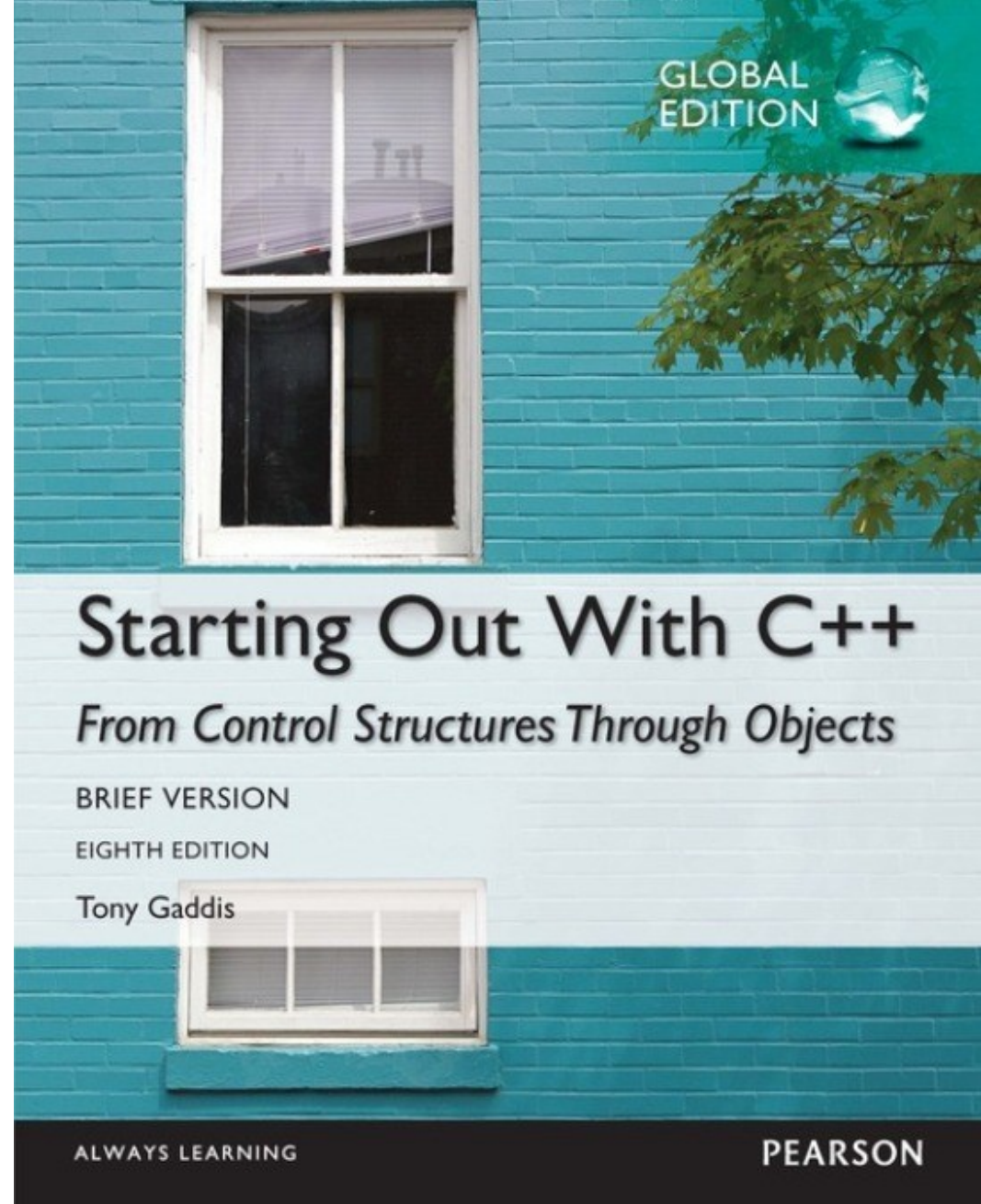


# Chapter 5:

## Loops and Files



# The Increment and Decrement Operators

- `++` is the increment operator.

It adds one to a variable.

`val++;` is the same as `val = val + 1;`

- `++` can be used before (prefix) or after (postfix) a variable:

`++val;`            `val++;`

# The Increment and Decrement Operators

- -- is the decrement operator.

It subtracts one from a variable.

