

4

Conditional Statements

PURPOSE

1. To work with relational operators
2. To work with conditional statements
3. To learn and use nested `if` statements
4. To learn and use logical operators
5. To learn and use the `switch` statement

PROCEDURE

1. Students should read the Pre-lab Reading Assignment before coming to lab.
2. Students should complete the Pre-lab Writing Assignment before coming to lab.

Contents	Pre-requisites	Approximate completion time	Page number	Check when done
Pre-lab Reading Assignment		20 min.	42	
Pre-lab Writing Assignment	Pre-lab reading	10 min.	48	
LESSON 4A				
Lab 4.1				
Relational Operators and the <code>if</code> Statement	Basic understanding of relational operators and the simple <code>if</code> statement	15 min.	48	
Lab 4.2				
<code>if/else</code> and Nested <code>if</code> Statements	Basic understanding of nested <code>if</code> statements	20 min.	49	
Lab 4.3				
Logical Operators	Basic understanding of logical operators	15 min.	50	
LESSON 4B				
Lab 4.4				
The <code>switch</code> Statement	Understanding of the <code>switch</code> statement	25 min.	51	
Lab 4.5				
Student Generated Code Assignments	Basic understanding of conditional statements	30 min.	52	

PRE-LAB READING ASSIGNMENT

Relational Operators

You have already seen that the statement `total = 5` is an assignment statement; that is, the integer 5 is placed in the variable called `total`. Nothing relevant to our everyday understanding of equality is present here. So how do we deal with equality in a program? How about greater than or less than? C++ allows the programmer to compare numeric values using **relational operators**. They are the following:

```
>    Greater than
<    Less than
>=   Greater than or equal to
<=   Less than or equal to
==   Equal to
!=   Not equal to
```

An expression of the form `num1 > num2` is called a **relational expression**. Note that it does *not* assert that `num1` is greater than `num2`. It actually tests to see if this is true. So relational expressions are boolean. Their value must be either *true* or *false*. The statement `cost != 9` is false if `cost` has value 9 and true otherwise. Consider the following code:

```
int years;
years = 6; // assignment statement years is assigned the value of 6
years == 5; // relational expression, not an assignment statement
years = years - 1; // assignment statement
years == 5; // relational expression
```

In this sequence the first occurrence of `years == 5` is a false statement whereas the second occurrence is true. Can you see why?

The `if` Statement

Sometimes we may only want a portion of code executed under certain conditions. To do so, we use **conditional statements**. For example, if you are writing a payroll program to compute wages, then the program should only compute overtime pay *if* the employee worked more than 40 hours in a given week. Otherwise, when the program is executed the overtime portion of the code should be bypassed. An **`if` statement** is one kind of conditional statement.

Consider the following program:

Sample Program 4.1:

```
// This program prints "You Pass" if a student's average is 60 or higher and prints
// "You Fail" otherwise

#include <iostream>
using namespace std;

int main()
{
    float average;
```

```

cout << "Input your average" << endl;
cin >> average;

if (average >= 60) // note the use of a relational operator
    cout << "You Pass" << endl;

if (average < 60)
    cout << "You Fail" << endl;

return 0;
}

```

Note that it is not possible for this program to print out both “You Pass” and “You Fail”. Only one of the `if` statements will be executed. Later we will see a way to write this program without using 2 `if` statements.

If you want to conditionally execute several statements using `if`, the following syntax is required:

```

if (expression)
{
    statement_1;
    statement_2;
    :
    statement_n;
}

```

Note the curly braces surrounding the set of statements to be conditionally executed.

The `if/else` Statement

In Sample Program 4.1 we used two `if` statements. A more elegant approach would be to use the **`if/else` statement** as follows:

```

if (average >= 60)
    cout << "You Pass" << endl;

else
    cout << "You Fail" << endl;

```

In every `if/else` statement the program can take only one of two possible paths. Multiple statements can be handled using curly braces in the same way as the `if` statement.

