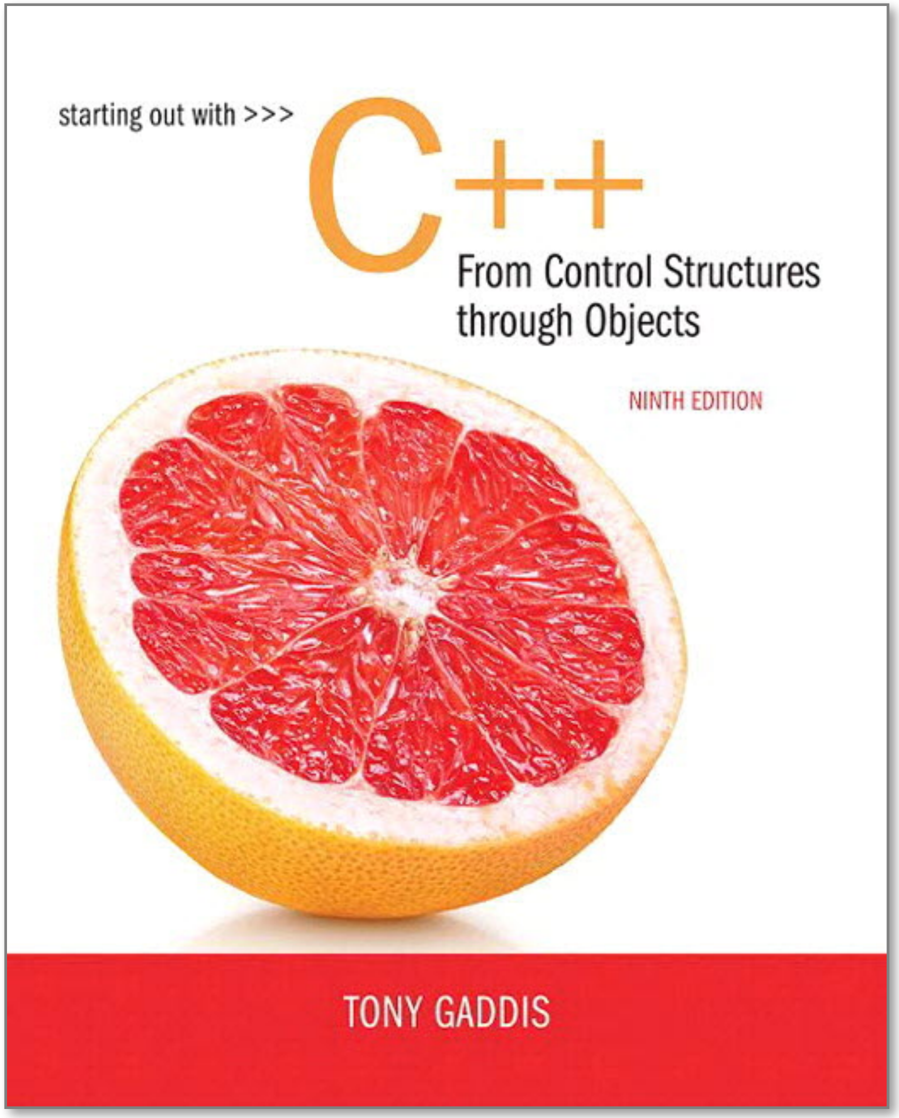
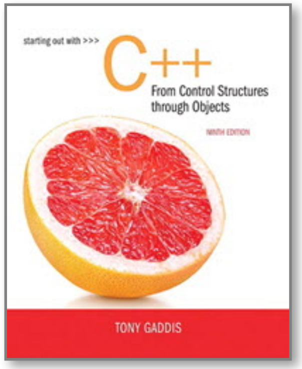
Chapter 2:

Introduction

to

C++





2.1

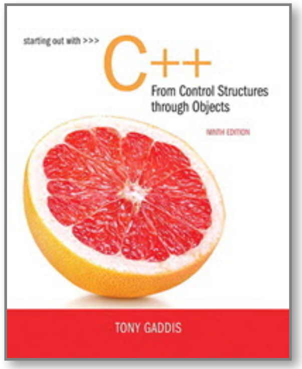
The Parts of a C++ Program

The Parts of a C++ Program

```
// sample C++ program          ←  comment
#include <iostream>            ←  preprocessor directive
using namespace std;           ←  which namespace to use
int main()                     ←  beginning of function named main
{                              ←  beginning of block for main
    cout << "Hello, there!";   ←  output statement
                  ↑
                  └─────────── string literal
    return 0;                  ←  Send 0 to operating system
}                              ←  end of block for main
```