`val--;` is the same as `val = val - 1;`

- -- can be also used before (prefix) or after (postfix) a variable:

`--val;`      `val--;`

# Prefix vs. Postfix

- `++` and `--` operators can be used in complex statements and expressions
- In prefix mode (`++val`, `--val`) the operator increments or decrements, *then* returns the value of the variable
- In postfix mode (`val++`, `val--`) the operator returns the value of the variable, *then* increments or decrements

# Prefix vs. Postfix - Examples

```
int num, val = 12;  
cout << val++; // displays 12,  
               // val is now 13;  
cout << ++val; // sets val to 14,  
               // then displays it  
num = --val;   // sets val to 13,  
               // stores 13 in num  
num = val--;   // stores 13 in num,  
               // sets val to 12
```

# Notes on Increment and Decrement

- Can be used in expressions:

```
result = num1++ + --num2;
```

- Must be applied to something that has a location in memory. Cannot have:

```
result = (num1 + num2)++;
```

- Can be used in relational expressions:

```
if (++num > limit)
```

pre- and post-operations will cause different comparisons

# Introduction to Loops:

## The `while` Loop

- Loop: a control structure that causes a statement or statements to repeat

- General format of the `while` loop:

```
while (expression)  
    statement;
```

- *statement*; can also be a block of statements enclosed in { }

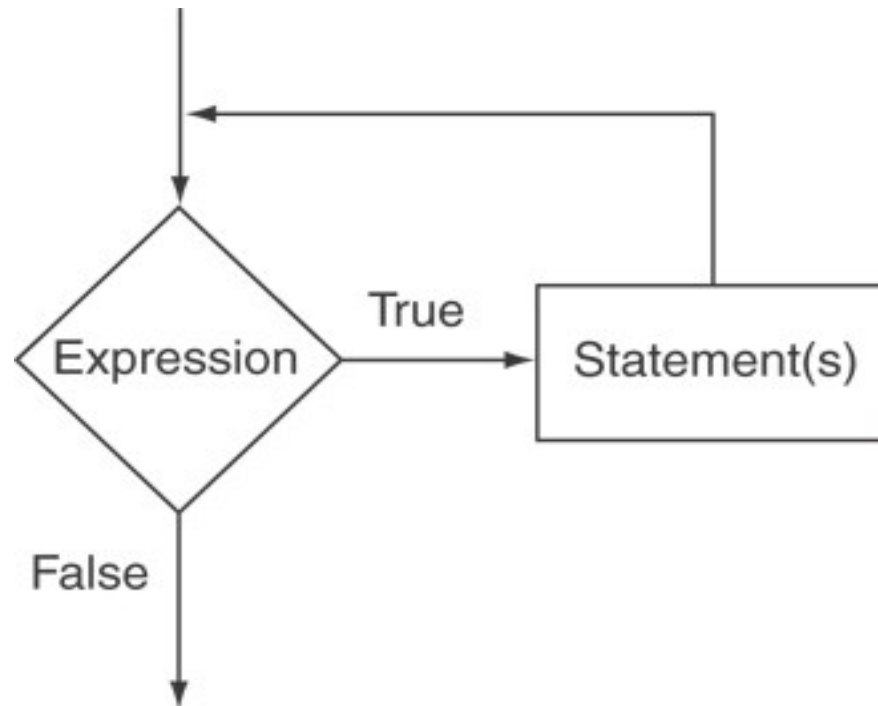
# The `while` Loop – How It Works

```
while (expression)  
    statement;
```

- ***expression* is evaluated**
  - if true, then *statement* is executed, and *expression* is evaluated again
  - if false, then the loop is finished and program statements following *statement* execute



