**Execution Control**

## CHAPTER 4

**Chapter Objectives**



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| --- | --- |
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|  | |
|  |  |

This chapter discusses techniques for changing the flow of control in a program, which may be necessary for two reasons:

* You may want to execute some parts of the code under certain circumstances only
* You may want to repeat a section of code a certain number of times

In Chapter 3 we used the array notation to gather numbers into a form where they could be processed collectively rather than individually. This chapter deals with ***code blocks*** (collections of one or more lines of code) that solve a particular segment of a problem in the same way. We will see how to define a code block, how to decide to execute a code block under certain conditions only, and how to repeat execution of a code block.

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# Concept: Code Blocks



Some languages identify code blocks by enclosing them in braces ({. . .}); others identify them by the level of indentation of the text. The MATLAB language uses the occurrence of key command words in the text to define the extent of code blocks. Keywords like if, switch, while, for, case, otherwise, else, elseif, and end are identified with blue coloring by the MATLAB text editor. They are not part of the code block, but they serve as instructions on what to do with the code block and as delimiters that define the extent of the code block.

# Conditional Execution in General



To this point, the statements written in our scripts (single code blocks) have been executed in sequence from the instruction at the top to the instruction at the bottom. However, it is frequently necessary to make choices about how to process a set of data based on some characteristic of that data. We have seen logical expressions that result in a Boolean result— true or false. This section discusses the code that implements the idea shown in Figure 4.1.

In the flowchart shown in Figure 4.1, a set of statements (the code block to be executed) is shown as a rectangle, a decision point is shown as a diamond, and the flow of program control is indicated by arrows. When decision points are drawn, there will be at least two arrows leaving that symbol, each labeled with the reason one would take that path. This concept makes the execution of a code block conditional upon some test. If the result of the test is true, the code block is executed. Otherwise, the code block is omitted, and the instruction(s) after the end of that code block is executed next.

An important generalization of this concept is shown in Figure 4.2. Here the solution is generalized to permit the first code block to be implemented under the first condition as before. Now, however, if that

If Condition

False

True Statements

**Figure 4.1** *Simple if statement*

**4.3** if Statements **83**

|  |  |
| --- | --- |
| Else | |
|  |  |

If Condition

True

|  |  |
| --- | --- |
| Statements (n) | |
|  |  |

|  |  |
| --- | --- |
| Statements (n+1) | |
|  |  |

False

Elseif Condition

True

|  |  |
| --- | --- |
| Statements (2) | |
|  |  |

False

. . .

Elseif Condition

False

|  |  |
| --- | --- |
| Statements (1) | |
|  |  |

**Figure 4.2** *Compound if statement*

first logical test returns false, a second test is performed to determine whether the second code block should be executed. If that test returns false, as many further tests as necessary may be performed, each with the appropriate code block to be implemented when the result is true. Finally, if none of these tests return true, the last code block, usually identified by the else keyword—(n 1 1) in the figure—is executed. As the flowchart shows, as soon as one of the code blocks is executed, the next instruction to execute is the one that follows the conditional code after the end statement. In particular, if there is no else clause, it is possible that no code at all is executed in this conditional statement.

There are two common styles in which to implement this conditional behavior. First we will discuss the most general form, the if statement, and then we will discuss the more restrictive, but tidier, switch statement. Both implementations are found in most modern languages, albeit with slightly different syntax. In each case, the code block to be implemented is all the statements between the key words colored blue by the MATLAB editor.

# 4.3 if Statements



Here we introduce the concept of a programming template. Many programming texts still use the idea of **flowcharts**, such as those illustrated in Figures 4.1 and 4.2, to describe the design of a solution in a manner independent of the code implementation. However, since this graphical form cannot be maintained with a text editor, if the design of the solution changes, it is difficult to maintain any design description that is separate from the code itself.

Throughout the remainder of this text, we will describe the overall design of a code module using a **design template**. Design templates are a textual form of flowchart consisting of the key words that control program flow and placeholders that identify the code blocks and expressions that are

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necessary to implement the solution logic. Design templates are powerful tools for the novice programmer to overcome the “blank sheet of paper” problem—“how do I start solving this problem?” All programmers need to do is recognize the nature of the solution and write down the appropriate template. Then solving a particular problem becomes the relatively simple task of writing the code blocks identified by the template.

To discuss the if statement, first we consider its general, language independent template and then its MATLAB implementation.