Special Characters

Character	Name	Meaning
//	Double slash	Beginning of a comment
#	Pound sign	Beginning of preprocessor directive
< >	Open/close brackets	Enclose filename in #include
( )	Open/close parentheses	Used when naming a function
{ }	Open/close brace	Encloses a group of statements
" "	Open/close quotation marks	Encloses string of characters
;	Semicolon	End of a programming statement



2.2

The `cout` Object

The `cout` Object

- Displays output on the computer screen
- You use the stream insertion operator `<<` to send output to `cout`:

```
    cout << "Programming is fun!";
```

The `cout` Object

- Can be used to send more than one item to cout:

```
cout << "Hello " << "there!";
```

Or:

```
cout << "Hello ";
cout << "there!";
```

The `cout` Object

- This produces one line of output:

```
cout << "Programming is ";
cout << "fun!";
```

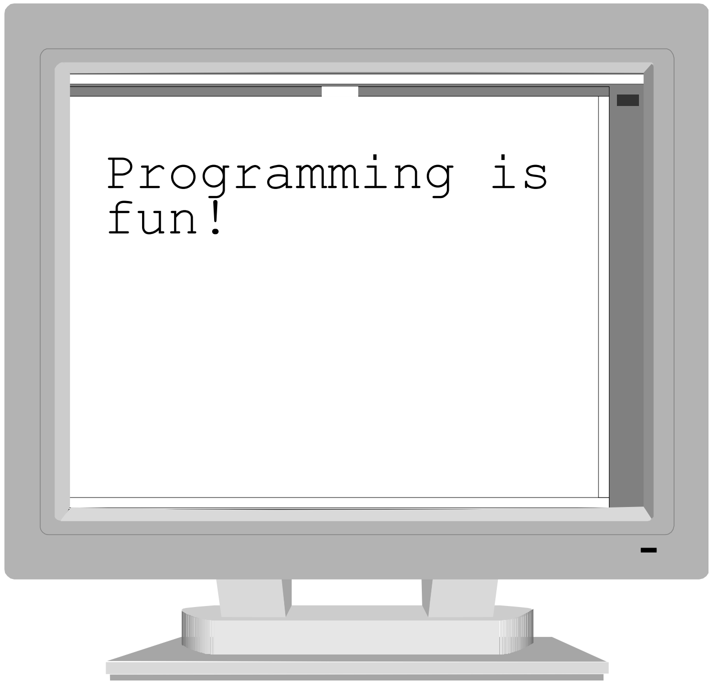
The `endl` Manipulator

- You can use the **`endl`** manipulator to start a new line of output. This will produce two lines of output:

```
cout << "Programming is" << endl;
cout << "fun!";
```

The `endl` Manipulator

```
cout << "Programming is" << endl;
cout << "fun!";
```



```
Programming is
fun!
```

The `endl` Manipulator

- You do NOT put quotation marks around **`endl`**

- The last character in **`endl`** is a lowercase L, not the number 1.

$$\texttt{endl} \xleftarrow{\quad\quad} \text{This is a lowercase L}$$

The `\n` Escape Sequence

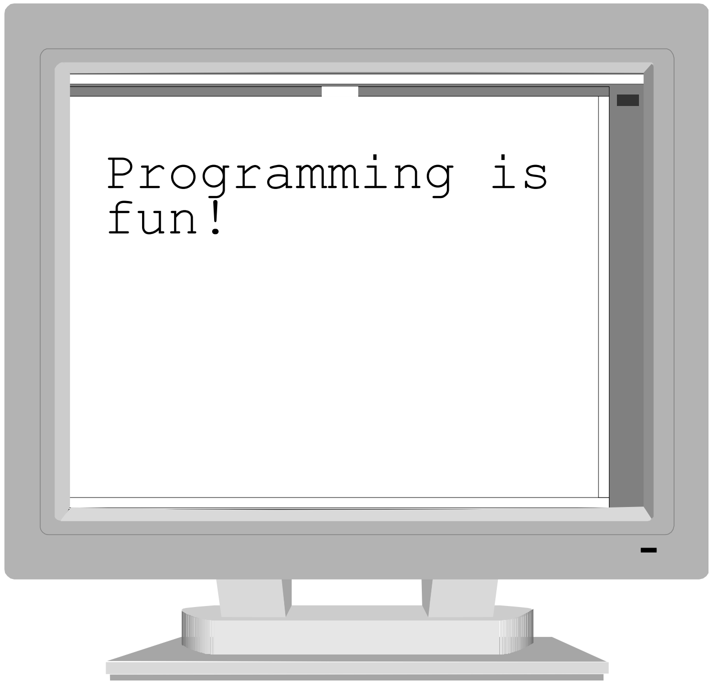
- You can also use the **`\n`** escape sequence to start a new line of output. This will produce two lines of output:

```
cout << "Programming is\n";
cout << "fun!";
```