# The Logic of a `while` Loop



# The `while` loop in Program 5-3

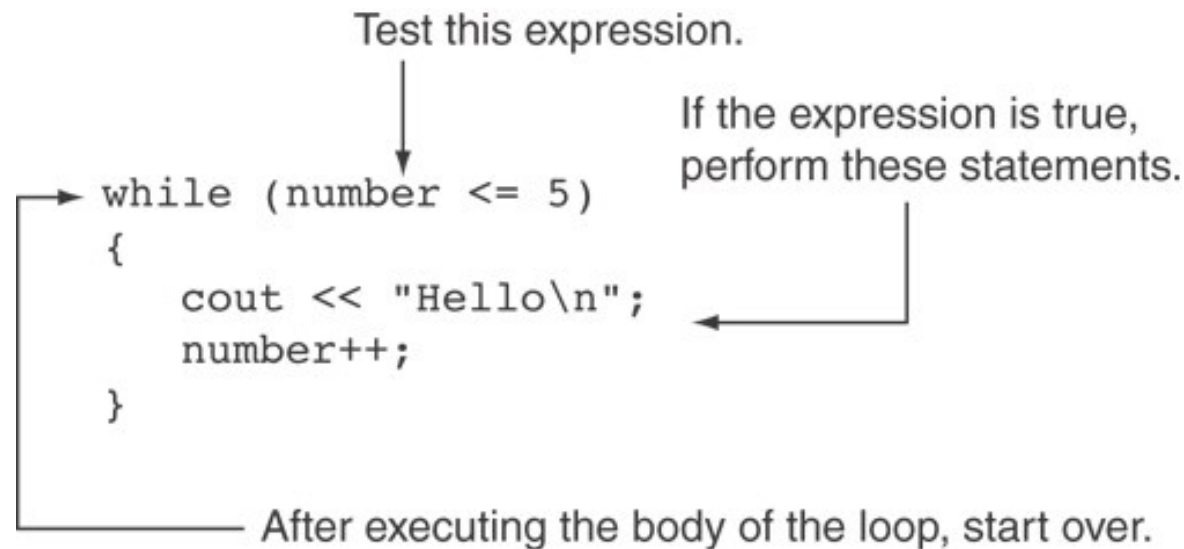
## Program 5-3

```
1 // This program demonstrates a simple while loop.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     int number = 1;
8
9     while (number <= 5)
10    {
11        cout << "Hello\n";
12        number++;
13    }
14    cout << "That's all!\n";
15    return 0;
16 }
```

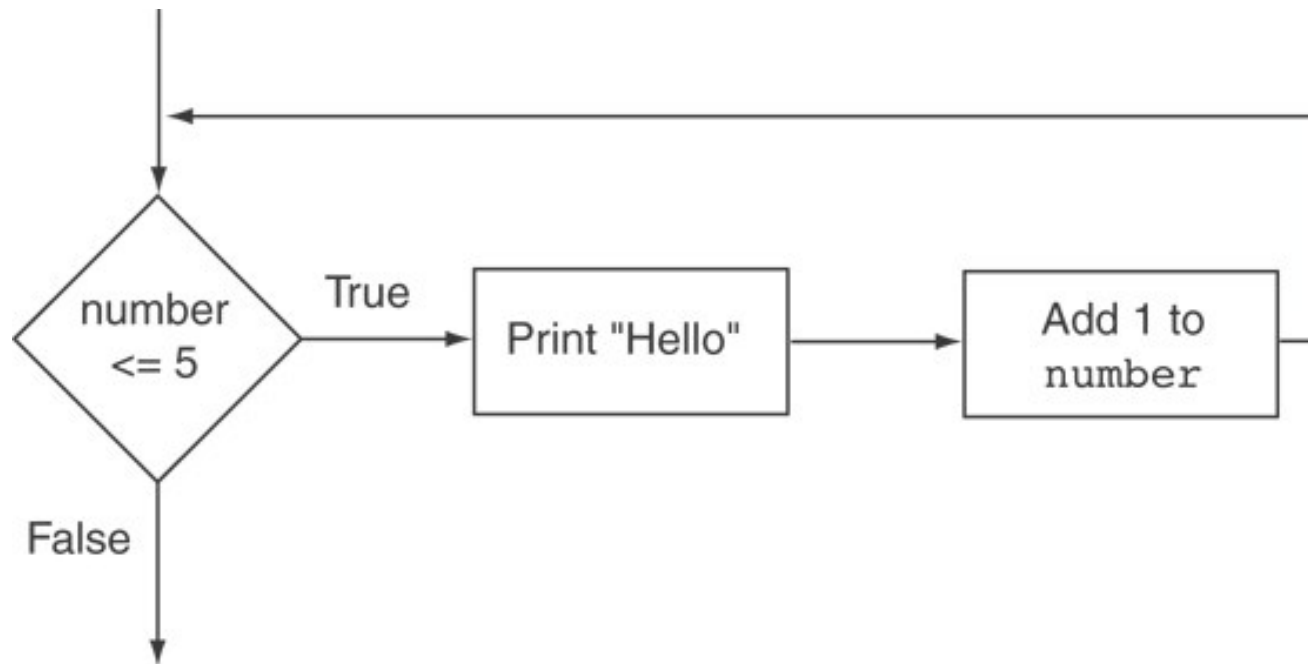
## Program Output

```
Hello
Hello
Hello
Hello
Hello
That's all!
```

