Chapter 4
Working with Math

This chapter describes the elements of Mathcad math expressions, the mechanics of creating and editing math expressions, and ways of controlling the appearance of math expressions.

The following sections make up this chapter:

Inserting math

How to enter math into a Mathcad worksheet. Introduction to the elements of Mathcad math expressions: numbers, vectors and matrices, strings, names, and operators.

Building expressions

How to create mathematical expressions in a straightforward way by just typing a stream of characters. How to create expressions by exploiting their structure.

Editing expressions

Inserting and deleting operators, changing the names of variables, and using Cut, Delete, Paste, and Copy, as well as equation drag and drop, to streamline your editing.

Math styles

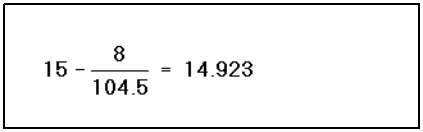
How to assign particular fonts, font sizes, font effects, and colors to the elements of your math regions.

Inserting math

You can place math equations and expressions anywhere you want in a Mathcad worksheet. All you have to do is click in the worksheet and start typing.

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

- Type numbers, letters, and math operators, or insert them by clicking buttons on Mathcad's math toolbars, to create a *math region*.



You'll notice that unlike a word processor, Mathcad by default understands anything you type at the crosshair cursor as math. If you want to create a *text region* instead, follow the procedures described in Chapter 5, "Working with Text."

You can also type math expressions in any math *placeholder*, which appears when you insert certain operators. See Chapter 9, "Operators," for more on Mathcad's mathematical operators and the placeholders that appear when you insert them.

The rest of this chapter introduces the elements of math expressions in Mathcad and describes the techniques you use to build and edit them. See the chapters in the **Computational Features** section of this *User's Guide* for details on numerical and symbolic calculation in Mathcad.

Numbers and complex numbers

This section describes the various types of numbers that Mathcad uses and how to enter them into math expressions. A single number in Mathcad is called a *scalar*. For information on entering groups of numbers in *arrays*, see "Vectors and matrices" on page 48.

Types of numbers

In math regions, Mathcad interprets anything beginning with one of the digits 0–9 as a number. A digit can be followed by:

- other digits
- a decimal point
- digits after the decimal point
- one of the letters **b**, **h**, or **o**, for binary, hexadecimal, and octal numbers, or **i** or **j** for imaginary numbers. These are discussed in more detail below. See "Suffixes for numbers" on page 348 in the Appendices for additional suffixes.

Note Mathcad uses the period (**.**) to signify the decimal point. The comma (**,**) is used to separate values in a range variable definition, as described in "Range variables" on page 125. So when you enter numbers greater than 999, do not use either a comma or a period to separate digits into groups of three. Simply type the digits one after another. For example, to enter ten thousand, type "**10000**".

Imaginary and complex numbers

To enter an imaginary number, follow it with *i* or *j*, as in **1i** or **2.5j**.

Note You cannot use *i* or *j* alone to represent the imaginary unit. You must always type **1i** or **1j**. If you don't, Mathcad thinks you are referring to a variable named either *i* or *j*. When the cursor is outside an equation that shows 1*i* or 1*j*, however, Mathcad hides the superfluous 1.

Although you can enter imaginary numbers followed by either *i* or *j*, Mathcad normally displays them followed by *i*. To have Mathcad display imaginary numbers with *j*, choose **Result** from the **Format** menu, check the "Set as default" box, and set "Imaginary value" to "j(J).". See "Formatting results" on page 134 for a full description of the result formatting options.

Mathcad accepts complex numbers of the form $a + bi$ (or $a + bj$), where a and b are ordinary numbers.

Binary numbers

To enter a number in binary, follow it with the lowercase letter **b**. For example, **11110000b** represents 240 in decimal. Binary numbers must be less than 2^{31}.

Octal numbers

To enter a number in octal, follow it with the lowercase letter **o**. For example, **25636o** represents 11166 in decimal. Octal numbers must be less than 2^{31}.

Hexadecimal numbers

To enter a number in hexadecimal, follow it with the lowercase letter **h**. For example, **2b9eh** represents 11166 in decimal. To represent digits above 9, use the upper or lowercase letters **A** through **F**. To enter a hexadecimal number that begins with a letter, you must begin it with a leading zero. If you don't, Mathcad will think it's a variable name. For example, use **0a3h** rather than **a3h** to represent the decimal number 163 in hexadecimal. Hexadecimal numbers must be less than 2^{31}.

Exponential notation

To enter very large or very small numbers in exponential notation, just multiply a number by a power of 10. For example, to represent the number $3 \cdot 10^8$, type **3*10^8**.

Vectors and matrices

A column of numbers is a *vector*, and a rectangular array of numbers is called a *matrix*. The general term for a vector or matrix is an *array*.

There are a number of ways to create an array in Mathcad. One of the simplest is by filling in an array of empty placeholders as discussed in this section. This technique is useful for arrays that are not too large. See Chapter 11, "Vectors, Matrices, and Data Arrays," for additional techniques for creating arrays of arbitrary size.

Tip You may wish to distinguish between the names of matrices, vectors, and scalars by font. For example, in many math and engineering books, names of vectors are set in bold while those of scalars are set in italic. See "Math styles" on page 67 for a description of how to do this.