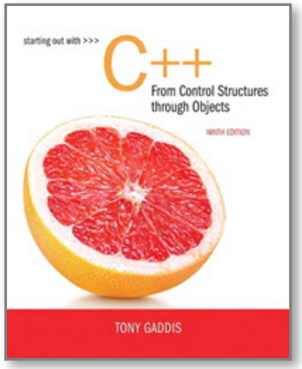
Notice that the **`\n`** is INSIDE the string.

The `\n` Escape Sequence

```
cout << "Programming is\n";
cout << "fun!";
```



```
Programming is
fun!
```

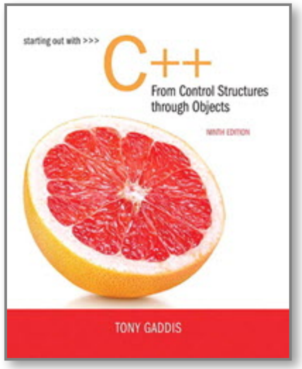


2.3

The #include Directive

The `#include` Directive

- Inserts the contents of another file into the program
- This is a preprocessor directive, not part of C++ language
- `#include` lines not seen by compiler
- Do <u>not</u> place a semicolon at end of `#include` line



2.4

Variables and Literals

Variables and Literals

- Variable: a storage location in memory
  - Has a name and a type of data it can hold
  - Must be defined before it can be used:

```
int item;
```

Variable Definition in Program 2-7

Program 2-7

```
// This program has a variable.
#include <iostream>
using namespace std;

int main()
{
   int number;

   number = 5;
   cout << "The value in number is " << number << endl;
   return 0;
}
```

Variable Definition

Program Output

```
The value in number is 5
```

Literals

- <u>Literal</u>: a value that is written into a program's code.

`"hello, there"` (string literal)

`12` (integer literal)

Integer Literal in Program 2-9

Program 2-9

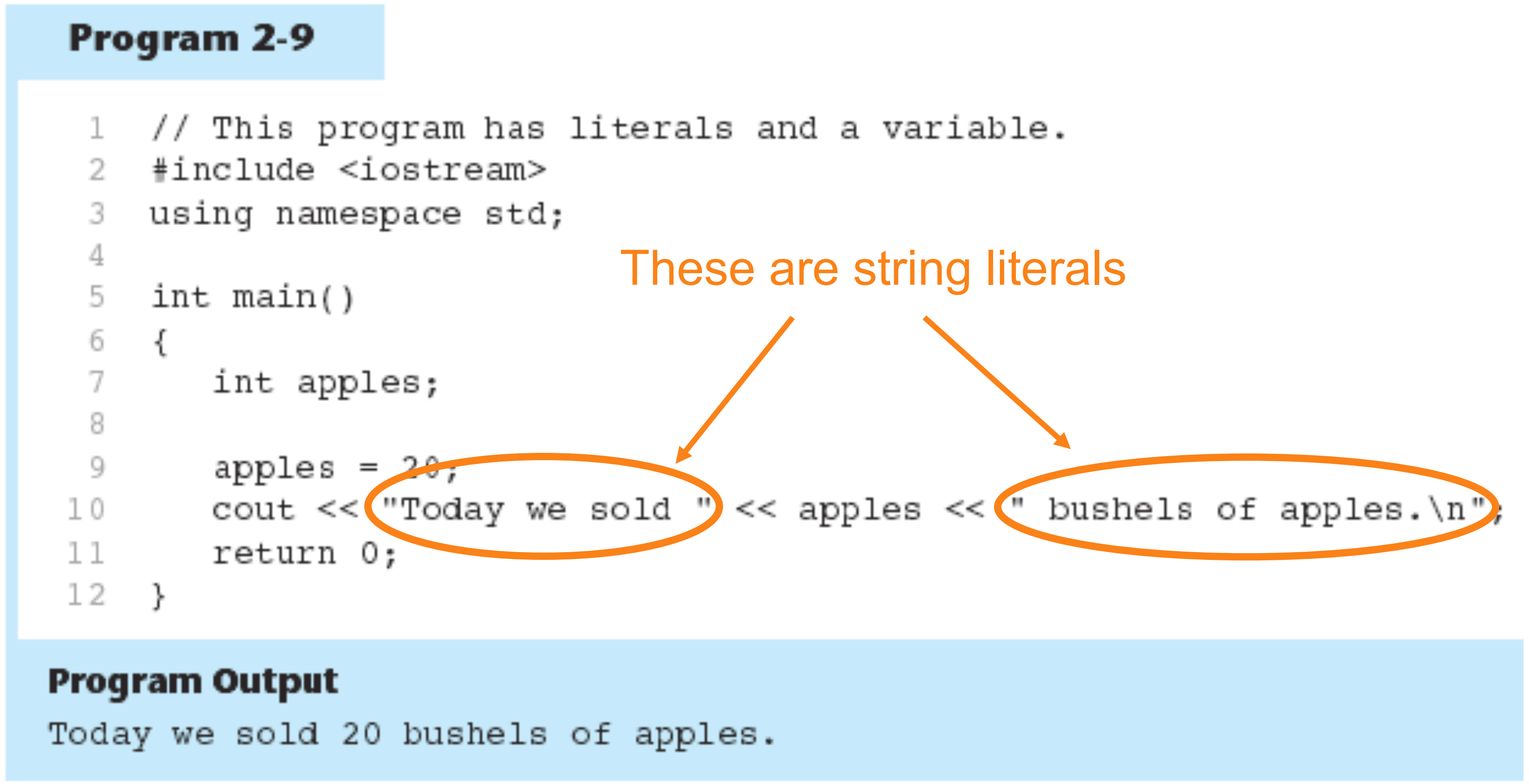
```
// This program has literals and a variable.
#include <iostream>
using namespace std;

int main()
{
   int apples;

   apples = 20;
   cout << "Today we sold " << apples << " bushels of apples.\n";
   return 0;
}
```

