8. JavaScript: Control Statements II

Who can control his fate?

—William Shakespeare

Not everything that can be counted counts, and not every thing that counts can be counted.

—Albert Einstein

Objectives

In this chapter you'll:

- Learn the essentials of counter-controlled repetition
- Use the `for` and `do`…`while` repetition statements to execute statements in a program repeatedly.
- Perform multiple selection using the `switch` selection statement.
- Use the `break` and `continue` program-control statements
- Use the logical operators to make decisions.

Outline

8.1. Introduction

In this chapter, we introduce JavaScript's remaining control statements (with the exception of `for` ... `in`, which is presented in Chapter 10). In later chapters, you'll see that control statements also are helpful in manipulating objects.

8.2. Essentials of Counter-Controlled Repetition

Counter-controlled repetition requires:

1. The *name* of a control variable (or loop counter).
2. The *initial value* of the control variable.
3. The *increment* (or *decrement*) by which the control variable is modified each time through the loop (also known as *each iteration of the loop*).
4. The condition that tests for the *final value* of the control variable to determine whether looping should continue.

To see the four elements of counter-controlled repetition, consider the simple script shown in Fig. 8.1, which displays lines of HTML5 text that illustrate the seven different font sizes supported by HTML5. The declaration in line 11 *names* the control variable (`counter`), *reserves* space for it in memory and sets it to an *initial value* of `1`. The declaration and initialization of `counter` could also have been accomplished by these statements:

```
var counter; // declare counter
counter = 1; // initialize counter to 1
```

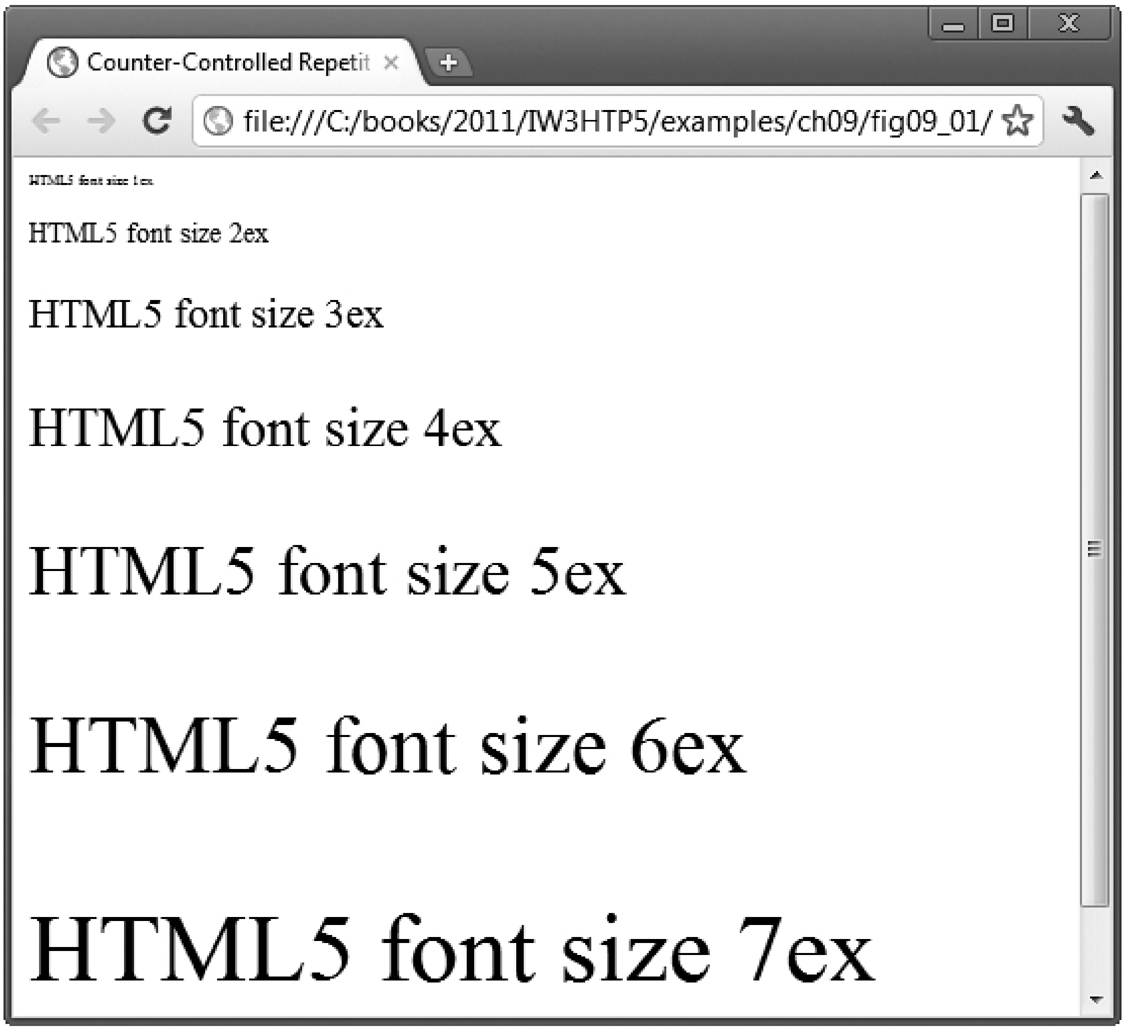
Lines 15–16 in the `while` statement write a paragraph element consisting of the string “ `HTML5 font size` ” concatenated with the control variable `counter` ’s value, which represents the font size. An inline CSS `style` attribute sets the `font-size` property to the value of `counter` concatenated with `ex` .

Line 17 in the `while` statement *increments* the control variable by 1 for each iteration of the loop (i.e., each time the body of the loop is performed). The loop-continuation condition (line 13) in the `while` statement tests whether the value of the control variable is less than or equal to `7` (the *final value* for which the condition is `true`). Note that the body of this `while` statement executes even when the control variable is `7` . The loop terminates when the control variable exceeds `7` (i.e., `counter` becomes `8`).

```
1  <!DOCTYPE html>
2
3  <!-- Fig. 8.1: WhileCounter.html -->
4  <!-- Counter-controlled repetition. -->
5  <html>
6    <head>
7      <meta charset = "utf-8">
8      <title>Counter-Controlled Repetition</title>
9      <script>
10
11         var counter = 1; // initialization
12
13         while ( counter <= 7 ) // repetition condition
14         {
15           document.writeln( "<p style = 'font-size: " +
16             counter + "ex'>HTML5 font size " + counter + "ex</p>" );
17           ++counter; // increment
18         } //end while
```

```

      </script>
   </head><body></body>
</html>
```


Counter-Controlled Repetit
file:///C:/books/2011/IW3HTP5/examples/ch09/fig09_01/

```
HTML5 font size 1ex
HTML5 font size 2ex
HTML5 font size 3ex
HTML5 font size 4ex
HTML5 font size 5ex
HTML5 font size 6ex
HTML5 font size 7ex
```

Fig. 8.1. Counter-controlled repetition.