# How the `while` Loop in Program 5-3 Lines 9 through 13 Works



# Flowchart of the `while` Loop in Program 5-3



# The `while` Loop is a Pretest Loop

*expression* is evaluated *before* the loop executes. The following loop will never execute:

```
int number = 6;
while (number <= 5)
{
    cout << "Hello\n";
    number++;
}
```

# Watch Out for Infinite Loops

- The loop must contain code to make *expression* **become** `false`
- Otherwise, the loop will have no way of stopping
- Such a loop is called an *infinite loop*, because it will repeat an infinite number of times

# Example of an Infinite Loop

```
int number = 1;
while (number <= 5)
{
    cout << "Hello\n";
}
```

# Using the `while` Loop for Input Validation

- Input validation is the process of inspecting data that is given to the program as input and determining whether it is valid.
- The while loop can be used to create input routines that reject invalid data, and repeat until valid data is entered.



# Using the `while` Loop for Input Validation

- Here's the general approach, in pseudocode:

*Read an item of input.*

*While the input is invalid*

*Display an error message.*

*Read the input again.*

*End While*

# Input Validation Example

```
cout << "Enter a number less than 10: ";
cin >> number;
while (number >= 10)
{
    cout << "Invalid Entry!"
        << "Enter a number less than 10: ";
    cin >> number;
}
```

# Counters

- Counter: a variable that is incremented or decremented each time a loop repeats
- Can be used to control execution of the loop (also known as the loop control variable)
- Must be initialized before entering loop

# A Counter Variable Controls the Loop in Program 5-6

## Program 5-6

```
1 // This program displays a list of numbers and
2 // their squares.
3 #include <iostream>
4 using namespace std;
5
6 int main()
7 {
8     const int MIN_NUMBER = 1,    // Starting number to square
9           MAX_NUMBER = 10;    // Maximum number to square
10
11     int num = MIN_NUMBER;        // Counter
12
13     cout << "Number Number Squared\n";
14     cout << "-----\n";
```

Continued...  
20

# A Counter Variable Controls the Loop in Program 5-6

```
15     while (num <= MAX_NUMBER)
16     {
17         cout << num << "\t\t" << (num * num) << endl;
18         num++; //Increment the counter.
19     }
20     return 0;
21 }
```

## Program Output

Number Number Squared

-----

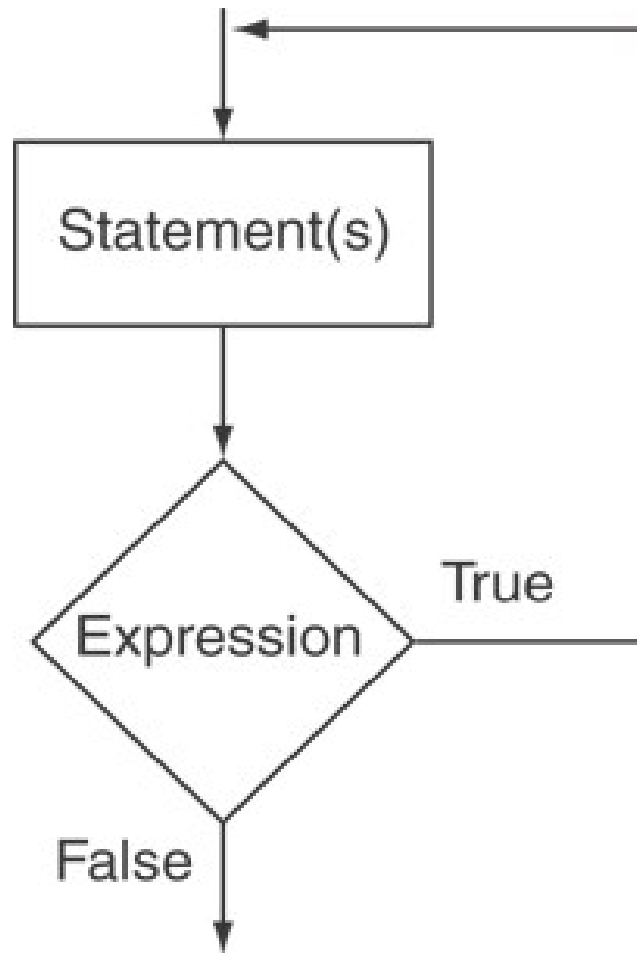
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100