20 is an integer literal

Program Output

```
Today we sold 20 bushels of apples.
```

String Literals in Program 2-9

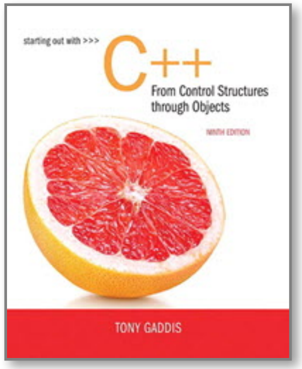


Program 2-9

```
// This program has literals and a variable.
#include <iostream>
using namespace std;

int main()
{
   int apples;

   apples = 20;
   cout << "Today we sold " << apples << " bushels of apples.\n";
   return 0;
}
```

Program Output

```
Today we sold 20 bushels of apples.
```



2.5

Identifiers

Identifiers

- An identifier is a programmer-defined name for some part of a program: variables, functions, etc.

C++ Key Words

Table 2-4 The C++ Key Words

alignas	const	for	private	throw
alignof	constexpr	friend	protected	true
and	const_cast	goto	public	try
and_eq	continue	if	register	typedef
asm	decltype	inline	reinterpret_cast	typeid
auto	default	int	return	typename
bitand	delete	long	short	union
bitor	do	mutable	signed	unsigned
bool	double	namespace	sizeof	using
break	dynamic_cast	new	static	virtual
case	else	noexcept	static_assert	void
catch	enum	not	static_cast	volatile
char	explicit	not_eq	struct	wchar_t
char16_t	export	nullptr	switch	while
char32_t	extern	operator	template	xor
class	false	or	this	xor_eq
compl	float	or_eq	thread_local	

You cannot use any of the C++ key words as an identifier. These words have reserved meaning.

Variable Names

- A variable name should represent the purpose of the variable. For example:

  ```
  itemsOrdered
  ```

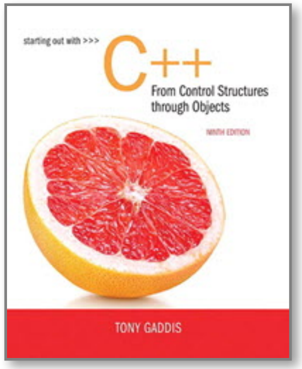
  The purpose of this variable is to hold the number of items ordered.

Identifier Rules

- The first character of an identifier must be an alphabetic character or and underscore (_),
- After the first character you may use alphabetic characters, numbers, or underscore characters.
- Upper- and lowercase characters are distinct

Valid and Invalid Identifiers

IDENTIFIER	VALID?	REASON IF INVALID
`totalSales`	Yes	
`total_Sales`	Yes	
`total.Sales`	No	Cannot contain `.`
`4thQtrSales`	No	Cannot begin with digit
`totalSale$`	No	Cannot contain `$`



2.6

Integer Data Types

Integer Data Types

- Integer variables can hold whole numbers such as 12, 7, and -99.

