Chapter 4: Selection

C++ PROGRAMMING:
PRINCIPLES AND PRACTICES FOR SCIENTISTS AND ENGINEERS

Objectives

- In this chapter, you will learn about:
  - Selection criteria
  - The **`if-else`** statement
  - Nested **`if`** statements
  - The **`switch`** statement
  - Program testing
  - Common programming errors

Selection Criteria

- `if-else` statement: Implements a decision structure for two alternatives

  Syntax:

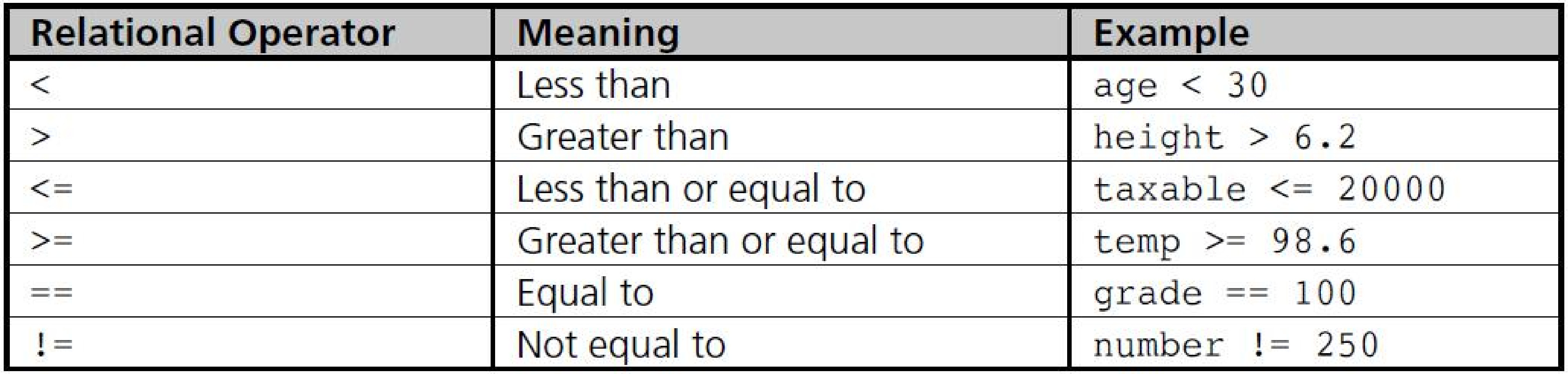
```
if (condition)
   statement executed if condition is true;
else
   statement executed if condition is false;
```

Selection Criteria (continued)

- The condition is evaluated to its numerical value:
  - A non-zero value is considered to be true
  - A zero value is considered to be false
- The **`else`** portion is optional
  - Executed only if the condition is false
- The condition may be any valid C++ expression

Relational Operators

- **Relational expression:** Compares two operands or expressions using **relational operators**



Relational Operator	Meaning	Example
`<`	Less than	`age < 30`
`>`	Greater than	`height > 6.2`
`<=`	Less than or equal to	`taxable <= 20000`
`>=`	Greater than or equal to	`temp >= 98.6`
`==`	Equal to	`grade == 100`
`!=`	Not equal to	`number != 250`

Table 4.1 C++'s Relational Operators

Relational Operators (continued)

- Relational expressions are evaluated to a numerical value of 1 or 0 only:
  - If the value is 1, the expression is true
  - If the value is 0, the expression is false
- **`char`** values are automatically coerced to **`int`** values for comparison purposes
- Strings are compared on a character by character basis
  - The string with the first lower character is considered smaller

Relational Operators (continued)

- Examples of string comparisons

Expression	Value	Interpretation	Comment
`"Hello"> "Good-bye"`	1	true	The first H in Hello is greater than the first G in Good-bye.
`"SMITH" > "JONES"`	1	true	The first S in SMITH is greater than the first J in JONES.
`"123" > "1227"`	1	true	The third character in 123, the 3, is greater than the third character in 1227, the 2.
`"Behop" > "Beehive"`	1	true	The third character in Behop, the h, is greater than the third character in Beehive, the second e.