# The do-while Loop

- do-while: a posttest loop – execute the loop, then test the `expression`
- General Format:

```
do
    statement; // or block in { }
while (expression);
```
- Note that a semicolon is required after `(expression)`
- Loop always executes at least once

# The Logic of a do-while Loop



# An Example `do-while` Loop

```
int x = 1;  
do  
{  
    cout << x << endl;  
} while(x < 0);
```

Although the test expression is false, this loop will execute one time because `do-while` is a posttest loop.



# A do-while Loop in Program 5-7

## Program 5-7

```
1 // This program averages 3 test scores. It repeats as
2 // many times as the user wishes.
3 #include <iostream>
4 using namespace std;
5
6 int main()
7 {
8     int score1, score2, score3; // Three scores
9     double average;             // Average score
10    char again;                  // To hold Y or N input
11
12    do
13    {
14        // Get three scores.
15        cout << "Enter 3 scores and I will average them: ";
16        cin >> score1 >> score2 >> score3;
17
18        // Calculate and display the average.
19        average = (score1 + score2 + score3) / 3.0;
20        cout << "The average is " << average << ".\n";
21
22        // Does the user want to average another set?
23        cout << "Do you want to average another set? (Y/N) ";
24        cin >> again;
25    } while (again == 'Y' || again == 'y');
26    return 0;
27 }
```

Continued...  
25

# A do-while Loop in Program 5-7

## Program Output with Example Input Shown in Bold

Enter 3 scores and I will average them: **80 90 70** [Enter]

The average is 80.

Do you want to average another set? (Y/N) **y** [Enter]

Enter 3 scores and I will average them: **60 75 88** [Enter]

The average is 74.3333.

Do you want to average another set? (Y/N) **n** [Enter]

# The `for` Loop

- Useful for counter-controlled loop

- General Format:

```
for(initialization; test; update)  
    statement; // or block in { }
```

- No semicolon after the `update` expression or after the `)`

# for Loop - Mechanics

```
for(initialization; test; update)  
    statement; // or block in { }
```

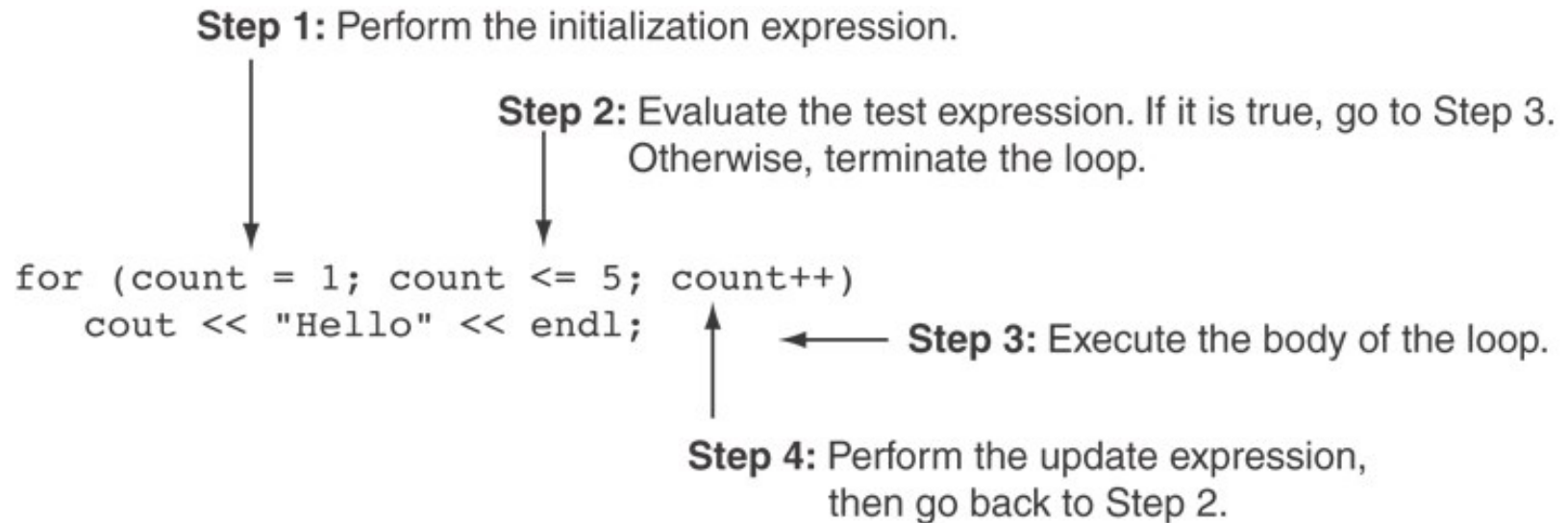
- 1) Perform *initialization*
- 2) Evaluate *test* expression
  - If true, execute *statement*
  - If false, terminate loop execution
- 3) Execute *update*, then re-evaluate *test* expression

