# Chapter 4: Making Decisions

## Starting Out with C++
## Early Objects
## Eighth Edition

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PEARSON

# Topics

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# 4.1 Relational Operators

- Used to compare numeric values to determine relative order
- Operators:

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

# Relational Expressions

- Relational expressions are Boolean (*i.e.*, evaluate to **`true`** or **`false`**)
- Examples:

  **`12 > 5`** is **`true`**

  **`7 <= 5`** is **`false`**

  if **`x`** is 10, then

  **`x == 10`** is **`true`**,

  **`x <= 8`** is **`false`**,

  **`x != 8`** is **`true`**, and

  **`x == 8`** is **`false`**

# Relational Expressions

- Can be assigned to a variable

```
bool result = (x <= y);
```

- Assigns **`0`** for **`false`**, **`1`** for **`true`**
- Do not confuse **`=`** (assignment) and **`==`** (equal to)

# 4.2 The `if` Statement

- Supports the use of a decision structure
- Allows statements to be conditionally executed or skipped over
- Models the way we mentally evaluate situations

  "If it is cold outside,
  wear a coat and wear a hat."

# Format of the `if` Statement

```
if (condition)
{
   statement1;
   statement2;
        …
   statementn;
}
```

No ; goes here

; goes here

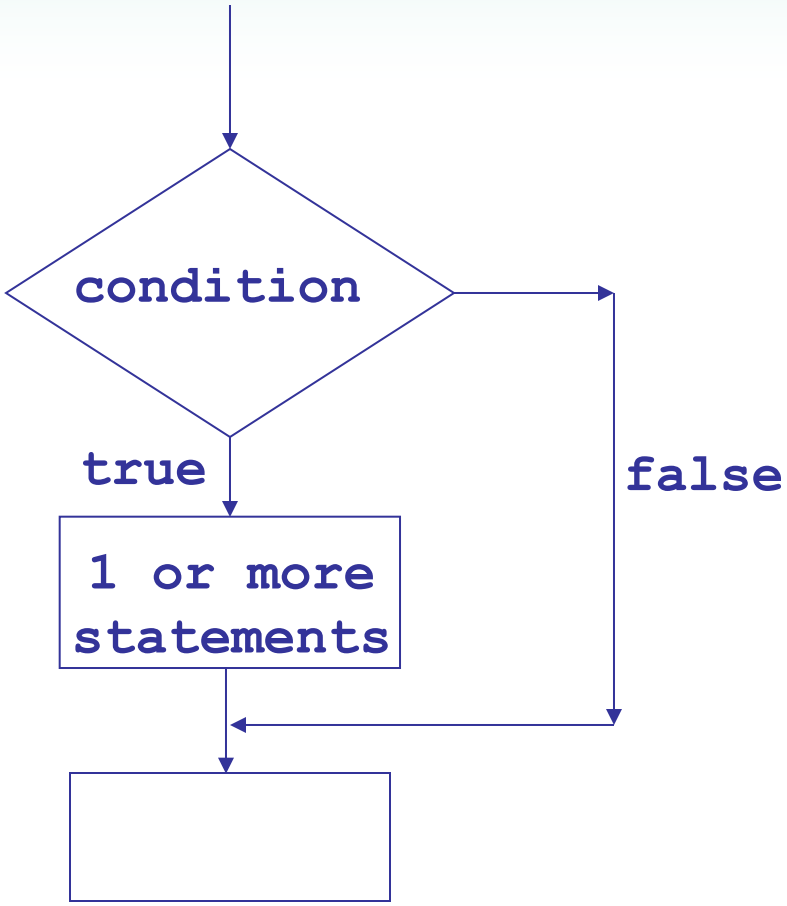
The block inside the braces is called the <u>body</u> of the `if` statement. If there is only 1 statement in the body, the `{ }` may be omitted.

# How the `if` Statement Works

- If `(`***`condition`***`)` is **`true`**, then the ***`statement(s)`*** in the body are executed.

- If `(`***`condition`***`)` is **`false`**, then the ***`statement(s)`*** are skipped.

