Bonus Chapter 2

Exploring AutoLISP

In Bonus Chapter 1, "Using the Express Tools," you were introduced to AutoLISP®, the AutoCAD® macro and programming language. You learned that you could take advantage of this powerful tool without having to know anything about its internal workings. In this chapter, you'll see how you can take more control of AutoLISP and have it do the things you want it to do for your own AutoCAD environment. You'll learn how to store information, such as text and point coordinates; how to create smart macros; and how to optimize AutoLISP's operation on your computer system.

Here are some words of advice as you begin this chapter: Be prepared to spend lots of time with your computer—not because programming in AutoLISP is all that difficult, but because it's so addictive! You've already seen how easy it is to use AutoLISP programs. We won't pretend that learning to program in AutoLISP is just as easy as using it, but it isn't as hard as you might think. Once you've created your first program, you'll be hooked. Note that AutoLISP is not available in AutoCAD LT®.

Understanding the Interpreter

You access AutoLISP through the AutoLISP *interpreter*, which is a little like a handheld calculator. When you enter information at the Command prompt, the interpreter *evaluates* it and then returns an answer. *Evaluating* means performing the instructions described by the information you provide. You could say that evaluation means "find the value of." The information you give the interpreter is like a formula, called an *expression* in AutoLISP.

Let's examine the interpreter's workings in more detail:

1. Start AutoCAD, open a new file, and save it as *TempBC2a*. You'll use this file just to experiment with AutoLISP.
2. At the Command prompt, enter **(+ 2 2)** ↵, and make sure you include a space between the characters in the parentheses. The answer, 4, appears in the Command window. AutoLISP has evaluated the formula (+ 2 2) and returned the answer, 4.

By entering information this way, you can perform calculations or even write short programs on the fly.

The plus sign you used in step 2 represents a *function*, an instruction telling the AutoLISP interpreter what to do. In many ways, it's like an AutoCAD command. A simple example of a function is the math function `Add`, represented by the plus sign. AutoLISP has many built-in functions, and you can create many of your own.

Defining Variables with *Setq*

Another calculator-like capability of the interpreter is its ability to remember values. You probably have a calculator that has some memory. This capability allows you to store the value of an equation for future use. In a similar way, the AutoLISP interpreter lets you store values using variables.

A *variable* is like a container that holds a value. That value can change many times in the course of a program's operation. You assign values to variables by using the `Setq` function. For example, let's assign the numeric value 1.618 to a variable named `Golden`. This value, often referred to as the *golden section*, is the ratio of a rectangular area's height to its width. Aside from having some interesting mathematical properties, the golden section is said to represent a ratio that occurs frequently in nature. Follow these steps:

1. At the Command prompt, enter **(setq Golden 1.618)** ↵. The value 1.618 appears just below the line you enter. The value of the `Golden` variable is now set to 1.618. Let's check it to make sure.
2. Enter **!Golden** ↵ at the Command prompt. As expected, the value 1.618 appears at the prompt.

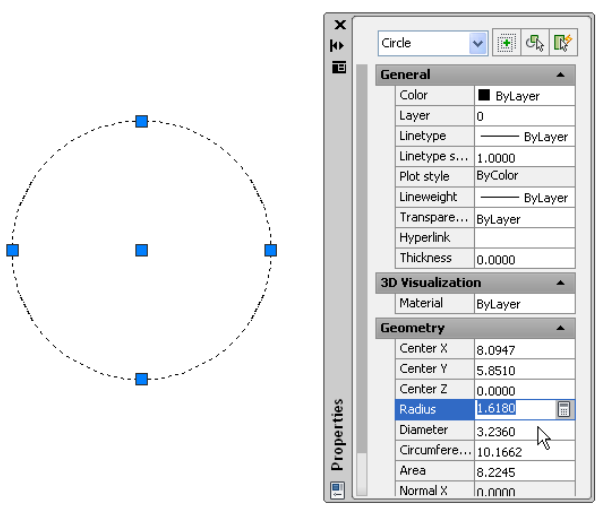
The exclamation point (!) acts as a special character that extracts the value of an AutoLISP variable at the prompt. From now until you close the drawing, you can access the value of `Golden` at any time by preceding the variable name with an exclamation point.

In addition to using math formulas as responses to prompts, you can use values stored as variables. Let's see how you can use the variable `Golden` as the radius for a circle:

1. Click the Circle button on the Draw panel of the Home tab.
2. At the `Specify center point:` prompt, pick a point in the center of your screen.
3. At the `Specify radius of circle or [Diameter]: prompt`, enter **!Golden** ↵. A circle appears with the radius 1.618. Check this using the Properties palette (see Figure BC2.1).

Numbers aren't the only things that you can store using `Setq`. Let's look at the variety of other data types that variables can represent.

FIGURE BC2.1
The circle, using the `Golden` variable as the radius



Understanding Data Types

Understanding the various data types and how they differ is important because they can be a source of confusion if not carefully used. Remember that you can't mix data types in most operations, and quotes and parentheses must always be used in opening and closing pairs.

Variables are divided into several categories called *data types.* Categorizing data into types lets AutoLISP determine precisely how to evaluate the data and keep programs running quickly. Your computer has different ways of storing various types of data, so the use of data types helps AutoLISP communicate with the computer more efficiently. Also, data types aid your programming efforts by forcing you to think of data as having certain characteristics. The following list describes each of the available data types:

Integers Integers are whole numbers. When a mathematical expression contains only integers, only an integer is returned. For example, the expression

```
(/ 2 3)
```

means 2 divided by 3. (The forward slash is the symbol for the division function.) This expression returns the value 0 because the answer is less than 1. Integers are best suited for counting and numbering. The numbers 1, 12, and 144 are all integers.

Real Numbers Real numbers, often referred to as reals, are numbers that include decimals. When a mathematical expression contains a real number, a real number is returned. For example, the expression

```
(/ 2.0 3)
```

returns the value 0.66667. Real numbers are best suited in situations that require accuracy. Examples of real numbers are 0.1, 3.14159, and 2.2.