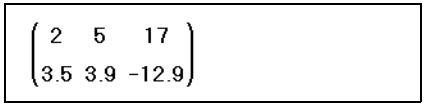
Creating a vector or matrix

To create a vector or matrix in Mathcad, follow these steps:

- Choose **Matrix** from the **Insert** menu or click  on the Matrix toolbar. The dialog box shown on the right appears.

- Enter a number of rows and a number of columns in the appropriate boxes. In this example, there are two rows and three columns. Then click "Create." Mathcad inserts a matrix of placeholders.

- Fill in the placeholders to complete the matrix. Press [**Tab**] to move from placeholder to placeholder.



You can use this matrix in equations, just as you would a number.

Tip The **Insert Matrix** dialog box also allows you to insert or delete a specified number of rows or columns from an array you have already created. See"Changing the size of a vector or matrix" on page 219.

Note Throughout this *User's Guide*, the term "vector" refers to a *column vector*. A column vector is simply a matrix with one column. You can also create a *row vector* by creating a matrix with one row and many columns.

Strings

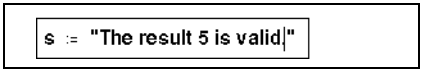
Although in most cases the math expressions or variables you work with in Mathcad are numbers or arrays, you can also work with *strings* (also called *string literals* or *string variables*). Strings can include any character you can type at the keyboard, including letters, numbers, punctuation, and spacing, as well as a variety of special symbols as listed in "ASCII codes" on page 353 in the Appendices. Strings differ from variable names or numbers because Mathcad always displays them between double quotes. You can assign a string to a variable name, use a string as an element of a vector or matrix, or use a string as the argument to a function.

To create a string:

- Click on an empty math placeholder in a math expression, usually on the right-hand side of a variable definition.

- Type the double-quote (**"**) key. Mathcad displays a pair of quotes and an insertion line between them.

- Type any combination of letters, numbers, punctuation, or spaces. Click outside the expression or press the right arrow key (→) when you are finished.



To enter a special character corresponding to one of the ASCII codes, do the following:

- Click to position the insertion point in the string.
- Hold down the [**Alt**] key, and type the number "0" followed immediately by the number of the ASCII code *using the numeric keypad at the right of the keyboard* in number-entry mode.
- Release the [**Alt**] key to see the symbol in the string.

For example, to enter the degree symbol (**°**) in a string, press [**Alt**] and type "0176" using the numeric keypad.

Note The double-quote key (**"**) has a variety of meanings in Mathcad, depending on the exact location of the cursor in your worksheet. When you want to enter a string, you must *always* have a blank placeholder selected.

Valid strings include expressions such as “The Rain in Spain Falls Mainly on the Plain,” “Invalid input: try a number less than -5,” and “Meets stress requirements.” A string in Mathcad, while not limited in size, always appears as a single line of text in your worksheet. Note that a string such as “123,” created in the way described above, is understood by Mathcad to be a string of characters rather than the number 123.

Tip Strings are especially useful for generating custom error messages in programs, as described in Chapter 15, “Programming.” Other string handling functions are listed in “String functions” on page 213. Use strings also to specify system paths for arguments to some Mathcad built-in functions; see “File access functions” on page 214.

Names

A *name* in Mathcad is simply a sequence of characters you type or insert in a math region. A name usually refers to a variable or function that you use in your computations. Mathcad distinguishes between two kinds of names:

- Built-in names, which are the names of variables and functions that are always available in Mathcad, and which you can use freely in building up math expressions.
- User-defined names, which are the names of variables and functions you create in your Mathcad worksheets.

Built-in names

Because Mathcad is an environment for numerical and symbolic computation, a large number of names are built into the product for use in math expressions. These built-in names include built-in *variables* and built-in *functions*.

- Mathcad includes several variables that, unlike ordinary variables, are already defined when you start Mathcad. These *predefined* or *built-in* variables either have a conventional value, like π (3.14159...) or e (2.71828...), or are used as system variables to control how Mathcad calculates. See “Built-in variables” on page 121 for more information.
- In addition to these predefined variables, Mathcad treats the names of all built-in *units* as predefined variables. For example, Mathcad recognizes the name “A” as the ampere, “m” as the meter, “s” as the second, and so on. Choose **Unit** from the **Insert** menu or click  on the Standard toolbar to insert one of Mathcad’s predefined units. See “Units and dimensions” on page 131 for more on built-in units in Mathcad.
- Mathcad includes a large number of built-in functions that handle a range of computational chores ranging form basic calculation to sophisticated curve fitting, matrix manipulation, and statistics. To access one of these built-in functions, you can simply type its name in a math region. For example, Mathcad recognizes the name “mean” as the name of the built-in *mean* function, which calculates the arithmetic mean of the elements of an array, and the name “eigenvals” as the name

of the built-in *eigenvals* function, which returns a vector of eigenvalues for a matrix.

You can also choose **Function** from the **Insert** menu or click  on the Standard toolbar to insert one of Mathcad's built-in functions. See Chapter 10, "Built-in Functions," for a broad overview of Mathcad's built-in functions.

User-defined variable and function names

Mathcad lets you use a wide variety of expressions as variable or function names.

Names in Mathcad can contain any of the following characters:

- Uppercase and lowercase letters.
- The digits 0 through 9, available on the keyboard or the Arithmetic toolbar.
- The underscore (_).
- The prime symbol (**'**). Note that this is not the same as an apostrophe. You'll find the prime symbol on the same key as the tilde (**~**).
- The percent symbol (**%**).
- Greek letters. To insert a Greek letter, click a button on the Greek toolbar or type the equivalent roman letter and press [**Ctrl**]**G**. The section "Greek letters" on page 52 gives more details.
- The infinity symbol ∞, which you insert by clicking  on the Calculus toolbar or by typing [**Ctrl**][**Shift**]**Z**.