8.3. `for` Repetition Statement

The **`for` repetition statement** conveniently handles all the details of counter-controlled repetition. Figure 8.2 illustrates the power of the `for` statement by reimplementing the script of Fig. 8.1. The outputs of these scripts are identical.

```
<!DOCTYPE html>

```

```
 3 <!-- Fig. 8.2: ForCounter.html -->
 4 <!-- Counter-controlled repetition with the for statement. -->
 5 <html>
 6   <head>
 7     <meta charset="utf-8">
 8     <title>Counter-Controlled Repetition</title>
 9     <script>
10
11        // Initialization, repetition condition and
12        // incrementing are all included in the for
13        // statement header.
14        for ( var counter = 1; counter <= 7; ++counter )
15           document.writeln( "<p style = 'font-size: " +
16              counter + "ex'>HTML5 font size " + counter + "ex</p>" );
17
18      </script>
19    </head><body></body>
20 </html>
```

Fig. 8.2. Counter-controlled repetition with the `for` statement.

When the `for` statement begins executing (line 14), the control variable `counter` is declared *and* initialized to `1`. Next, the loop-continuation condition, `counter <= 7`, is checked. The condition contains the *final value* (`7`) of the control variable. The initial value of `counter` is `1`. Therefore, the condition is satisfied (i.e., `true`), so the body statement (lines 15–16) writes a paragraph element in the `body` of the HTML5 document. Then, variable `counter` is incremented in the expression `++counter` and the loop continues execution with the loop-continuation test. The control variable is now equal to `2`, so the final value is not exceeded and the program performs the body statement again (i.e., performs the next iteration of the loop). This process continues until the control variable `counter` becomes `8`, at which point the loop-continuation test fails and the repetition terminates.

The program continues by performing the first statement after the `for` statement. (In this case, the script terminates, because the interpreter reaches the end of the script.)

Figure 8.3 takes a closer look at the `for` statement at line 14 of Fig. 8.2. The `for` statement's first line (including the keyword `for` and everything in parentheses after it) is often called the **`for` statement header**. Note that the `for` statement "does it all"—it specifies each of the items needed for counter-controlled repetition with a control variable. Remember that a block is a group of statements enclosed in curly braces that can be placed anywhere that a single statement can be placed, so you can use a block to put multiple statements into the body of a `for` statement, if necessary.

A Closer Look at the `for` Statement's Header

Figure 8.3 uses the loop-continuation condition `counter <= 7`. If you incorrectly write `counter < 7`, the loop will execute only *six* times. This is an example of the common logic error called an **off-by-one error**.

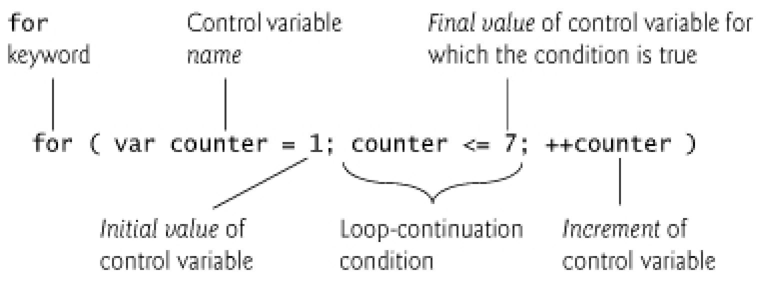

for keyword
Control variable name
Final value of control variable for which the condition is true
for (var counter = 1; counter <= 7; ++counter)
Initial value of control variable
Loop-continuation condition
Increment of control variable

Fig. 8.3. `for` statement header components.

General Format of a `for` Statement

The general format of the `for` statement is

for (*initialization*; *loopContinuationTest*; *increment*)
  statements

where the *initialization* expression names the loop's control variable and provides its initial value, *loopContinuationTest* is the expression that tests the loop-continuation condition (containing the final value of the control variable for which the condition is `true`), and *increment* is an expression that increments the control variable.

Optional Expressions in a `for` Statement Header

The three expressions in the `for` statement's header are optional. If *loop-ContinuationTest* is omitted, the loop-continuation condition is `true`, thus creating an *infinite loop*. One might omit the *initialization* expression if the control variable is initialized before the loop. One might omit the *increment* expression if the increment is calculated by statements in the loop's body or if no increment is needed. The two semicolons in the header are required.

Arithmetic Expressions in the `for` Statement's Header

The initialization, loop-continuation condition and increment portions of a `for` statement can contain arithmetic expressions. For example, assume that `x = 2` and `y = 10`. If `x` and `y` are not modified in the body of the loop, then the statement

```
for ( var j = x; j <= 4 * x * y; j += y / x )
```

is equivalent to the statement

```
for ( var j = 2; j <= 80; j += 5 )
```

Negative Increments

The "increment" of a `for` statement may be negative, in which case it's really a *decrement* and the loop actually counts *downward*.

Loop-Continuation Condition Initially `false`

If the loop-continuation condition initially is `false`, the `for` statement's body is not performed. Instead, execution proceeds with the statement following the `for` statement.

ERROR-PREVENTION TIP 8.1

Although the value of the control variable can be changed in the body of a `for` statement, avoid changing it, because doing so can lead to subtle errors.

Flowcharting a `for` Statement

The `for` statement is flowcharted much like the `while` statement. For example, Fig. 8.4 shows the flowchart of the `for` statement in lines 14–17 of Fig. 8.2. This flowchart makes it clear that the initialization occurs only once and that incrementing occurs *after* each execution of the body statement. Note that, besides *small circles* and *arrows*, the flowchart contains only *rectangle symbols* and a *diamond symbol*.