Strings Strings are text values. They're always enclosed in double quotes. Here are some examples of strings: "1", "George", and "Enter a value".

Lists Lists are groups of values enclosed in parentheses. Lists provide a convenient way to store whole sets of values in one variable. There are two classes of lists: those meant to be evaluated and those intended as repositories for data. In the strictest sense, AutoLISP programs are lists because they're enclosed in parentheses. Here are some examples of lists: (6.0 1.0 0.0), (A B C D), and (setq golden 1.618).

Elements There are two basic elements in AutoLISP: atoms and lists. We've already described lists. An atom is an element that can't be taken apart. Atoms are further grouped into two categories: numbers and symbols. A number can be a real number or an integer. A symbol, on the other hand, is often a name given to a variable, such as point1 or dx2. A number can be used as part of a symbol's name; however, its name must always start with a letter. Think of a symbol as a name given to a variable or function as a means of identifying it.

Using Arguments and Functions

In the previous exercise, you used the `Setq` function to store variables. The way you used `Setq` is typical of all functions.

Functions act on *arguments* to accomplish a task. An argument can be a symbol, a number, or a list. A simple example of a function acting on numbers is the addition of 0.618 and 2. In AutoLISP, this function is entered as

```
(+ 0.618 2)
```

and returns the value 2.618.

This formula—the function followed by the arguments—is called an *expression*. It starts with the left (opening) parenthesis, then the function, then the arguments, and finally the right (closing) parenthesis.

Arguments can also be *expressions*. An expression is a list that contains a function and arguments for that function. You can *nest* expressions. For example, here is how to assign the value returned by 0.618 + 2 to the variable `Golden`:

```
(setq Golden (+ 0.618 2))
```

This is called a *nested expression.* Whenever expressions are nested, the deepest nest is evaluated first, then the next deepest, and so on. In this example, the expression adding 0.618 to 2 is evaluated first. On the next level out, `setq` assigns the result of the expression (+ 0.168 2) to the variable `Golden`.

Arguments to functions can also be variables. For example, suppose you use `setq` to assign the value 25.4 to a variable called `Mill`. You can then find the result of dividing `Mill` by `Golden`, as follows:

1. Enter **(setq Mill 25.4)** ↵ to create a new variable called `Mill`.
2. Enter **(/ Mill Golden)** ↵. (As mentioned earlier, the forward slash is the symbol for the division function.) This returns the value 15.6984. You can assign this value to yet another variable.
3. Enter **(setq B (/ Mill Golden))** ↵ to create a new variable, `B`. Now you have three variables, `Golden`, `Mill`, and `B`, which are all assigned values that you can later retrieve, either in an AutoCAD command (by entering an **!** followed by the variable) or as arguments in an expression.

Watching Parentheses and Quotes

You must remember to close all sets of parentheses when using nested expressions. Take the same care to enter the second quote in each pair of quotes used to enclose a string.

If you get the prompt showing a parenthesis or set of parentheses followed by the > symbol, such as

```
(_>
```

then you know you have an incomplete AutoLISP expression. This is the AutoLISP prompt. The number of parentheses in the prompt indicates how many parentheses are missing in your expression. If you see this prompt, you must type the closing parenthesis the number of times indicated by the number. AutoCAD won't evaluate an AutoLISP program that has the wrong number of parentheses or quotes.

Using Text Variables with AutoLISP

The examples so far have shown only numbers being manipulated, but you can manipulate text in a similar way. Variables can be assigned text strings that can later be used to enter values in commands requiring text input. For text variables, you must enclose text in quotation marks as in the following example:

```
(setq text1 "This is how text looks in AutoLISP")
```

This example shows a sentence being assigned to the variable `text1`.

Strings can also be *concatenated*, or joined together, to form new strings. Here is an example of how two pieces of text can be added together:

```
(setq text2 (strcat "This is the first part and "
                    "this is the second part")
)
```

Here, the AutoLISP function `strcat` is used to join the two strings. The result is as follows:

```
"This is the first part and this is the second part"
```

Strings and numeric values can't be evaluated together, however. This may seem like a simple rule, but if not carefully considered, it can lead to confusion. For example, it's possible to assign the number 1 to a variable as a text string by entering this:

```
(setq foo "1")
```

Later, you may accidentally try to add this string variable to an integer or real number and AutoCAD will return an error message.

The `Setq` and the addition and division functions are but three of the many functions available to you. AutoLISP offers all the usual math functions, plus many others used to test and manipulate variables. Table BC2.1 shows some commonly used math functions.

Table BC2.1: Math functions available in AutoLISP

Operation	Example
Add	(+ *number number*)
Subtract	(– *number number*)
Multiply	(* *number number*)
Divide	(/ *number number*)
Find largest number in list	(Max *number number*)
Find smallest number in list	(Min number number)
Find the remainder of a division	(Rem *number number*)
Add 1 to *number*	(1+ *number*)
Subtract 1 from *number*	(1– *number*)
Find the absolute value of *number*	(Abs *number*)
Arc tangent of *angle*	(Atan *angle in radians*)
Cosine of *angle*	(Cos *angle in radians*)
e raised to the *n*th power	(Exp *n*)
Νυμβερ raised to the *n*th power	(Expt *number n*)
Greatest common denominator	(Gcd *integer integer*)
Natural log of *number*	(Log *number*)
Sine of *angle*	(Sin *angle in radians*)
Square root of *number*	(Sqrt *number*)

Storing Points as Variables

Like numeric values, point coordinates can also be stored and retrieved. But because coordinates are sets of two or three numeric values, they have to be handled differently. AutoLISP provides the `Getpoint` function to handle the acquisition of points. Try the following to see how it works:

1. At the Command prompt, enter **(getpoint)** ↵. The Command prompt goes blank momentarily.
2. Pick a point near the middle of the screen. In the prompt area, you see the coordinate of the point you picked.