Table 2-6 Integer Data Types

Data Type	Typical Size	Typical Range
`short int`	2 bytes	−32,768 to +32,767
`unsigned short int`	2 bytes	0 to +65,535
`int`	4 bytes	−2,147,483,648 to +2,147,483,647
`unsigned int`	4 bytes	0 to 4,294,967,295
`long int`	4 bytes	−2,147,483,648 to +2,147,483,647
`unsigned long int`	4 bytes	0 to 4,294,967,295
`long long int`	8 bytes	−9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
`unsigned long long int`	8 bytes	0 to 18,446,744,073,709,551,615

Defining Variables

- Variables of the same type can be defined
  - On separate lines:
```
int length;
int width;
unsigned int area;
```
  - On the same line:
```
int length, width;
unsigned int area;
```
- Variables of different types must be in different definitions

Integer Types in Program 2-10

```
// This program has variables of several of the integer types.
#include <iostream>
using namespace std;

int main()
{
   int checking;
   unsigned int miles;
   long diameter;

    checking = -20;
    miles = 4276;
    diameter = 100000;
    cout << "We have made a long journey of " << miles;
    cout << " miles.\n";
    cout << "Our checking account balance is " << checking;
    cout << "\nThe galaxy is about " << diameter;
    cout << " light years in diameter.\n";
    return 0;
}
```

This program has three variables: checking, miles, and diameter

Integer Literals

- An integer literal is an integer value that is typed into a program's code. For example:

```
itemsOrdered = 15;
```

In this code, 15 is an integer literal.

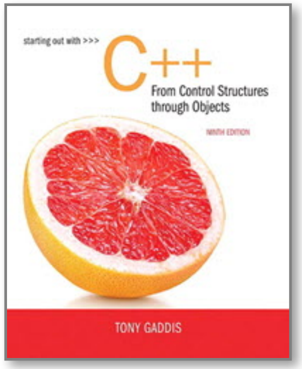
Integer Literals in Program 2-10

```
// This program has variables of several of the integer types.
#include <iostream>
using namespace std;

int main()
{
    int checking;
    unsigned int miles;
    long diameter;

     checking = -20;
     miles = 4276;
     diameter = 100000;
     cout << "We have made a long journey of " << miles;
     cout << " miles.\n";
     cout << "Our checking account balance is " << checking;
     cout << "\nThe galaxy is about " << diameter;
     cout << " light years in diameter.\n";
     return 0;
}
```

Integer Literals

Integer Literals

- Integer literals are stored in memory as `int`s by default
- To store an integer constant in a long memory location, put '`L`' at the end of the number: `1234L`
- To store an integer constant in a long long memory location, put '`LL`' at the end of the number: `324LL`
- Constants that begin with '`0`' (zero) are base 8: `075`
- Constants that begin with '`0x`' are base 16: `0x75A`



2.7

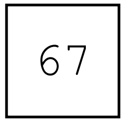
The `char` Data Type

The `char` Data Type

- Used to hold characters or very small integer values
- Usually 1 byte of memory
- Numeric value of character from the character set is stored in memory:

CODE:
```
char letter;
letter = 'C';
```

MEMORY:
```
letter
```



Character Literals

- Character literals must be enclosed in single quote marks. Example:

```
'A'
```

Character Literals in Program 2-14

Program 2-14

```
// This program uses character literals.
#include <iostream>
using namespace std;

int main()
{
    char letter;

    letter = 'A';
    cout << letter << '\n';
    letter = 'B';
    cout << letter << '\n';
    return 0;
}
```

Program Output

```
A
B
```

Character Strings

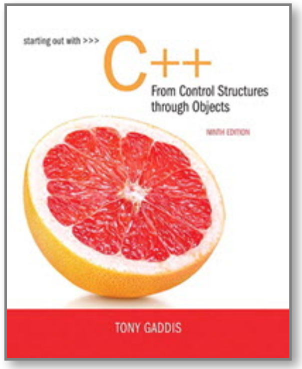
- A series of characters in consecutive memory locations:

  `"Hello"`

- Stored with the null terminator, `\0`, at the end:

- Comprised of the characters between the " "

H	e	l	l	o	\0



2.8

The C++ `string` Class

The C++ `string` Class

- Special data type supports working with strings

```
#include <string>
```

- Can define `string` variables in programs:

```
string firstName, lastName;
```

- Can receive values with assignment operator:

```
firstName = "George";
lastName = "Washington";
```