The following are examples of valid names:

alpha	**b**
xyz700	**A1_B2_C3_D4%%%**
F1'	**a%%**

The following restrictions apply to variable names:

- A name cannot start with one of the digits 0 through 9. Mathcad interprets anything beginning with a digit as either an imaginary number ($2i$ or $3j$), a binary, octal, or hexadecimal number (e.g., 5o, 7h), or as a number *times* a variable ($3 \cdot x$).
- The infinity symbol, ∞, can only appear as the first character in a name.
- Any characters you type after a period (**.**) appear as a subscript. This is discussed in "Literal subscripts" on page 52.
- All characters in a name must be in the same font, have the same point size, and be in the same style (italic, bold, etc.). Greek letters can, however, appear in any variable name. See "Math styles" on page 67.
- Mathcad does not distinguish between variable names and function names. Thus, if you define *f*(*x*), and later on you define the variable *f*, you will find that you cannot use *f*(*x*) anywhere below the definition for *f*.

- Although you can redefine Mathcad's names for built-in functions, constants, and units, keep in mind that their built-in meanings will no longer exist after the definition. For example, if you define a variable *mean*, Mathcad's built-in function *mean*(**v**) can no longer be used.

Tip Mathcad distinguishes between uppercase and lowercase letters. For example, *diam* is a different variable from *DIAM*. Mathcad also distinguishes between names in different fonts, as discussed in "Math styles" on page 67. Thus, *Diam* is also a different variable from ***Diam***.

Greek letters

There are two ways to enter a Greek variable name in Mathcad:

- Click on the appropriate letter on the Greek toolbar. To see this toolbar, click  on the Math toolbar, or choose **Toolbars⇒Greek** from the **View** menu.
- Type the *Roman equivalent* of the Greek symbol and then press [**Ctrl**]**G**. For example, to enter ϕ, press **f[Ctrl]G**. See "Greek letters" on page 349 in the Appendices for a table of Greek letters and their Roman equivalents.

Note Although many of the uppercase Greek letters look like ordinary capital letters, they are *not* the same. Mathcad distinguishes between Greek and Roman letters, even if they appear typographically equivalent.

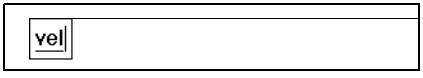
Tip Because it is used so frequently, the Greek letter π can also be typed by pressing [**Ctrl**][**Shift**]**P**.

Literal subscripts

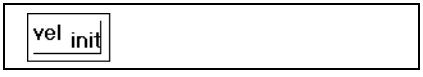
If you include a period in a variable name, Mathcad displays whatever follows the period as a subscript. You can use these *literal subscripts* to create variables with names like vel_{init} and u_{air}.

To create a literal subscript, follow these steps:

- Type the portion of the name that appears before the subscript.



- Type a period (**.**), followed by the portion of the name that is to become the subscript.



Note Do not confuse literal subscripts with *array* subscripts, which are generated with the left bracket key (**[**) or by clicking  on the Arithmetic toolbar. Although they appear similar—a literal subscript appears below the line, like an array subscript, but with a slight space before the subscript—they behave quite differently in computations. A literal subscript is simply a cosmetic part of a variable name. An array subscript represents a reference to an array element. See Chapter 11, "Vectors, Matrices, and Data Arrays," for a description of how to use subscripts with arrays.

Operators

As described in the previous section, certain characters, like letters and digits, make up parts of names and numbers. Other characters, like ***** and **+**, represent "operators."

Operators are symbols like "+" and "–" that link variables and numbers together to form *expressions*. The variables and numbers linked together by operators are called *operands*. For example, in an expression like:

$$a^{x+y}$$

the operands for the "+" are x and y. The operands for the *exponent* operator are a and the expression $x + y$.

You type the common arithmetic operators using the standard keystrokes, like ***** and **+**, you use in your spreadsheet and other applications. But all of Mathcad's operators can be entered with keystrokes or by clicking buttons in the Math toolbars. For example, you insert Mathcad's derivative operator by typing **?** or by clicking  on the Calculus toolbar. See "Operators" on page 334 in the Appendices for a complete list of operators. Mathcad's operators are also discussed in detail in Chapter 9, "Operators."

Building expressions

You can create many mathematical expressions by simply typing in a stream of characters, or by inserting appropriate operators from the Math toolbars. For example, if you type the characters

3/4+5^2=

you get the result shown at right.

$$\frac{3}{4+5^2} = 0.103$$

On the surface, Mathcad's equation editor seems very much like a simple text editor, but there's more to it than this. Mathematical expressions have a well-defined struc-

ture and Mathcad's equation editor is designed specifically to work within that structure. In Mathcad, mathematical expressions are not so much typed-in as they are built.

Mathcad automatically assembles the various parts that make up an expression using the rules of precedence and some additional rules that simplify entering denominators, exponents, and expressions in radicals. For example, when you type / or click  on the Arithmetic toolbar to create a fraction, Mathcad stays in the denominator until you press [**Space**] to select the entire expression.