Here, `Getpoint` pauses AutoCAD and waits for you to pick a point. Once you do, it returns the coordinate of the point you pick in the form of a list. The list shows the x-, y-, and z- axes enclosed by parentheses.

You can store the coordinates obtained from `Getpoint` using the `Setq` function. Try the following:

1. Enter **(setq point1 (getpoint))** ↵.
2. Pick a point on the screen.
3. Enter **!point1** ↵.

Here you stored a coordinate list in a variable called `point1`. You then recalled the contents of `point1` using the `!`. The value of the coordinate is in the form of a list with the X, Y, and Z values appearing as real numbers separated by spaces instead of the commas to which you are accustomed.

Creating a Simple Program

So far, you've learned how to use AutoLISP to do simple math and to store values as variables. Certainly, AutoLISP has enormous value with these capabilities alone, but you can do a good deal more. In this section, you'll examine how to combine these three capabilities—math calculations, variables, and lists—to write and then examine a program for drawing a rectangle.

Writing the Program Directly into AutoLISP

You'll start by typing the program directly into the AutoLISP interpreter. This will show you how you can create a program on the fly:

1. Press F2 to flip to a text display.
2. At the Command prompt, enter **(defun c:rec ()** ↵. You get a new prompt that looks like this:

   ```
   (_>
   ```

   This is the AutoLISP prompt. It tells you, among other things, that you're in the AutoLISP interpreter. While you see this prompt, you can enter instructions to AutoLISP. You'll automatically exit the interpreter when you have finished entering the program. A program is considered complete when you've entered the last parenthesis, thereby balancing all the parentheses in your program.
3. Very carefully enter the following several lines. If you make a mistake while typing a line, use the arrow keys to navigate to the location of the error and then highlight and correct the error. Each

time you enter a line and press ↵, you'll see the AutoLISP prompt appear. Once you've entered the final closing parenthesis, you can't go back to fix a line:

```
(setq Pt1 (getpoint "Pick first corner point:" ))↵
(setq Pt3 (getpoint "Pick opposite corner:" ))↵
(setq Pt2 (list (nth 0 Pt3) (nth 1 Pt1)))↵
(setq Pt4 (list (nth 0 Pt1) (nth 1 Pt3)))↵
(command "Pline" Pt1 Pt2 Pt3 Pt4 "C")↵
)↵
```

AutoLISP Isn't Case Sensitive

It doesn't matter if you type entries in uppercase or lowercase letters; AutoLISP will work either way. The only time you must be careful with uppercase and lowercase letters is when you use string data types.

Once you enter the last parenthesis, you return to the standard AutoCAD Command prompt.

4. Check the lines you entered against the listing in step 3, and make sure you entered everything correctly. If you find a mistake, start over from the beginning and reenter the program.

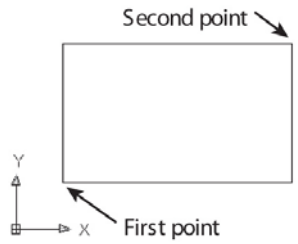
Use AutoLISP While Performing Other Functions

You can use AutoLISP programs transparently, as long as the program doesn't contain an embedded AutoCAD command.

When you're done, you get the message `C:REC`. This confirms that the rectangle-drawing program is stored in memory. Let's see it in action:

1. Enter **Rec** ↵ at the Command prompt.
2. At the `Pick first corner point:` prompt, pick a point at coordinate 1,1.
3. At the `Pick opposite corner:` prompt, pick a point at 6,4. A box appears between the two points you picked (see Figure BC2.2).

FIGURE BC2.2
Using the rectangle-drawing program



Dissecting the Rectangle Program

The rectangle-drawing program incorporates all the things you've learned so far. Let's see how it works. First, it finds the two corner coordinates of a rectangle, which it gets from you as input; then, it extracts parts of those coordinates to derive the coordinates for the other two corners of the rectangle. Once it knows all four coordinates, the program can draw the lines connecting them. Figure BC2.3 illustrates what the rec program does. Next, we'll look at the program in more detail.

Getting Input from the User

In the previous exercise, you started with the following line:

```
(defun c:rec ()
```

You may recall from Bonus Chapter 1 that the `defun` function lets you create commands. The name that follows the `defun` function is the name of the command as you enter it through the keyboard. The `c:` tells AutoLISP to make this program act like a command. If the `c:` was omitted, you'd have to enter (rec) to view the program. The set of empty parentheses is for an argument list, which we'll discuss later.

In the next line, the variable `Pt1` is assigned a value for a point you enter using your cursor. `Getpoint` is the AutoLISP function that pauses the AutoLISP program and allows you to pick a point using your cursor or to enter a coordinate. Once a point is entered, `Getpoint` returns the coordinate of that point as a list.

Immediately following `Getpoint` is a line that reads as follows:

```
"Pick first corner point:"
```

`Getpoint` allows you to add a prompt in the form of text. You may recall that when you first used `Getpoint`, it caused the prompt to go blank. Instead of a blank, you can use text as an argument to the `Getpoint` function to display a prompt describing what action to take.

The third line is similar to the second. It uses `Getpoint` to get the location of another point and then assigns that point to the variable `Pt3`:

```
(setq Pt3 (getpoint "Pick opposite corner:" ))
```

Once AutoLISP has the two corners, it has all the information it needs to find the other two corners of the rectangle.