### General Template

Template 4.1 shows the general template for the if statement. Note the following:

* + - * The only essential ingredients are the first if statement, one code block, and the end statement. All other features may be added as the logic requires.
      * The code blocks may contain any sequence of legal MATLAB statements, including other if statements (nested ifs), switch statements, or iterations (see Section 4.5).
      * Nested if statements with a code block are an alternative implementation of a logical AND statement.
      * Recall that logical operations can be applied to a vector, resulting in a vector of Boolean values. This vector may be used as a logical expression. The if statement will accept this expression as true if all of the elements are true.

### MATLAB Implementation

Listing 4.1 shows the MATLAB solution to a typical logical problem: determining whether a day is a weekday or a weekend day. It is assumed that the variable day is a number containing integer values from 1 to 7.

**Template 4.1** General template for the if statement

if <logical expression 1>

<code block 1>

elseif <logical expression 2>

<code block 2>

.

.

.

elseif <logical expression n>

<code block n>

else End

<default code block>

* 1. if Statements **85**

**Listing 4.1** if statement example

* + 1. if day == 7 % Saturday
    2. state = 'weekend'
    3. elseif day == 1 % Sunday
    4. state = 'weekend'
    5. else
    6. state = 'weekday'
    7. end

In Listing 4.1:

Line 1: The first logical expression determines whether day is 7. Line 2: The corresponding code block sets the value of the variable

state to the string 'weekend'. In general, there can be as many

statements within a code block as necessary.

Line 3: The second logical expression determines whether day is 1. Line 4: The corresponding code block also sets the value of the

variable state to the string 'weekend'.

Line 5: The key word else introduces the default code block executed when none of the previous tests pass.

Line 6: The default code block sets the value of the variable state to the string 'weekday'.

Exercise 4.1 gives you the opportunity to practice using if statements, and Listing 4.2 shows a script that will satisfy Exercise 4.1.



**Exercise 4.1** Using if statements

Write a script that uses input(...) to request a numerical grade in percentage and uses if statements to convert that grade to a letter grade according to the following table:

90% and better: A 80%–90%: B

70%–80%: C

60%–70%: D

Below 60%: F

Test your script by running it repeatedly for legal and illegal values of the grade percentage.

Check your work against the script shown in Listing 4.2.

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**Listing 4.2** Script with if statements

1. grade = input('what grade? ');
2. if grade >= 90
3. letter = 'A'
4. elseif grade >= 80
5. letter = 'B'
6. elseif grade >= 70
7. letter = 'C'
8. elseif grade >= 60
9. letter = 'D'
10. else
11. letter = 'F'
12. end

In Listing 4.2:

Line 1: Requests a grade value from the user with the input(...) function. The prompt appears in the Command window, and the system waits for a line of text from the user and converts that line as it would any other Command window line, returning the result to the variable grade.

Line 2: The first logical expression looks for the grade that earns an A.

Line 3: The corresponding code block sets the value of the variable

letter to 'A'.

Lines 4–9: The corresponding logic for letter grades B, C, and D. Lines 10–12: The default logic setting the variable letter to 'F'.

### Important Ideas

There are two important ideas that are necessary for the successful implementation of if statements: the general form of the logical expressions and short-circuit analysis.

### Common Pitfalls 4.1

The MATLAB Command window echoes logical results as 1 (true) or 0 (false). In spite of this appearance, logical values are ***not*** numeric and should never be treated as if they were.

**Logical Expressions** The if statement requires a logical expression for its condition. A logical expression is any collection of constants, variables, and operators whose result is a Boolean true or false value.

Logical expressions can be created in the following ways:

* + - * The value of a Boolean constant (e.g., true or false)
      * The value of a variable containing a Boolean result (e.g., found)
      * The result of a logical operation on two scalar quantities (e.g., A > 5)
  1. if Statements **87**
     + The result of logically negating a Boolean quantity using the unary negation operator (e.g., ~found)
     + The result of combining multiple scalar logical expressions with the operators && or || (e.g., A && B or A || B)
     + The results of the functions that are the logical equivalent of the &&,

||, and ~ operators: and(A, B) or(A, B) and not(A)

* + - The results of other functions that operate on Boolean vectors:

any(...) and all(...)

The result from any(...) will be true if any logical value in the vector is true. The result from all(...) will be true only if all logical values in the vector are true. The function all(...) is implicitly called if you supply a vector of logical values to the if statement, as shown in Listing 4.3.

In Listing 4.3:

Line 1: Makes the variable A a logical vector.

Line 2: Using this as a logical expression, internally converts this expression to all(A).

Line 3: All the values of A are not true; therefore, the above code body does not execute.

Line 4: Now, all the elements of A are true.

Lines 5–6: If we repeat the test, the code body will now execute.