Typing in names and numbers

When you type in names or numbers, Mathcad behaves very much like a standard word processor. As you type, you see the characters you type appear behind a vertical *editing line*. The left and right arrow keys move this vertical editing line to the left or to the right a character at a time, just as they would in a word processor. There are, however, two important differences:

- As it moves to the right, the vertical editing line leaves behind a trail. This trail is a "horizontal editing line." Its importance becomes apparent when you begin working with operators.

- Unless the equation you've clicked in already has an operator in it, pressing [**Space**] turns the math region into a text region. It is not possible to turn a text region back into a math region.

Typing in operators

The key to working with operators is learning to specify what variable or expression is to become an *operand*. There are two ways to do this:

- You can type the operator first and fill in the placeholders with operands, or
- You can use the editing lines to specify what variable or expression you want to turn into an operand.

The first method feels more like you're building a skeleton and filling in the details later. This method may be easier to use when you're building very complicated expressions, or when you're working with operators like summation that require many operands but don't have a natural typing order.

The second method feels more like straight typing and can be much faster when expressions are simple. In practice, you may find yourself switching back and forth as the need arises.

Here's how to create the expression a^{x+y} using the first method:

- Press **^** to create the exponent operator, or click  on the Arithmetic toolbar. You see two placeholders.

- Click in the lower placeholder and type **a**.

- Click in the upper placeholder.

- Type **+**.

- Click in the remaining placeholders and type **x** and **y**.

To use the editing lines to create the expression a^{x+y}, proceed as follows:

- Type **a**. The line beneath the *a* indicates that *a* becomes the first operand of whatever operator you type next.

- Press **^** to create the exponent operator. As promised, *a* becomes the first operand of the exponent. The editing lines now surround another placeholder.

- Type **x+y** in this placeholder to complete the expression.

Note that in this example, you could type the expression the same way you'd say it out loud. However, even this simple example already contains an ambiguity. When you say "*a* to the *x* plus *y*" there's no way to tell if you mean a^{x+y} or $a^{x}+y$. For more complicated expressions, the number of ambiguities increases dramatically.

Although you can always resolve ambiguities by using parentheses, doing so can quickly become cumbersome. A better way is to use the editing lines to specify the operands of whatever operator you type. The following example illustrates this by describing how to create the expression $a^{x}+y$ instead of a^{x+y}.

- Enter **a^x** as you did in the previous example. Note how the editing lines hold the *x* between them. If you were to type **+** at this point, the *x* would become the first operand of the plus.

- Press [**Space**]. The editing lines now hold the entire expression a^x.

- Now type **+**. Whatever was held between the editing lines now becomes the first operand of the plus.

- In the remaining placeholder, type **y**.

Multiplication

A common way to show multiplication between two variables on a piece of paper is to place them next to each other. For example, expressions like ax or $a(x + y)$ are easily understood to mean "*a* times *x*" and "*a* times the quantity *x* plus *y*," respectively.

This cannot be done with Mathcad variables for the simple reason that when you type **ax**, Mathcad has no way of knowing whether you mean "*a* times *x*" or "the variable named *ax*." Similarly, when you type **a(x+y)**, Mathcad cannot tell if you mean "*a* times the quantity *x* plus *y*" or whether you mean "the function *a* applied to the argument $x + y$."

Note In the special case when you type a numerical constant followed immediately by a variable name, such as **4x**, Mathcad interprets the expression to mean the constant multiplied by the variable: $4 \cdot x$. Mathcad displays a space between the constant and the variable to indicate that the multiplication is implied. You can produce math notation in this way that closely approximates the notation you see in textbooks and reference books. However, Mathcad reserves certain letters, such as "*i*" for the imaginary unit and "*o*" for octal, as suffixes for numbers, and in these cases does not attempt to multiply the number by a variable name but rather treats the expression as a single number with a suffix.

To avoid ambiguity in your everyday work, we recommend that you always press ***** explicitly to indicate multiplication, as shown in the following example:

- Type **a** followed by *****. Mathcad inserts a small dot after the "*a*" to indicate multiplication.

- In the placeholder, type the second factor, **x**.

An annotated example

When it comes to editing equations, knowing how to use the editing lines assumes an importance similar to knowing where to put the flashing vertical bar (insertion point) you see in most word processors. A word processor can use a simple vertical bar because text is inherently one-dimensional, like a line. New letters go either to the left or to the right of old ones. An equation, on the other hand, is really *two-dimensional*, with a structure more like a trees with branches than like a line of text. As a result, Mathcad has to use a *two-dimensional* version of that same vertical bar. That's why there are two editing lines: a vertical line and a horizontal line.

Suppose, for example, that you want to type the slightly more complicated expression

$$\frac{x - 3 \cdot a^2}{-4 + \sqrt{y + 1}}$$

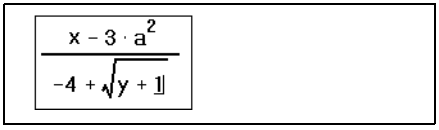
Watch what happens to the editing lines in the following steps:

- Type **x-3*a^2**. Since the editing lines contain just the "2," only the "2" becomes the numerator when you press the **/**. Since we want the whole expression, $x - 3 \cdot a^2$, to be the numerator, we must make the editing lines hold that entire expression.

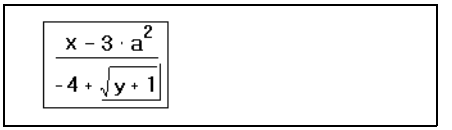
- To do so, press [**Space**]. Each time you press [**Space**], the editing lines hold more of the expression. You need to press [**Space**] three times to enclose the entire expression.