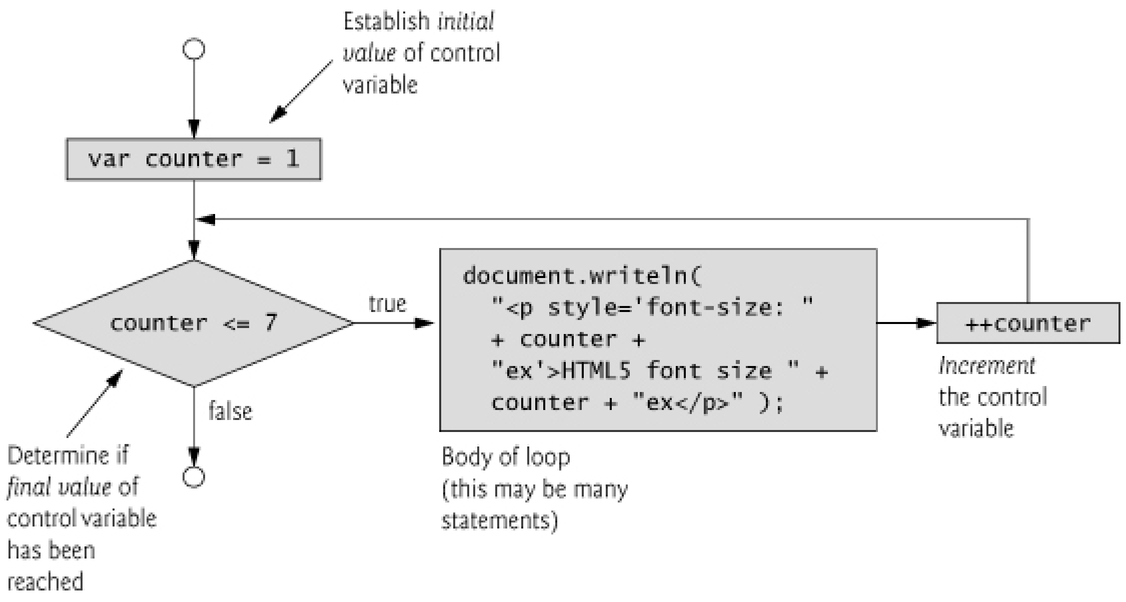

Establish *initial value* of control variable
var counter = 1
counter <= 7
true
false
document.writeln("<p style='font-size: " + counter + "ex'>HTML5 font size " + counter + "ex</p>");
++counter
Increment the control variable
Determine if *final value* of control variable has been reached
Body of loop (this may be many statements)

Fig. 8.4. `for` repetition statement flowchart.

8.4. Examples Using the `for` Statement

The examples in this section show methods of varying the control variable in a `for` statement. In each case, we write the appropriate `for` header. Note the change in the relational operator for loops that *decrement* the control variable.

a. Vary the control variable from `1` to `100` in increments of `1`.

```
for ( var i = 1; i <= 100; ++i )
```

b. Vary the control variable from `100` to `1` in increments of `-1` (i.e., *decrements* of `1`).

```
for ( var i = 100; i >= 1; --i )
```

c. Vary the control variable from `7` to `77` in steps of `7`.

```
for ( var i = 7; i <= 77; i += 7 )
```

d. Vary the control variable from `20` to `2` in steps of `-2`.

```
for ( var i = 20; i >= 2; i -= 2 )
```

COMMON PROGRAMMING ERROR 8.1

Not using the proper relational operator in the loop-continuation condition of a loop that counts downward (e.g., using `i <= 1` instead of `i >= 1` in a loop that counts down to 1) is a logic error.

Summing Integers with a `for` Statement

Figure 8.5 uses the `for` statement to sum the even integers from `2` to `100`. Note that the increment expression (line 13) adds `2` to the control variable `number` *after* the body executes during each iteration of the loop. The loop terminates when `number` has the value `102` (which is *not* added to the sum), and the script continues executing at line 16.

```
1  <!DOCTYPE html>
2
3  <!-- Fig. 8.5: Sum.html -->
```

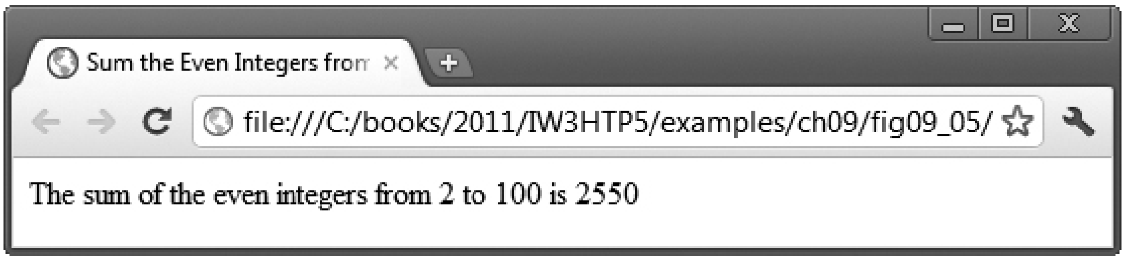
```
<!-- Summation with the for repetition structure. -->
<html>
  <head>
    <meta charset = "utf-8">
    <title>Sum the Even Integers from 2 to 100</title>
    <script>

       var sum = 0;

       for ( var number = 2; number <= 100; number += 2 )
          sum += number;

       document.writeln( "The sum of the even integers " +
          "from 2 to 100 is " + sum );

     </script>
   </head><body></body>
</html>
```


Sum the Even Integers from
file:///C:/books/2011/IW3HTP5/examples/ch09/fig09_05/

```
The sum of the even integers from 2 to 100 is 2550
```

Fig. 8.5. Summation with the `for` repetition structure.

The body of the `for` statement in Fig. 8.5 actually could be merged into the rightmost (increment) portion of the `for` header by using a comma, as follows:

```
for ( var number = 2; number <= 100; sum += number, number += 2)
   ;
```

In this case, the comma represents the **comma operator**, which guarantees that the expression to its left is evaluated before the expression to its right. Similarly, the initialization `sum= 0` could be merged into the initialization section of the `for` statement.

GOOD PROGRAMMING PRACTICE 8.1

Although statements preceding a `for` statement and in the body of a `for` statement can often be merged into the `for` header, avoid doing so, because it makes the program more difficult to read.

Calculating Compound Interest with the `for` Statement

The next example computes compound interest (compounded yearly) using the `for` statement. Consider the following problem statement:

A person invests $1000.00 in a savings account yielding 5 percent interest. Assuming that all the interest is left on deposit, calculate and print the amount of money in the account at the end of each year for 10 years. Use the following formula to determine the amounts:

$a = p\,(1 + r)^n$

where

p is the original amount invested (i.e., the principal)

r is the annual interest rate

n is the number of years

a is the amount on deposit at the end of the nth year.

This problem involves a loop that performs the indicated calculation for each of the 10 years the money remains on deposit. Figure 8.6 presents the solution to this problem, displaying the results in a table. Lines 9–18 define an embedded CSS style sheet that formats various aspects of the table. The CSS property **`border-collapse`** (line 11) with the value `collapse` indicates that the table's borders should be merged so that there is no extra space between adjacent cells or between cells and the table's border. Lines 13–14 specify the formatting for the `table`, `td` and `th` elements, indicating that they should all have a `1px solid black` border and padding of `4px` around their contents.

```
 1  <!DOCTYPE html>
 2
 3  <!-- Fig. 8.6: Interest.html -->
 4  <!-- Compound interest calculation with a for loop. -->
 5  <html>
 6     <head>
 7        <meta charset = "utf-8">
 8        <title>Calculating Compound Interest</title>
 9        <style type = "text/css">
10           table        { width: 300px;
11                          border-collapse: collapse;
12                          background-color: lightblue; }
13           table, td, th { border: 1px solid black;
14                          padding: 4px; }
15           th           { text-align: left;
16                          color: white;
17                          background-color: darkblue; }
18           tr.oddrow    { background-color: white; }
19        </style>
20        <script>
21
22           var amount; // current amount of money
23           var principal = 1000.00; // principal amount
24           var rate = 0.05; // interest rate
25
26           document.writeln("<table>" ); // begin the table
27           document.writeln(
28              "<caption>Calculating Compound Interest</caption>" );
```