The `if/else if` Statement

The `if/else` statement works well if there are only two possible paths to follow. However, what if there are more than two possibilities? For example, suppose we need to decide what kind of vacation to take based on a yearly work bonus:

```

if the bonus is less than $1,000, we set up a tent and eat hot dogs in the back yard
if the bonus is less than $10,000 and greater than or equal to $1,000, we go to
    Disney World
if the bonus is $10,000, we go to Hawaii

```

We could code this using the **if/else if** statement as follows:

```
float bonus;

cout << "Please input the amount of your yearly bonus" << endl;
cin >> bonus;

if (bonus < 1000)
    cout << "Another vacation eating hot dogs on the lawn" << endl;

else if (bonus < 10000)
    cout << "Off to Disney World!" << endl;

else if (bonus == 10000)
    cout << "Lets go to Hawaii!" << endl;
```

Can you explain why the first **else if** conditional statement does not require a greater than or equal to 1000 condition?

In general we can use as many **else if** expressions as needed to solve a given problem.

The Trailing **else**

What happens in the code above if the bonus entered is greater than \$10,000? Actually, nothing will happen since none of the conditional expressions are true in this case. Sometimes it is advantageous to add a final or **trailing else** at the end of a chain of **if/else if** statements to handle "all other cases." For example, we could modify the code to read:

```
if (bonus < 1000)
    cout << "Another vacation on the lawn" << endl;
else if (bonus < 10000)
    cout << "Off to Disney World!" << endl;
else if (bonus == 10000)
    cout << "Lets go to Hawaii!" << endl;
else
{
    cout << bonus << " is not a valid bonus" << endl;
    cout << "Please run the program again with valid data" << endl;
} // Note the necessary use of the curly brackets here
```

Of course, few would complain about a bonus greater than \$10,000 and the Hawaii trip could still be done on this budget. However, if the maximum possible bonus is \$10,000, then the **trailing else** will let the user know that an illegal value has been entered.

Nested **if** Statements

Often programmers use an **if** statement within another **if** statement. For example, suppose a software engineering company wants to screen applicants first for experienced programmers and second for C++ programmers specifically. One possible program is the following:

Sample Program 4.2:

```

#include <iostream>
using namespace std;

int main()
{
    char programmer, cPlusPlus;

    cout << "Before we consider your application, answer the following"
         << endl;
    cout << " yes ( enter Y ) or no ( enter N )" << endl;
    cout << "Are you a computer programmer?" << endl;

    cin >> programmer;

    if (programmer == 'Y')
    {
        cout << "Do you program in C++?" << endl;
        cin >> cPlusPlus;

        if (cPlusPlus == 'Y')
            cout << " You look like a promising candidate for employment"
                 << endl;
        else if (cPlusPlus == 'N')
            cout << " You need to learn C++ before further consideration"
                 << endl;
        else
            cout << " You must enter Y or N" << endl;
    }

    else if (programmer == 'N')
        cout << " You are not currently qualified for employment" << endl;

    else
        cout << " You must enter Y or N" << endl;
    return 0;
}

```

Note how C++ programmers are identified using a nested if statement. Also note how the trailing else is used to detect invalid input.

Logical Operators

By using relational operators C++ programmers can create relational expressions. Programmers can also combine truth values into a single expression by using **logical operators**. For example, instead of a statement such as “if it is sunny, then we will go outside,” one may use a statement such as “if it is sunny and it is warm, then we will go outside.” Note that this statement has two smaller statements “it is sunny” and “it is warm” joined by the **AND** logical operator. To evaluate to true, both the sunny and warm requirements must be met.

The **NOT** operator negates a single statement. For example, “it is sunny” can be negated by “it is not sunny.”