# `if` Statement Flow of Control



# Example `if` Statements

```
if (score >= 60)
   cout << "You passed." << endl;

if (score >= 90)
{
   grade = 'A';
   cout << "Wonderful job!" << endl;
}
```

# `if` Statement Notes

- `if` is a keyword.  It must be lowercase
- `(`***`condition`***`)` must be in (  )
- Do not place `;` after `(`***`condition`***`)`
- Don't forget the { } around a multi-statement body

# `if` Statement Style Recommendations

- Place each ***`statement;`*** on a separate line after **`(`*`condition`*`)`**
- Indent each statement in the body
- When using { and } around the body, put { and } on lines by themselves

# What is **`true`** and **`false`**?

- An expression whose value is 0 is considered **`false`**.
- An expression whose value is non-zero is considered **`true`**.
- An expression need not be a comparison – it can be a single variable or a mathematical expression.

# Flag

- A variable that signals a condition
- Usually implemented as a **`bool`**
- Meaning:
  - **`true`**: the condition exists
  - **`false`**: the condition does not exist
- The flag value can be both set and tested with **`if`** statements

# Flag Example

Example:

```
bool validMonths = true;
        …
if (months < 0)
   validMonths = false;
        …
if (validMonths)
   moPayment = total / months;
```

# Integer Flags

- Integer variables can be used as flags
- Remember that 0 means false, any other value means true

```
int allDone = 0;  // set to false
        …
  if (count > MAX_STUDENTS)
     allDone = 1;  // set to true
        …
  if (allDone)
     cout << "Task finished";
```

# 4.3 The **`if/else`** Statement

- Allows a choice between statements depending on whether **`(`*`condition`*`)`** is **`true`** or **`false`**
- Format:

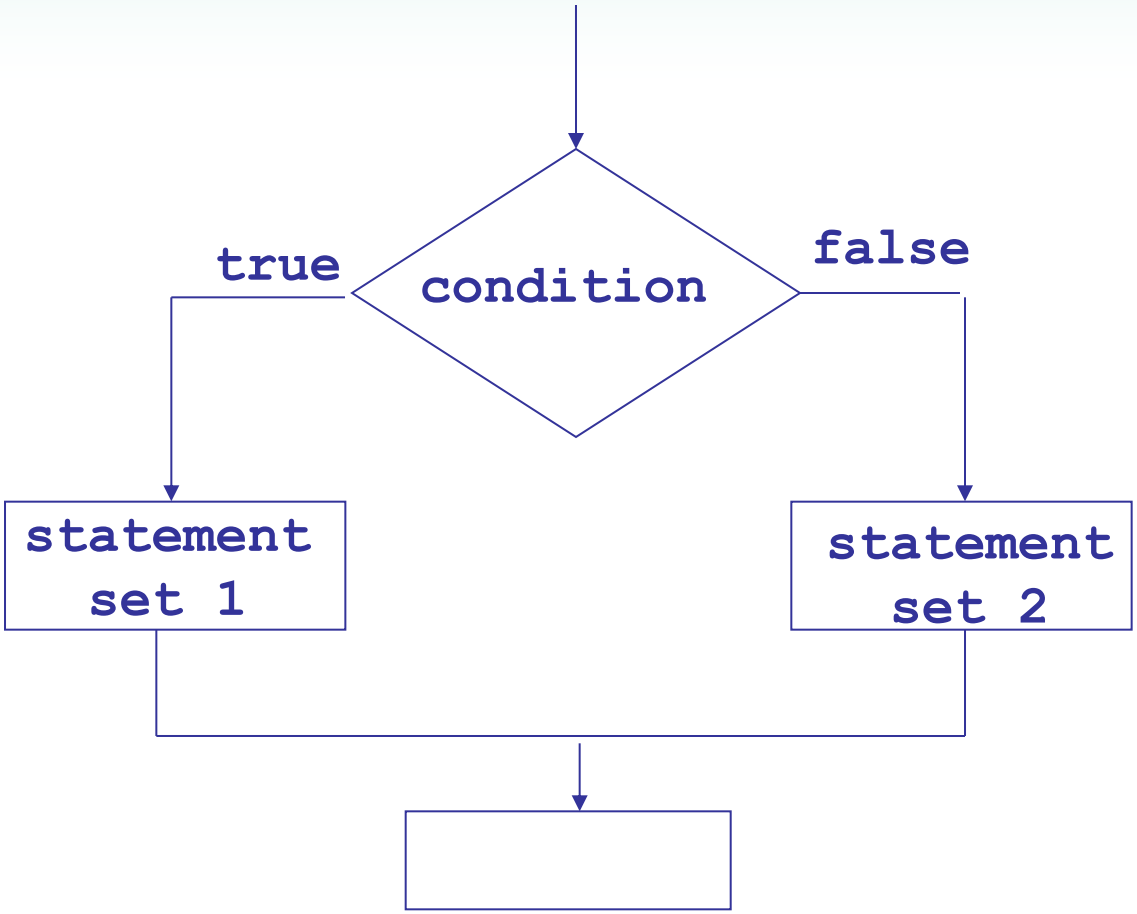
```
if (condition)
{
    statement set 1;
}
else
{
    statement set 2;
}
```

