define variables, and one *evaluation*, which computes a result.

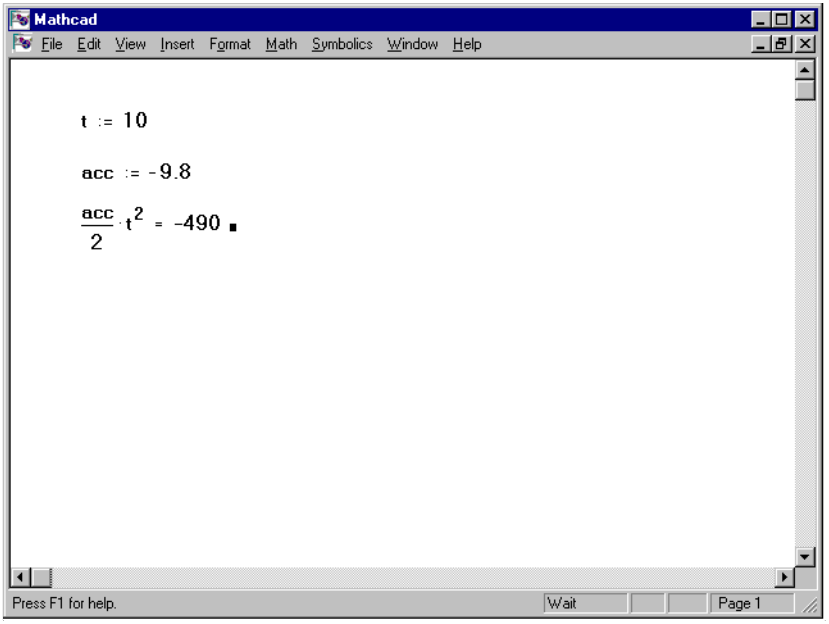


Figure 1-3: Calculating with variables.

Mathcad updates results as soon as you make changes. For example, If you click on the 10 on your screen and change it to some other number, Mathcad changes the result as soon as you press [↵] or click outside of the equation.

Entering text

Mathcad handles text as easily as it does equations, so you can make notes about the calculations you are doing. To begin typing text, click in an empty space and do any one of the following: choose **Text Region** from the **Insert** menu, press the double-quote key (**"**), or click on the text region button on the toolbar.

Here's how to enter some text:

- Click in the blank space to the right of the equations you entered. You'll see a small crosshair.
- Press **"** to tell Mathcad that you're about to enter some text. Mathcad changes the crosshair into a vertical line called the insertion point. Characters you type appear behind this line. A box surrounds the insertion point, indicating you are now in a text region. This box is called a text box. It will grow as you enter text.
- Type **`Equations of motion`**

Mathcad shows the text in the worksheet, next to the equations (Figure 1-4).

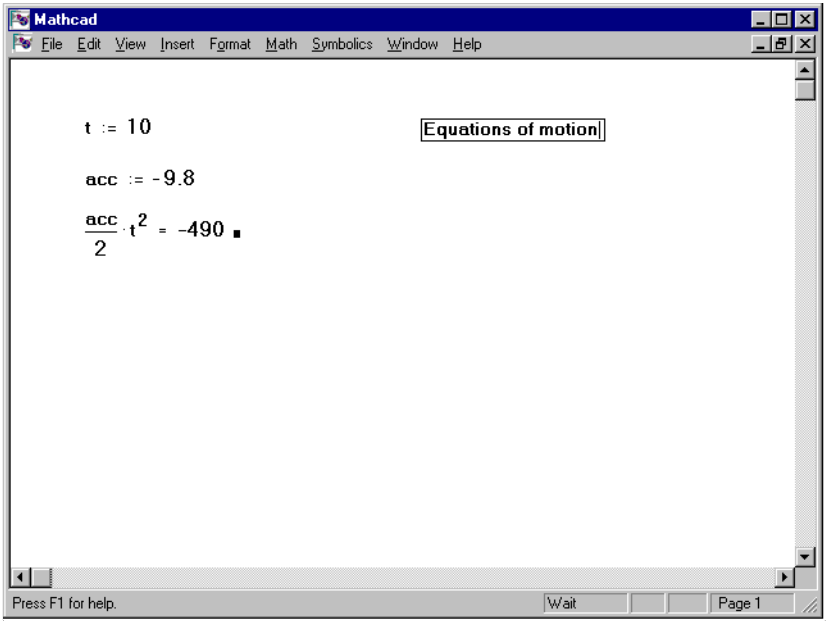


Figure 1-4: Entering text. Notice the text box surrounding it.