Logical Operators

- AND (`&&`): Condition is true only if both expressions are true
- OR (`||`): Condition is true if either one or both of the expressions is true
- NOT (`!`): Changes an expression to its opposite state; true becomes false, false becomes true

Logical Operators (continued)

Operator	Associativity
`! unary - ++ --`	Right to left
`* / %`	Left to right
`+ -`	Left to right
`< <= > >=`	Left to right
`== !=`	Left to right
`&&`	Left to right
`||`	Left to right
`= += -= *= /=`	Right to left

Table 4.2 Operator Precedence and Associativity

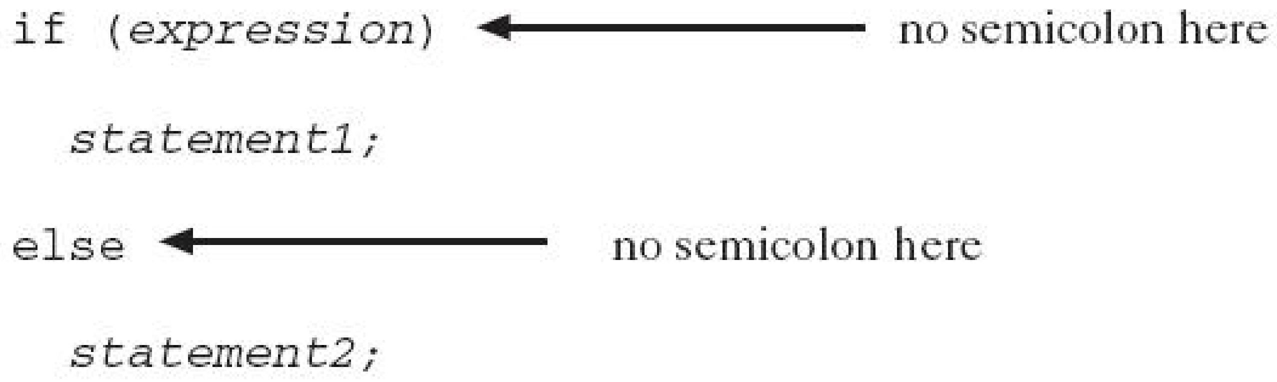
A Numerical Accuracy Problem

- Comparing single and double precision values for equality (==) can lead to errors because values are stored in binary
- Instead, test that the absolute value of the difference is within an acceptable range
  - Example:

```
abs(operandOne – operandTwo) < 0.000001
```

The `if-else` Statement

- **`if-else`** performs instructions based on the result of a comparison
- Place statements on separate lines for readability
- Syntax:



```
if (expression)
  statement1;
else
  statement2;
```

The `if-else` Statement (cont'd)

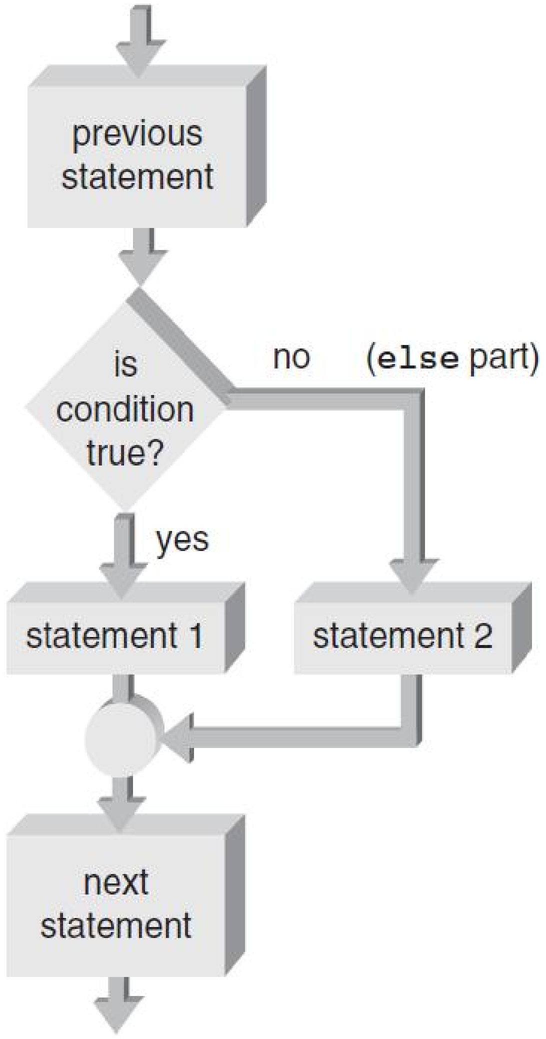


Figure 4.2
The **`if-else`** flowchart

The `if-else` Statement (continued)