# for Loop - Example

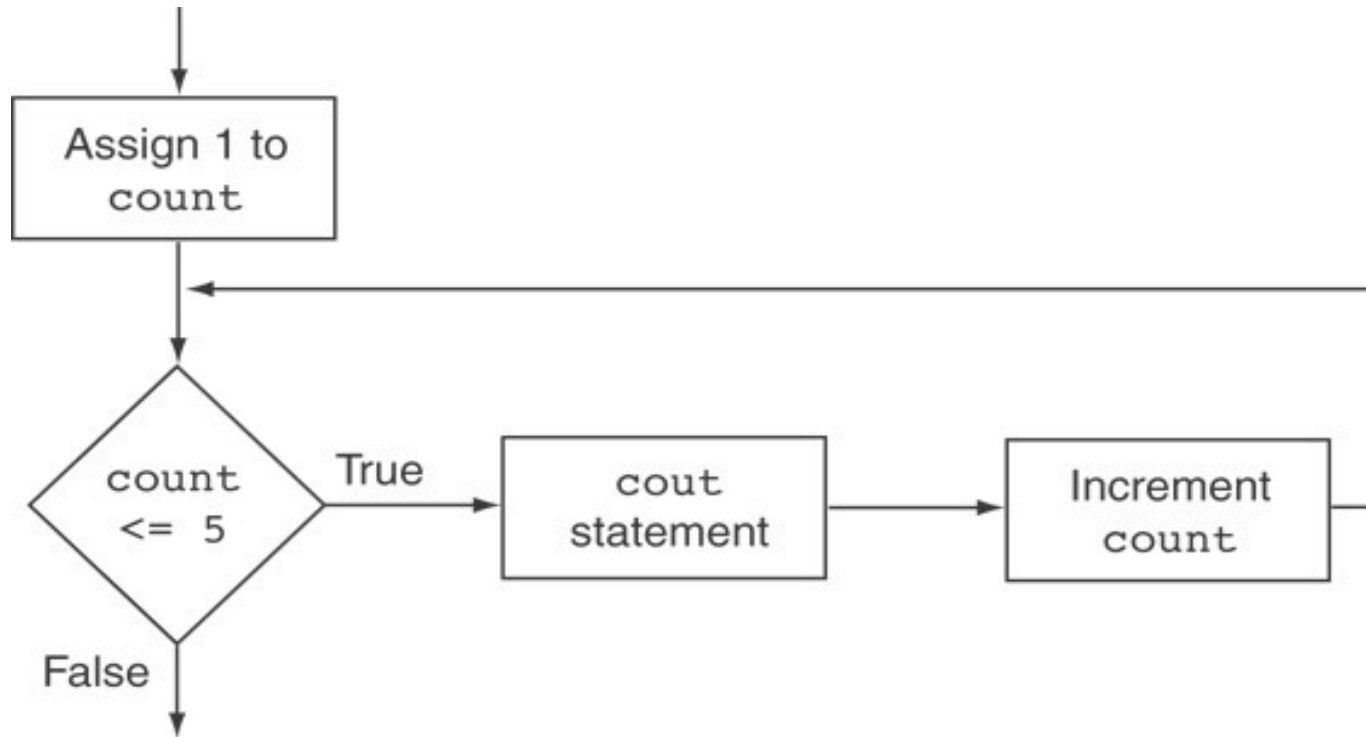
```
int count;
```

```
for (count = 1; count <= 5; count++)  
    cout << "Hello" << endl;
```