- Now press **/** to create a division bar, or click ÷ on the Arithmetic toolbar. Note that the numerator is whatever was enclosed between the editing lines when you pressed **/**.

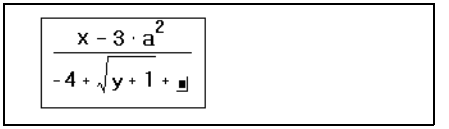
- Now type **-4+** and click √ on the Arithmetic toolbar. Then type **y+1** under the radical to complete the denominator.



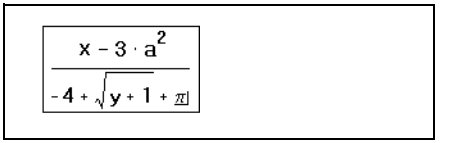
- To add something *outside* the radical sign, press [**Space**] twice make the editing lines hold the radical. For example, to add the number π to the denominator, press [**Space**] twice.



- Press **+**. Since the editing lines were holding the entire radical, it is the entire radical that becomes the first operand when you press **+**.



- Click π on the Arithmetic toolbar. This is one of Mathcad's built-in variables.



Editing expressions

This section describes how to make changes to an existing expression.

The simplest changes you can make are discussed in "Changing a name or number" on page 59. Here, the underlying tree structure of a math expression doesn't matter. As a result, the equation editor behaves very much like a text editor.

Complexities in editing equations arise from working with operators. That's because it's only when you start working with operators that the underlying structure of a math expression shows up. We describe how to insert an operator, apply an operator to an existing expression, and delete an operator.

The equation editor normally works from left to right. If you want to insert an operator *before* an existing expression, or if you want to apply a function to an existing expression, see "Inserting an operator" on page 59 and "Applying a function to an expression" on page 65.

Although Mathcad inserts parentheses wherever required to prevent ambiguity, you may want to add parentheses to clarify an expression or delete extraneous parentheses. To do so, use the techniques described in "Inserting parentheses" on page 64 and "Deleting parentheses" on page 65.

When working with a complicated expression, it is often easier to work with more manageable subexpressions within it. The sections "Moving parts of an expression" on page 66 and "Deleting parts of an expression" on page 67 describe how to use **Cut**, **Copy**, and **Paste** and the equation drag and drop feature to do so.

Changing a name or number

To edit a name or number:

- Click on it with the mouse. This places the vertical editing line wherever you clicked the mouse.
- Move the vertical editing line if necessary by pressing the [→] and [←] keys.
- If you type a character, it appears just to the left of the vertical editing line. Pressing [**Bksp**] removes the character to the left of the vertical editing line. Pressing [**Delete**] removes the character to the right of the vertical editing line.

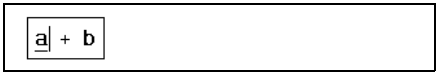
If you need to change several occurrences of the same name or number, you may find it useful to choose **Replace** from the **Edit** menu. To search for a sequence of characters, choose **Find** from the **Edit** menu. These commands are discussed further in "Text tools" on page 82.

Inserting an operator

The easiest place to insert an operator is between two characters in a name or two numbers in a constant. For example, here's how to insert a plus sign between two characters:

- Place the editing lines where you want the plus sign to be.

- Press the **+** key, or click  on the Arithmetic toolbar.



Note You never need to insert a space when typing an equation. Mathcad inserts spaces automatically around operators wherever doing so is appropriate. If you do try to insert a space, Mathcad assumes you meant to type text rather than math and converts your math region into a text region accordingly.

Operators such as division and exponentiation result in more dramatic formatting changes. For example, when you insert a divide sign, Mathcad moves everything that comes after the divide sign into the denominator. Here's how you insert a divide sign:

- Place the editing lines where you want the divide sign to be.

- Press the **/** key or click  on the Arithmetic toolbar. Mathcad reformats the expression to accommodate the division.

Some operators require only one operand. Examples are the square root, absolute value, and complex conjugate operators. To insert one of these, place the editing lines on either side of the operand and press the appropriate keystroke. Many of these operators are available on the Arithmetic toolbar as well. For example, to turn *x* into $\sqrt{x}$ do the following:

- Place the editing lines around the "*x*," either preceding or following the character.

- Press \ to insert the square root operator, or click  on the Arithmetic toolbar.

Applying an operator to an expression

The methods described in the previous section work most predictably when you want to apply an operator to a variable or a number. If, however, you want to apply an operator to an *entire expression*, there are two ways to proceed:

- Surround that expression in parentheses and proceed as described in the previous section, or
- Use the editing lines to specify the expression to which you want to apply the operator.

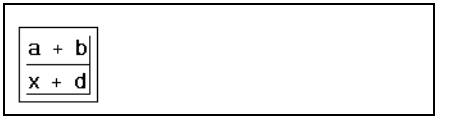
Although the first method may be more intuitive, it is slower since you need to type pairs of parentheses. The more efficient, second method is the subject of this section. The sections "Inserting parentheses" on page 64 and "Deleting parentheses" on page 65 describe ways to work with parentheses more efficiently.

The editing lines consist of a horizontal line and a vertical line that moves left to right along the horizontal line. To make an operator apply to an expression, select the expression by placing it between the two editing lines. The following examples show how typing **`*c`** results in completely different expressions depending on what was selected.

