

Chapter 2:

Introduction to C++



2.1

The Parts of a C++ Program



The Parts of a C++ Program (1 of 2)

```
// sample C++ program
#include <iostream>
using namespace std;
int main()
{
    cout << "Hello, world!";
    return 0;
}
```



The Parts of a C++ Program (2 of 2)

```
// 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, world!"; ← output statement
    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 (1 of 3)

- Displays output on the computer screen
- You use the stream insertion operator `<<` to send output to `cout`:
 - `cout << "Programming is fun!";`



The `cout` Object (2 of 3)

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

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

Or:

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



The `cout` Object (3 of 3)

- This produces one line of output:

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



The `endl` Manipulator (1 of 3)

- 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 (2 of 3)

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



The `endl` Manipulator (3 of 3)

- You do NOT put quotation marks around `endl`
- The last character in `endl` is a lowercase L, not the number 1.

`endl` ← This is a lowercase L



The `\n` Escape Sequence (1 of 2)

- 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 (2 of 2)

```
cout << "Programming is\n";  
cout << "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 not 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

Program 2-8

```
1  // This program has a variable.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      int number;
8
9      number = 5;
10     cout << "The value in number is " << number << endl;
11     return 0;
12 }
```

← Variable Definition

Program Output

The value in number is 5



Literals

- Literal: a value that is written into a program's code.

`"hello, there"` (string literal)

`12` (integer literal)




Integer Literal

Program 2-10

```
1 // This program has literals and a variable.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     int apples;
8
9     apples = 20;
10    cout << "Today we sold " << apples << " bushels of apples.\n";
11    return 0;
12 }
```

20 is an integer literal



Program Output

Today we sold 20 bushels of apples.

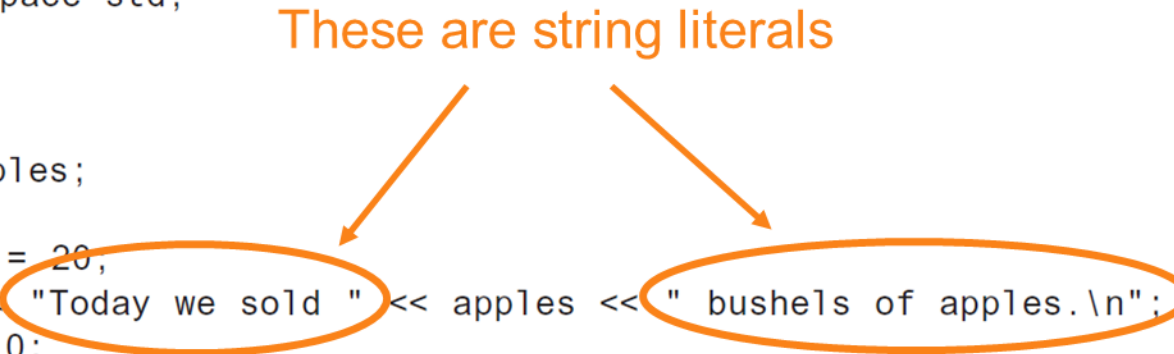


String Literals

Program 2-10

```
1 // This program has literals and a variable.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     int apples;
8
9     apples = 20;
10    cout << "Today we sold " << apples << " bushels of apples.\n";
11    return 0;
12 }
```

These are string literals



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

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

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 an 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
<code>totalSales</code>	Yes	
<code>total_Sales</code>	Yes	
<code>total.Sales</code>	No	Cannot contain .
<code>4thQtrSales</code>	No	Cannot begin with digit
<code>totalSale\$</code>	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
<code>short int</code>	2 bytes	-32,768 to +32,767
<code>unsigned short int</code>	2 bytes	0 to +65,535
<code>int</code>	4 bytes	-2,147,483,648 to +2,147,483,647
<code>unsigned int</code>	4 bytes	0 to 4,294,967,295
<code>long int</code>	4 bytes	-2,147,483,648 to +2,147,483,647
<code>unsigned long int</code>	4 bytes	0 to 4,294,967,295
<code>long long int</code>	8 bytes	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
<code>unsigned long long int</code>	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 2-11

```
1 // This program has variables of several of the integer types.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     int checking;
8     unsigned int miles;
9     long diameter;
10
11     checking = -20;
12     miles = 4276;
13     diameter = 100000;
14     cout << "We have made a long journey of " << miles;
15     cout << " miles.\n";
16     cout << "Our checking account balance is " << checking;
17     cout << "\nThe galaxy is about " << diameter;
18     cout << " light years in diameter.\n";
19     return 0;
20 }
```

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



Integer Literals (1 of 2)

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

```
itemsOrdered = 15;
```

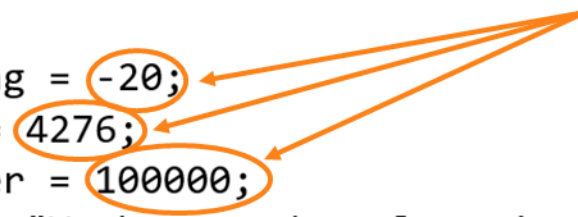
In this code, 15 is an integer literal.