**Short-Circuit Evaluation** When evaluating a sequence of logical && or ||, MATLAB will stop processing when it finds the first result that makes all subsequent processing irrelevant. This concept is best illustrated by an example. Assume that A and B are logical results and you want to evaluate A && B. Since the result of this is true only if both A and B are true, if you evaluate A and the result is false, no value of B can change the outcome A &&

1. Therefore, there is no reason to evaluate any more components of a logical

and expression once a false result has been found. Similarly, if you want A

|| B, if A is found to be true, you do not need to evaluate B. For example,

suppose you want to test the *n*th element of a vector v using a variable n,

and you are concerned that n might not be a legal index value.

**Listing 4.3** The if statement with a logical vector

* 1. A = [true true false]
  2. if A

% will not execute

* 1. end
  2. A(3) = true;
  3. if A

% will execute

* 1. end

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The following code could be used:

if (n <= length(v)) && (v(n) > 0)

% success!

end

If n were not a legal index, the indexed accessor v(n) would cause an error for attempting to reach beyond the end of the vector. However, by putting the test of n first, the short-circuit logic would not process the second part of the expression if the test of n failed.

# 4.4 switch Statements



A switch statement implements the logic shown in Figure 4.2 in a different programming style by allowing the programmer to consider a number of different cases for the value of one variable. First we consider the general, language-independent template for switch statements, and then its MATLAB implementation.

### General Template

Template 4.2 shows the general template for the switch statement.

Note the following:

* + - * All tests refer to the value of the same parameter
      * case specifications may be either a single value or a set of parameters enclosed in braces { ... }
      * otherwise specifies the code block to be executed when none of the case values apply
      * The code blocks may contain any sequence of legal MATLAB statements, including other if statements (nested ifs), switch statements, or iterations

**Template 4.2** General template for the switch statement

switch <parameter>

case <case specification 1>

<code block 1>

case <case specification 2>

<code block 2>

.

.

end

case <case specification n>

<code block n> otherwise

<default code block>

* 1. switch Statements **89**

### MATLAB Implementation

Listing 4.4 shows the MATLAB implementation of a typical logical problem: determining the number of days in a month. It assumes that the value of month is 1 . . . 12, and leapYear is a logical variable identifying the current year as a leap year.

### Style Points 4.1

The usual description of the logic suggests that the last case in Listing 4.4 could be the otherwise clause. However, that would prevent you from being able to detect bad month number values, as this code does.

### Hint 4.1

The second parameter to the input(...) statement prevents MATLAB from attempting to parse the data provided, returning a string instead. Without that activity suppressed, if you enter the string 'yes', MATLAB will rush off looking for a variable by that name.

### Style Points 4.2

The use of indentation is not required in the MATLAB language, and it has no significance with regard to syntax. However, the appropriate use of indentation greatly improves the legibility of code and you should use it. You have probably already noted that in addition to colorizing control statements, the text editor automatically places the control statements in the indented positions illustrated in Listings 4.3 and 4.4.

In Listing 4.4:

Line 1: All tests refer to the value of the variable month.

Line 2: This case specification is a cell array (See Chapter 7 for specifics) containing the indices of the months with 30 days.

Line 3: The code block extends from the case statement to the next control statement (case, otherwise, or end).

Line 5: This code block contains an if statement to deal with the February case. It presumes that a Boolean variable leapYear has been created to indicate whether this month is in a leap year.

Lines 10–11: Deal with the remaining months.

Line 13: A built-in MATLAB function that announces the error and terminates the script.

**Listing 4.4** Example of a switch statement

* + - 1. switch month

2. case {9, 4, 6, 11}

% Sept, Apr, June, Nov

1. days = 30;
2. case 2 % Feb
3. if leapYear
4. days = 29;
5. else
6. days = 28;
7. end

10. case {1, 3, 5, 7, 8, 10, 12}

% other months

1. days = 31;
2. otherwise
3. error('bad month index')
4. end

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**Exercise 4.2** Using the switch statement

Write and test the script in Listing 4.4 using input(...) to request a numerical month value.

You will need to preset a value for leapYear.

Test your script by running it repeatedly for legal and illegal values of the month.

Modify your script to ask whether the current year is a leap year. (It’s best to ask only for February.) You could use code like the following:

ans = input('leap year (yes/no)', 's'); leapYear = (ans(1) == 'y');

Test this new script thoroughly.

Try this script without the second parameter to input(...). Can you explain what is happening?

Modify the script again to accept the year rather than yes/no, and implement the logic to determine whether that year is a leap year.

Try using the switch statement in Exercise 4.2.