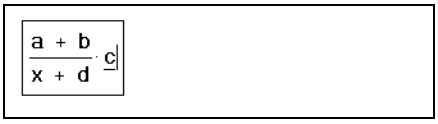
- Here, the two editing lines hold only the numerator. This means any operator you type will apply only to the numerator.

- Typing **`*c`** results in this expression. Note how the expression held between the editing lines became the first operand of the multiplication.

- Here, the editing lines hold the entire fraction. This means any operator you type will apply to the entire fraction.



- Typing ***c** results in this expression. Note how everything between the editing lines became the first operand of the multiplication.



- Here, the editing lines hold the entire fraction as they did in the previous example. However, this time the vertical editing line is on the *left* side instead of on the right side.

- Typing ***c** results in this expression. Note how the expression enclosed by the editing lines became the *second* rather than the first operand of the multiplication. This happened because the vertical editing line was on the *left* side rather than the right side.

Controlling the editing lines

You use the following techniques to control what's between the editing lines:

- Click on an operator. Depending on where on the operator you click, you'll find the vertical editing line either on the left or on the right of the operator, with the horizontal line selecting an operand of the operator. If you want to move the vertical editing line from one side to the other of the currently selected expression, press [**Insert**].
- Use the left and right arrow keys to move the vertical editing line one character at a time. The horizontal editing line selects an operand of the nearest operator. If your expression contains built-up fractions, you can also use the up and down arrow keys to move the editing lines.
- Press [**Space**] to select progressively larger parts of the expression with the editing lines. Each time you press [**Space**], the editing lines enclose more and more of the expression, until eventually they enclose the entire expression. Pressing [**Space**] one more time brings the editing lines back to where they were when you started.

Tip You can also *drag-select* a parts of an expression to hold it between the editing lines. When you do this, the selected expression is highlighted in reverse video. Note that whatever you type next overwrites the highlighted expression.

The following example walks you through a short cycle of using [**Space**]:

- This is the starting position. The two editing lines hold just the single variable "*d*."

- Pressing [**Space**] makes the editing lines grow so that they now hold the entire denominator.

- Pressing [**Space**] once makes the editing lines grow again so that they now hold the entire expression.

- At this point, the editing lines can't become any longer. Pressing [**Space**] brings the editing lines back to the starting point of the cycle.

You'll notice that in stepping through the previous cycle there was never an intermediate step in which the editing lines held just the numerator. Nor was there ever a step in which the editing lines held just the *a* or just the *b* in the numerator. That's because the sequence of steps the editing lines go through as you press [**Space**] depends on the starting point of the cycle.

To set the starting point of the cycle, either click on the appropriate part of the expression as described earlier, or use the arrow keys to move around the expression. The arrow keys walk the editing lines through the expression in the indicated direction. Keep in mind, however, that the idea of "up" and "down" or "left" and "right" may not always be obvious, particularly when the expression becomes very complicated or if it involves summations, integrals, and other advanced operators.

Note Editing of strings differs from editing of other math expressions because you must use the arrow keys or click outside the string to move out of a string. Pressing [**Space**], which can be used in other expressions to change the position of the editing lines, is interpreted as just another character in a string.

Deleting an operator

To delete an operator connecting two variable names or constants:

- Place the vertical editing line after the operator.

- Press [**BkSp**].

Now you can easily insert a new operator to replace the one you deleted just by typing it in.

Tip You can also delete an operator by placing the editing lines *before* it and pressing [**Delete**].

In the above examples, it is easy to see what "before" and "after" mean because the expressions involved naturally flow from left to right, the same way we read. Fractions behave the same way. Since we naturally say "*a* over *b*," putting the editing lines "after" the division bar means putting them just before the *b*. Similarly, putting the editing lines "before" the division bar means putting them immediately after the *a*. The following example illustrates this:

- Place the vertical editing lines *after* the division bar.

- Press [**BkSp**].

To delete an operator having only one operand (for example, $\sqrt{x}$, $|x|$, or $x!$):

- Position the editing lines just after the operator.

- Press [**BkSp**].

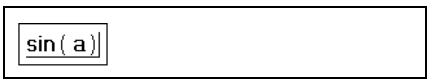
For certain operators, it may not be clear where to put the editing lines. For example, it is not clear when looking at $|x|$ or $\bar{x}$ what "before" and "after" mean. When this happens, Mathcad resolves the ambiguity by referring to the spoken form of the expression. For example, since you read $\bar{x}$ as "*x* conjugate," the bar is treated as being *after* the *x*.

Inserting a minus sign

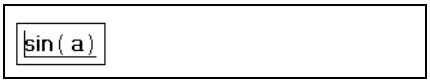
The minus sign that means "negation" uses the same keystroke as the one that means "subtract." To determine which one to insert, Mathcad looks at where the vertical editing line is. If it's on the left, Mathcad inserts the "negation" minus sign. If it's on the right, Mathcad inserts the "subtract" minus sign. To move the vertical editing line from one side to the other, use [**Insert**].

The following example shows how to insert a minus sign in front of "sin(*a*)."

- Click on the sin(*a*). If necessary, press [**Space**] to select the entire expression.



- If necessary, press [**Insert**] to move the vertical editing line all the way to the left.



- Type **-**, or click [−] on the Arithmetic toolbar, to insert a minus sign.

If what you really want to do is turn $\sin(a)$ into $1 - \sin(a)$, insert another operator (say, "+") as described in the section "Inserting an operator" on page 59. Then replace the operator with a minus sign as described in the section "Deleting an operator" on page 62. Notice that in Mathcad the unary negation symbol in the expression $-\sin(a)$ appears smaller than the minus sign in expressions such as $1 - \sin(a)$.