To enter a second line of text, just press [↵] and continue typing:

- Press [↵].
- Then type **`for falling body under gravity.`**
- Click in a different spot in the worksheet or press [**Shift**][↵] to move out of the text region. The text box will disappear once you have done this. Don't use the [↵] key. If you press [↵], Mathcad will insert a line break in the text instead of leaving the text region.

Figure 1-5 shows the worksheet with two lines of text and the cursor outside the text region. Since you are outside the text region, the cursor appears as a small cross, and the text box is no longer visible.

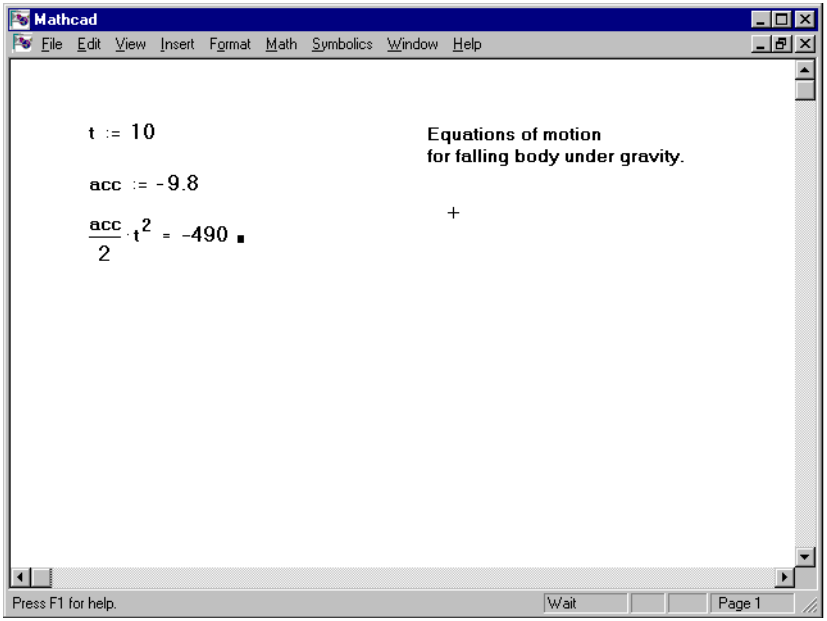


Figure 1-5: After clicking outside of a text region.

You can set the width of a text region and change the font, size, and style of the text in it. For more information on how to do these things, see Chapter 5, “Text.”

Regions and menus

Mathcad lets you enter equations and text anywhere in the worksheet. Each equation or piece of text is a *region*. Mathcad creates an invisible rectangle to hold each region. A Mathcad worksheet is a collection of such regions. To see these regions, choose **Regions** from the **View** menu. Mathcad will display blank space in gray and leave any regions in the default color. To turn the blank space back into the default color, choose **Regions** from the **View** menu again.

To start a new region, you must first click in blank space. This leaves a small crosshair wherever you clicked the mouse. To start an equation, just start typing anywhere you put the crosshair, or choose **Math Region** from the **Insert** menu. To create a text region, first choose **Text Region** from the **Insert** menu. Whichever you do, Mathcad will place a box around the region you're working with.

In addition to equations and text, Mathcad supports a variety of plot regions. Plots are introduced in “Graphs” on page 32.

Iterative calculations

Mathcad can do repeated or iterative calculations as easily as individual calculations. Mathcad uses a special variable called a *range variable* to perform iteration.

Range variables take on a range of values, such as all the integers from 0 to 10. 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.

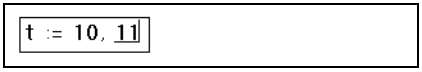
This section describes how to use range variables to do iterative calculations.

Creating a range variable

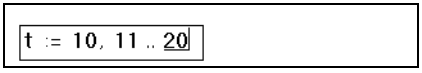
To compute equations for a range of values, first create a range variable. In the problem shown in Figure 1-5, for example, you can compute results for a range of values of *t* from 10 to 20 in steps of 1. To do so, follow these steps:

- First, change *t* into a range variable by editing its definition. Click on the **10** in the equation **t := 10**. The insertion point should be next to the 10 as shown on the right.

- 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.



- Now click outside the equation for *t*. Mathcad begins to compute with *t* defined as a range variable. Since *t* now takes on eleven different values, there must also be eleven different answers. These are displayed in the table shown in Figure 1-6. You may have to resize your window or scroll down to see the whole table.