# Iteration in General



**Iteration** allows controlled repetition of a code block. Control statements at the beginning of the code block specify the manner and extent of the repetition:

* The for loop is designed to repeat its code block a fixed number of times and largely automates the process of managing the iteration.
* The while loop is more flexible in character. In contrast to the fixed repetition of the for loop, its code block can be repeated a variable number of times, depending on the values of data being processed. It is much more of a “do-it-yourself” iteration kit.

The if and switch statements allow us to decide to skip code blocks based on conditions in the data. The for and while constructs allow us to repeat code blocks. Note, however, that the MATLAB language is designed to avoid iteration. Under most circumstances of processing numbers, the array processing operations built into the language make do-it-yourself loop constructs unnecessary.

# for Loops



Figure 4.3 shows a simple for loop. The hexagonal shape illustrates the control of repetition. The repeated execution of the code block is performed under the control of a loop-control variable. It is first set to an initial value

* 1. for Loops **91**

For

<Loop>

Done

Computations

**Figure 4.3** *Structure of a* for *loop*

that is tested against a terminating condition. If the terminating test succeeds, the program leaves the for loop. Otherwise, the computations in the code block are performed using the current value of that variable. When one pass through the code block is finished, the variable is updated to its next value, and control returns to the termination test.

### General for Loop Template

The general template for implementing for loops is shown in Template 4.3. All of the mechanics of iteration control are handled automatically in the variable specification section. In some languages—especially those with their origins in C—the variable specification is a formidable collection of statements that provide great generality of loop management. The designers of the MATLAB language, with its origins in matrix processing, chose a much simpler approach for specifying the variable range, as shown in the general template. The repetition of the code block is managed completely by the specification of the loop control variable.

### MATLAB Implementation

The core concept in the MATLAB for loop implementation is in the style of the variable specification, which is accomplished as follows:

<variable specification>: <variable> = <vector>

where <variable> is the name of the loop control variable and <vector> is any vector that can be created by the techniques discussed in Chapter 3. If

**Template 4.3** General template for the for statement

for <variable specification>

<code block>

end

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we were to use the variable specification x = A, MATLAB would proceed as follows:

1. Set an invisible index to 1.
2. Repeat steps 3 to 5 as long as that index is less than or equal to the length of A.
3. Set the value of x to A(index)
4. Evaluate the code block with that value of x
5. Increment the index

For a simple example of for loops, the code shown in Listing 4.5 solves a problem that should be done in a single MATLAB instruction: max(A) where A is a vector of integers. However, by expanding this into a for loop, we see the basic structure of the for loop at work.

In Listing 4.5:

Line 1: Creates a vector A with six elements.

Line 2: The tidiest way to find limits of a collection of numbers is to seed the result, theMax, with the first number.

Line 3: Iterates across the values of A.

Lines 4–6: The code block extends from the for statement to the

### Common Pitfalls 4.2

By setting the default answer to the first value, we avoid the problem of seeding the result with a value that could be already outside the range of the vector values. For example, we might think that theMax = 0; would be a satisfactory seed. However, this would not do well if all the elements of A were negative.

associated end statement. The code will be executed the same number of times as the length of A *even if you change the value of* x *within the code block*. At each iteration, the value of x will be set to the next element from the array A.

Line 8: The fprintf(...)function is a very flexible means of formatting output to the Command window. See the discussion in Chapter 8, or enter the following in the Command window:

> help fprintf

**Listing 4.5** Example of a for statement

* 1. A = [6 12 6 91 13 6] % initial vector
  2. theMax = A(1); % set initial max value
  3. for x = A % iterate through A
  4. if x > theMax % test each element
  5. theMax = x;
  6. end
  7. end
  8. fprintf('max(A) is %d\n', theMax);
  9. for Loops **93**

### IndexingImplementation

The above for loop implementation may seem very strange to those with a C-based language background, in which the loop-control variable is usually an index into the array being traversed rather than an element from that array. In order to illustrate the difference, we will adapt the code from Listing 4.5 to solve a slightly different problem that approximates the behavior of max(A). This time we need to know not only the maximum value in the array, but also its index. This requires that we resort to indexing the array in a more conventional style, as shown in Listing 4.6.

In Listing 4.6:

Line 1: Generalizes the creation of the vector A using the rand(...) function to create a vector with 10 elements each between 0 and 100. The ceil(...) function rounds each value up to the next higher integer.

Lines 2 and 3: Initialize theMax and theIndex.

Line 4: Creates an anonymous vector of indices from 1 to the length of A and uses it to define the loop-control variable, index.

Line 5: Extracts the appropriate element from A to operate with as before.

Lines 6 and 7: The same comparison logic as shown in Listing 4.5. Line 8: In addition to saving the new max value, we save the index where it occurs.