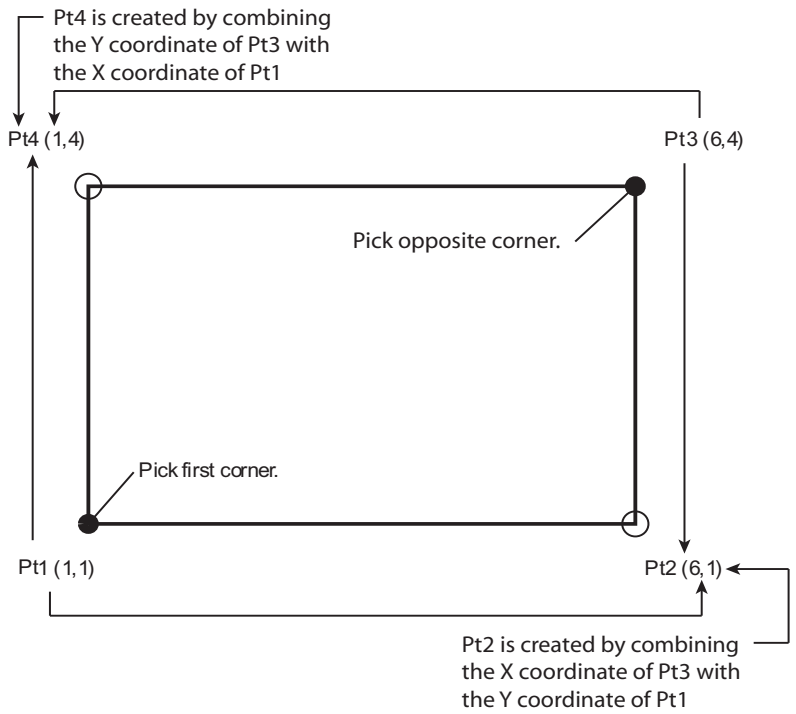


FIGURE BC2.3
The rec program draws a rectangle by getting two corner points of the rectangle from you and then recombining coordinates from those two points to find the other two points of the rectangle.

Taking Lists Apart

The next thing AutoLISP must do is take apart `Pt1` and `Pt3` to extract their x- and y-coordinates and then reassemble those coordinates to get the other corner coordinates. AutoLISP must take the x-coordinate from `Pt3` and the y-coordinate from `Pt1` to get the coordinate for the lower-right corner of the rectangle (see Figure BC2.3). To do this, you use two new functions: `Nth` and `List`.

The `Nth` function extracts a single element from a list. Because coordinates are lists, `Nth` can be used to extract an X, Y, or Z component from a coordinate list. In the fourth line of the program, you see this:

```
(nth 0 Pt3)
```

Here the 0 immediately following the `Nth` function in the previous example tells `Nth` to take element number 0 from the coordinate stored as `Pt3`. `Nth` starts counting from 0 rather than 1, so the first element of `Pt3` is considered item number 0. This is the X component of the coordinate stored as `Pt3`.

To see how `Nth` works, try the following:

1. Enter **!point1** ↵. You see the coordinate list you created earlier using `Getpoint`.
2. Enter **(nth 0 point1)** ↵. You get the first element of the coordinate represented by `point1`.

Immediately following the first `Nth` expression is another `Nth` expression similar to the previous one:

```
(nth 1 Pt1)
```

Here, `Nth` extracts element number 1, the second element, from the coordinate stored as `Pt1`. This is the Y component of the coordinate stored as `Pt1`. If you like, try the previous exercise again, but this time enter **(nth 1 point1)** and see what value you get.

Combining Elements into a List

AutoLISP has extracted the X component from `Pt3` and the Y component of `Pt1`. They must now be joined together into a new list. This is where the `List` function comes in. The `List` expression looks like this:

```
(list (nth 0 pt3) (nth 1 pt1))
```

You know that the first `Nth` expression extracts an X component and that the second extracts a Y component, so the expression can be simplified to look like this:

```
(list X Y)
```

Here `X` is the value derived from the first `Nth` expression, and `Y` is the value derived from the second `Nth` expression. The `List` function recombines its arguments into another list, in this case another coordinate list.

Finally, the outermost function of the expression uses `Setq` to create a new variable called `Pt2`, which is the new coordinate list derived from the `List` function. The following is a schematic version of the fourth line of the rec program provided so that you can see what is going on more clearly:

```
(setq pt2 (list X Y))
```

`Pt2` is a coordinate list derived from combining the *X* component from `Pt3` and the *Y* component from `Pt1`.

Try the following exercise to see how `List` works:

1. Enter **(list 5 6)** ↵. The list `(5 6)` appears in the prompt.
2. Enter **(list (nth 0 point1) (nth 1 point1))** ↵. The x- and y-coordinates of `point1` appear in a list, excluding the z-coordinate.

The fifth line is similar to the fourth. It creates a new coordinate list using the X value from `Pt1` and the Y value from `Pt2`:

```
(setq Pt4 (list (nth 0 Pt1) (nth 1 Pt3)))
```

The next-to-last line tells AutoCAD to draw a polyline through the four points to create a box:

```
(command "Pline" Pt1 Pt2 Pt3 Pt4 "C")
```

The `Command` function issues the `Pline` command and then inputs the variables `Pt1` through `Pt4`. Finally, it enters `C` to close the polyline. Note that in this expression, keystroke entries, such as `"Pline"` and `"C"`, are enclosed in quotes.

At the very end, the single parenthesis balances the very first parenthesis in the first line. Remember that the parentheses have to be balanced.

Getting Other Input from the User

In your rec program, you prompted the user to pick some points by using the `Getpoint` function. Several other functions allow you to pause for input and tell the user what to do. Nearly all these functions begin with the `Get` prefix.

Table BC2.2 shows a list of these `Get` functions. They accept single values or, in the case of points, a list of two values.

In `Getstring`, string values are case sensitive. This means that if you enter a lowercase letter in response to `Getstring`, it's saved as a lowercase letter; uppercase letters are saved as uppercase letters. You can enter numbers in response to the `Getstring` function, but they're saved as strings and can't be used in mathematical operations. Also, AutoLISP automatically adds quotes to string values it returns, so you don't have to enter any.