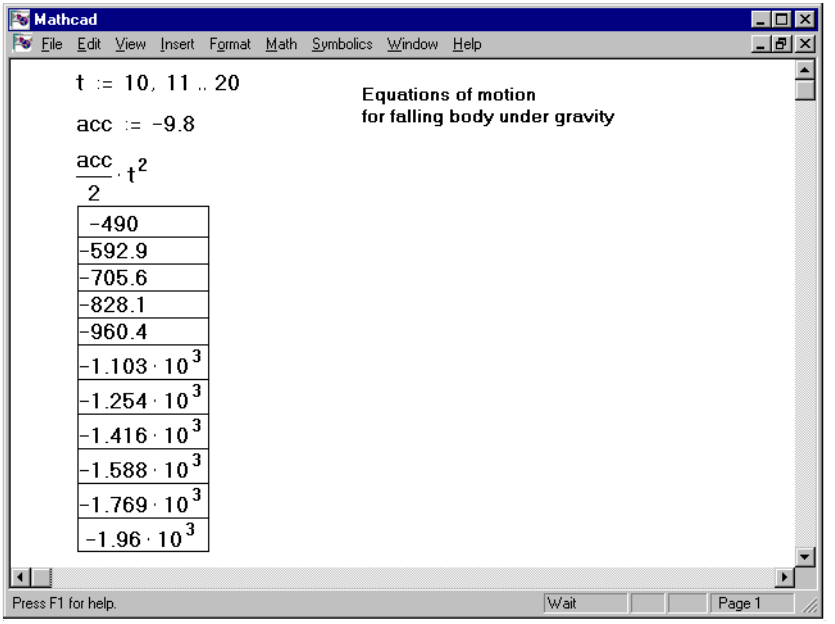
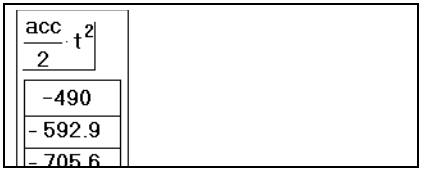


Figure 1-6: Generating a table of answers with a range variable.

Defining a function

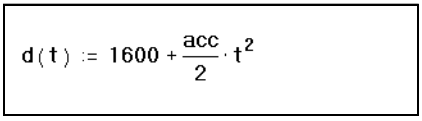
You can gain additional flexibility by defining functions. Here's how to add a function definition to your worksheet:

- First delete the table. To do so, click anywhere in the table press [**Space**] until you've enclosed everything between the two editing lines.



- Now 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 of the function is *t*. You can use this function to evaluate the above expression for different values of *t*. To do so, simply replace *t* with an appropriate number. For example:

- To evaluate the function at the value 3.5, type **d(3.5)=**. Mathcad returns the correct value as shown on the right.

$d(3.5) = 939.975$

- To evaluate the function once for each value of *t* you defined earlier, click below the other equations and type **d(t)=**.

  Mathcad shows a table of values (Figure 1-7). The first two values, $1.11 \cdot 10^3$ and $1.007 \cdot 10^3$, are in exponential (powers of 10) notation.