Line 11: This is our first occurrence where a logical line of code extends beyond the physical limitations of a single line. Since MATLAB normally uses the end of the line to indicate the end of an operation, we use ellipses (...) to specify that the logic is continued onto the next line.

You can enter and run these scripts by following Exercise 4.3.

**Listing 4.6** for statement using indexing

1. A = floor(rand(1,10)\*100)

* + 1. theMax = A(1);
    2. theIndex = 1;
    3. for index = 1:length(A)
    4. x = A(index);
    5. if x > theMax
    6. theMax = x;
    7. theIndex = index;
    8. end
    9. end
    10. fprintf('the max value in A is %d at %d\n', ...
    11. theMax, theIndex);

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**Exercise 4.3** Producing for statement results

Enter and run the scripts in Listings 4.5 and 4.6. They should each produce the following results:

A =

6 12 6 91 13 61 26 22 71 54

the max value in A is 91 at 4

>>

### Breaking out of a for Loop

If you are in a for loop and find a circumstance where you really do not want to continue iterating, the break statement will skip immediately out of the innermost containing loop. If you want to continue iterating but omit all further steps of the current iteration, you can use the continue statement.

# 4.7 while Loops



We use while loops in general to obtain more control over the number of times the iteration is repeated. Figure 4.4 illustrates the control flow for a while loop. Since the termination test is performed before the loop is entered, the loop control expression must be initialized to a state that will normally permit loop entry. It is possible that the code block is not executed at all—for example—if there is no data to process.

### 4.7.1 General while Template

Template 4.4 shows the general template for implementing while loops. The logical expression controlling the iteration is testing some state of the workspace; therefore, two things that were automatic in the for loop must be manually accomplished with the while loop: initializing the test and updating the workspace in the code block so that the test will eventually fail and the iteration will stop.

Initialization

while

<Expression>

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
|  | Computations | |
|  |  |

False

True

**Figure 4.4** *Structure of a* while *loop*

* 1. while Loops **95**

**Template 4.4** General template for the while statement

<initialization>

while <logical expression>

<code block> % must make some changes

% to enable the loop to terminate

end

### MATLAB while Loop Implementation

For the sake of consistency, Listing 4.7 shows you how to solve the same problem using the while syntax.

In Listing 4.7:

Lines 1–3: Create a test vector and initialize the answers as before. Line 4: Initializes the index value since this is manually updated. Line 5: This test will fail immediately if the vector A is empty.

Line 6: Extracts the item x from the array (good practice in general to clarify your code).

Lines 7–9: The same test as before to update the maximum value. Line 11: “Manually” updates the index to move the loop closer to finishing.

Enter and run the script as described in Exercise 4.4.

**Listing 4.7** while statement example

1. A = floor(rand(1,10)\*100)

* + - 1. theMax = A(1);
      2. theIndex = 1;
      3. index = 1;
      4. while index <= length(A)
      5. x = A(index);
      6. if x > theMax
      7. theMax = x;
      8. theIndex = index;
      9. end
      10. index = index + 1;
      11. end
      12. fprintf('the max value in A is %d at %d\n', ...
      13. theMax, theIndex);



**Exercise 4.4** Producing while statement results

Enter and run the script in Listing 4.7. It should produce the following results:

A =

6 12 6 91 13 61 26 22 71 54

the max value in A is 91 at 4

>>

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### Loop-and-a-Half Implementation

Listing 4.8 illustrates the implementation of the loop-and-a-half iteration style, in which we must enter the loop and perform some computation before realizing that we do not need to continue. Here we continually ask the user for the radius of a circle until an illegal radius is entered, which is our cue to terminate the iteration. For each radius entered, we want to display the area and circumference of the circle with that radius.

### Style Points 4.3

We wrote the for loop examples in two styles: the direct access style and the indexing style. Many people code in the indexing style even when the index value is not explicitly required. This is slightly tacky and demonstrates a lack of appreciation for the full power of the MATLAB language.

### Style Points 4.4

The use of break and continue statements is frowned upon in programming circles for the same reason that the goto statement has fallen into disrepute—they make it more difficult to understand the flow of control through a complex program. It is preferable to express the logic for remaining in a while loop explicitly in its controlling logical expression, combined with if statements inside the loop to skip blocks of code. However, sometimes this latter approach causes code to be more complex than would be the case with judicious use of break or continue.

In Listing 4.8:

Line 1: Initializes the radius value to allow the loop to be entered the first time.

Line 2: We will remain in this loop until the user enters an illegal radius. Line 3: The input(...)function shows the user the text string,

parses what is typed, and stores the

result in the variable provided.