- Can be displayed via `cout`

```
cout << firstName << " " << lastName;
```

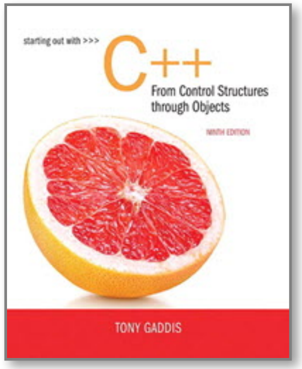
The `string` class in Program 2-15

Program 2-15

```
// This program demonstrates the string class.
#include <iostream>
#include <string> // Required for the string class.
using namespace std;

int main()
{
   string movieTitle;

   movieTitle = "Wheels of Fury";
   cout << "My favorite movie is " << movieTitle << endl;
   return 0;
}
```

Program Output

```
My favorite movie is Wheels of Fury
```



2.9

Floating-Point Data Types

Floating-Point Data Types

- The floating-point data types are:
  float
  double
  `long double`
- They can hold real numbers such as:
  12.45 -3.8
- Stored in a form similar to scientific notation
- All floating-point numbers are signed

Floating-Point Data Types

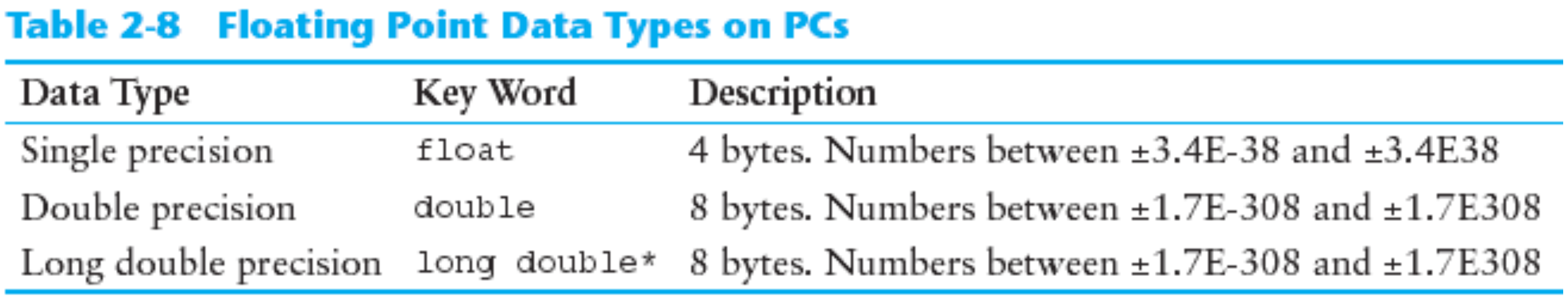


Table 2-8 Floating Point Data Types on PCs

Data Type	Key Word	Description
Single precision	`float`	4 bytes. Numbers between ±3.4E-38 and ±3.4E38
Double precision	`double`	8 bytes. Numbers between ±1.7E-308 and ±1.7E308
Long double precision	`long double*`	8 bytes. Numbers between ±1.7E-308 and ±1.7E308

Floating-Point Literals

- Can be represented in
  - Fixed point (decimal) notation:

    `31.4159`　　　　`0.0000625`
  - E notation:

    `3.14159E1`　　　　`6.25e-5`
- Are `double` by default
- Can be forced to be float (`3.14159f`) or long double (`0.0000625L`)

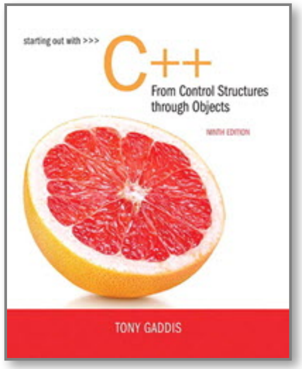
Floating-Point Data Types in Program 2-16

Program 2-16

```
// This program uses floating point data types.
#include <iostream>
using namespace std;

int main()
{
   float distance;
   double mass;

   distance = 1.495979E11;
   mass = 1.989E30;
   cout << "The Sun is " << distance << " meters away.\n";
   cout << "The Sun\'s mass is " << mass << " kilograms.\n";
   return 0;
}
```

Program Output

```
The Sun is 1.49598e+011 meters away.
The Sun's mass is 1.989e+030 kilograms.
```



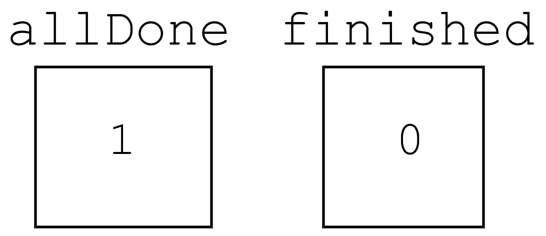
2.10

The `bool` Data Type

The `bool` Data Type

- Represents values that are `true` or `false`
- `bool` variables are stored as small integers
- `false` is represented by 0, `true` by 1:

```
bool allDone = true;
bool finished = false;
```