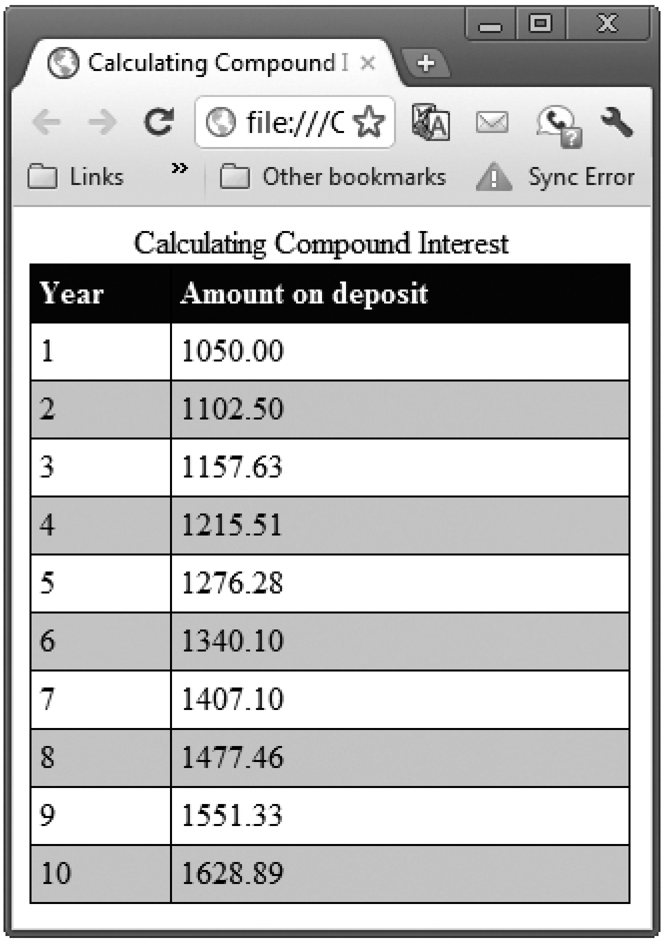
```
         document.writeln(
            "<thead><tr><th>Year</th>" ); // year column heading
         document.writeln(
            "<th>Amount on deposit</th>" ); // amount column heading
         document.writeln( "</tr></thead><tbody>" );

         // output a table row for each year
         for ( var year = 1; year <= 10; ++year )
         {
            amount = principal * Math.pow( 1.0 + rate, year );

            if ( year % 2 !== 0 )
               document.writeln( "<tr class='oddrow'><td>" + year +
                  "</td><td>" + amount.toFixed(2) + "</td></tr>" );
            else
               document.writeln( "<tr><td>" + year +
                  "</td><td>" + amount.toFixed(2) + "</td></tr>" );
         } //end for

         document.writeln( "</tbody></table>" );

      </script>
   </head><body></body>
</html>
```



Calculating Compound Interest

Year	Amount on deposit
1	1050.00
2	1102.50
3	1157.63
4	1215.51
5	1276.28
6	1340.10
7	1407.10
8	1477.46
9	1551.33
10	1628.89

Fig. 8.6. Compound interest calculation with a `for` loop.

Outputting the Beginning of an HTML5 `table`

Lines 22–24 declare three variables and initialize `principal` to `1000.0` and `rate` to `.05`. Line 26 writes an HTML5 `<table>` tag, and lines 27–28 write the `caption` that summarizes the table's content. Lines 29–30 create the table's header section (`<thead>`), a row (`<tr>`) and a column heading (`<th>`) containing "`Year`." Lines 31–32 create a table heading for "`Amount on deposit`", write the closing `</tr>` and `</thead>` tags, and write the opening tag for the body of the table (`<body>`).

Performing the Interest Calculations

The `for` statement (lines 36–46) executes its body 10 times, incrementing control variable `year` from 1 to 10 (note that `year` represents *n* in the problem statement). JavaScript does *not* include an exponentiation operator—instead, we use the `Math` object's `pow` method. `Math.pow(x, y)` calculates the value of `x` raised to the `y` th power. Method `Math.pow` takes two numbers as arguments and returns the result. Line 38 performs the calculation using the formula given in the problem statement.

Formatting the `table` Rows

Lines 40–45 write a line of HTML5 markup that creates the next row in the table. If it's an odd-numbered row, line 41 indicates that the row should be formatted with the CSS style class `oddrow` (defined on line 18) —this allows us to format the background color differently for odd- and even-numbered rows to make the table more readable. The first column is the current `year` value. The second column displays the value of `amount`. Line 48 writes the closing `</tbody>` and `</table>` tags after the loop terminates.

`Number` Method `toFixed`

Lines 42 and 45 introduce the **`Number` object** and its **`toFixed` method**. The variable `amount` contains a numerical value, so JavaScript represents it as a `Number` object. The `toFixed` method of a `Number` object formats the value by rounding it to the specified number of decimal places. On line 34, `amount.toFixed(2)` outputs the value of amount with *two* decimal places, which is appropriate for dollar amounts.

A Warning about Displaying Rounded Values

Variables `amount`, `principal` and `rate` represent numbers in this script. Remember that JavaScript represents all numbers as floating-point numbers. This feature is convenient in this example, because we're dealing with fractional parts of dollars and need a type that allows decimal points in its values.

Unfortunately, floating-point numbers can cause trouble. Here's a simple example of what can go wrong when using floating-point numbers to represent dollar amounts displayed with two digits to the right of the decimal point: Two dollar amounts stored in the machine could be 14.234 (which would normally be rounded to 14.23 for display as a dollar amount) and 18.673 (which would normally be rounded to 18.67). When these amounts are added, they produce the *internal* sum 32.907, which would normally be rounded to 32.91 for display purposes. Thus your printout could appear as:

```
  14.23
+ 18.67
-------
  32.91
```

but a person adding the individual numbers as printed would expect the sum to be 32.90. You've been warned!

8.5. `switch` Multiple-Selection Statement

Previously, we discussed the `if` single-selection statement and the `if`…`else` double-selection statement. Occasionally, an algorithm will contain a series of decisions in which a variable or expression is tested separately for each of the values it may assume, and different actions are taken for each value. JavaScript provides the `switch` multiple-selection statement to handle such decision making. The script in Fig. 8.7 demonstrates three different CSS list formats determined by the value the user enters.

```
<!DOCTYPE html>

<!-- Fig. 8.7: SwitchTest.html -->
<!-- Using the switch multiple-selection statement. -->
<html>
  <head>
    <meta charset = "utf-8">
    <title>Switching between HTML5 List Formats</title>
    <script>

      var choice; // user's choice
      var startTag; // starting list item tag
      var endTag; // ending list item tag
      var validInput = true; // true if input valid else false
      var listType; // type of list as a string

```

```
choice = window.prompt( "Select a list style:\n" +
   "1 (numbered), 2 (lettered), 3 (roman numbered)", "1" );

switch ( choice )
{
  case "1":
    startTag = "<ol>";
    endTag = "</ol>";
    listType = "<h1>Numbered List</h1>";
    break;
  case "2":
    startTag = "<ol style = 'list-style-type: upper-alpha'>";
    endTag = "</ol>";
    listType = "<h1>Lettered List</h1>";
    break;
  case "3":
    startTag = "<ol style = 'list-style-type: upper-roman'>";
    endTag = "</ol>";
    listType = "<h1>Roman Numbered List</h1>";
    break;
  default:
    validInput = false;
    break;
} //end switch

if ( validInput === true )
{
  document.writeln( listType + startTag );

  for ( var i = 1; i <= 3; ++i )
    document.writeln( "<li>List item " + i + "</li>" );

  document.writeln( endTag );
} //end if
else
  document.writeln( "Invalid choice: " + choice );
```

```

      </script>
   </head><body></body>
</html>
```

Javascript
X

Fig. 8.7. Using the `switch` multiple-selection statement.