# How the **`if/else`** Works

- If **`(`*`condition`*`)`** is **`true`**, ***`statement set 1`*** is executed and ***`statement set 2`*** is skipped.

- If **`(`*`condition`*`)`** is **`false`**, ***`statement set 1`*** is skipped and ***`statement set 2`*** is executed.

# `if/else` Flow of Control



# Example **`if/else`** Statements

```
if (score >= 60)
   cout << "You passed.\n";
else
  cout << "You did not pass.\n";

if (intRate > 0)
{  interest = loanAmt * intRate;
   cout << interest;
}
else
   cout << "You owe no interest.\n";
```

# Comparisons with floating-point numbers

- It is difficult to test for equality when working with floating point numbers.

- It is better to use
  - greater than, less than tests, or
  - test to see if value is very close to a given value

# 4.4 The `if/else if` Statement

- Chain of `if` statements that test in order until one is found to be true
- Also models thought processes

  "If it is raining, take an umbrella,
  else, if it is windy, take a hat,
  else, if it is sunny, take sunglasses."

# `if/else if` Format

```
if (condition 1)
{   statement set 1;
}
else if (condition 2)
{   statement set 2;
}
        …
else if (condition n)
{   statement set n;
}
```

# Using a Trailing **`else`**

- Used with **`if/else if`** statement when all of the conditions are false
- Provides a default statement or action that is performed when none of the conditions is true
- Can be used to catch invalid values or handle other exceptional situations

# Example **if/else if** with Trailing **else**

```
if (age >= 21)
   cout << "Adult";
else if (age >= 13)
   cout << "Teen";
else if (age >= 2)
   cout << "Child";
else
   cout << "Baby";
```

# 4.5 Menu-Driven Program

- Menu: list of choices presented to the user on the computer screen
- Menu-driven program: program execution controlled by user selecting from a list of actions
- Menu can be implemented using **`if/else if`** statements

# Menu-driven Program Organization

- Display list of numbered or lettered choices for actions.
- Input user's selection of number or letter
- Test user selection in **`(condition)`**
  - if a match, then execute code to carry out desired action
  - if not, then test with next **`(condition)`**

# 4.6 Nested `if` Statements

- An **`if`** statement that is part of the **`if`** or **`else`** part of another **`if`** statement
- Can be used to evaluate > 1 data item or condition

```
if (score < 100)
{
    if (score > 90)
        grade = 'A';
}
```

# Notes on Coding Nested **`if`**s

- An **`else`** matches the nearest previous **`if`** that does not have an **`else`**

```
if (score < 100)
   if (score > 90)
      grade = 'A';
   else ...  // goes with second if,
             // not first one
```