The **OR** operator is similar to the **AND** in that it connects two statements. However, there is an ambiguity about the meaning of the word *or* in English. In the statement “tonight at 8:00 I will go to the concert in the park or I will go to the stadium to see the ball game,” the word **or** is *exclusive*. That is, I can go to the concert or to the game, but not both. However, in the statement “I need to draw an ace or a king to have a good poker hand,” the word **or** is *inclusive*. In other words, I can draw a king, an ace, or even both, and I will have a good hand. So we have a choice to make. Let A and B be two statements. A OR B could mean A or B but not both. It could also mean A or B or both. In computer science we use the second meaning of the word *or*. For example, in the statement “if it is sunny or it is warm, then I will go outside,” there are three scenarios where I will go outside: if it is sunny but not warm, if it is warm but not sunny, or if it is sunny and warm.

The syntax used by C++ for logical operators is the following:

```
AND    &&
OR     ||
NOT    !
```

Consider the following:

```
if (dollars <= 0 || !(accountActive) )
    cout << " You may not withdraw money from the bank";
```

It is good programming practice to enclose the operand after the (!) operator in parentheses. Unexpected things can happen in complicated expressions if you do not. When will this code execute the `cout` statement? What type of variable do you think `accountActive` is?

The switch Statement

We have already seen how `if` statements can affect the branching of a program during execution. Another way to do this is using the **switch statement**. It is also a conditional statement. The `switch` statement uses the value of an integer expression to determine which group of statements to branch through. The sample program below illustrates the syntax.

Sample Program 4.3:

```
#include <iostream>
using namespace std;

int main()
{
    char grade;

    cout << "What grade did you earn in Programming I?" << endl;
    cin >> grade;

    switch( grade )    // This is where the switch statement begins
    {
        case 'A':cout << "an A - excellent work!" << endl;
                break;
```

```

    case 'B':cout << "you got a B - good job" << endl;
        break;
    case 'C':cout << "earning a C is satisfactory" << endl;
        break;
    case 'D':cout << "while D is passing, there is a problem" << endl;
        break;
    case 'F':cout << "you failed - better luck next time" << endl;
        break;
    default:cout << "You did not enter an A, B, C, D, or F" << endl;
}
return 0;
}

```

Note the use of the curly braces that enclose the cases and the use of `break`; after each case. Also, consider the variable `grade`. It is defined as a character data type and the case statements have character arguments such as 'B'. This seems to contradict what we said above, namely that the `switch` statement uses the value of integer expressions to determine branching. However, this apparent contradiction is resolved by the compiler automatically converting character data into the integer data type. Finally, notice the role of the default statement. The default branch is followed if none of the case expressions match the given `switch` expression.

Character & string comparisons

So far, relational operators have been used to compare numeric constants and variables. Characters and string objects can also be compared with the same operators. For example:

```

char letter = 'F';
string word = "passed";

switch(letter)
{
    case 'A': cout << "Your grade is A." << endl;
        break;
    case 'B': cout << "Your grade is B." << endl;
        break;
    case 'C': cout << "Your grade is C." << endl;
        break;
    case 'D': cout << "Your grade is D." << endl;
        break;
    case 'F': word = "failed";
        break;
    default: cout << "You did not enter an A,B,C,D or F" << endl;
}

if (word == "passed")
    cout << "You passed" << endl;
else
    cout << "You failed" << endl;

```

What is printed?

PRE-LAB WRITING ASSIGNMENT

Fill-in-the-Blank Questions

1. The two possible values for a relational expression are _____ and _____.
2. C++ uses the _____ symbol to represent the AND operator.
3. The switch statement and if statements are examples of _____ statements.
4. In C++ is the meaning of the OR logical operator inclusive or exclusive? _____
5. C++ uses the _____ symbol to represent the OR operator.
6. It is good programming practice to do what to the operand after the NOT operator? _____
7. The switch statement uses the value of a(n) _____ expression to determine which group of statements to branch through.
8. In a switch statement the _____ branch is followed if none of the case expressions match the given switch expression.
9. C++ allows the programmer to compare numeric values using _____.
10. The C++ symbol for equality is _____.

