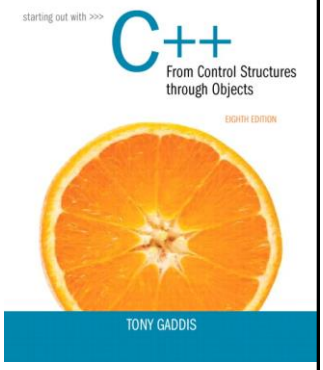
Chapter 2:

Introduction

to

C++



2.1

The Parts of a C++ Program

The Parts of a C++ Program

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

- `//` 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
  - `"Hello, there!"` 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!";
```

The `endl` Manipulator

- 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

- 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!";
```

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 in Program 2-7

Program 2-7

```
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 in Program 2-9

Program 2-9

```
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 in Program 2-9

Program 2-9

```
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

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

Program 2-10

```
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 days;
10
11    checking = -20;
12    miles = 4276;
13    days = 189000;
14    cout << "We have made a long journey of " << miles;
15    cout << " miles.\n";
16    cout << "Our checking account balance is " << checking;
17    cout << "\nAbout " << days << " days ago Columbus ";
18    cout << "stood on this spot.\n";
19    return 0;
20 }
```

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

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

Program 2-10

```
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 days;
10
11    checking = -20;
12    miles = 4276;
13    days = 189000;
14    cout << "We have made a long journey of " << miles;
15    cout << " miles.\n";
16    cout << "Our checking account balance is " << checking;
17    cout << "\nAbout " << days << " days ago Columbus ";
18    cout << "stood on this spot.\n";
19    return 0;
20 }
```

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`

67

Character Literals

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

```
'A'
```


Character Literals in Program 2-14

Program 2-14

```
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 `" "`

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

```
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

- 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

```
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;
bool finished = false;
```

allDone	finished
1	0

Boolean Variables in Program 2-17

Program 2-17

```
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

- 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

```
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 in Program 2-20

Program 2-20

```
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

- 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

```
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 2-28

```
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