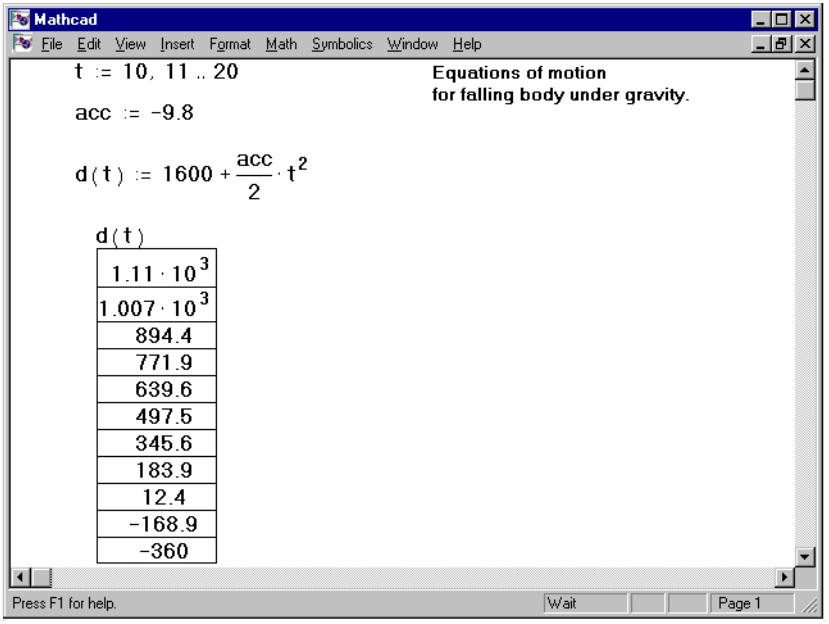


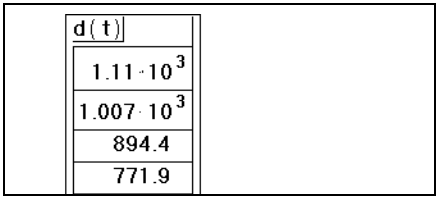
Figure 1-7: Using a function to return a table of answers.

Formatting a result

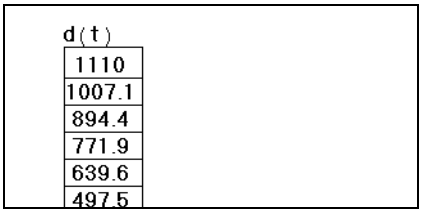
You can set the display format for any number Mathcad calculates and displays. This means changing the number of decimal places shown, changing exponential notation to ordinary decimal notation, and so on.

For example, here's how to change the table in Figure 1-7 so that none of the numbers in it are displayed in exponential notation:

- Click on the table with the mouse.



- Choose **Number** from the **Format** menu. You see the Format Number dialog box. This box contains settings that affect how results are displayed, including the number of decimal places, the use of exponential notation, and whether the number is shown in decimal, octal, or hexadecimal. The option button beside "Set for current region only" should be filled in. This indicates that whatever you do in this dialog box affects only the result you've selected.
- The default setting for Exponential Threshold is 3. This means that only numbers greater than or equal to 10^3 are displayed in exponential notation. Click to the right of the 3, press [**BkSp**] and type **6**.
- Click the "OK" button. The equation changes to reflect the new result format—1110 is no longer shown in exponential notation.



When you format a result, only the display of the result is affected. Mathcad maintains full precision internally.

Graphs

Mathcad can show both two-dimensional Cartesian and polar graphs, contour plots, surface plots, and a variety of other three-dimensional plots. These are all examples of *plot regions*.

This section describes how to create a simple two-dimensional graph showing the points calculated in the previous section.

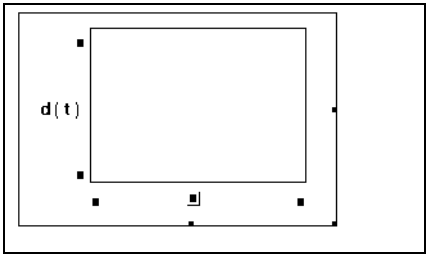
Creating a graph

To create a graph in Mathcad, click in blank space where you want the graph to appear and choose **Graph⇒X-Y Plot** from the **Insert** menu. 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: Mathcad graphs one point for each value of the range variable used in the graph. In most cases you will enter the range variable, or an expression depending on the range variable, on the *x*-axis of the plot. But the QuickPlot feature in Mathcad lets you plot expressions even when you don't specify the range variable directly in the plot.

For example, here's how to create a QuickPlot of the function $d(t)$ defined in the previous section:

- Position the crosshair and type **d(t)**. Make sure the editing lines remain displayed on the expression.

- Now 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 Figure 1-8. A sample line appears under the "*d*(*t*)." This helps you identify the different curves when you plot more than one function. Unless you specify otherwise, Mathcad draws straight lines between the points and fills in the missing axis limits.