LESSON 4A

LAB 4.1 Relational Operators and the if Statement

Exercise 1: Bring in the file initialize.cpp from the Lab 4 folder. The code follows:

```
// This program tests whether or not an initialized value
// is equal to a value input by the user

// PLACE YOUR NAME HERE

#include <iostream>
using namespace std;

int main( )
{
    int num1,                // num1 is not initialized
        num2 = 5;           // num2 has been initialized to 5

    cout << "Please enter an integer" << endl;
    cin >> num1;

    cout << "num1 = " << num1 << " and num2 = " << num2 << endl;

    if (num1 = num2)
        cout << "Hey, that's a coincidence!" << endl;
```



```

        if (num1 != num2)
            cout << "The values are not the same" << endl;

    return 0;
}

```

Exercise 1: Run the program several times using a different input each time. Does the program do what you expect? If so, explain what it is doing. If not, locate the error and fix it.

Exercise 2: Modify the program so that the user inputs both values to be tested for equality. Make sure you have a prompt for each input. Test the program with pairs of values that are the same and that are different.

Exercise 3: Modify the program so that when the numbers are the same it prints the following lines:

```

The values are the same.
Hey that's a coincidence!

```

Exercise 4: Modify the revised Exercise 3 program by replacing the two if statements with a single if/else statement. Run the program again to test the results.

LAB 4.2 if/else if Statements

Bring in the file `grades.cpp` from the Lab 4 folder. The code follows:

```

// This program prints "You Pass" if a student's average is
// 60 or higher and prints "You Fail" otherwise

// PLACE YOUR NAME HERE
#include <iostream>
using namespace std;

int main()
{
    float average;    // holds the grade average

    cout << "Input your average:" << endl;
    cin >> average;

    if (average > 60)
        cout << "You Pass" << endl;

    if (average < 60)
        cout << "You Fail" << endl;

    return 0;
}

```

Exercise 1: Run the program three times using 80, 55 and 60 for the average.

What happens when you input 60 as the average? Modify the first if statement so that the program will also print “You Pass” if the average equals 60.

Exercise 2: Modify the program so that it uses an if/else statement rather than two if statements.

Exercise 3: Modify the program from Exercise 2 to allow the following categories: Invalid data (data above 100), ‘A’ category (90–100), ‘B’ category (80–89), “You Pass” category (60–79), “You Fail” category (0–59).

What will happen to your program if you enter a negative value such as -12?

Lab 4.3 Logical Operators

Retrieve LogicalOp.cpp from the Lab 4 folder. The code is as follows:

```
// This program illustrates the use of logical operators

// PLACE YOUR NAME HERE

#include <iostream>
using namespace std;

int main()
{
    char year;
    float gpa;

    cout << "What year student are you ?" << endl;
    cout << "Enter 1 (freshman), 2 (sophomore), 3 (junior), or 4 (senior)"
        << endl << endl;
    cin >> year;

    cout << "Now enter your GPA" << endl;
    cin >> gpa;

    if (gpa >= 2.0 && year == '4')
        cout << "It is time to graduate soon" << endl;

    else if (year != '4' || gpa < 2.0)
        cout << "You need more schooling" << endl;

    return 0;
}
```

Exercise 1: How could you rewrite `gpa >= 2.0` in the first if statement using the NOT operator?

Exercise 2: Could you replace `year != '4'` in the else if statement with `year < 4` or `year <= 3`? Why or why not?

Exercise 3: If you replace

```
if ( gpa >= 2.0 && year == '4')
```

with

```
if ( gpa >= 2.0 || year == '4')
```

and replace

```
else if ( year != '4' || gpa < 2.0)
```

with

```
else if ( year != '4' && gpa < 2.0)
```

which students will graduate and which will not graduate according to this new program?

Does this handle all cases (i.e., all combinations of year and gpa)?

Exercise 4: Could you replace `else if (year != '4' || gpa < 2.0)` with the single word `else`?