Program 4.1

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

int main()
{
  double radius;

  cout << "Please type in the radius: ";
  cin  >> radius;

  if (radius < 0.0)
    cout << "A negative radius is invalid" << endl;
  else
    cout << "The area of this circle is " << 3.1416 * pow(radius,2) << endl;

  return 0;
}
```

Compound Statements

- **Compound statement:** A sequence of single statements contained between braces
  - Creates a block of statements
  - A block of statements can be used anywhere that a single statement is legal
  - Any variable declared within a block is usable only within that block
- **Scope:** The area within a program where a variable can be used
  - A variable's scope is based on where the variable is declared

Block Scope (continued)

```
{    // start of outer block
   int a = 25;
   int b = 17;

   cout << "The value of a is " << a
        <<" and b is " << b << endl;

   {     // start of inner block
     double a = 46.25;

     int c = 10;
     cout << "a is now " << a
          << " b is now " << b
          << " and c is " << c << endl;
   }    // end of inner block

   cout << "a is now " << a
        << " and b is " << b << endl;
}    // end of outer block
```

One-Way Selection

- **One-way selection:** An **`if`** statement without the optional **`else`** portion

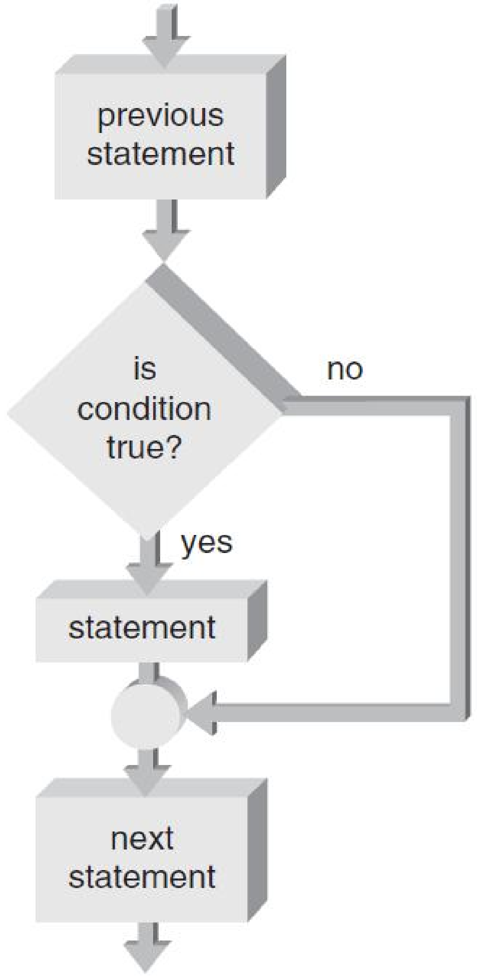