Line 11 declares the variable `choice`. This variable stores the user's choice, which determines what type of HTML5 ordered list to display. Lines 12–13 declare variables `startTag` and `endTag`, which will store the HTML5 tags that will be used to create the list element. Line 14 declares variable `validInput` and initializes it to `true`. The script uses this variable to determine whether the user made a valid choice (indicated by the value of `true`). If a choice is invalid, the script sets `validInput` to `false`. Line 15 declares variable `listType`, which will store an `h1` element indicating the list type. This heading appears before the list in the HTML5 document.

Lines 17–18 prompt the user to enter a `1` to display a numbered list, a `2` to display a lettered list and a `3` to display a list with roman numerals. Lines 20–40 define a **`switch` statement** that assigns to the variables `startTag`, `endTag` and `listType` values based on the value input by the user in the `prompt` dialog. We create these different lists using the CSS property **`list-style-type`**, which allows us to set the numbering system for the list. Possible values include `decimal` (numbers—the *default*), `lower-roman` (lowercase Roman numerals), `upper-roman` (uppercase Roman numerals), `lower-alpha` (lowercase letters), `upper-alpha` (uppercase letters), and more.

The `switch` statement consists of a series of **`case` labels** and an optional **`default` case** (which is normally placed last). When the flow of control reaches the `switch` statement, the script evaluates the **controlling ex-**

pression (`choice` in this example) in the parentheses following keyword `switch` . The value of this expression is compared with the value in each of the `case` labels, starting with the first `case` label. Assume that the user entered `2` . Remember that the value typed by the user in a `prompt` dialog is returned as a string. So, the string `2` is compared to the string in each `case` in the `switch` statement. If a match occurs (`case "2":`), the statements for that `case` execute. For the string `2` (lines 28–31), we set `startTag` to an opening `ol` tag with the style property `list-style-type` set to `upper-alpha` , set `endTag` to `"</ol>"` to indicate the end of an ordered list and set `listType` to `"<h1>Lettered List</h1>"` . If no match occurs between the controlling expression's value and a `case` label, the `default` case executes and sets variable `validInput` to `false` .

The **`break`** statement in line 31 causes program control to proceed with the first statement after the `switch` statement. The `break` statement is used because the `case` s in a `switch` statement would otherwise run together. If `break` is not used anywhere in a `switch` statement, then each time a match occurs in the statement, the statements for that case *and* all the remaining `case` s execute.

Next, the flow of control continues with the `if` statement in line 42, which tests whether the variable `validInput` is `true` . If so, lines 44–49 write the `listType` , the `startTag` , three list items (`<li>`) and the `endTag` . Otherwise, the script writes text in the HTML5 document indicating that an invalid choice was made (line 52).

Flowcharting the `switch` Statement

Each `case` can have multiple actions (statements). The `switch` statement is different from others in that braces are *not* required around multiple actions in a `case` of a `switch` . The general `switch` statement (i.e., using a `break` in each `case`) is flowcharted in Fig. 8.8.

Fig. 8.8. `switch` multiple-selection statement.

The flowchart makes it clear that each `break` statement at the end of a `case` causes control to exit from the `switch` statement immediately. The `break` statement is *not* required for the last `case` in the `switch` statement (or the `default` case, when it appears last), because program control simply continues with the next statement after the `switch` statement. Having several `case` labels listed together (e.g., `case 1: case 2:` with no statements between the cases) simply means that the *same* set of actions is to occur for each of these cases.

8.6. `do` … `while` Repetition Statement

The **`do` … `while` repetition statement** is similar to the `while` statement. In the `while` statement, the loop-continuation test occurs at the *beginning* of the loop, *before* the body of the loop executes. The `do` … `while` statement tests the loop-continuation condition *after* the loop body executes—therefore, *the loop body always executes at least once.* When a `do` … `while` terminates, execution continues with the statement after the `while` clause. It's not necessary to use braces in a `do` … `while` statement if there's only one statement in the body.

The script in Fig. 8.9 uses a `do` … `while` statement to display each of the six different HTML5 heading types (`h1` through `h6`). Line 11 declares control variable `counter` and initializes it to `1`. Upon entering the `do` ... `while` statement, lines 14–16 write a line of HTML5 text in the document. The value of control variable `counter` is used to create the starting and ending header tags (e.g., `<h1>` and `</h1>`) and to create the line of text to display (e.g., `This is an h1 level head`). Line 17 increments the `counter` before the loop-continuation test occurs at the bottom of the loop.

```
1  <!DOCTYPE html>
2
3  <!-- Fig. 8.9: DoWhileTest.html -->
4  <!-- Using the do...while repetition statement. -->
5  <html>
6    <head>
7      <meta charset = "utf-8">
8      <title>Using the do...while Repetition Statement</title>
9      <script>
10
11        var counter = 1;
12
13        do {
14          document.writeln( "<h" + counter + ">This is " +
15            "an h" + counter + " level head" + "</h" +
16            counter + ">" );
17          ++counter;
18        } while ( counter <= 6 );
19
20     </script>
21
22   </head><body></body>
23 </html>
```

Fig. 8.9. Using the `do … while` repetition statement.

Flowcharting the `do … while` Statement

The `do … while` flowchart in Fig. 8.10 makes it clear that the loop-continuation test does not occur until the action executes at least *once*.

Fig. 8.10. `do … while` repetition statement flowchart.

COMMON PROGRAMMING ERROR 8.2

Infinite loops are caused when the loop-continuation condition never becomes `false` in a `while`, `for` or `do … while` statement. To prevent this, make sure that there's not a semicolon immediately after the header of a `while` or `for` statement. In *a counter-controlled loop, make sure that the control variable is incremented (or decremented) in the body of the loop. In a sentinel-controlled loop, the sentinel value should eventually be input.*

8.7. `break` and `continue` Statements

In addition to the selection and repetition statements, JavaScript provides the statements `break` and **`continue`** to alter the flow of control. Section 8.5 demonstrated how `break` can be used to terminate a `switch` statement's execution. This section shows how to use `break` in repetition statements.