- Proper indentation aids comprehension

# 4.7 Logical Operators

Used to create relational expressions from other relational expressions

| Operator | Meaning | Explanation |
|---|---|---|
| && | **AND** | New relational expression is true if both expressions are true |
| \|\| | **OR** | New relational expression is true if either expression is true |
| ! | **NOT** | Reverses the value of an expression; true expression becomes false, false expression becomes true |

# Logical Operator Examples

```
int x = 12, y = 5, z = -4;
```

| | |
|---|---|
| `(x > y) && (y > z)` | `true` |
| `(x > y) && (z > y)` | `false` |
| `(x <= z) \|\| (y == z)` | `false` |
| `(x <= z) \|\| (y != z)` | `true` |
| `!(x >= z)` | `false` |

# Logical Precedence

| | |
|---|---|
| Highest | `!` |
| | `&&` |
| Lowest | `\|\|` |

Example:

```
(2 < 3) || (5 > 6) && (7 > 8)
```

is true because AND is evaluated before OR

# More on Precedence

| | |
|---|---|
| Highest | arithmetic operators |
| ↓ | relational operators |
| Lowest | logical operators |

Example:

$$8 < 2 + 7 \;||\; 5 == 6 \quad \text{is true}$$

# Checking Numeric Ranges with Logical Operators

- Used to test if a value is within a range

```
if (grade >= 0 && grade <= 100)
   cout << "Valid grade";
```

- Can also test if a value lies outside a range

```
if (grade <= 0 || grade >= 100)
   cout << "Invalid grade";
```

- Cannot use mathematical notation

```
if (0 <= grade <= 100) //Doesn't
                       //work!
```

# 4.8 Validating User Input

- Input validation: inspecting input data to determine if it is acceptable
- Want to avoid accepting bad input
- Can perform various tests
  - Range
  - Reasonableness
  - Valid menu choice
  - Zero as a divisor

# 4.9 More About Blocks and Scope

- Scope of a variable is the block in which it is defined, from the point of definition to the end of the block
- Variables are usually defined at the beginning of a function
- They may instead be defined close to the place where they are first used

# More About Blocks and Scope

- Variables defined inside `{ }` have local or block scope
- When in a block that is nested inside another block, you can define variables with the same name as in the outer block.
  - When the program is executing in the inner block, the outer definition is not available
  - This is generally not a good idea

# 4.10 More About Characters and Strings

- Can use relational operators with characters and string objects

```
if (menuChoice == 'A')
if (firstName == "Beth")
```

- Comparing characters is really comparing ASCII values of characters
- Comparing string objects is comparing the ASCII values of the characters in the strings. Comparison is character-by-character
- Cannot compare C-style strings with relational operators

# Testing Characters

require **`cctype`** header file

| FUNCTION | MEANING |
|---|---|
| **`isalpha`** | **`true`** if arg. is a letter, **`false`** otherwise |
| **`isalnum`** | **`true`** if arg. is a letter or digit, **`false`** otherwise |
| **`isdigit`** | **`true`** if arg. is a digit 0-9, **`false`** otherwise |
| **`islower`** | **`true`** if arg. is lowercase letter, **`false`** otherwise |