Inserting parentheses

Mathcad places parentheses automatically as needed to maintain the precedence of operations. There may be instances, however, when you want to place parentheses to clarify an expression or to change the overall structure of the expression. You can either insert a matched pair of parentheses all at once or insert the parentheses one at a time. We recommend you insert a matched pair since this avoids the possibility of unmatched parentheses.

To enclose an expression with a matched pair of parentheses:

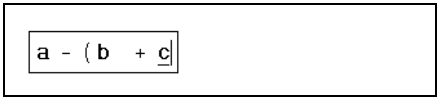
- Select the expression by placing it between the editing lines. Do this by clicking on the expression and pressing [**Space**] one or more times.

- Type the single-quote key (**'**), or click [( )] on the Arithmetic toolbar. The selected expression is now enclosed by parentheses.

It is sometimes necessary to insert parentheses one at a time using the **(** and **)** keys. For example, to change $a - b + c$ to $a - (b + c)$ do the following:

- Move the editing lines just to the left of the *b*. Make sure the vertical editing line is on the left as shown. Press [**Insert**] if necessary to move it over.

- Type **(**. Now click to the right of the *c*. Make sure the vertical editing line is to the right as shown. Press [**Insert**] if necessary to move it over.



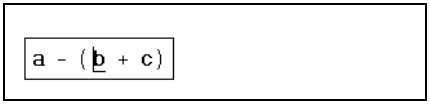
- Type **)**.

Deleting parentheses

You cannot delete one parenthesis at a time. Whenever you delete one parenthesis, Mathcad deletes the matched parenthesis as well. This prevents you from inadvertently creating an expression having unmatched parentheses.

To delete a matched pair of parentheses:

- Move the editing lines to the right of the "(".



- Press [**BkSp**]. Note that you could also begin with the editing lines to the left of the ")"and press [**Delete**] instead.

Applying a function to an expression

To turn an expression into the argument of a function, follow these steps:

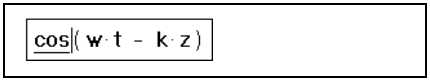
- Click in the expression and press [**Space**] until the entire expression, $w \cdot t - k \cdot z$, is held between the editing lines.

- Type the single-quote key (**'**), or click  on the Arithmetic toolbar. The selected expression is enclosed by parentheses.

- Press [**Space**]. The editing lines now hold the parentheses as well.

- If necessary, press the [**Insert**] key. The vertical editing line switches to the left side. If the vertical editing line is already on the left side, skip this step.

- Now type the name of the function. If the function you wish to use is a built-in function, you can also choose **Function** from the **Insert** menu or click  on the Standard toolbar and double-click the name of the function.



Moving parts of an expression

The menu commands **Cut**, **Copy**, and **Paste** from the **Edit** menu are useful for editing complicated expressions. They function as follows:

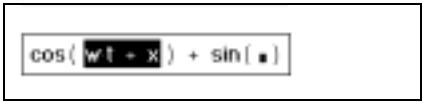
- **Cut** (on the Standard toolbar) deletes whatever is between the editing lines and copies it to the Clipboard.
- **Copy** (on the Standard toolbar) takes whatever is between the editing lines and copies it to the Clipboard.
- **Paste** (on the Standard toolbar) takes whatever is on the Clipboard and places it into your worksheet, either into a placeholder or into the blank space between other regions.

The **Copy** and **Paste** commands use the Clipboard to move expressions from one place to another. You can, however, bypass the Clipboard by using Mathcad's *equation drag and drop* feature.

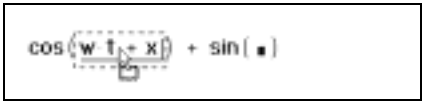
Suppose you want to build the expression

$$\cos(wt + x) + \sin(wt + x)$$

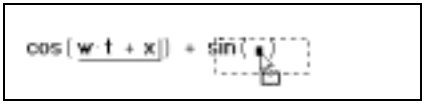
- Drag-select the argument to the cosine function so that it is highlighted in reverse video.



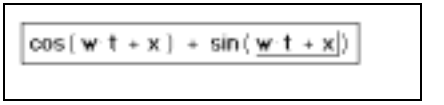
- Press and hold down [**Ctrl**] and the mouse button. The pointer changes to indicate that it carries the selected expression with it. It continues to carry the selected expression until you release the mouse button.



- With the mouse button still held down, drag the pointer over the placeholder.



- Release the mouse button. The pointer drops the expression into the placeholder. It then recovers its original form.



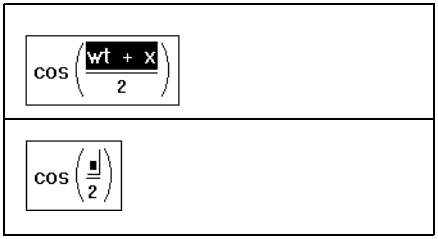
Tip You can drag and drop expressions, or even entire math regions, into placeholders in other expressions or into any blank space in your worksheet. Just be sure you don't let go of the mouse button before you've dragged the expression to wherever you want to drop it. If you're trying to drop the expression into a placeholder, be sure to position the pointer carefully over the placeholder.

Deleting parts of an expression

You can delete part of an expression by using either the [**Delete**] key or the [**BkSp**] key. If you use this method, whatever you delete is *not* placed on the Clipboard. This is useful when you intend to replace whatever you delete with whatever is currently on the Clipboard.