Figure 4.3 A one-way selection `if` statement

Problems Associated with the `if-else` Statement

- Common problems with **`if-else`** statements:
  - Misunderstanding what an expression is
  - Using the assignment operator (**`=`**) instead of the relational operator (**`==`**)

Nested `if` Statements

- **`if-else`** statement can contain any valid C++ statement, including another **`if-else`**
- Nested **`if`** statement: an **`if-else`** statement completely contained within another **`if-else`**
- Use braces to block code, especially when inner **`if`** statement does not have its own **`else`**

Nested `if` Statements (continued)

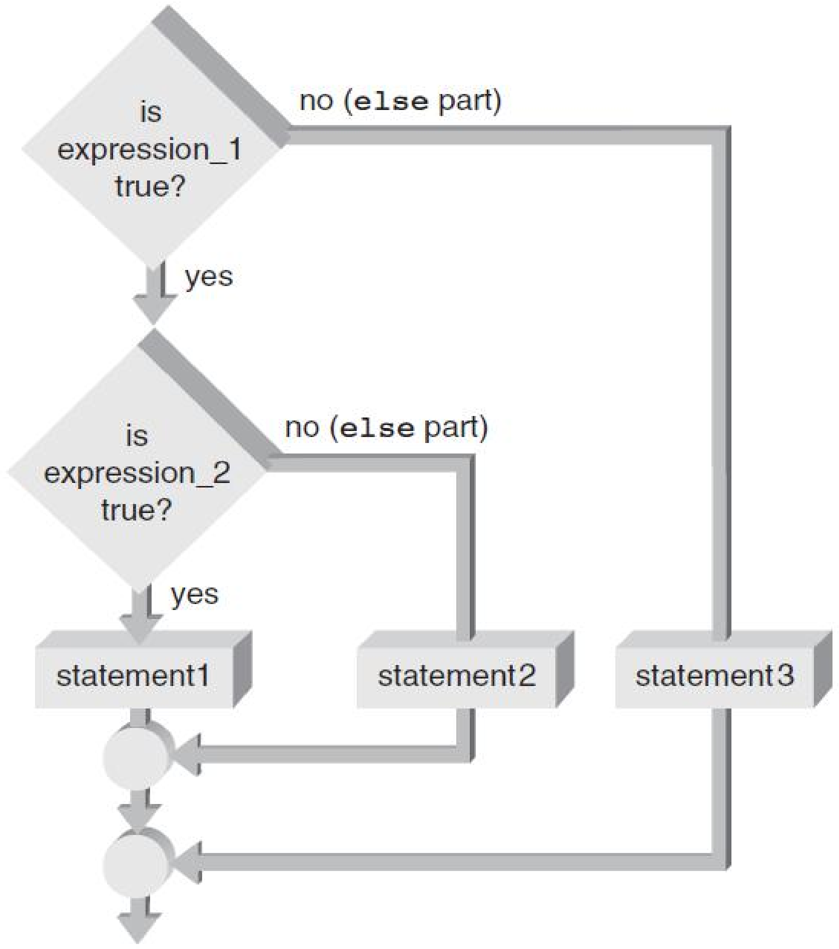


Figure 4.4a
Nested within the **`if`** part

The `if-else` Chain

- **`if-else`** chain: A nested **`if`** statement occurring in the **`else`** clause of the outer **`if-else`**
- If any condition is true, the corresponding statement is executed and the chain terminates
- Final **`else`** is only executed if no conditions were true
  - Serves as a catch-all case
- **`if-else`** chain provides one selection from many possible alternatives

The `if-else` Chain (continued)

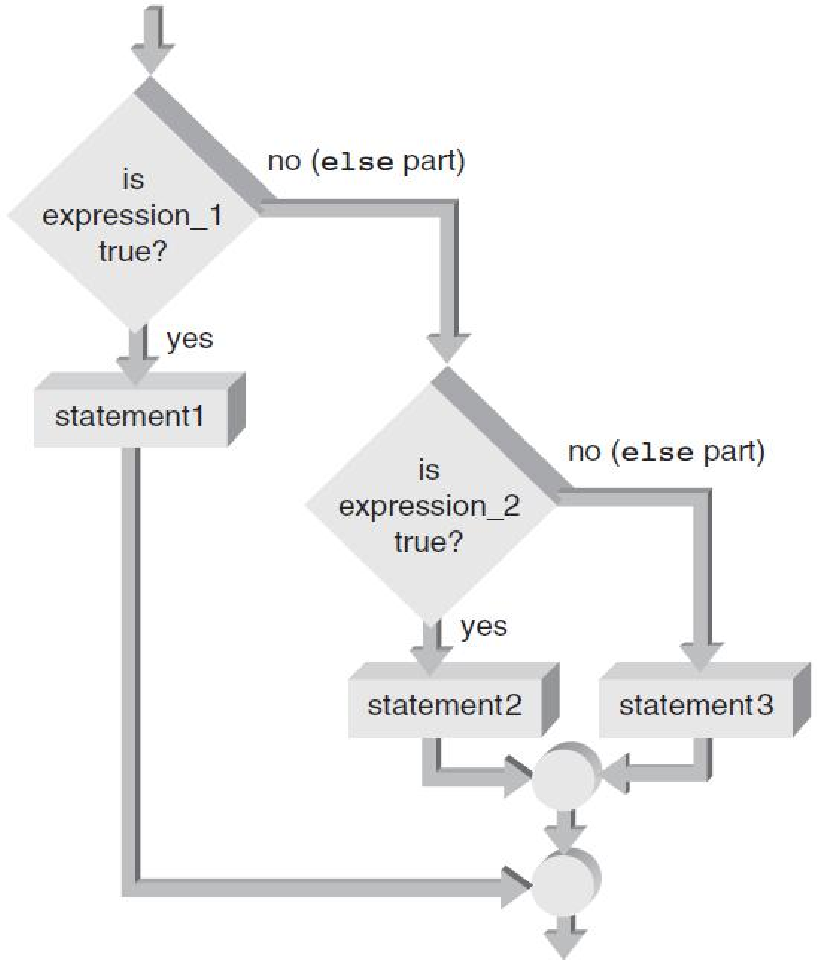
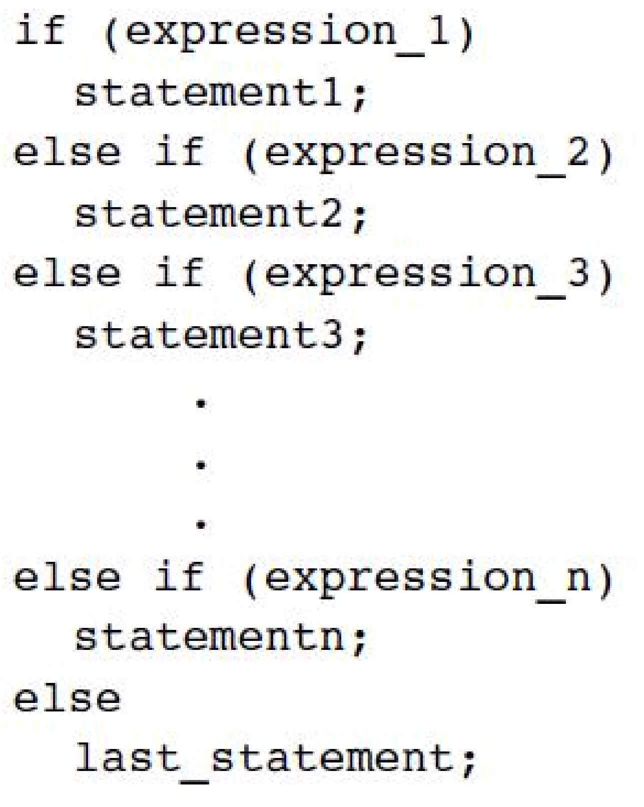


Figure 4.4b
Nested within the **`else`** part

The `if-else` Chain (continued)

- General form of an **`if-else`** chain



