CSW 232
Computer Programming (1)

SPRING 2024

Lecture 02 – Introduction to C++
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The Basics of a C++ Program

- **Function**: collection of statements; when executed, accomplishes something
  - May be predefined or standard

- **Syntax**: rules that specify which statements (instructions) are legal

- **Programming language**: a set of rules, symbols, and special words

- **Semantic rule**: meaning of the instruction

Comments

- Comments are for the reader, not the compiler
- Two types:
  - Single line

```
// This is a C++ program. It prints the sentence:
// Welcome to C++ Programming.
```

  - Multiple line

```
/*
   You can include comments that can
   occupy several lines.
*/
```

Special Symbols

- Special symbols

```
+
-
*
/
.
;
?
,
<=
!=
==
>=
```

Reserved Words (Keywords)

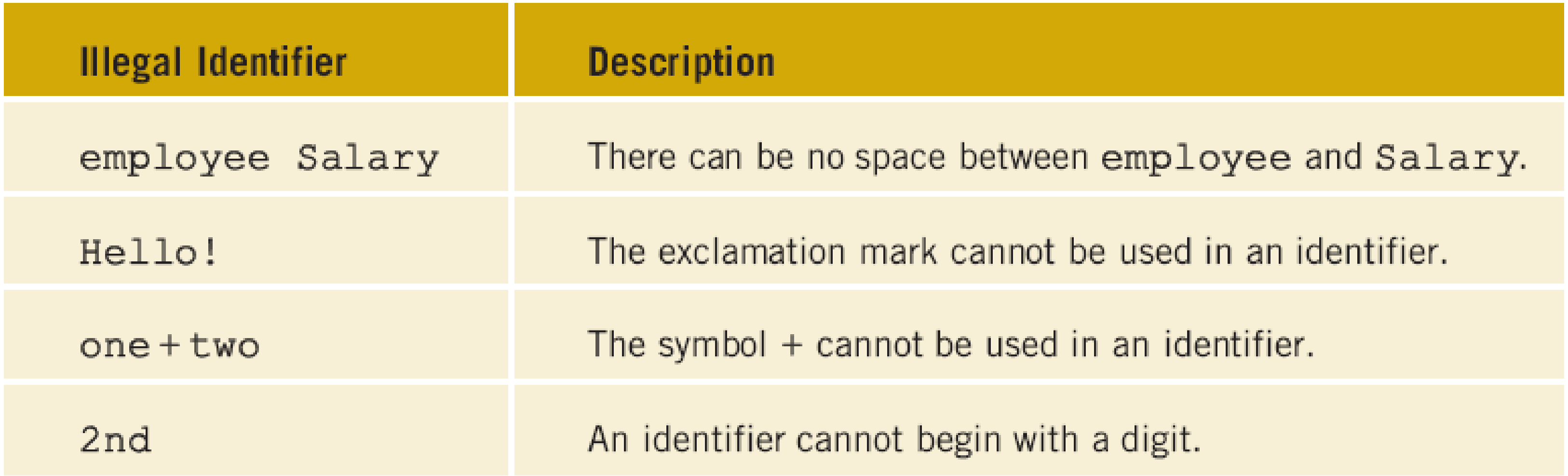
- Reserved words, keywords, or word symbols
  - Include:
    - `int`
    - `float`
    - `double`
    - `char`
    - `const`
    - `void`
    - `return`

Identifiers

- Consist of letters, digits, and the underscore character (_)
- Must begin with a letter or underscore
- C++ is case sensitive
  - `NUMBER` is not the same as `number`
- Two predefined identifiers are `cout` and `cin`
- Unlike reserved words, predefined identifiers may be redefined, but it is not a good idea

Identifiers

- The following are legal identifiers in C++:
  - `first`
  - `conversion`
  - `payRate`
- Examples of Illegal identifiers:



Illegal Identifier	Description
`employee Salary`	There can be no space between `employee` and `Salary`.
`Hello!`	The exclamation mark cannot be used in an identifier.
`one+two`	The symbol + cannot be used in an identifier.
`2nd`	An identifier cannot begin with a digit.