Table BC2.2: Functions that pause to allow input

Function	Description
`Getint`	Allows entry of integer values.
`Getreal`	Allows entry of real values.
`Getstring`	Allows entry of string or text values.
`Getkword`	Allows filtering of string entries through a list of keywords.
`Getangle`	Allows keyboard or mouse entry of angles based on the standard AutoCAD compass points (returns values in radians).
`Getorient`	Allows keyboard or mouse entry of angles based on the `Units` command setting for angles (returns values in radians).
`Getdist`	Allows keyboard or mouse entry of distances (always returns values as real numbers, regardless of the unit format used).
`Getpoint`	Allows keyboard or mouse entry of point values (returns values as coordinate lists).
`Getcorner`	Allows selection of a point by using a window.*
`Initget`	Allows definition of a set of keywords for the `Getkword` function; keywords are strings, as in `(initget Yes No ")`.

** This function requires a base point value as a first argument. This base point defines the first corner of the window. A window appears, allowing you to select the opposite corner.*

Just as with `Getpoint`, all these `Get` functions allow you to create a prompt by following the function with the prompt enclosed by quotation marks, as in the following expression:

```
(getpoint "Pick the next point:" )
```

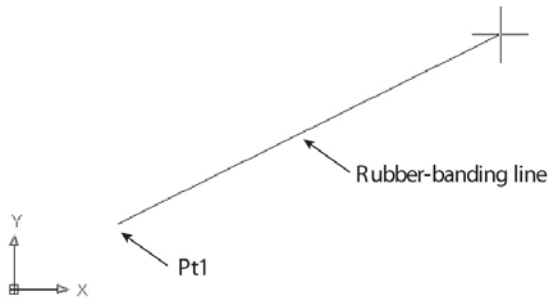
This expression displays the prompt `Pick the next point:` while AutoCAD waits for your input.

The functions `Getangle`, `Getorient`, `Getdist`, `Getcorner`, and `Getpoint` let you specify a point from which the angle, distance, or point is to be measured, as in the following expression:

```
(getangle Pt1 "Pick the next point:" )
```

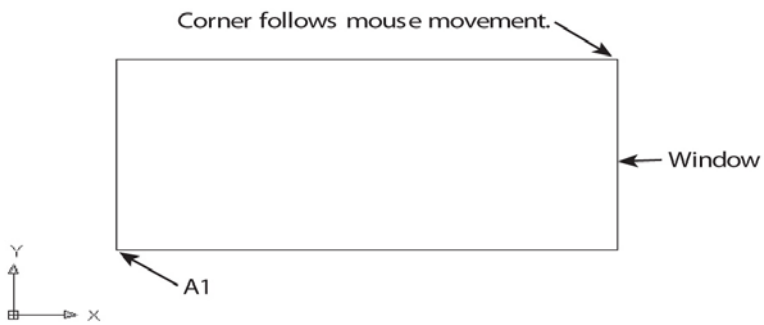
Here, `Pt1` is a previously defined point variable. A rubber-banding line appears from the coordinate defined by `Pt1` (see Figure BC2.4).

FIGURE BC2.4
Using `Getangle`



Once you pick a point, the angle defined by `Pt1` and the point you pick are returned in radians. You can also enter a relative coordinate through the keyboard in the unit system currently being used in your drawing. `Getangle` and `Getdist` prompt you for two points if a point variable isn't provided. `Getcorner` always requires a point argument and generates a window rather than a rubber-banding line (see Figure BC2.5).

FIGURE BC2.5
Using `Getcorner`



Selecting Objects with AutoLISP

Eventually you'll want to create an AutoLISP expression that will act on an object or set of objects. You can use a simple command function to select a single object, but if you need to be able to edit multiple objects, you'll have to employ an additional function.

Making a Single Selection

You can easily create an AutoLISP expression that lets you select a single object and perform an operation on it. Here is an example of a macro that rotates an object 90°:

```
(defun c:r90 () (command "rotate" pause "" pause "90"))
```

In this example, the `pause` after `"rotate"` allows you to make a selection. The double quotes that follow act like an ↵, and then another pause lets you select a rotation point. Finally, 90 is supplied to tell the Rotate command to rotate your selection 90°.

If you load this macro into AutoCAD and run it, you're prompted to select an object. You're then immediately prompted to pick a point for the rotation center. You won't be allowed to continue to select other objects the way you can with most AutoCAD commands.

But what if you want that macro to let you make several selections instead of just one? At this point, you almost know enough to create a program to do that. The only part missing is `Ssget`.

The *Ssget* Function

So far, you know you can assign numbers, text, and coordinates to variables. `Ssget` is a function that assigns a set of objects to a variable, as demonstrated in the following exercise:

1. Draw a few random lines on the screen.
2. Enter **(setq ss1 (ssget))** ↵.
3. At the `Select objects:` prompt, select the lines using any standard selection method. You can select objects just as you would at any object-selection prompt.
4. When you're done selecting objects, press ↵. You get the message `<Selection set: n>`, in which *n* is an alphanumeric value that identifies the selection set.
5. Start the Move command and, at the object-selection prompt, enter **!ss1** ↵. The lines you selected previously are highlighted.
6. Press ↵, and then pick two points to finish the Move command.

In this exercise, you stored a selection set as the variable `ss1`. You can recall this selection set from the Command prompt using the `!`, just as you did with other variables.

Using *Ssget* in an Expression

You can also use the `ss1` variable in an AutoLISP expression. For example, the `r90` macro in the next exercise lets you select several objects to be rotated 90°:

1. Enter **(defun c:r90 (/ ss1)** ↵ . The AutoLISP prompt appears.
2. To complete the macro, enter **(setq ss1 (ssget))(command "rotate" ss1 "" pause "90"))** and press 8.
3. Enter **r90** ↵ to start the macro.
4. At the `Select objects:` prompt, select a few of the random lines you drew earlier.
5. Press ↵ to confirm your selection, and then pick a point near the center of the screen. The lines you selected rotate 90°.

The `defun` function tells AutoLISP that this is to be a command called `r90`. A list follows the name of the macro; it's called an *argument list*. We'll look at argument lists a bit later in this chapter.

Following the argument list is the `(setq ss1 (ssget))` expression you used in the previous exercise. This is where the new macro stops and asks you to select a set of objects to be applied later to the Rotate command.

