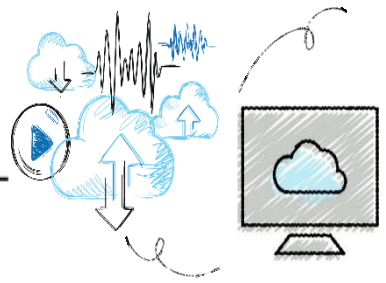
Chapter 3

Input/Output



Objectives (1 of 2)

- In this chapter, you will:
  - Learn what a stream is and examine input and output streams
  - Explore how to read data from the standard input device
  - Learn how to use predefined functions in a program
  - Explore how to use the input stream functions **`get`**, **`ignore`**, **`putback`**, and **`peek`**

Objectives (2 of 2)

- Become familiar with input failure
- Learn how to write data to the standard output device
- Discover how to use manipulators in a program to format output
- Learn how to perform input and output operations with the **`string`** data type
- Learn how to debug logic errors
- Become familiar with file input and output

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I/O Streams and Standard I/O Devices (1 of 3)

- I/O: sequence of bytes (stream of bytes) from source to destination
  - Bytes are usually characters, unless program requires other types of information
  - Stream: sequence of characters from the source to the destination
  - Input stream: sequence of characters from an input device to the computer
  - Output stream: sequence of characters from the computer to an output device

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I/O Streams and Standard I/O Devices (2 of 3)

- Use **`iostream`** header file to receive data from keyboard and send output to the screen
  - Contains definitions of two data types:
    - **`istream`**: input stream
    - **`ostream`**: output stream
  - Has two variables:
    - **`cin`**: stands for common input
    - **`cout`**: stands for common output

I/O Streams and Standard I/O Devices (3 of 3)

- Variable declaration is similar to:
  - `istream cin;`
  - `ostream cout;`
- To use **`cin`** and **`cout`**, the preprocessor directive **`#include <iostream>`** must be used
- Input stream variables: type **`istream`**
- Output stream variables: type **`ostream`**

cin and the Extraction Operator >> (1 of 7)

- The syntax of an input statement using **cin** and the extraction operator **>>** is

```
cin >> variable >> variable...;
```

- The extraction operator **>>** is binary
  - Left-side operand is an input stream variable
    - Example: **cin**
  - Right-side operand is a variable

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cin and the Extraction Operator >> (2 of 7)

- No difference between a single **cin** with multiple variables and multiple **cin** statements with one variable in each statement

```
cin >> payRate >> hoursWorked;

cin >> payRate;
cin >> hoursWorked;
```

- When scanning, **>>** skips all whitespace
  - Blanks and certain nonprintable characters
- **>>** distinguishes between character **2** and number **2** by the right-side operand of **>>**
  - If type **char** or **int** (or **double**), the **2** is treated as a character or as a number **2**, respectively

cin and the Extraction Operator >> (3 of 7)

TABLE 3-1 Valid Input for a Variable of the Simple Data Type

Data Type of a	Valid Input for a
char	One printable character except the blank.
int	An integer, possibly preceded by a + or - sign.
double	A decimal number, possibly preceded by a + or - sign. If the actual data input is an integer, the input is converted to a decimal number with the zero decimal part.

- Entering a **char** value into an **int** or **double** variable causes serious errors, called input failure

`cin` and the Extraction Operator >> (4 of 7)

- When reading data into a **`char`** variable
  - **>>** skips leading whitespace, finds and stores only the next character
  - Reading stops after a single character
- To read data into an **`int`** or **`double`** variable
  - **>>** skips leading whitespace, reads **+** or **−** sign (if any), reads the digits (including decimal for floating-point variables)
  - Reading stops on whitespace or a non-digit character

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cin and the Extraction Operator >> (5 of 7)

EXAMPLE 3-1

Suppose you have the following variable declarations:

```
int a, b;
double z;
char ch;
```

The following statements show how the extraction operator >> works.

	Statement	Input	Value Stored in Memory
1	`cin >> ch;`	`A`	`ch = 'A'`
2	`cin >> ch;`	`AB`	`ch = 'A', 'B'` is held for later input
3	`cin >> a;`	`48`	`a = 48`
4	`cin >> a;`	`46.35`	`a = 46, .35` is held for later input
5	`cin >> z;`	`74.35`	`z = 74.35`
6	`cin >> z;`	`39`	`z = 39.0`
7	`cin >> z >> a;`	`65.78 38`	`z = 65.78, a = 38`
8	`cin >> a >> b;`	`4 60`	`a = 4, b = 60`
9	`cin >> a >> z;`	`46 32.4 68`	`a = 46, z = 32.4, 68` is held for later input

cin and the Extraction Operator >> (6 of 7)

EXAMPLE 3-2

Suppose you have the following variable declarations:

```
int a;
double z;
char ch;
```

The following statements show how the extraction operator >> works.