`break` Statement

The `break` statement, when executed in a `while`, `for`, `do`... `while` or `switch` statement, causes *immediate exit* from the statement. Execution continues with the first statement after the structure. Figure 8.11 demonstrates the `break` statement in a `for` repetition statement. During each iteration of the `for` statement in lines 13–19, the script writes the value of `count` in the HTML5 document. When the `if` statement in line 15 detects that `count` is `5`, the `break` in line 16 executes. This statement terminates the `for` statement, and the program proceeds to line 21 (the next statement in sequence immediately after the `for` statement), where the script writes the value of `count` when the loop terminated (i.e., `5`). The loop executes line 18 only *four* times.

```
1  <!DOCTYPE html>
2
3  <!-- Fig. 8.11: BreakTest.html -->
4  <!-- Using the break statement in a for statement. -->
5  <html>
6    <head>
7      <meta charset = "utf-8">
8      <title>
9        Using the break Statement in a for Statement
```

```
    </title>
    <script>

      for ( var count = 1; count <= 10; ++count )
      {
        if ( count == 5 )
          break; // break loop only if count == 5

        document.writeln( count + " " );
      } //end for

      document.writeln(
        "<p>Broke out of loop at count = " + count + "</p>" );

    </script>
  </head><body></body>
</html>
```

Fig. 8.11. Using the `break` statement in a `for` statement.

`continue` Statement

The `continue` statement, when executed in a `while`, `for` or `do`... `while` statement, skips the remaining statements in the body of the statement and proceeds with the next iteration of the loop. In `while` and `do`... `while` statements, the loop-continuation test evaluates immediately after the `continue` statement executes. In `for` statements, the increment expression executes, then the loop-continuation test evaluates. Improper placement of `continue` before the increment in a `while` may result in an *infinite loop*.

Figure 8.12 uses `continue` in a `for` statement to skip line 19 if line 16 determines that the value of `count` is `5`. When the `continue` statement executes, the script skips the remainder of the `for` statement's body (line 19). Program control continues with the increment of the `for` statement's control variable (line 14), followed by the loop-continuation test to determine whether the loop should continue executing. Although `break` and `continue` execute quickly, you can accomplish what they do with the other control statements, which many programmers feel results in better engineered software.

```
1  <!DOCTYPE html>
2
3  <!-- Fig. 8.12: ContinueTest.html -->
4  <!-- Using the continue statement in a for statement. -->
5  <html>
6    <head>
7      <meta charset = "utf-8">
8      <title>
9        Using the continue Statement in a for Statement
10      </title>
11
12      <script>
13
14        for ( var count = 1; count <= 10; ++count )
15        {
16          if ( count == 5 )
17            continue; // skip remaining loop code only if count == 5
18
19          document.writeln( count + " " );
20        } //end for
21
22        document.writeln( "<p>Used continue to skip printing 5</p>" );
```

```

      </script>

   </head><body></body>
</html>
```

Fig. 8.12. Using the `continue` statement in a `for` statement.

8.8. Logical Operators

So far, we've studied only **simple conditions** such as `count <= 10`, `total > 1000` and `number != sentinelValue`. These conditions were expressed in terms of the relational operators `>`, `<`, `>=` and `<=`, and the equality operators `==` and `!=`. Each decision tested *one* condition. To make a decision based on multiple conditions, we performed these tests in separate statements or in nested `if` or `if`...`else` statements.

JavaScript provides **logical operators** that can be used to form more complex conditions by *combining* simple conditions. The logical operators are **`&&`** (**logical AND**), **`||`** (**logical OR**) and **`!`** (**logical NOT**, also called **logical negation**).

`&&` (Logical AND) Operator

Suppose that, at some point in a program, we wish to ensure that two conditions are *both* `true` before we choose a certain path of execution. In this case, we can use the logical `&&` operator, as follows:

```
if ( gender == 1 && age >= 65 )
  ++seniorFemales;
```

This `if` statement contains two simple conditions. The condition `gender == 1` might be evaluated to determine, for example, whether a person is a female. The condition `age >= 65` is evaluated to determine whether a person is a senior citizen. The `if` statement then considers the combined condition

```
gender == 1 && age >= 65
```

This condition is `true` if and only if *both* of the simple conditions are `true`. If this combined condition is indeed `true`, the count of `seniorFemales` is incremented by `1`. If either or both of the simple conditions are `false`, the program skips the incrementing and proceeds to the statement following the `if` statement. The preceding combined condition can be made more readable by adding redundant parentheses:

```
( gender == 1 ) && ( age >= 65 )
```

The table in Fig. 8.13 summarizes the `&&` operator. The table shows all four possible combinations of `false` and `true` values for *expression1* and *expression2*. Such tables are often called **truth tables**. JavaScript evaluates to `false` or `true` all expressions that include relational operators, equality operators and/or logical operators.

Fig. 8.13. Truth table for the `&&` (logical AND) operator.

`||` (Logical OR) Operator

Now let's consider the `||` (logical OR) operator. Suppose we wish to ensure that *either or both* of two conditions are `true` before we choose a certain path of execution. In this case, we use the `||` operator, as in the following program segment:

```
if ( semesterAverage >= 90 || finalExam >= 90 )
   document.writeln( "Student grade is A" );
```

This statement also contains two simple conditions. The condition `semesterAverage >= 90` is evaluated to determine whether the student deserves an “A” in the course because of a solid performance throughout the semester. The condition `finalExam >= 90` is evaluated to determine whether the student deserves an “A” in the course because of an outstanding performance on the final exam. The `if` statement then considers the combined condition

```
semesterAverage >= 90 || finalExam >= 90
```

and awards the student an “A” if either or both of the simple conditions are `true`. Note that the message `"Student grade is A"` is *not* printed *only* when *both* of the simple conditions are `false`. Figure 8.14 is a truth table for the logical OR operator (`||`).

Fig. 8.14. Truth table for the `||` (logical OR) operator.

The `&&` operator has a higher precedence than the `||` operator. Both operators associate from left to right. An expression containing `&&` or `||` operators is evaluated only until truth or falsity is known. Thus, evaluation of the expression

```
gender == 1 && age >= 65
```

stops immediately if `gender` is not equal to `1` (i.e., the entire expression is `false`) and continues if `gender` is equal to `1` (i.e., the entire expression could still be `true` if the condition `age >= 65` is `true`). Similarly, the `||` operator immediately returns `true` if the first operand is `true`.

This performance feature for evaluation of logical AND and logical OR expressions is called **short-circuit evaluation**.