# A Closer Look at the Previous Example



# Flowchart for the Previous Example



# A for Loop in Program 5-9

## Program 5-9

```
1 // This program displays the numbers 1 through 10 and
2 // their squares.
3 #include <iostream>
4 using namespace std;
5
6 int main()
7 {
8     const int MIN_NUMBER = 1,    // Starting value
9           MAX_NUMBER = 10;    // Ending value
10    int num;
11
12    cout << "Number Number Squared\n";
13    cout << "-----\n";
14
15    for (num = MIN_NUMBER; num <= MAX_NUMBER; num++)
16        cout << num << "\t\t" << (num * num) << endl;
17
18    return 0;
19 }
```

Continued...  
32



# A `for` Loop in Program 5-9

## Program Output

Number Number Squared

-----

1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100

# The `for` Loop is a Pretest Loop

- The `for` loop tests its test expression before each iteration, so it is a pretest loop.
- The following loop will never iterate:

```
for (count = 11; count <= 10; count++)  
    cout << "Hello" << endl;
```

# for Loop - Modifications

- You can have multiple statements in the *initialization* expression. Separate the statements with a comma:


Initialization Expression

```
int x, y;  
for (x=1, y=1; x <= 5; x++)  
{  
    cout << x << " plus " << y  
        << " equals " << (x+y)  
        << endl;  
}
```

# for Loop - Modifications

- You can also have multiple statements in the *update* expression. Separate the statements with a comma:

```
int x, y;  
for (x=1, y=1; x <= 5; x++, y++)  
{  
    cout << x << " plus " << y  
        << " equals " << (x+y)  
        << endl;  
}
```



# for Loop - Modifications

- You can omit the *initialization* expression if it has already been done:

```
int sum = 0, num = 1;  
for (; num <= 10; num++)  
    sum += num;
```

# for Loop - Modifications

- You can declare variables in the *initialization* expression:

```
int sum = 0;  
for (int num = 0; num <= 10; num++)  
    sum += num;
```

The scope of the variable `num` is the `for` loop.

# Keeping a Running Total

- running total: accumulated sum of numbers from each repetition of loop
- accumulator: variable that holds running total

```
int sum=0, num=1; // sum is the accumulator
while (num <= 10)
{
    sum += num;
    num++;
}
cout << "Sum of numbers 1 – 10 is"
      << sum << endl;
```

# Sentinels

- sentinel: value in a list of values that indicates end of data
- Used to terminate input when user may not know how many values will be entered



# A Sentinel in Program 5-13

## Program 5-13

```
1  // This program calculates the total number of points a
2  // soccer team has earned over a series of games. The user
3  // enters a series of point values, then -1 when finished.
4  #include <iostream>
5  using namespace std;
6
7  int main()
8  {
9      int game = 1,    // Game counter
10         points,      // To hold a number of points
11         total = 0;    // Accumulator
12
13     cout << "Enter the number of points your team has earned\n";
14     cout << "so far in the season, then enter -1 when finished.\n\n";
15     cout << "Enter the points for game " << game << ": ";
16     cin >> points;
17
18     while (points != -1)
19     {
20         total += points;
21         game++;
22         cout << "Enter the points for game " << game << ": ";
23         cin >> points;
24     }
25     cout << "\nThe total points are " << total << endl;
26     return 0;
27 }
```

Continued...  
41

# A Sentinel in Program 5-13

## Program Output with Example Input Shown in Bold

Enter the number of points your team has earned  
so far in the season, then enter -1 when finished.

Enter the points for game 1: **7 [Enter]**  
Enter the points for game 2: **9 [Enter]**  
Enter the points for game 3: **4 [Enter]**  
Enter the points for game 4: **6 [Enter]**  
Enter the points for game 5: **8 [Enter]**  
Enter the points for game 6: **-1 [Enter]**

The total points are 34

# Deciding Which Loop to Use

- The `while` loop is a conditional pretest loop
  - Iterates as long as a certain condition exists
  - Validating input
  - Reading lists of data terminated by a sentinel
- The `do-while` loop is a conditional posttest loop
  - Always iterates at least once
  - Repeating a menu
- The `for` loop is a pretest loop
  - Built-in expressions for initializing, testing, and updating
  - Situations where the exact number of iterations is known

# Nested Loops

- A nested loop is a loop inside the body of another loop
- Inner (inside), outer (outside) loops:

```
for (row=1; row<=3; row++) //outer
    for (col=1; col<=3; col++) //inner
        cout << row * col << endl;
```

# Nested Loops - Notes

- Inner loop goes through all repetitions for each repetition of outer loop
- Inner loop repetitions complete sooner than outer loop
- Total number of repetitions for inner loop is product of number of repetitions of the two loops.