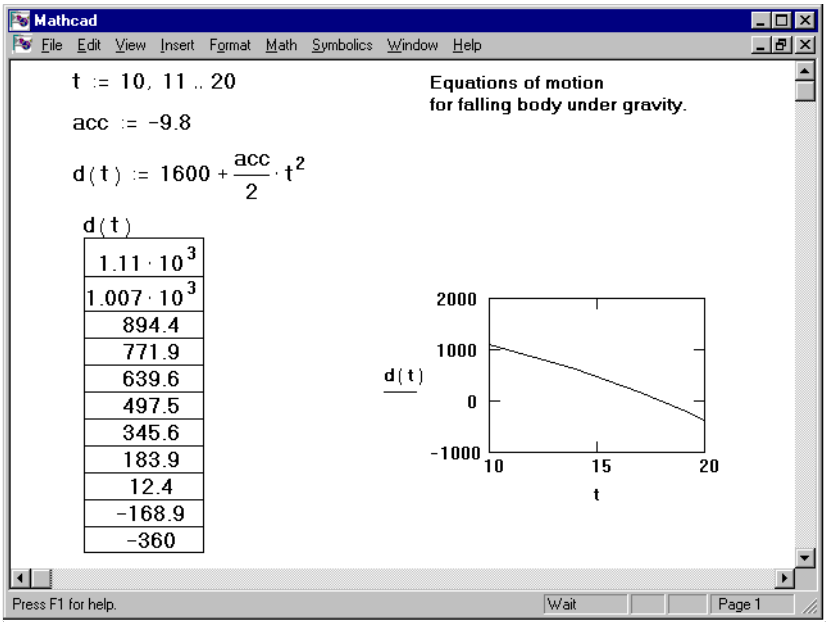


Figure 1-8: Graph of d(t) versus t.

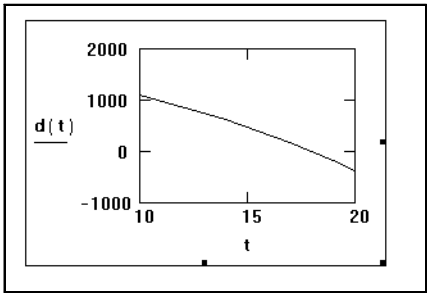
For detailed information on creating and formatting graphs, see Chapter 20, "Graphs."

Resizing a graph

The graph shown in Figure 1-8 is the default size. It's easy to make a graph in Mathcad any size you want: just select the graph and stretch it to the desired size.

To resize a graph, follow these steps:

- Click the mouse just outside the graphics region. This anchors one corner of the selection rectangle.
- Press and hold down the mouse button. With the button still held, drag the mouse toward the plot region. A dashed selection rectangle emerges from the anchor point.
- When the selection rectangle just encloses the graphics region, let go of the mouse button. The dashed rectangle will turn into a solid rectangle with handles.



- Move the mouse pointer to any of the handles. It will change to a double-headed arrow.
- Press and hold down the mouse button. With the mouse button still pressed, move the mouse. The graphics region will be stretched in the direction of motion.
- Once the graphics region is the right size, let go of the mouse button.
- Click outside the graph to deselect it.

Figure 1-9 shows the result: a larger graph.

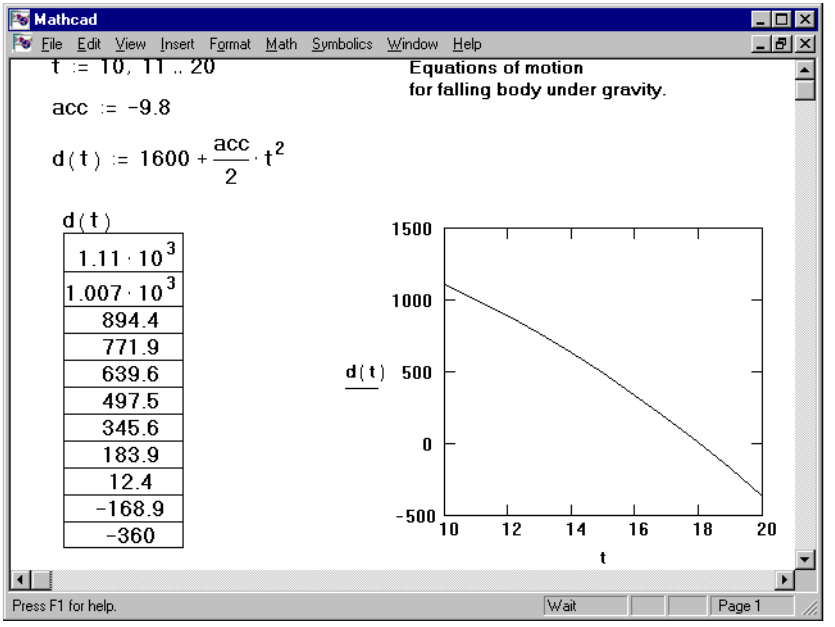


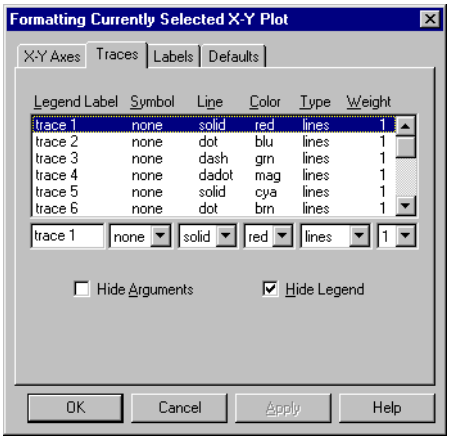
Figure 1-9: New graph, after resizing.