`!` (Logical Negation) Operator

JavaScript provides the `!` (logical negation) operator to enable you to “reverse” the meaning of a condition (i.e., a `true` value becomes `false`, and a `false` value becomes `true`). Unlike the logical operators `&&` and `||`, which combine two conditions (i.e., they’re *binary* operators), the logical negation operator has only a single condition as an operand (i.e., it’s a *unary* operator). The logical negation operator is placed before a condition to choose a path of execution if the original condition (without the logical negation operator) is `false`, as in the following program segment:

```
if ( ! ( grade == sentinelValue ) )
   document.writeln( "The next grade is " + grade );
```

The parentheses around the condition `grade == sentinelValue` are needed because the logical negation operator has a higher precedence than the equality operator. Figure 8.15 is a truth table for the logical negation operator.

Fig. 8.15. Truth table for operator `!` (logical negation).

In most cases, you can avoid using logical negation by expressing the condition differently with an appropriate relational or equality operator. For example, the preceding statement may also be written as follows:

```
if ( grade != sentinelValue )
   document.writeln( "The next grade is " + grade );
```

Boolean Equivalents of Nonboolean Values

An interesting feature of JavaScript is that most nonboolean values can be converted to a boolean `true` or `false` value (if they're being used in a context in which a boolean value is needed). Nonzero numeric values are considered to be `true`. The numeric value zero is considered to be `false`. Any string that contains characters is considered to be `true`. The empty string (i.e., the string containing no characters) is considered to be `false`. The value `null` and variables that have been declared but not initialized are considered to be `false`. All objects (such as the browser's `document` and `window` objects and JavaScript's `Math` object) are considered to be `true`.

Operator Precedence and Associativity

Figure 8.16 shows the precedence and associativity of the JavaScript operators introduced up to this point. The operators are shown top to bottom in decreasing order of precedence.

Fig. 8.16. Precedence and associativity of the operators discussed so far.

8.9. Web Resources

www.deitel.com/javascript/

The Deitel JavaScript Resource Center contains links to some of the best JavaScript resources on the web. There you'll find categorized links to JavaScript tools, code generators, forums, books, libraries, frameworks and more. Also check out the tutorials for all skill levels, from introductory to advanced. Be sure to visit the related Resource Centers on HTML5 (www.deitel.com/HTML5/) and CSS3 (www.deitel.com/css3/).

Summary

Section 8.2 Essentials of Counter-Controlled Repetition

- Counter-controlled repetition requires: the name of a control variable, the initial value of the control variable, the increment (or decrement) by which the control variable is modified each time through the loop, and the condition that tests for the final value of the control variable to determine whether looping should continue.

Section 8.3 `for` Repetition Statement

- The `for` statement (p. 253) conveniently handles all the details of counter-controlled repetition with a control variable.
- The `for` statement's first line (including the keyword for and everything in parentheses after it) is often called the `for` statement header (p. 254).
- You can use a block to put multiple statements into the body of a `for` statement.
- The `for` statement takes three expressions: an initialization, a condition and an expression.
- The three expressions in the `for` statement are optional. The two semicolons in the `for` statement are required.
- The initialization, loop-continuation condition and increment portions of a `for` statement can contain arithmetic expressions.
- The "increment" of a `for` statement may be negative, in which case it's called a decrement and the loop actually counts downward.
- If the loop-continuation condition initially is `false`, the body of the `for` statement is not performed. Instead, execution proceeds with the statement following the `for` statement.

Section 8.4 Examples Using the `for` Statement

- JavaScript does not include an exponentiation operator. Instead, we use the `Math` object's `pow` method for this purpose. `Math.pow(x, y)` calculates the value of `x` raised to the `y` th power.

- Floating-point numbers can cause trouble as a result of rounding errors.

- To prevent implicit conversions in comparisons, which can lead to unexpected results, JavaScript provides the strict equals (`===`) and strict does not equal (`!==`) operators.

Section 8.5 `switch` Multiple-Selection Statement

- JavaScript provides the `switch` multiple-selection statement (p. 263), in which a variable or expression is tested separately for each of the values it may assume. Different actions are taken for each value.

- The CSS property `list-style-type` (p. 263) allows you to set the numbering system for the list. Possible values include `decimal` (numbers—the default), `lower-roman` (lowercase roman numerals), `upper-roman` (uppercase roman numerals), `lower-alpha` (lowercase letters), `upper-alpha` (uppercase letters), and more.

- The `switch` statement consists of a series of case labels and an optional default case (which is normally placed last, p. 263). When the flow of control reaches the `switch` statement, the script evaluates the controlling expression in the parentheses following keyword `switch` . The value of this expression is compared with the value in each of the `case` labels, starting with the first `case` label (p. 263). If the comparison evaluates to `true` , the statements after the case label are executed in order until a `break` statement is reached.

- The `break` statement is used as the last statement in each `case` to exit the switch statement immediately.

- Each `case` can have multiple actions (statements). The `switch` statement is different from other statements in that braces are not required around multiple actions in a `case` of a `switch`.

- The `break` statement is not required for the last `case` in the `switch` statement, because program control automatically continues with the next statement after the `switch` statement.

- Having several `case` labels listed together (e.g., `case 1: case 2:` with no statements between the cases) simply means that the same set of actions is to occur for each case.

Section 8.6 `do`… `while` Repetition Statement

- The `do`… `while` statement (p. 264) tests the loop-continuation condition *after* the loop body executes—therefore, *the loop body always executes at least once.*

Section 8.7 `break` and `continue` Statements

- The `break` statement, when executed in a repetition statement, causes immediate exit from the statement. Execution continues with the first statement after the repetition statement.

- The `continue` statement, when executed in a repetition statement, skips the remaining statements in the loop body and proceeds with the next loop iteration. In `while` and `do`… `while` statements, the loop-continuation test evaluates immediately after the `continue` statement executes. In `for` statements, the increment expression executes, then the loop-continuation test evaluates.

Section 8.8 Logical Operators

- JavaScript provides logical operators that can be used to form more complex conditions by combining simple conditions. The logical operators are `&&` (logical AND; p. 268), `||` (logical OR; p. 268) and `!` (logical NOT, also called logical negation; p. 268).

- The && operator is used to ensure that two conditions are both `true` before choosing a certain path of execution.

- JavaScript evaluates to `false` or `true` all expressions that include relational operators, equality operators and/or logical operators.

- The `||` (logical OR) operator is used to ensure that either or both of two conditions are `true` before choosing choose a certain path of execution.

- The `&&` operator has a higher precedence than the `||` operator. Both operators associate from left to right.

- An expression containing `&&` or `||` operators is evaluated only until truth or falsity is known. This is called short-circuit evaluation (p. 270).

- JavaScript provides the `!` (logical negation) operator to enable you to “reverse” the meaning of a condition (i.e., a `true` value becomes `false`, and a `false` value becomes `true`).

- The logical negation operator has only a single condition as an operand (i.e., it’s a unary operator). The logical negation operator is placed before a condition to evaluate to `true` if the original condition (without the logical negation operator) is `false`.

- The logical negation operator has a higher precedence than the equality operator.