# Nested for Loop in Program 5-14

```
26 // Determine each student's average score.
27 for (int student = 1; student <= numStudents; student++)
28 {
29     total = 0; // Initialize the accumulator.
30     for (int test = 1; test <= numTests; test++)
31     {
32         double score;
33         cout << "Enter score " << test << " for ";
34         cout << "student " << student << ": ";
35         cin >> score;
36         total += score;
37     }
38     average = total / numTests;
39     cout << "The average score for student " << student;
40     cout << " is " << average << ".\n\n";
41 }
```

Inner Loop

Outer Loop

# Breaking Out of a Loop

- Can use `break` to terminate execution of a loop

```
int n;  
for(n = 1; n <= 5; n++)  
{  
    cout << "*" << endl;  
    if(n == 2)  
        break;  
}
```

- When used in an inner loop, terminates that loop only and goes back to outer loop

# The `continue` Statement

- Can use `continue` to go to end of loop and prepare for next repetition

```
int n = 1;
while(n < 10)
{
    if (n == 5)
    {
        n = n + 1;
        continue;
    }
    cout << "n = " << n << endl;
    n++;
}
```



# Using Files for Data Storage

- Can use files instead of keyboard, monitor screen for program input, output
- Allows data to be retained between program runs
- Steps:
  - *Open* the file
  - *Use* the file (read from, write to, or both)
  - *Close* the file

# Files: What is Needed

- Use `fstream` header file for file access

- File stream types:

  - `ifstream` for input from a file

  - `ofstream` for output to a file

  - `fstream` for input from or output to a file

- Define file stream objects:

  - `ifstream infile;`

  - `ofstream outfile;`

# Opening Files

- Create a link between file name (outside the program) and file stream object (inside the program)
- Use the `open` member function:

```
infile.open("inventory.dat");  
outfile.open("report.txt");
```
- Filename may include drive, path info.
- Output file will be created if necessary; existing file will be erased first
- Input file must exist for `open` to work

# Testing for File Open Errors

- Can test a file stream object to detect if an open operation failed:

```
infile.open("test.txt");  
if (!infile)  
{  
    cout << "File open failure!";  
}
```

- Can also use the `fail` member function

```
if (infile.fail())  
{  
    cout << "File open failure!";  
}
```

# Using Files

- Can use output file object and `<<` to send data to a file:

```
outfile << "Inventory report";
```

- Can use input file object and `>>` to copy data from file to variables:

```
infile >> partNum;
```

```
infile >> qtyInStock >> qtyOnOrder;
```

# Using Loops to Process Files

- The stream extraction operator `>>` returns `true` when a value was successfully read, `false` otherwise
- Can be tested in a `while` loop to continue execution as long as values are read from the file:

```
while (inputFile >> number) ...
```

# Closing Files

- Use the `close` member function:

```
infile.close();  
outfile.close();
```

- Don't wait for operating system to close files at program end:
  - may be limit on number of open files

# Letting the User Specify a Filename

- In many cases, you will want the user to specify the name of a file for the program to open.
- In C++ 11, you can pass a `string` object as an argument to a file stream object's `open` member function.



# Letting the User Specify a Filename in Program 5-24

## Program 5-24

```
1  // This program lets the user enter a filename.
2  #include <iostream>
3  #include <string>
4  #include <fstream>
5  using namespace std;
6
7  int main()
8  {
9      ifstream inputFile;
10     string filename;
11     int number;
12
13     // Get the filename from the user.
14     cout << "Enter the filename: ";
15     cin >> filename;
16
17     // open the file.
18     inputFile.open(filename);
19
20     // If the file successfully opened, process it.
21     if (inputFile)
```

Continued...  
57

# Letting the User Specify a Filename in Program 5-24

```
22     {
23         // Read the numbers from the file and
24         // display them.
25         while (inputFile >> number)
26         {
27             cout << number << endl;
28         }
29
30         // Close the file.
31         inputFile.close();
32     }
33     else
34     {
35         // Display an error message.
36         cout << "Error opening the file.\n";
37     }
38     return 0;
39 }
```

## Program Output with Example Input Shown in Bold

```
Enter the filename: ListOfNumbers.txt [Enter]
100
200
300
400
500
600
700
```