This is described fully in Chapter 8.

Line 4: We want to present the area and circumference only if the radius has a legal value. Since this test occurs in the middle of the while loop, we call this “loop-and- a-half” processing.

Lines 5–8: Compute and display the area and circumference of a circle.

Try this script in Exercise 4.5.

**Listing 4.8** Loop-and-a-half example

* + - 1. clear
      2. clc
      3. close all

% Listing 04.08 Loop-and-a-half example 4. R = 1;

1. while R > 0
2. R = input('Enter a radius: ');
3. if R > 0
4. area = pi \* R^2;
5. circum = 2 \* pi \* R;
6. . fprintf('area = %f; circum = %f\n', ... 1 1 . area, circum);
7. . end
8. end

**4.8** Engineering Example—Computing Liquid Levels **97**



**Exercise 4.5** Producing loop-and-a-half test results

Enter and run the script in Listing 4.8. It should produce the following results:

Enter a radius: 4

area = 50.265482; circum = 25.132741 Enter a radius: 3

area = 28.274334; circum = 18.849556 Enter a radius: 100

area = 31415.926536; circum = 628.318531

Enter a radius: 0

>>

### 4.7.4 Breaking a while Loop

As with the for loop, break will exit the innermost while loop, and continue

will skip to the end of the loop but remain within it.

* 1. **Engineering Example—Computing Liquid Levels**

Figure 4.5 shows a cylindrical tank of height *H* and radius *r* with a spherical cap on each end (also of radius, *r* ). If the height of the liquid is *h*, what is the volume of liquid in the tank? Clearly, the calculation of the volume of liquid in the tank depends upon the relationship between *h, H,* and *r*:



* + - If *h* is less than *r*, we need the volume, *v*, of a partially filled sphere given by:

1 2

*v* = p*h* (3*r* - *h*) 3

* + - If *h* is greater than *r* but less than *H* 2 *r*, we need the volume of a fully filled hemisphere plus the volume of a cylinder of height *h* 2 *r*:

2

*v* = p*r* 3

3

+ p*r*

2(*h* - *r* )

H

h r

**Figure 4.5** *A tank containing liquid*

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* If *h* is greater than *H* 1 *r*, we need the volume of a fully filled sphere plus the volume of a cylinder of height *H* 1 *2r* minus the partially empty upper hemisphere of height *H* 1 *h*:

4 3 2 1 2

*v* = p*r*

3

+ p*r*

(*H* - 2*r* ) -

p(*H* - *h*) (3*r* - *H* + *h*) 3

The script to perform this calculation is shown in Listing 4.9. Rather than performing the computations for one liquid level only, we should write the script so that we continue to consider tanks of different dimensions and different liquid heights for each tank until the user indicates that he needs no more results.

In Listing 4.9:

Line 1: Initializes the value to keep it in the first while loop. Lines 3 and 4: Get the tank sizes.

Line 5: Initializes the value to keep it in the inner while loop. Line 7: Gets the liquid height.

Lines 8–14: Calculations for legal values of *h*. Notice that no dot operators are required here, because these conditional computations will not work correctly with vectors of *H, r,* or *h*.

**Listing 4.9** Script to compute liquid levels

1. another\_tank = true;
2. while another\_tank
3. H = input('Overall tank height: ');
4. r = input('tank radius: ');
5. more\_heights = true;
6. while more\_heights
7. h = input('liquid height: ');
8. if h < r

9. v = (1/3)\*pi\*h.^2.\*(3\*r-h);

10. elseif h < H-r

11. v = (2/3)\*pi\*r^3 + pi\*r^2\*(h-r);

12. elseif h <= H

13. v = (4/3)\*pi\*r^3 + pi\*r^2\*(H-2\*r) ...

14. - (1/3)\*pi\*(H-h)^2\*(3\*r-H+h);

1. else
2. disp('liquid level too high')
3. continue
4. end
5. fprintf( ...

20. 'rad %0.2f ht %0.2f level %0.2f vol %0.2f\n', ...

1. r, H, h, v);
2. more\_heights = input('more levels? (y/n)','s')=='y';
3. end
4. another\_tank = input('another tank? (y/n)','s')=='y';
5. end

Chapter Summary **99**

**Table 4.1 Results for liquid levels**

Overall tank height: 10

tank radius: 2

liquid height: 1

radius 2.00 height 10.00 level 1.00 vol 5.24

more levels? (y/n)y

liquid height: 8

radius 4.00 height 8.00 level 8.00 vol 268.08

more levels? (y/n)

another tank? (y/n)

Lines 15 and 16: Illegal *h* values end up here.