LESSON 4B

LAB 4.4 The switch Statement

Exercise 1: Bring in the file `switch.cpp` from the Lab 4 folder. This is Sample Program 4.3 from the Pre-lab Reading Assignment. The code is shown below. Remove the `break` statements from each of the cases. What is the effect on the execution of the program?

```
// This program illustrates the use of the switch statement.

// PLACE YOUR NAME HERE

#include <iostream>
using namespace std;

int main()
{
    char grade;

    cout << "What grade did you earn in Programming I ?" << endl;
    cin >> grade;

    switch( grade )           // This is where the switch statement begins
    {
        case 'A': cout << "an A - excellent work !" << endl;
                  break;
        case 'B': cout << "you got a B - good job" << endl;
                  break;
        case 'C': cout << "earning a C is satisfactory" << endl;
                  break;
        case 'D': cout << "while D is passing, there is a problem" << endl;
                  break;
    }
}
```

```

        case 'F': cout << "you failed - better luck next time" << endl
                break;
        default: cout << "You did not enter an A, B, C, D, or F" << endl;
    }

    return 0;
}

```

Exercise 2: Add an additional switch statement that allows for a Passing option for a grade of D or better. Use the sample run given below to model your output.

Sample Run:

```

What grade did you earn in Programming I ?
A
YOU PASSED!
an A - excellent work!

```

Exercise 3: Rewrite the program `switch.cpp` using `if` and `else if` statements rather than a switch statement. Did you use a trailing `else` in your new version? If so, what did it correspond to in the original program with the switch statement?

LAB 4.5 Student Generated Code Assignments

Option 1: Write a program that prompts the user for their quarterly water bill for the last four *quarters*. The program should find and output their average *monthly* water bill. If the average bill exceeds \$75, the output should include a message indicating that too much water is being used. If the average bill is at least \$25 but no more than \$75, the output should indicate that a typical amount of water is being used. Finally, if the average bill is less than \$25, the output should contain a message praising the user for conserving water. Use the sample run below as a model for your output.

Sample Run 1:

```

Please input your water bill for quarter 1:
300

Please input your water bill for quarter 2:
200

Please input your water bill for quarter 3:
225

Please input your water bill for quarter 4:
275

```

Your average monthly bill is \$83.33. You are using excessive amounts of water

Sample Run 2:

Please input your water bill for quarter 1:

100

Please input your water bill for quarter 2:

150

Please input your water bill for quarter 3:

75

Please input your water bill for quarter 4:

125

Your average monthly bill is \$37.50. You are using a typical amount of water

Option 2: The local t-shirt shop sells shirts that retail for \$12. Quantity discounts are given as follow:

Number of Shirts	Discount
5–10	10%
11–20	15%
21–30	20%
31 or more	25%

Write a program that prompts the user for the number of shirts required and then computes the total price. Make sure the program accepts only nonnegative input.

Use the following sample runs to guide you:

Sample Run 1:

How many shirts would you like ?

4

The cost per shirt is \$12 and the total cost is \$48

Sample Run 2:

How many shirts would you like ?

0

The cost per shirt is \$12 and the total cost is \$0

Sample Run 3:

How many shirts would you like ?

8

The cost per shirt is \$10.80 and the total cost is \$86.40

Sample Run 4:

How many shirts would you like ?

-2

Invalid Input: Please enter a nonnegative integer

Option 3: The University of Guinness charges \$3000 per semester for in-state tuition and \$4500 per semester for out-of-state tuition. In addition, room and board is \$2500 per semester for in-state students and \$3500 per semester for out-of-state students. Write a program that prompts the user for their residential status (i.e., in-state or out-of-state) and whether they require room and board (Y or N). The program should then compute and output their bill for that semester.

Use the sample output below:

Sample Run 1:

Please input "I" if you are in-state or "O" if you are out-of-state:

I

Please input "Y" if you require room and board and "N" if you do not:

N

Your total bill for this semester is \$3000

Sample Run 2:

Please input "I" if you are in-state or "O" if you are out-of-state:

O

Please input "Y" if you require room and board and "N" if you do not:

Y

Your total bill for this semester is \$8000