The next expression uses the `Command` function. `Command` lets you include standard AutoCAD command-line input in an AutoLISP program. In this case, the input starts by issuing the Rotate command. It then applies the selection set stored by `ss1` to the Rotate command's object-selection prompt. Next, the two `""` marks indicate an ↵. The `Pause` lets the user select a base point for the rotation. Finally, the value 90 is applied to the Rotate command's angle prompt. When entered at the Command prompt, the entire expression would look like this:

```
Command: Rotate↵
Select objects:!ss1↵
Select objects:↵
Specify base point: (pause for input)
Specify rotation angle or [Copy/Reference] <0>: 90↵
```

In this macro, the `Ssget` function adds flexibility by allowing the user to select as many objects as desired. (You could use the `Pause` function in place of the variable `ss1`, but with `Pause` you can't anticipate whether the user will use a window, pick points, or select a previous selection set.)

Controlling Memory Consumption with Local Variables

Selection sets are memory hogs in AutoLISP. If you create too many of them, you'll end up draining AutoLISP's memory reserves. To limit the memory used by selection sets, you can turn them into *local variables*. Local variables are variables that exist only while the program is executing its instructions. Once the program is finished, local variables are discarded.

The vehicle for making variables local is the *argument list*. Let's look again at the set of empty parentheses that immediately follow the program name in the rec program:

```
(defun c:rec () ...)
```

If you include a list of variables between those parentheses, those variables become local. In the new `r90` macro you just looked at, the `ss1` selection-set variable is a local variable:

```
(defun c:r90 (/ ss1)...)
```

Watch Those Spaces

The space after the / in the argument list is very important. Your macro won't work properly without it.

The argument list starts with a forward slash and then a space followed by the list of variables. Once the `r90` macro is done with its work, any memory assigned to `ss1` can be recovered.

Sometimes, you'll want a variable to be accessible at all times by all AutoLISP programs. Such variables are known as *global variables*. You can use global variables to store information in the current editing session. You could even store a few selection sets as global variables. To control memory consumption, however, use global variables sparingly.

Controlling the Flow of an AutoLISP Program

A typical task for a program is to execute one function or another depending on an existing condition. This type of operation is often called an *if-then-else conditional statement*: "If a condition is met, then perform computation A; or else perform computation B." AutoLISP offers the `If` function to facilitate this type of operation.

Using the *If* Function

The `If` function requires two arguments. The first argument must be a value that returns true or false—in the case of AutoLISP, `T` for true or `nil` for false. The second argument is the action to take if the value returned is true. It's like saying, "If true then do A," where "true" is the first argument and "A" is the second. Optionally, you can supply a third argument, which is the action to take if the value returned is nil ("If true then do A; or else do B").

Why Use the If Function?

A common use for the if-then-else statement is to direct the flow of a program in response to a user's yes or no reply to a prompt. If the user responds with a yes to the prompt `Do you want to continue?`, for example, that response can be used in the if-then-else statement to direct the program to go ahead and perform some function, such as erasing objects or drawing a box.

Here is an example of an `If` expression:

```
(if Exst (+ a b) (* a b))
```

Here the value of the `Exst` variable determines which of the two following expressions is evaluated. If `Exst` has a value, it returns `T` for true; that is, when AutoLISP evaluates `Exst`, the value returned is `T`. The expression then evaluates the second argument, `(+ a b)`, which is itself an expression. If `Exst` doesn't have a value or is nil, the expression evaluates the third argument, `(* a b)`.

Several special AutoLISP functions test variables for specific conditions. For example, you can test a number to see if it's equal to, less than, or greater than another number. In this expression, if `A` is equal to `B`, the second argument is evaluated:

```
(if (= A B) (+ A B) (* A B))
```

In this expression, if `A` is greater than `B`, the second argument is evaluated:

```
(if (> A B) (+ A B) (* A B))
```

The functions that test for `T` or `nil` are called *predicates* and *logical operators*. Table BC2.3 shows a list of these functions.

Table BC2.3: Predicates and logical operators

Function	Returns `T` (True) if...
<	One numeric value is less than another

Function	Returns T (True) if...
>	One numeric value is greater than another
<=	One numeric value is less than or equal to another
>=	One numeric value is greater than or equal to another
=	Two numeric or string values are equal
/=	Two numeric or string values aren't equal
eq	Two values are exactly the same
equal	Two values are the same (approximate)
atom	A symbol represents an atom (as opposed to a list)
listp	A symbol represents a list
minusp	A numeric value is negative
numberp	A symbol is a number, real or integer
zerop	A symbol evaluates to 0
and	All of several expressions or atoms return non-nil
not	A symbol is nil
null	A list is nil
or	One of several expressions or atoms returns non-nil

Let's see how conditional statements, predicates, and logical operators work together. Suppose you want to write a program that either multiplies two numbers or adds the numbers together. You want the program to ask the user which action to take depending on which of the two values is greater. Follow these steps:

1. Enter the following program at the Command prompt, just as you did for the rec program:

```
(defun c:mul-add ()↵
(setq A (getreal "Enter first number:" ))↵
(setq B (getreal "Enter second number:" ))↵
(if (< A B) (+ a b) (* a b))↵
)↵
```

2. Run the program by entering **Mul-add** ↵.
3. At the `Enter first number:` prompt, enter **3** ↵.
4. At the `Enter second number:` prompt, enter **4** ↵. The value 7.0 is returned.
5. Run the program again, but this time enter **4** at the first prompt and **3** at the second prompt. This time you get the returned value 12.0.

In this program, the first two `Setq` expressions get two numbers from you. The conditional statement that follows, `(< A B)`, tests to see if the first number you entered is less than the second. If this predicate function returns `T` for true, `(+ a b)` is evaluated. If it returns `nil` for false, `(* a b)` is evaluated.