Line 17: Goes to the end of the inner loop, skipping the printout. Lines 19–21: Print the result.

Line 22: More levels when “y” is entered. Line 24: Another tank when “y” is entered.

Table 4.1 shows some typical results.

**Chapter Summary**

*This chapter presented techniques for changing the flow of control of a program for condition execution and repetitive execution:*



* + The most general conditional form is the if statement, with or without the accompanying elseif and else statements
  + The switch statement considers different cases of the values of a countable variable
  + A for loop in its most basic form executes a code block for each of the elements of a vector
  + A while loop repeats a code block a variable number of times, as long as the conditions specified for continuing the repetition remain true

**100 Chapter 4** Execution Control



## Special Characters, Reserved Words, and Functions

|  |  |  |
| --- | --- | --- |
| **Special Characters, Reserved Words, and Functions** | **Description** | **Discussed in This Section** |
| false | Logical false | 4.2 |
| true | Logical true | 4.2 |
| break | A command within a loop module that forces | 4.6.4, 4.7.4 |
|  | control to the statement following the |  |
|  | innermost loop |  |
| case | A specific value within a switch statement | 4.1, 4.4.1 |
| continue | Skips to the end of the innermost loop, but | 4.6.4, 4.7.4 |
|  | remains inside it |  |
| else | Within an if statement, begins the code block executed when the condition is false | 4.1, 4.3.2 |
| elseif | Within an if statement, begins a second test when the first condition is false | 4.1, 4.3.2 |
| end | Terminates an if, switch, for, or while module | 4.1, 4.3.2 |
| for var = v | A code module repeats as many times as there are elements in the vector v | 4.1, 4.6 |
| if <exp> | Begins a conditional module; the following code block is executed if the logical expression | 4.1, 4.3.2 |
|  | <exp> is true |  |
| input(str) | Requests and parses input from the user | 4.3.2 |
| otherwise | Catch-all code block at the end of a switch  statement | 4.1, 4.4.1 |
| switch(variable) | Begins a code module selecting specific values of the variable (must be countable) | 4.1, 4.4.1 |
| while <exp> | A code module repeats as long as the logical | 4.1 |
|  | expression <exp> is true |  |
| all(a) | True if all the values in a, a logical vector, a, are true | 4.3.3 |
| and(a, b) | True if both a and b are true (can be vectors) | 4.3.3 |
| any(a) | True if any of the values in a, a logical vector, is true | 4.3.3 |
| not(a) | True if a is false; false if a is true (can be vectors) | 4.3.3 |
| or(a, b) | True if either a or b is true (can be vectors) | 4.3.3 |

**Self Test**

*Use the following questions to check your understanding of the material in this chapter:*



Programming Projects **101**

### True or False

1. MATLAB keywords are colored green by the editor.
2. Indentation is required in MATLAB to define code blocks.
3. It is possible that no code at all is executed by if or switch

constructs.

1. The word true is a valid logical expression.
2. When evaluating a sequence of logical && expressions, MATLAB will stop processing when it finds the first true result.
3. The for loop repeats the enclosed code block a fixed number of times even if you modify the index variable within the code block.
4. Using a break statement is illegal in a while loop.
5. The logical expression used in a while loop specifies the conditions for exiting the loop.

### Fill in the Blanks

1. MATLAB uses in the text to define the extent of code blocks.
2. The function is implicitly called by MATLAB if you supply a vector of logical values to the if statement.
3. It is good practice to include in a switch statement to trap illegal values entering the switch.
4. There is no reason to evaluate any more components of a logical or expression once a(n) result has been found.
5. A while loop can be repeated a number of times, depending on the

being processed.

1. If you are in a(n) loop, you can use the break

statement to skip immediately out of the loop.

## Programming Projects

1. Write a script to solve this problem. Assume that you have a vector named D. Using iteration (for and/or while) and conditionals (if and/or switch), separate vector D into four vectors posEven, negEven, posOdd, and negOdd.



* + posEven contains all of the positive even numbers in D.
  + negEven contains all of the negative even numbers in D.
  + posOdd contains all of the positive odd numbers in D.
  + negOdd contains all of the negative odd numbers in D.