```
if (expression_1)
  statement1;
else if (expression_2)
  statement2;
else if (expression_3)
  statement3;
        .
        .
        .
else if (expression_n)
  statementn;
else
  last_statement;
```

The `switch` Statement

- **`switch`** statement: Provides for one selection from many alternatives
- **`switch`** keyword starts the statement
  - Is followed by the expression to be evaluated
- **`case`** keyword identifies a value to be compared to the switch expression
  - When a match is found, statements in this **`case`** block are executed
- All further cases after a match is found are executed unless a **`break`** statement is found

The `switch` Statement (continued)

- **`default`** case is executed if no other case value matches were found
- **`default`** case is optional

A Case Study: Solving Quadratic Equations

- **Data validation:** Use defensive programming techniques to validate user input
  - Includes code to check for improper data before an attempt is made to process it further
- **Solving quadratic equations:** Use the software development procedure to solve for the roots of a quadratic equation

A Closer Look: Program Testing

- Theory: A comprehensive set of test runs would test all combinations of input and computations, and would reveal all errors
- Reality: There are too many combinations to test for any program except a very simple one
- Example:
  - One program with 10 modules, each with five **`if`** statements, always called in the same order
  - There are 2^5 paths through each module, and more than 2^{50} paths through the program!

A Closer Look: Program Testing (continued)

- Conclusion: there is no error-free program, only one in which no errors have recently been encountered

Common Programming Errors

- Using the assignment operator (`=`) instead of the relational operator (`==`) for an equality test
- Placing a semicolon immediately after the condition
- Assuming a structural problem with an `if-else` causes the error instead of focusing on the data value being tested
- Using nested `if` statements without braces to define the structure

Summary

- Relational expressions, or conditions, are used to compare operands
- If the relation expression is true, its value is **`1`**; if false, its value is **`0`**
- Use logical operators **`&&`** (AND), **`||`** (OR), and **`!`** (NOT) to construct complex conditions
- **`if-else`** allows selection between two alternatives

Summary (continued)

- An `if` expression that evaluates to `0` is false; if non-zero, it is true
- `if` statements can be nested
- Chained `if` statement provides a multiway selection
- Compound statement: contains any number of individual statements enclosed in braces

Summary (continued)

- **`switch`** statement: Provides a multiway selection
- **`switch`** expression: Evaluated and compared to each **`case`** value
  - If a match is found, execution begins at that case’s statements and continues unless a **`break`** is encountered