Formatting a graph

The graph in Figure 1-9 still has the default characteristics: numbered linear axes, no grid lines, and points connected with solid lines. You can change these characteristics by *formatting* the graph, just as you earlier formatted a number.

To format the graph, follow these steps:

- Double-click on the graph to bring up the appropriate dialog box. This box contains settings for all available plot format options. To learn more about these settings, see Chapter 20, "Graphs."
- Click on the Traces tab in the dialog box to see the correct page.



- Click on "trace 1" in the scrolling list under "Legend Label." Mathcad places the current settings for trace 1 in the boxes under the corresponding columns of the scrolling list.
- Click on the arrow under the "Type" column to see a drop-down list of trace types.
- Choose "bar" from this drop-down list by clicking on it.
- Click on the "OK" button to show the result of changing the setting. Mathcad shows the graph as a bar chart instead of connecting the points with lines (Figure 1-10). Note that the sample line under the $d(t)$ now has a bar on top of it.
- Click outside the graph to deselect it.

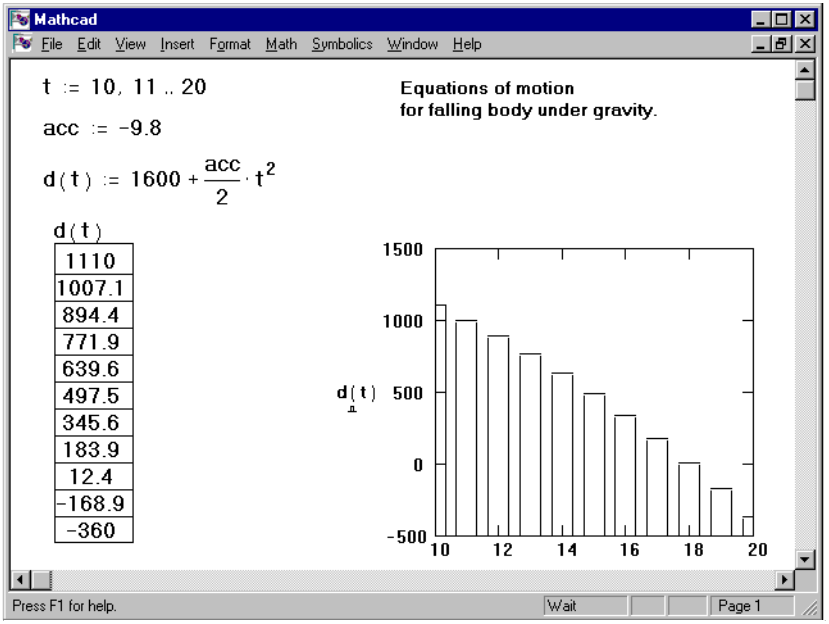


Figure 1-10: Graph formatted as a bar chart.

Saving, printing, and quitting

Once you've created a worksheet, you will probably want to save or print it. This section explains how to save and print in Mathcad.

Saving a worksheet

To save the file,

- Choose **Save** from the **File** menu or click on the disk icon in the toolbar. If the file has never been saved before, the **Save As** dialog box appears. Otherwise, Mathcad saves the file with no further prompting.
- Type the name of the file in the text box provided. By default, Mathcad saves the file either in the folder in which Mathcad is installed or in the folder from which you most recently opened a worksheet during the current session. To save to another folder, locate the folder using the Save As dialog box.

By default Mathcad saves the file in Mathcad (MCD) format, but you have the option of saving in RTF format to be able to open the file in a word processor. You may also save the file as a template for future Mathcad worksheets, or in a format compatible with earlier Mathcad versions. For more information on saving and opening files, see Chapter 4, “Worksheet Management.”

Printing

To print, choose **Print** from the **File** menu or click on the printer icon in the toolbar. You may preview the printed page by choosing **Print Preview** from the **File** menu

For more information on printing, see Chapter 4, “Worksheet Management.”

Quitting Mathcad

When you're done using Mathcad, choose **Exit** from the **File** menu. Mathcad closes down all its windows and returns you to the Desktop. If you've made any changes in your worksheets since the last time you saved, a dialog box appears asking if you want to discard or save your changes. If you have moved the toolbar, font bar, or math palettes, Mathcad remembers their locations for the next time you open the application.