You'll often find that you need to perform not just one but several steps, depending on some condition. Here is a more complex `If` expression that evaluates several expressions at once:

```
(if (= A B) (progn (* A B)(+ A B)(- A B) ))
```

In this example, the function `Progn` tells the `If` function that several expressions are to be evaluated if `(= A B)` returns true.

Repeating an Expression

Sometimes, you'll want your program to evaluate a set of expressions repeatedly until a particular condition is met. If you're familiar with Basic, you know this function as a *loop*.

You can repeat steps in an AutoLISP program by using the `While` function in conjunction with predicates and logical operators. Like the `If` function, `While`'s first argument must be one that returns a `T` or `nil`. You can have as many other arguments to the `While` function as you like as long as the first argument is a predicate function:

```
(while test (expression 1) (expression 2) (expression 3) . . .)
```

The `While` function isn't the only one that will repeat a set of instructions. The `Repeat` function causes a set of instructions to be executed several times, but unlike `While`, `Repeat` requires an integer value for its first argument as in the following:

```
(Repeat 14 (expression 1) (expression 2) (expression 3) . . .)
```

In this example, `Repeat` will evaluate each expression 14 times.

A third function, `Foreach`, evaluates an expression for each element of a list. The arguments to `Foreach` are first a variable, then a list whose elements are to be evaluated, and then the expression used to evaluate each element of the list:

```
(foreach var1 ( list1 ) (expression var1))
```

`Foreach` is a bit more difficult to understand at first because it involves a variable, a list, and an expression all working together.

Using Other Built-in Functions

At this point, you've seen several useful programs created with just a handful of AutoLISP functions. Although we can't give a tutorial showing you how to use every available AutoLISP function, in these final sections we'll demonstrate a few more. This is far from a complete list, but it should be enough to get you well on your way to making AutoLISP work for you. Experiment with the functions at your leisure, but remember, using AutoLISP can be addictive!

Keeping Track of Data Types

In many of the examples in the following sections, you'll see numeric values or lists as arguments. As in all AutoLISP functions, you can use a variable as an argument as long as the variable's value is of the proper data type.

Geometric Operations

These functions are useful for manipulating geometric data. (And don't forget the `Get` functions listed earlier in Table BC2.2.)

An Apostrophe Means Don't Evaluate

In some examples, an apostrophe (') precedes a list. This apostrophe tells AutoLISP not to evaluate the list but to treat it as a repository of data.

Angle Finds the angle between two points and returns a value in radians. For example,

```
(angle '(6.0 4.0 0.0) '(6.0 5.0 0.0))
```

returns 1.5708. This example uses two coordinate lists for arguments, but point variables can also be used.

Distance Finds the distance between two points. The value returned is in base units. Just like Angle, Distance requires two coordinates as arguments. The expression

```
(distance (6.0 4.0 0.0) (6.0 5.0 0.0))
```

returns 1.0.

Polar Returns a point in the form of a coordinate list based on the location of a point, an angle, and a distance. The expression

```
(polar (1.0 1.0 0.0) 1.5708 1.0)
```

returns (0.999996 2.0 0.0). The first argument is a coordinate list, the second is an angle in radians, and the third is a distance in base units. The point must be a coordinate list.

Inters Returns the intersection point of two vectors, with each vector described by two points. The points must be in this order: The first two points define the first vector, and the second two points define the second vector. The expression

```
(inters
'(1.0 4.0 0.0)'(8.0 4.0 0.0)'(5.0 2.0 0.0)'(5.0 9.0 0.0)
)
```

returns (5.0 4.0 0.0). If the intersection point doesn't lie between either of the two vectors, you can still obtain a point, provided you include a non-nil fifth argument.

String Operations

These functions allow you to manipulate strings. Although you can't supply strings for the text input of the text command, you can use the `Command` function with string variables to enter text, as in the following:

```
(Setq note "Hello World")
 (command "text" (getpoint) "2.0" "0" note)
```

In this example, `note` is first assigned a string value. Then the `Command` function is used to issue the `Text` command and place the text in the drawing. Notice the `(getpoint)` function, which is included to obtain a point location.

Two other string functions, `Substr` and `Strcat`, let you manipulate text:

Substr Returns a portion of a string, called a substring, beginning at a specified location. The expression

```
(substr "string" 3 4)
```

returns *string***.** The first argument is the string containing the substring to be extracted. The second argument, 3, tells `Substr` where to begin the new string; this value must be an integer. The third argument, 4, is optional and tells `Substr` how long the new string should be in characters. The length must also be an integer.

Strcat Combines several strings, and the result is a string. The expression

```
(strcat string1  string2  etc. )
```

returns *string1 string2 etc.* In this example, the

```
etc.
```

indicates that you can have as many string values as you want.

Converting Data Types

While using AutoLISP, you'll often have to convert values from one data type to another. For example, because most angles in AutoLISP must be represented in radians, you must convert them to degrees before you can use them in commands. You can do so using the `Angtos` function. `Angtos` converts a real number representing an angle in radians into a string in the degree format you desire. The following example converts an angle of 1.57 radians into surveyor's units with a precision of four decimal places:

```
(angtos 1.57 4 4)
```

This expression returns N 0d2'44"E. The first argument is the angle in radians, the second argument is a code that tells AutoLISP which format to convert the angle to, and the third argument tells AutoLISP the degree of precision desired. (The third argument is optional.) The conversion codes for `Angtos` are as follows:

0 = Degrees

1 = Degrees/minutes/seconds

2 = Grads

3 = Radians

4 = Surveyor's units

Converting Radians

The `Angtos` and `Rtos` functions are especially useful for converting radians to any of the standard angle formats available in AutoCAD. For example, using `Angtos`, you can convert 0.785398 radians to 45d0'0", or N 45d0'0"E. Using `Rtos`, you can convert the distance value of 42 to 42.00, or 3'-6" (3 feet, 6 inches). Be aware that `Angtos` and `Rtos` also convert numeric data into strings.