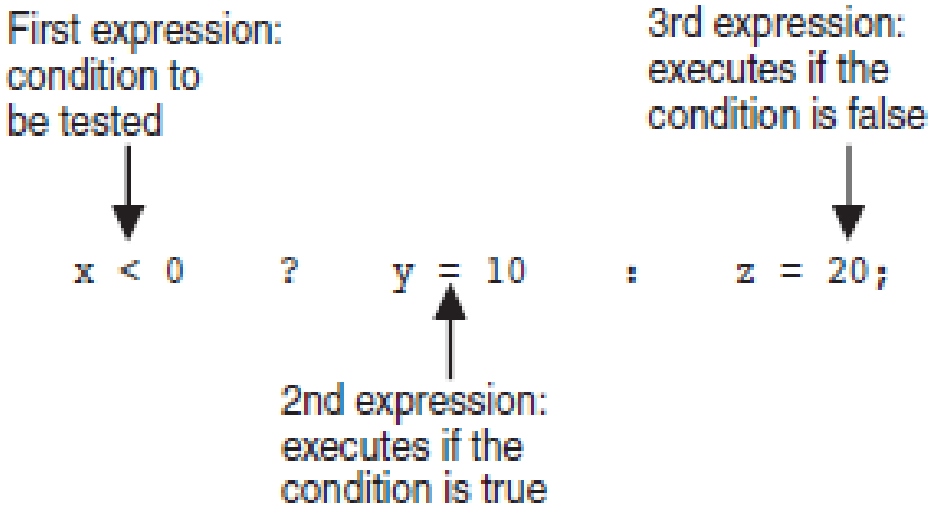
# Character Testing

require **`cctype`** header file

| FUNCTION | MEANING |
|---|---|
| **`isprint`** | **`true`** if arg. is a printable character, **`false`** otherwise |
| **`ispunct`** | **`true`** if arg. is a punctuation character, **`false`** otherwise |
| **`isupper`** | **`true`** if arg. is an uppercase letter, **`false`** otherwise |
| **`isspace`** | **`true`** if arg. is a whitespace character, **`false`** otherwise |

# 4.11 The Conditional Operator

- Can use to create short **`if/else`** statements
- Format: **`expr ? expr : expr;`**



# 4.12 The `switch` Statement

- Used to select among statements from several alternatives
- May sometimes be used instead of `if/else if` statements

# **switch** Statement Format

```
switch (IntExpression)
{
  case exp1: statement set 1;
  case exp2: statement set 2;
  ...
  case expn: statement set n;
  default:   statement set n+1;
}
```

# **`switch`** Statement Requirements

1) ***`IntExpression`*** must be a **`char`** or an integer variable or an expression that evaluates to an integer value
2) ***`exp1`*** through ***`expn`*** must be constant integer type expressions and must be unique in the **`switch`** statement
3) **`default`** is optional but recommended

# How the **`switch`** Statement Works

1) ***`IntExpression`*** is evaluated

2) The value of ***`intExpression`*** is compared against ***`exp1`*** through ***`expn`***.

3) If ***`IntExpression`*** matches value ***`expi`***, the program branches to the statement(s) following ***`expi`*** and continues to the end of the **`switch`**

4) If no matching value is found, the program branches to the statement after **`default:`**

# The **`break`** Statement

- Used to stop execution in the current block
- Also used to exit a **`switch`** statement
- Useful to execute a single **`case`** statement without executing statements following it

# Example **switch** Statement

```
switch (gender)
{
  case 'f': cout << "female";
            break;
  case 'm': cout << "male";
            break;
  default : cout << "invalid gender";
}
```

# Using **`switch`** with a Menu

**`switch`** statement is a natural choice for menu-driven program

- display menu
- get user input
- use user input as **`IntExpression`** in **`switch`** statement
- use menu choices as **`exp`** to test against in the **`case`** statements

# 4.13 Enumerated Data Types

- Data type created by programmer
- Contains a set of named constant integers
- Format:

```
enum name {val1, val2, … valn};
```

- Examples:

```
enum Fruit {apple, grape, orange};
enum Days {Mon, Tue, Wed, Thur, Fri};
```

# Enumerated Data Type Variables

- To define variables, use the enumerated data type name

```
Fruit snack;
Days workDay, vacationDay;
```

- Variable may contain any valid value for the data type

```
snack = orange;      // no quotes
if (workDay == Wed) // none here
```

# Enumerated Data Type Values

- Enumerated data type values are associated with integers, starting at 0

```
enum Fruit {apple, grape, orange};
```

0 1 2

- Can override default association

```
enum Fruit {apple = 2, grape = 4,
            orange = 5}
```

# Enumerated Data Type Notes

- Enumerated data types improve the readability of a program
- Enumerated variables can not be used with input statements, such as **`cin`**
- Will not display the name associated with the value of an enumerated data type if used with **`cout`**

# Chapter 4: Making Decisions

# The End!!