- Most nonboolean values can be converted to a boolean `true` or `false` value. Nonzero numeric values are considered to be `true`. The numeric value zero is considered to be `false`. Any string that contains characters is considered to be `true`. The empty string (i.e., the string containing no characters) is considered to be `false`. The value `null` and variables that have been declared but not initialized are considered to be `false`. All objects (e.g., the browser’s `document` and `window` objects and JavaScript’s `Math` object) are considered to be `true`.

Self-Review Exercises

8.1 State whether each of the following is *true* or *false*. If *false*, explain why.

a. The `default` case is required in the `switch` selection statement.

b. The `break` statement is required in the last case of a `switch` selection statement.

c. The expression `( x > y && a < b )` is true if either `x > y` is true or `a < b` is true.

d. An expression containing the `||` operator is true if either or both of its operands is true.

8.2 Write a JavaScript statement or a set of statements to accomplish each of the following tasks:

a. Sum the odd integers between 1 and 99. Use a `for` statement. Assume that the variables `sum` and `count` have been declared.

b. Calculate the value of `2.5` raised to the power of `3`. Use the `pow` method.

c. Print the integers from 1 to 20 by using a `while` loop and the counter variable `x`. Assume that the variable `x` has been declared, but not initialized. Print only five integers per line. [*Hint:* Use the calculation `x % 5`. When the value of this expression is `0`, start a new paragraph in the HTML5 document.]

d. Repeat Exercise 8.2(c), but using a `for` statement.

8.3 Find the error in each of the following code segments, and explain how to correct it:

a.

```
x = 1;
while ( x <= 10 );
  ++x;
}
```

b.

```
switch ( n )
{
  case 1:
    document.writeln( "The number is 1" );
  case 2:
    document.writeln( "The number is 2" );
    break;
  default:
    document.writeln( "The number is not 1 or 2" );
    break;
}
```

c. The following code should print the values from 1 to 10:

```
n = 1;
while ( n < 10 )
  document.writeln( n++ );
```

Answers to Self-Review Exercises

8.1

a. False. The `default` case is optional. If no default action is needed, then there's no need for a `default` case.

b. False. The `break` statement is used to exit the `switch` statement. The `break` statement is not required for the last case in a `switch` statement.

c. False. Both of the relational expressions must be true for the entire expression to be true when using the `&&` operator.

d. True.

8.2

a.

```
sum = 0;
for ( count = 1; count <= 99; count += 2 )
   sum += count;
```

b.

```
Math.pow( 2.5, 3 )
```

c.

```
x = 1;
document.writeln( "<p>" );
while ( x <= 20 ) {
   document.write( x + " " );
   if ( x % 5 == 0 )
      document.write( "</p><p>" );
   ++x;
}
```

d.

```
document.writeln( "<p>" );
for ( x = 1; x <= 20; x++ ) {
    document.write( x + " " );
   if ( x % 5 == 0 )
      document.write( "</p><p>" );
}
document.writeln( "</p>" );
```

8.3

a. Error: The semicolon after the `while` header causes an infinite loop, and there's a missing left brace.

Correction: Replace the semicolon by a `{`, or remove both the `;` and the `}`.

b. Error: Missing `break` statement in the statements for the first `case`.

Correction: Add a `break` statement at the end of the statements for the first `case`. Note that this missing statement is not necessarily an error if you want the statement of `case 2:` to execute every time the `case 1:` statement executes.

c. Error: Improper relational operator used in the `while` continuation condition.

Correction: Use `<=` rather than `<`, or change `10` to `11`.

Exercises

8.4 Find the error in each of the following segments of code. [*Note:* There may be more than one error.]

a.

```
For ( x = 100, x >= 1, ++x )
  document.writeln( x );
```

b. The following code should print whether integer value is odd or even:

```
switch ( value % 2 ) {
  case 0:
    document.writeln( "Even integer" );
  case 1:
    document.writeln( "Odd integer" );
}
```

c. The following code should output the odd integers from 19 to 1:

```
for ( x = 19; x >= 1; x += 2 )
  document.writeln( x );
```

d. The following code should output the even integers from 2 to 100:

```
counter = 2;
do {
    document.writeln( counter );
    counter += 2;
  } While ( counter < 100 );
```

8.5 What does the following script do?

```
<!DOCTYPE html>

<!-- Exercise 8.5: ex08_05.html -->
<html>
  <head>
    <meta charset = "utf-8">
    <title>Mystery</title>
    <script>

      document.writeln( "<table>" );

      for ( var i = 1; i <= 7; i++ )
      {
        document.writeln( "<tr>" );

        for ( var j = 1; j <= 5; j++ )
          document.writeln( "<td>(" + i + ", " + j + ")</td>" );

        document.writeln( "</tr>" );
      } // end for

      document.writeln( "</table>" );

     </script>
   </head><body />
 </html>
```

8.6 Write a script that finds the smallest of several nonnegative integers. Assume that the first value read specifies the number of values to be input from the user.

8.7 Write a script that calculates the product of the odd integers from 1 to 15, then outputs HTML5 text that displays the results.

8.8 Modify the compound interest program in Fig. 8.6 to repeat its steps for interest rates of 5, 6, 7, 8, 9 and 10 percent. Use a `for` statement to vary the interest rate. Use a separate table for each rate.

8.9 One interesting application of computers is drawing graphs and bar charts (sometimes called histograms). Write a script that reads five numbers between 1 and 30. For each number read, output HTML5 text that displays a line containing the same number of adjacent asterisks. For example, if your program reads the number 7, it should output HTML5 text that displays `*******`.

8.10 ***("The Twelve Days of Christmas" Song)*** Write a script that uses repetition and a `switch` structures to print the song "The Twelve Days of Christmas." You can find the words at the site

www.santas.net/twelvedaysofchristmas.htm

8.11 A mail-order house sells five different products whose retail prices are as follows: product 1, $2.98; product 2, $4.50; product 3, $9.98; product 4, $4.49; and product 5, $6.87. Write a script that reads a series of pairs of numbers as follows:

a. Product number

b. Quantity sold for one day

Your program should use a `switch` statement to determine each product's retail price and should calculate and output HTML5 that displays the total retail value of all the products sold last week. Use a `prompt` dialog to obtain the product number and quantity from the user. Use a sentinel-controlled loop to determine when the program should stop looping and display the final results.

8.12 Assume that `i = 1`, `j = 2`, `k = 3` and `m = 2`. What does each of the given statements print? Are the parentheses necessary in each case?

a. `document.writeln( i == 1 );`

b. `document.writeln( j == 3 );`

c. `document.writeln( i >= 1 && j < 4 );`

d. `document.writeln( m <= 99 && k < m );`

e. `document.writeln( j >= i || k == m );`

f. `document.writeln( k + m < j || 3 - j >= k );`

g. `document.writeln( !( k > m ) );`

8.13 Given the following `switch` statement:

```
switch ( k )
{
  case 1:
    break;
  case 2:
  case 3:
    ++k;
    break;
  case 4:
     --k;
     break;
   default:
     k *= 3;
 } //end switch

 x = k;
```

What values are assigned to `x` when `k` has values of 1, 2, 3, 4 and 10?