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***For example:***

if D = [-4,-3,-2,-1,0,1,2,3,4],

posEven=[2,4], negEven=[-4,-2], posOdd=[1,3] and negOdd=[-3,-1]

1. You must use either for or while to solve the following problems.
2. Iterate through a vector, A, using a for loop, and create a new

vector, B, containing logical values. The new vector should

contain true for positive values and false for all other values. For

example, if A = [−300 2 5 −63 4 0 −46], the result should be

B = [false true true false true true false]

1. Iterate through the vector, A, using a while loop, and return a new vector, B, containing true for positive values and false for all other values.
2. Iterate through a logical array, N, using a for loop, and return a new vector, M, containing the value 2 wherever an element of N is true and the value −1 (not a logical value) wherever N is false. For example, if N = [true false false true true false true], the result should be M = [2 −1 −1 2 2 −1 2]
3. Iterate through an array, Z, using a while loop. Replace every element with the number 3 until you reach a number larger than

50. Leave the rest unchanged. For example, if Z = [4 3 2 5 7 9 0

64 34 43], after running your script, Z = [3 3 3 3 3 3 3 3 34 43]

1. You are hiring grad students to work for your company, which you have recently started. The Human Resources department has asked you to write a script that will help them determine the chances of an individual applicant getting a job after interviewing. The following table outlines the rules for determining the chances for the applicant to get a job:

|  |  |
| --- | --- |
| GPA Value | Chance of Being Hired |
| GPA>= 3.5 | 90% |
| 3.0<= GPA < 3.5 | 80% |
| 2.5 <= GPA < 3.0 | 70% |
| 2.0 <= GPA < 2.5 | 60% |
| 1.5 <= GPA < 2.0 | 40% |
| GPA < 1.5 | 30% |

Your script should repeatedly ask the user for a GPA value and compute the student’s chances of being hired. It should continue asking for GPA values until a negative number is entered. For example:

* GPA input: 4 should give the answer 0.9
* GPA input: 3.5 should give the answer 0.9
* GPA input: 3.4 should give the answer 0.8

Programming Projects **103**

1. You were just hired for a summer internship with one of the area’s best software companies; however, on your first day of work you learn that for the next three months, the only job you will have is to convert binary (base 2) numbers into decimal numbers (base 10). You decide to write a script that will repetitively ask the user for a binary number and return its decimal equivalent until an illegal number (one containing digits other than 0 or 1) is entered. The number entered should contain only the digits 0 and 1. The rightmost digit has the value 20 and the digit N places to the left of that has the value 2N. For example, entering 110101 returns

53 = 25 + 24 + 23 + 20

You must use iteration to solve this problem. Note: The input (...) function prompts the user for a value, parses the characters entered according to normal MATLAB rules, and returns the result.

1. You have a friend who has too many clothes to store in his or her tiny wardrobe. Being a good friend, you offer to help to decide whether each piece of clothing is worth saving. You decide to write a script that will compute the value of each piece of clothing. A piece of clothing has five attributes that can be used to determine its value. The attributes are: condition, color, price, number of matches, and comfort. Each attribute will be rated on a scale of 1 to 5. Write a script called clothes that will ask the user for the ratings for each attribute and store the result in a vector. The order of attributes in the vector is: [condition color price matches comfort]

The script should compute a value between 0 and 100; 100 represents a good piece of clothing, while 0 represents a bad piece of clothing. The points that should be given for each attribute are shown below:

Condition: 1=>0; 2=>5; 3=>10; 4=>15; 5=>20

Color: 1 => blue => 12;

2 => red => 2;

3 => pink => 15;

4 => yellow => 20;

5 => white => 12

Price: 1 => 8, 2–3 => 16, 4–5 => 20

Matches: 1–2 => 8, 3–5 => 19

Comfort: 1 => 6, 2–3 => 13, 4–5 =>18

Note: If a number other than 1–5 is assigned for one of the

attributes, no points should be given.

1. A “yard” is a traditional English container. It is 36 inches long, and can be approximated by a 4-inch diameter glass sphere attached to a conical section whose narrow end is 1 inch in diameter, and

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### Hint

whose wide end is 6 inches in diameter. Write a script to do the following:

1. ask the user for the height of the liquid in the yard, and
2. calculate the volume of liquid needed to fill the yard to that level.
3. Now that you’re comfortable with iteration, you’re going to have to solve an interesting problem. It seems that the Math department at a rival university has once again dropped the ball, and forgotten the value of pi. You are to write a function called mypi, which consumes a number that specifies the required accuracy and then approximates the value of pi to that accuracy. You are going to use the following algorithm based on geometric probability.

Think about a quarter circle inside of a unit square (the quarter circle has area p/4). You pick a random point inside the square. If it is in the quarter circle, you get a “hit”; and if not, you get a “miss.” The approximate area of the quarter circle will be given by the number of hits divided by the number of points you chose.

Your function should repeat the process of counting hits and misses until at least 10,000 tries have been

you could use the function rand (...) in this problem.

made, and the successive estimates of pi are within the prescribed accuracy. It should return the estimated value of pi.