	Statement	Input	Value Stored in Memory
1	`cin >> a >> ch >> z;`	`57 A 26.9`	`a = 57, ch = 'A', z = 26.9`
2	`cin >> a >> ch >> z;`	`57 A` `26.9`	`a = 57, ch = 'A', z = 26.9`

3	`cin >> a >> ch >> z;`	`57`
		`A`
		`26.9`
			`a = 57, ch = 'A', z = 26.9`

4	`cin >> a >> ch >> z;`	`57A26.9`	`a = 57, ch = 'A', z = 26.9`

cin and the Extraction Operator >> (7 of 7)

EXAMPLE 3-3

Suppose you have the following variable declarations:

```
int a, b;
double z;
char ch, ch1, ch2;
```

The following statements show how the extraction operator >> works.

	Statement	Input	Value Stored in Memory
1	`cin >> z >> ch >> a;`	`36.78B34`	`z = 36.78, ch = 'B', a = 34`
2	`cin >> z >> ch >> a;`	`36.78` `B34`	`z = 36.78, ch = 'B', a = 34`
3	`cin >> a >> b >> z;`	`11 34`	`a = 11, b = 34,` computer waits for the next number
4	`cin >> a >> z;`	`78.49`	`a = 78, z = 0.49`
5	`cin >> ch >> a;`	`256`	`ch = '2', a = 56`
6	`cin >> a >> ch;`	`256`	`a = 256,` computer waits for the input value for `ch`
7	`cin >> ch1 >> ch2;`	`A B`	`ch1 = 'A', ch2 = 'B'`

Using Predefined Functions in a Program (1 of 3)

- A function (subprogram) is a set of instructions
  - When activated, it accomplishes a task
- **`main`** executes when a program is run
- Other functions execute only when called
- C++ includes a wealth of functions
  - Predefined functions are organized as a collection of libraries called header files

Using Predefined Functions in a Program (2 of 3)

- Header file may contain several functions
- To use a predefined function, you need the name of the appropriate header file
  - You also need to know:
    - Function name
    - Number of parameters required
    - Type of each parameter
    - What the function is going to do

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Using Predefined Functions in a Program (3 of 3)

- To use **pow** (power), include **cmath**
  - Two numeric parameters
  - Syntax: **pow(x,y) = x^y**
    - **x** and **y** are the arguments or parameters
  - In **pow(2,3)**, the parameters are **2** and **3**

cin and the get Function

- The **get** function
  - Inputs next character (including whitespace)
  - Stores in memory location indicated by its argument
- The syntax of **cin** and the **get** function

```
cin.get(varChar);
```

  - **varChar** is a **char** variable
    - It is the argument (or parameter) of the function

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cin and the ignore Function (1 of 2)

- **`ignore`** function
  - Discards a portion of the input
- The syntax to use the function **`ignore`** is:

```
cin.ignore(intExp, chExp);
```

  - **`intExp`** is an integer expression
  - **`chExp`** is a char expression
- If **`intExp`** is a value m, the statement says to ignore the next m characters or all characters until the character specified by **`chExp`**

cin and the ignore Function (2 of 2)

EXAMPLE 3-5

Consider the declaration:

```
int a, b;
```

and the input:

```
25 67 89 43 72
12 78 34
```

Now consider the following statements:

```
cin >> a;
cin.ignore(100, '\n');
cin >> b;
```

The first statement, `cin >> a;`, stores `25` in `a`. The second statement, `cin.ignore(100, '\n');`, discards all of the remaining numbers in the first line. The third statement, `cin >> b;`, stores `12` (from the next line) in `b`.

The `putback` and `peek` Functions (1 of 2)

- **`putback`** function
  - Places previous character extracted by the get function from an input stream back to that stream
- **`peek`** function
  - Returns next character from the input stream
  - Does not remove the character from that stream

The `putback` and `peek` Functions (2 of 2)

- Syntax for `putback`

```
istreamVar.putback(ch);
```

  - **`istreamVar`**: an input stream variable (such as **`cin`**)
  - **`ch`** is a **`char`** variable

- Syntax for **`peek`**

```
ch = istreamVar.peek();
```

  - **`istreamVar`**: an input stream variable (such as **`cin`**)
  - **`ch`** is a **`char`** variable

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The Dot Notation between I/O Stream Variables and I/O Functions: A Precaution

- In the statement

  ```
  cin.get(ch);
  ```

  cin and **get** are two separate identifiers separated by a dot
- Called the dot notation, the dot separates the input stream variable name from the member, or function, name
- In C++, the dot is the member access operator

Input Failure

- Things can go wrong during execution
- If input data does not match corresponding variables, the program may run into problems
- Trying to read a letter into an `int` or `double` variable will result in an input failure
- If an error occurs when reading data
  - Input stream enters the fail state