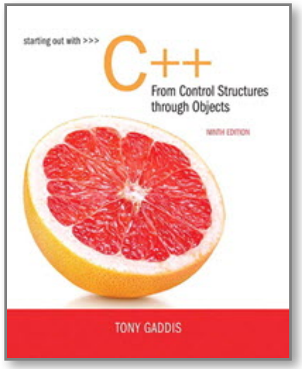
Boolean Variables in Program 2-17

Program 2-17

```
// This program demonstrates boolean variables.
#include <iostream>
using namespace std;

int main()
{
   bool boolValue;

   boolValue = true;
   cout << boolValue << endl;
   boolValue = false;
   cout << boolValue << endl;
   return 0;
}
```

Program Output

```
1
0
```



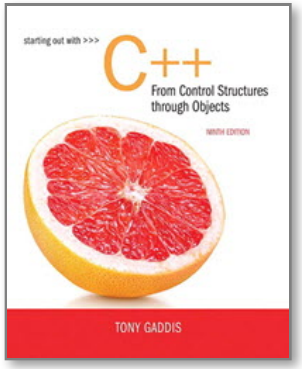
2.11

Determining the Size of a Data Type

Determining the Size of a Data Type

- The `sizeof` operator gives the size of any data type or variable:

```
double amount;
cout << "A double is stored in "
     << sizeof(double) << "bytes\n";
cout << "Variable amount is stored in "
     << sizeof(amount)
    << "bytes\n";
```



2.12

Variable Assignments and Initialization

Variable Assignments and Initialization

- An assignment statement uses the `=` operator to store a value in a variable.

```
item = 12;
```

- This statement assigns the value 12 to the `item` variable.

Assignment

- The variable receiving the value must appear on the left side of the = operator.
- This will NOT work:

```
// ERROR!
12 = item;
```

Variable Initialization

- To initialize a variable means to assign it a value when it is defined:

  int length = 12;

- Can initialize some or all variables:

```
int length = 12, width = 5, area;
```

Variable Initialization in Program 2-19

Program 2-19

```
// This program shows variable initialization.
#include <iostream>
using namespace std;

int main()
{
   int month = 2, days = 28;

   cout << "Month " << month << " has " << days << " days.\n";
   return 0;
}
```

Program Output

```
Month 2 has 28 days.
```

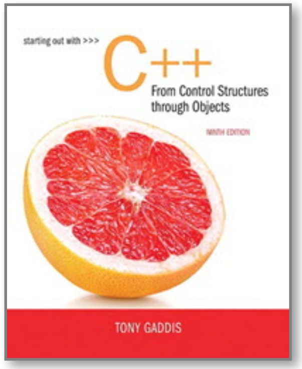
Declaring Variables With the `auto` Key Word

- C++ 11 introduces an alternative way to define variables, using the `auto` key word and an initialization value. Here is an example:

```
auto amount = 100;  <--------- int
```

- The `auto` key word tells the compiler to determine the variable’s data type from the initialization value.

```
auto interestRate= 12.0;  <--------- double
auto stockCode = 'D';     <--------- char
auto customerNum = 459L;  <--------- long
```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2.13

Scope

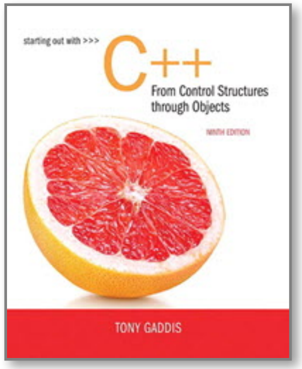
Scope

- The <u>scope</u> of a variable: the part of the program in which the variable can be accessed
- A variable cannot be used before it is defined

Variable Out of Scope in Program 2-20

Program 2-20

```
// This program can't find its variable.
#include <iostream>
using namespace std;

int main()
{
   cout << value; // ERROR! value not defined yet!

   int value = 100;
   return 0;
}
```



2.14

Arithmetic Operators

Arithmetic Operators

- Used for performing numeric calculations
- C++ has unary, binary, and ternary operators:
  - unary (1 operand) `-5`
  - binary (2 operands) `13 - 7`
  - ternary (3 operands) `exp1 ? exp2 : exp3`