Integer Literals in Program 2-11

```
1 // This program has variables of several of the integer types.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     int checking;
8     unsigned int miles;
9     long diameter;
10
11     checking = -20;
12     miles = 4276;
13     diameter = 100000;
14     cout << "We have made a long journey of " << miles;
15     cout << " miles.\n";
16     cout << "Our checking account balance is " << checking;
17     cout << "\nThe galaxy is about " << diameter;
18     cout << " light years in diameter.\n";
19     return 0;
20 }
```

Integer Literals



Integer Literals (2 of 2)

- Integer literals are stored in memory as `ints` 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

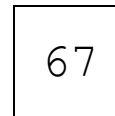
- Used to hold characters or very small integer values
- Usually 1 byte of memory
- Numeric value of character from the character set is stored in memory:

CODE:

```
char letter;  
letter = 'C';
```

MEMORY:

letter



Character Literals (1 of 2)

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

'A'



Character Literals (2 of 2)

Program 2-15

```
1  // This program uses character literals.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      char letter;
8
9      letter = 'A';
10     cout << letter << '\n';
11     letter = 'B';
12     cout << letter << '\n';
13     return 0;
14 }
```

Program Output

A
B

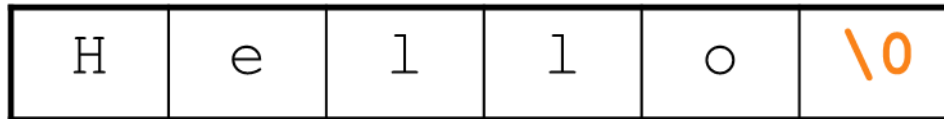


Character Strings

- A series of characters in consecutive memory locations:

`"Hello"`

- Stored with the null terminator, `\0`, at the end:
- Comprised of the characters between the " "



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

Program 2-16

```
1  // This program demonstrates the string class.
2  #include <iostream>
3  #include <string> // Required for the string class.
4  using namespace std;
5
6  int main()
7  {
8      string movieTitle;
9
10     movieTitle = "Wheels of Fury";
11     cout << "My favorite movie is " << movieTitle << endl;
12     return 0;
13 }
```

Program Output

My favorite movie is Wheels of Fury



2.9

Floating-Point Data Types



Floating-Point Data Types (1 of 2)

- 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 (2 of 2)

Table 2-8 Floating Point Data Types on PCs

Data Type	Key Word	Description
Single precision	<code>float</code>	4 bytes. Numbers between $\pm 3.4\text{E-}38$ and $\pm 3.4\text{E}38$
Double precision	<code>double</code>	8 bytes. Numbers between $\pm 1.7\text{E-}308$ and $\pm 1.7\text{E}308$
Long double precision	<code>long double*</code>	8 bytes. Numbers between $\pm 1.7\text{E-}308$ and $\pm 1.7\text{E}308$



Floating-Point Literals

- Can be represented in

Fixed point (decimal) notation:

`31.4159`

`0.0000625`

E notation:

`3.14159E1`

`6.25e-5`

- `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 2-17

```
1  // This program uses floating-point data types.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      float distance;
8      double mass;
9
10     distance = 1.495979E11;
11     mass = 1.989E30;
12     cout << "The Sun is " << distance << " meters away.\n";
13     cout << "The Sun\'s mass is " << mass << " kilograms.\n";
14     return 0;
15 }
```

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;    allDone    finished
bool finished = false;  

|   |
|---|
| 1 |
|---|



|   |
|---|
| 0 |
|---|


```



Boolean Variables

Program 2-18

```
1  // This program demonstrates boolean variables.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      bool boolValue;
8
9      boolValue = true;
10     cout << boolValue << endl;
11     boolValue = false;
12     cout << boolValue << endl;
13     return 0;
14 }
```

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 (1 of 2)

- 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 (2 of 2)

Program 2-20

```
1  // This program shows variable initialization.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      int month = 2, days = 28;
8
9      cout << "Month " << month << " has " << days << " days.\n";
10     return 0;
11 }
```

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
```



2.13

Scope

Scope

- The scope 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

Program 2-21

```
1  // This program can't find its variable.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      cout << value; // ERROR! value not defined yet!
8
9      int value = 100;
10     return 0;
11 }
```



2.14

Arithmetic Operators



Arithmetic Operators (1 of 2)

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



Binary Arithmetic Operators

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



Arithmetic Operators (2 of 2)

Program 2-22

```
1 // This program calculates hourly wages, including overtime.
2 #include <iostream>
3 using namespace std;
4
5 int main()
6 {
7     double regularWages,           // To hold regular wages
8           basePayRate = 18.25,     // Base pay rate
9           regularHours = 40.0,     // Hours worked less overtime
10          overtimeWages,           // To hold overtime wages
11          overtimePayRate = 27.78,  // Overtime pay rate
12          overtimeHours = 10,       // Overtime hours worked
13          totalWages;               // To hold total wages
14
15     // Calculate the regular wages.
16     regularWages = basePayRate * regularHours;
17
18     // Calculate the overtime wages.
19     overtimeWages = overtimePayRate * overtimeHours;
20
21     // Calculate the total wages.
22     totalWages = regularWages + overtimeWages;
23
24     // Display the total wages.
25     cout << "Wages for this week are $" << totalWages << endl;
26     return 0;
27 }
```

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

- Named constant (constant variable): 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 2-29

```
1  // This program calculates the circumference of a circle.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7      // Constants
8      const double PI = 3.14159;
9      const double DIAMETER = 10.0;
10
11     // Variable to hold the circumference
12     double circumference;
13
14     // Calculate the circumference.
15     circumference = PI * DIAMETER;
16
17     // Display the circumference.
18     cout << "The circumference is: " << circumference << endl;
19     return 0;
20 }
```

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