The `clear` Function

- Once in a fail state, all further I/O statements using that stream are ignored
- The program continues to execute with whatever values are stored in variables
  - This causes incorrect results
- The **`clear`** function restores the input stream to a working state
- The syntax of the function **`clear`** is:

```
istreamVar.clear();
```

Output and Formatting Output

- Syntax of **cout** when used with **<<**

```
cout << expression or manipulator << expression or manipulator...;
```

- **expression** is evaluated
- **value** is printed
- **manipulator** is used to format the output
  - Example: **endl**

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`setprecision` Manipulator

- Syntax

```
setprecision(n)
```

- Outputs decimal numbers with up to **`n`** decimal places
- Must include the header file **`iomanip`**
  - **`#include <iomanip>`**

`fixed` Manipulator

- **`fixed`** outputs floating-point numbers in a fixed decimal format
  - Example: **`cout << fixed;`**
  - Disable by using the stream member function **`unsetf`**
    - Example: **`cout.unsetf(ios::fixed);`**
- **`scientific`** manipulator outputs floating-point numbers in scientific format

`showpoint` Manipulator

- **`showpoint`** forces output to show the decimal point and trailing zeros
- Examples
  - **`cout << showpoint;`**
  - **`cout << fixed << showpoint;`**

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C++14 Digit Separator

- Reading and writing of long numbers can be error prone
- In C++, commas cannot be used to separate the digits of a number
- C++14 introduces digit separator ' (single-quote character)
  - Example: `87523872918` can be represented as `87'523'872'918`

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setw

- Outputs the value of an expression in a specified number of columns
  - **`cout << setw(5) << x << endl;`**
- If number of columns exceeds the number of columns required by the expression
  - Output of the expression is right-justified
  - Unused columns to the left are filled with spaces
- Must include the header file **`iomanip`**

Additional Output Formatting Tools

- Additional formatting tools that give you more control over your output:
  - **`setfill`** manipulator
  - **`left`** and **`right`** manipulators
  - **`unsetf`** manipulator

`setfill` Manipulator

- Output stream variables can use `setfill` to fill unused columns with a character

```
ostreamVar << setfill(ch);
```

- Example:
  - `cout << setfill('#');`

`left` and `right` Manipulators

- **`left`** manipulator left-justifies the output

```
ostreamVar << left;
```

- Disable **`left`** by using **`unsetf`**

```
ostreamVar.unsetf(ios::left);
```

- **`right`** manipulator right-justifies the output

```
ostreamVar << right;
```

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Types of Manipulators

- Two types of manipulators
  - Those with parameters
  - Those without parameters
- Parameterized stream manipulators require the **`iomanip`** header
  - **`setprecision`**, **`setw`**, and **`setfill`**
- Manipulators without parameters require the **`iostream`** header
  - **`endl`**, **`fixed`**, **`scientific`**, **`showpoint`**, and **`left`**

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Input/Output and the `string` Type

- An input stream variable (such as **`cin`**) and **`>>`** operator can read a string into a variable of the data type **`string`**
- The extraction operator:
  - Skips any leading whitespace characters
  - Stops reading at a whitespace character
- The function **`getline`** reads until end of the current line

```
getline(istreamVar, strVar);
```

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Debugging: Understanding Logic Errors and Debugging with `cout` statements

- Syntax errors are reported by the compiler
- Logic errors are typically not caught by the compiler
  - Spot and correct using **`cout`** statements
    - Temporarily insert an output statement
  - Correct the problem
  - Remove output statement

File Input/Output

- A file is an area in secondary storage to hold info
- File I/O is a five-step process
  1. Include **`fstream`** header
  2. Declare file stream variables
  3. Associate the file stream variables with the input/output sources – referred to as opening the files
  4. Use the file stream variables with **>>, <<,** or other input/output functions
  5. Close the files

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Quick Review (1 of 3)

- Stream: infinite sequence of characters from a source to a destination
  - Input stream: from a source to a computer
  - Output stream: from a computer to a destination
  - **`cin`**: common input
  - **`cout`**: common output
  - To use **`cin`** and **`cout`**, include `iostream` header

Quick Review (2 of 3)

- **`get`** reads data character-by-character
- **`ignore`** skips data in a line
- **`putback`** puts last character retrieved by `get` back to the input stream
- **`peek`** returns next character from input stream, but does not remove it
- Attempting to read invalid data into a variable causes the input stream to enter the fail state

Quick Review (3 of 3)

- The manipulators **`setprecision`**, **`fixed`**, **`showpoint`**, **`setw`**, **`setfill`**, **`left`**, and **`right`** can be used for formatting output
- Include **`iomanip`** for the manipulators **`setprecision`**, **`setw`**, and **`setfill`**
- Header **`fstream`** contains the definitions of **`ifstream`** and **`ofstream`**

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