Binary Arithmetic Operators

SYMBOL	OPERATION	EXAMPLE	VALUE OF `ans`
`+`	addition	`ans = 7 + 3;`	10
`-`	subtraction	`ans = 7 - 3;`	4
`*`	multiplication	`ans = 7 * 3;`	21
`/`	division	`ans = 7 / 3;`	2
`%`	modulus	`ans = 7 % 3;`	1

Arithmetic Operators in Program 2-21

Program 2-21

```
// This program calculates hourly wages, including overtime.
#include <iostream>
using namespace std;

int main()
{
   double regularWages,            // To hold regular wages
          basePayRate = 18.25,     // Base pay rate
          regularHours = 40.0,     // Hours worked less overtime
          overtimeWages,           // To hold overtime wages
          overtimePayRate = 27.78, // Overtime pay rate
          overtimeHours = 10,      // Overtime hours worked
          totalWages;              // To hold total wages

   // Calculate the regular wages.
   regularWages = basePayRate * regularHours;

   // Calculate the overtime wages.
   overtimeWages = overtimePayRate * overtimeHours;

   // Calculate the total wages.
   totalWages = regularWages + overtimeWages;

   // Display the total wages.
   cout << "Wages for this week are $" << totalWages << endl;
   return 0;
}
```

Program Output

```
Wages for this week are $1007.8
```

A Closer Look at the / Operator

- `/` (division) operator performs integer division if both operands are integers

```
cout << 13 / 5;     // displays 2
cout << 91 / 7;     // displays 13
```

- If either operand is floating point, the result is floating point

```
cout << 13 / 5.0;   // displays 2.6
cout << 91.0 / 7;   // displays 13.0
```

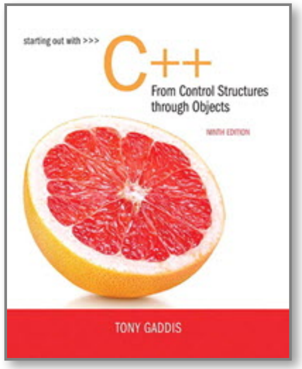
A Closer Look at the `%` Operator

- `%` (modulus) operator computes the remainder resulting from integer division

```
cout << 13 % 5;     // displays 3
```

- `%` requires integers for both operands

```
cout << 13 % 5.0; // error
```



2.15

Comments

Comments

- Used to document parts of the program
- Intended for persons reading the source code of the program:
  - Indicate the purpose of the program
  - Describe the use of variables
  - Explain complex sections of code
- Are ignored by the compiler

Single-Line Comments

- Begin with `//` through to the end of line:

```
int length = 12; // length in
  inches
int width = 15;  // width in inches
int area;        // calculated area

// calculate rectangle area
area = length * width;
```

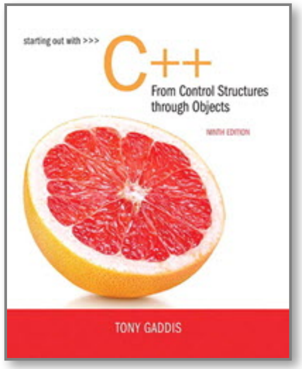
Multi-Line Comments

- Begin with `/*`, end with `*/`
- Can span multiple lines:

```
/* this is a multi-line
   comment
*/
```

- Can begin and end on the same line:

```
int area;   /* calculated area */
```



2.16

Named Constants

Named Constants

- <u>Named constant</u> (<u>constant variable</u>): variable whose content cannot be changed during program execution
- Used for representing constant values with descriptive names:

```
    const double TAX_RATE = 0.0675;
    const int NUM_STATES = 50;
```

- Often named in uppercase letters

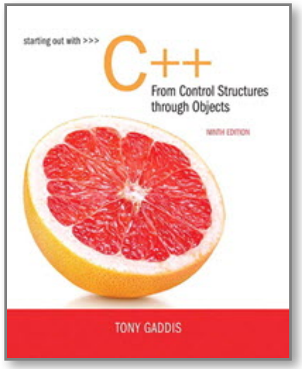
Named Constants in Program 2-28

Program 2-28

```cpp
// This program calculates the circumference of a circle.
#include <iostream>
using namespace std;

int main()
{
   // Constants
   const double PI = 3.14159;
   const double DIAMETER = 10.0;

   // Variable to hold the circumference
   double circumference;

   // Calculate the circumference.
   circumference = PI * DIAMETER;

   // Display the circumference.
   cout << "The circumference is: " << circumference << endl;
   return 0;
}
```

Program Output

```
The circumference is: 31.4159
```



2.17

Programming Style

Programming Style

- The visual organization of the source code
- Includes the use of spaces, tabs, and blank lines
- Does not affect the syntax of the program
- Affects the readability of the source code