Now that you've seen an example of what the `Angtos` data-type conversion can do, let's briefly look at similar functions:

Atof and Atoi Atof converts a string to a real number. The expression

```
(atof "33.334")
```

returns 33.334.

`Atoi` converts a string to an integer. The expression

```
(atoi "33.334")
```

returns 33.

Itoa and Rtos Itoa converts an integer to a string. The argument must be an integer. The expression

```
(itoa 24)
```

returns "24".

`Rtos` converts a real number to a string. As with `Angtos`, a format code and precision value are specified. The expression

```
(rtos 32.3 4 2)
```

returns "2'-8 1/4\"".

Why the \ Sign?

You may notice the \ just after the 1/4 in the returned value. This is an AutoLISP symbol indicating that the following " symbol is part of the string text and not the closing " that indicates the end of the string.

The first argument is the value to be converted, the second argument is the conversion code, and the third argument is the precision value. The codes are as follows:

1 = Scientific

2 = Decimal

3 = Engineering

4 = Architectural

5 = Fractional

Fix and Float Fix converts a real number into an integer. The expression

```
(fix 3.3334)
```

returns 3.

`Float` converts an integer into a real number. The expression

```
(float 3)
```

returns 3.0**.**

Storing Your Programs as Files

When you exit AutoCAD, the rec program will vanish. But just as you were able to save keyboard shortcuts in Bonus Chapter 1*,* you can create a text file containing the rec program. That way, you'll have ready access to it at all times.

To save your programs, open a text editor and enter them through the keyboard just as you entered the rec program, including the first line that contains the `defun` function. Be sure you save the file with the `.lsp` filename extension. You can recall your program by choosing Load Application from the Manage tab's Applications panel, which opens the Load/Unload Applications dialog box.

If you prefer, you can use the manual method for loading AutoLISP programs. This involves the `Load` AutoLISP function. Just as with all other functions, it's enclosed by parentheses. In Bonus Chapter 1, you loaded the `GETAREA.LSP` file using the Load/Unload Applications dialog box. To use the `Load` function instead to load `GETAREA.LSP`, enter the following:

```
(Load "getarea")
```

`Load` is one of the simpler AutoLISP functions because it requires only one argument: the name of the AutoLISP file you want to load. Notice that you don't have to include the `.lsp` filename extension.

If the AutoLISP file resides in a folder that isn't in the current path, you need to include the path in the filename as in the following example:

```
(Load "C:/Mastering AutoCAD/Projects/Bonus Chapter 2/getarea")
```

Instead of the usual Windows `\`, `/` is used to indicate folders. The forward slash is used because the backslash has special meaning to AutoLISP in a string value: It tells AutoLISP that a special character follows. If you attempted to use `\` in the previous example, you'd get an error message.

As you may guess, the `Load` function can be a part of an AutoLISP program. It can also be included as part of a menu to load specific programs whenever you select a menu item. Chapter 26, "Customizing Toolbars, Menus, Linetypes, and Hatch Patterns," discussed customizing the menu.

Protecting Against Malicious Code

AutoCAD offers two system variables, SECURELOAD and TRUSTEDPATHS, to help you maintain a virus-free environment by restricting the location where AutoCAD loads executable files and scripts. TRUSTEDPATHS enables you to define a location on your computer where you store trusted AutoCAD files that contain code. Enter TRUSTEDPATHS ↵ at the command prompt and then enter the full path name for your trusted location.

SECURELOAD lets you control whether AutoCAD uses the TRUSTEDPATHS setting. Enter `SECURELOAD` ↵, and then enter one of the following numeric values:

- 0 to disable TRUSTEDPATHS
- 1 to enable TRUSTEDPATHS with a warning message that appears when attempting to load from a nonsecure path
- 2 to enable TRUSTEDPATHS without the warning message

Using Scripts

Before AutoLISP, scripts were used to automate tasks in AutoCAD, and many users still use scripts for simple tasks. Scripts are simply a list of instructions for AutoCAD to perform a set of operations. You store scripts in text files using the Windows Notepad application.

To write a script, open a text file and type in your AutoCAD instructions as if you were entering them at the AutoCAD Command prompt. If a command requires point input or object selections, you can supply coordinate locations. You have to be very careful to make sure your text file contains the exact keystrokes that would be used if you were entering them in AutoCAD.

Once you have entered your script, make sure the very last line has a return at the end (press the Enter key). Then you can save your script file with the `.scr` filename extension.

To run the script in AutoCAD, type **Script** ↵, and then use the Select Script File dialog box that appears to select and run your script. You'll probably have to test your script and make adjustments before it works perfectly.

Scripts are very inflexible, and one missing keystroke or misplaced space can render your script useless. Today, you have AutoLISP and the Action Recorder to handle most automation projects. But if you have a simple operation that is repetitive, a script can be a useful tool.

Getting More Help with AutoLISP

We hope you'll be enticed into trying some programming on your own and learning more about AutoLISP. You can find a wealth of information on the AutoCAD 2017 Help website:

1. Choose Help from the Help flyout on the Communication Center. The Autodesk Exchange dialog box opens with the Help tab active.
2. In the panel on the left, expand the Developer's Documentation list and select one of the two options: the AutoLISP Developers Guide or the AutoLISP Reference Guide. Additional options are displayed in the main body of the page.

The AutoLISP Developers Guide offers instructions on the Visual LISP programming environment and also provides some online tutorials. This guide can be helpful to new users. The AutoLISP Reference Guide is intended for users with a basic knowledge of AutoLISP and provides detailed information on the AutoLISP functions.

As you work with AutoLISP material in the Help tab of the Autodesk Exchange AutoCAD dialog box, you'll also see references to Visual LISP. This is a self-contained programming environment for AutoLISP. Visual LISP is an excellent tool if you intend to make extensive use of AutoLISP in your work. Once you understand the basics of AutoLISP, you may want to explore Visual LISP through the tutorial in the AutoCAD Help system. You can find the Visual LISP tutorial under the AutoLISP Tutorial section.