To delete part of an expression *without* placing it on the Clipboard:

- Drag-select the part of the expression (in this case, the numerator) so that it is highlighted in reverse video.
- Press [**Delete**] or [**BkSp**]. This removes the numerator and leaves behind a placeholder.



Note If you select an expression with the editing lines instead of drag-selecting as shown above, you must press [**Bksp**] or [**Delete**] *twice* to remove it. In this case, [**Bksp**] removes the expression to the left of the editing lines, and [**Delete**] removes to the right.

Math styles

You may already have encountered *styles* in your other applications to determine the appearance of text or other elements. By making changes to text styles rather than to individual text elements in a word processing document, you can make sweeping and strikingly uniform changes in the way that documents looks. (Mathcad also supports styles to determine the appearance of Mathcad text regions, as described in Chapter 5, "Working with Text.") You can get this same kind of leverage by using *math styles* to assign particular fonts, font sizes, font styles and effects, and colors to the elements of your math expressions.

Mathcad has predefined math styles that govern the default appearance of all the math in your worksheet, but you can define and apply additional styles to enhance the appearance of your equations.

Mathcad's predefined math styles are:

- **Variables**, which governs the default appearance of all variables.
- **Constants**, which governs the default appearance of all numbers you type in math regions as well as all numbers that appear in results.

Whenever you type a variable name, Mathcad:

- Assigns to it a math style named “Variables.”
- Looks up the font, font size, and font style and effects associated with “Variables.”
- Displays the variable name using the characteristics associated with the style named “Variables.”

Similarly, when you type a number or when a result is calculated, Mathcad:

- Assigns to it a math style named “Constants.”
- Looks up the font, font size, and font style and effects associated with “Constants.”
- Displays the number using the characteristics associated with the style named “Constants.”

Editing math styles

To change Mathcad’s default style for all variables and plots:

- Click on a variable name in your worksheet.
- Choose **Equation** from the **Format** menu. The style name “Variables” is selected.
- Click “Modify” to change the font associated with the “Variables” style. You’ll see a dialog box for changing fonts.
- Click “OK.” Mathcad changes the font of all variables in the worksheet.

If you change the Variables style, you may also want to change the style used for numbers so that the two look good together. To do so:

- Click on a number.
- Choose **Equation** from the **Format** menu to see the Equation Format dialog box. The style name “Constants” is now selected.
- Follow the procedure given above for modifying the Variables style.

You can also use the Formatting toolbar to change the font, font size, or font style associated with a math style. For example, to use the Formatting toolbar to modify some of the settings for the Variables math style, click on a variable, then click on the appropriate Formatting toolbar button to make variables bold, italic, or underlined or to specify the font or point size in the drop-down lists.

Note Mathcad's line-and-character grid does not respond automatically to changes in the font sizes used in text and math. Changing font characteristics, particularly font sizes, may cause regions to overlap. You can separate these regions by choosing **Separate Regions** from the **Format** menu.

You may wish to have your equations display in a different color than your default text regions to avoid confusing the two. To change the default color of all equations in your worksheet,

- Choose **Equation** from the **Format** menu.
- Select a color in the "Default Equation Color" drop-down list.
- Click "OK."

Applying math styles

The "Variables" and "Constants" styles govern the default appearance of all math in your worksheet. These two style names cannot be changed. You may, however, create and apply additional math styles, named as you choose, in your worksheets and templates.

To see what math style is currently assigned to a name or number, simply click in the name or number, and look at the style window on the Formatting toolbar.

Alternatively, click the name or number and choose **Equation** from the **Format** menu. The math style associated with whatever you clicked on appears in the drop-down list in the Equation Format dialog box.

If you click on the button to the right of "Variables" in either the Formatting toolbar or the Equation Format dialog box, you'll see a drop-down list of available math styles. If you now choose "User 1" and click "OK," a new math style is applied to the selected element and its appearance changes accordingly.

In this way you can apply any of a variety of math styles to:

- individual variable names in an expression, or
- individual numbers in a math expression (but not in computed results, which always display in the "Constants" style).

For example, many math books show vectors in a bold, underlined font. If you want to use this convention, do the following:

- Choose **Equation** from the **Format** menu.

- Click the down arrow beside the name of the current math styles to see a drop-down list of available math styles.
- Click on an unused math style name like “User 1” to select it. The name “User 1” should now appear in the “New Style Name” text box. Click in this text box and change the name to something like “Vectors.”
- Click “Modify” to change this style to a bold, underlined font.

This creates a math style called “Vectors” with the desired appearance. When you’re done defining the style, click “OK.”

Now rather than individually changing the font, font size, and font style for names of vectors, you can simply change their math styles.

Note All names, whether function names or variable names, are font sensitive. This means that $\mathbf{x}$ and x refer to different variables, and $\mathbf{f}(x)$ and $f(x)$ refer to different functions. In deciding whether two variable names are the same, Mathcad actually checks *math styles* rather than fonts. To avoid having distinct variables that look identical, don’t create a math style with exactly the same font, size, and other characteristics as another math style.

Saving math styles

Once you’ve completed a set of math styles that you like, you need not repeat the process for other worksheets. You can save math style information by saving a worksheet as a template.

To apply math style information to another worksheet, open your template from the **File** menu and copy the contents of the worksheet to the template. For more information about worksheet templates, see Chapter 7, “Worksheet Management.”