Whitespaces

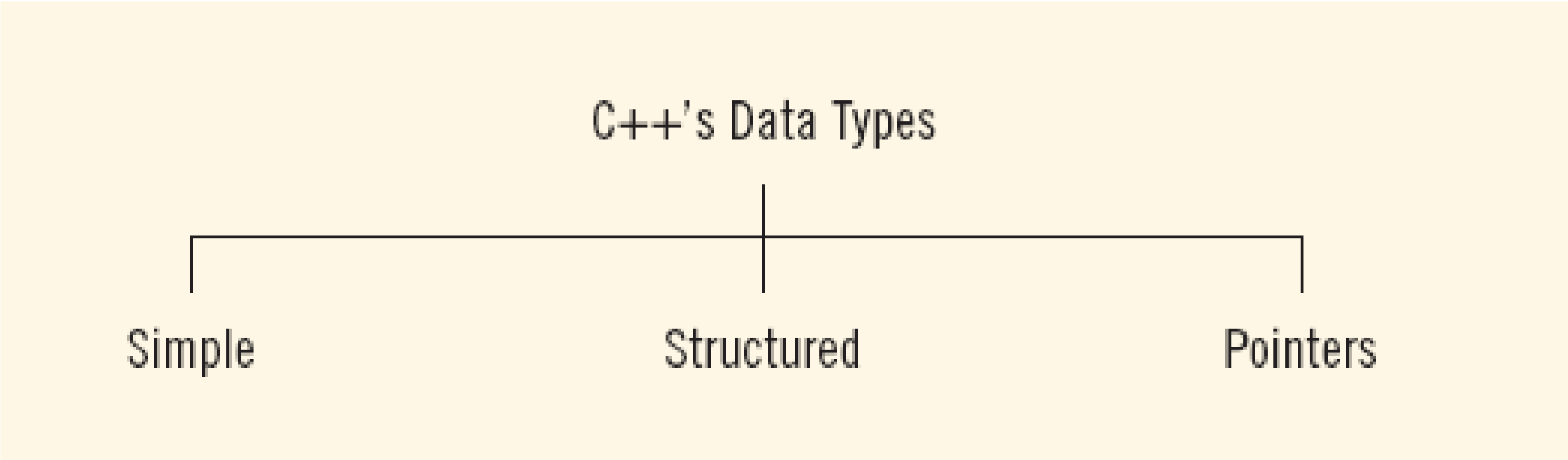
- Every C++ program contains whitespaces
  - Include blanks, tabs, and newline characters

- Used to separate special symbols, reserved words, and identifiers

- Proper utilization of whitespaces is important
  - Can be used to make the program readable

Data Types

- Data type: set of values together with a set of operations
- C++ data types fall into three categories:



C++'s Data Types

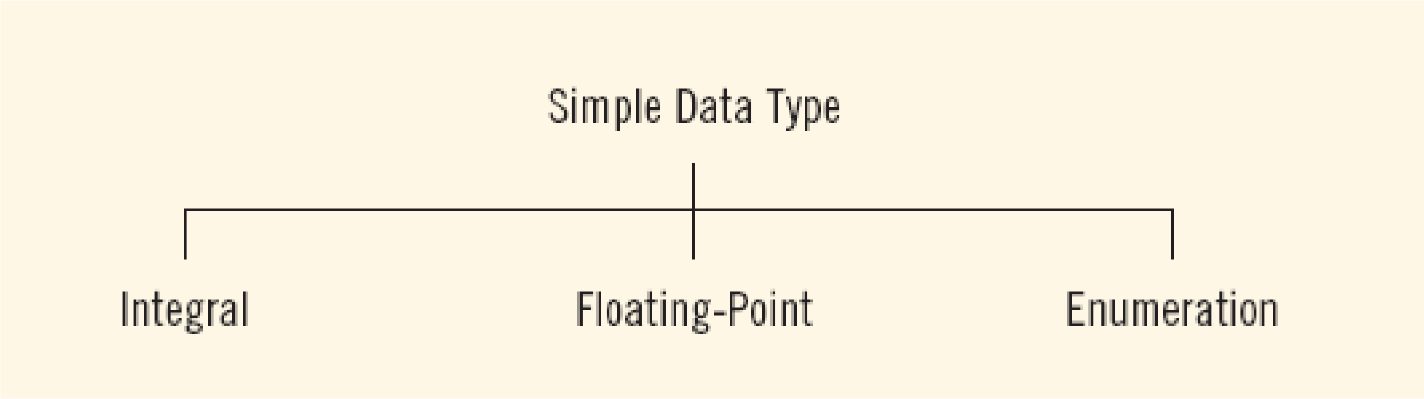
Simple

Structured

Pointers

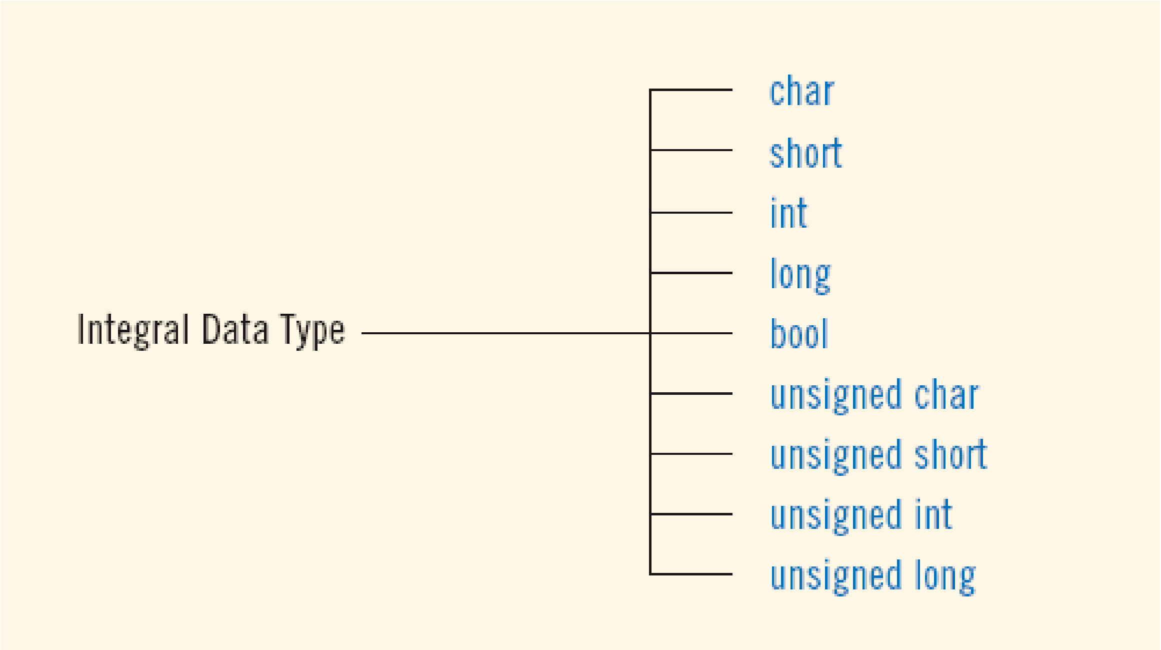
Simple Data Types

- Three categories of simple data
  - Integral: integers (numbers without a decimal)
  - Floating-point: decimal numbers
  - Enumeration type: user-defined data type



Simple Data Types

- Integral data types are further classified into nine categories:



Integral Data Type

char

short

int

long

bool

unsigned char

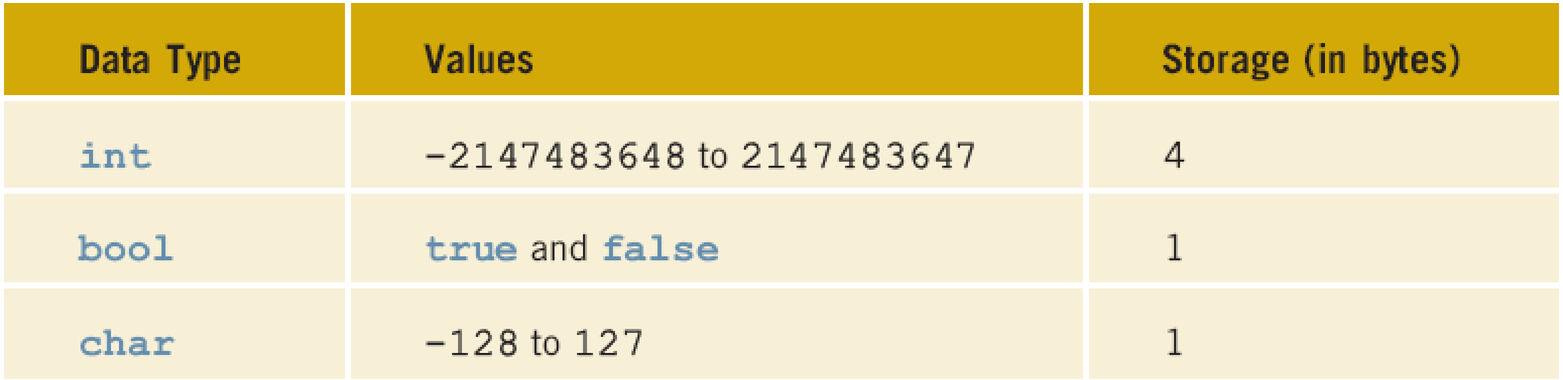
unsigned short

unsigned int

unsigned long

Simple Data Types

- Different compilers may allow different ranges of values



Data Type	Values	Storage (in bytes)
`int`	-2147483648 to 2147483647	4
`bool`	`true` and `false`	1
`char`	-128 to 127	1

`int` Data Type

- Examples:

  ```
  -6728
  0
  78
  +763
  ```

- Positive integers do not need a + sign
- No commas are used within an integer
  - Commas are used for separating items in a list

`bool` **Data Type**

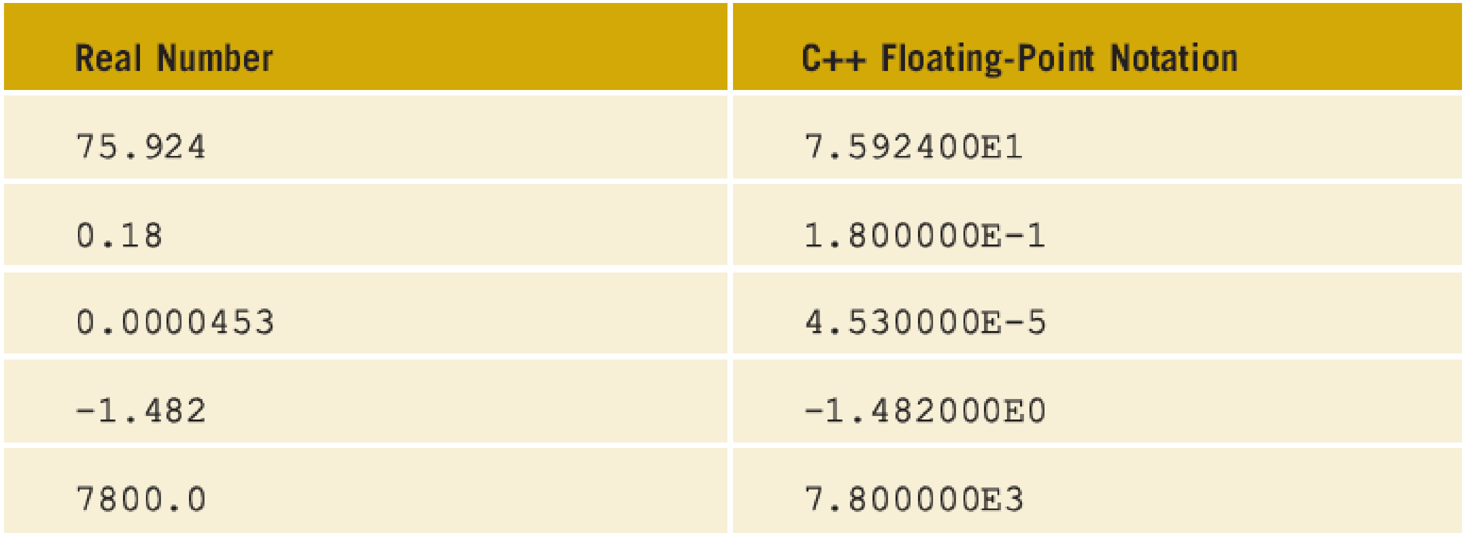
- `bool` type
  - Two values: `true` and `false`
  - Manipulate logical (Boolean) expressions
- `true` and `false` are called logical values
- `bool`, `true`, and `false` are reserved words

`char` Data Type

- The smallest integral data type
- Used for characters: letters, digits, and special symbols
- Each character is enclosed in single quotes
  - `'A'`, `'a'`, `'0'`, `'*'`, `'+'`, `'$'`, `'&'`
- A blank space is a character and is written `' '`, with a space left between the single quotes

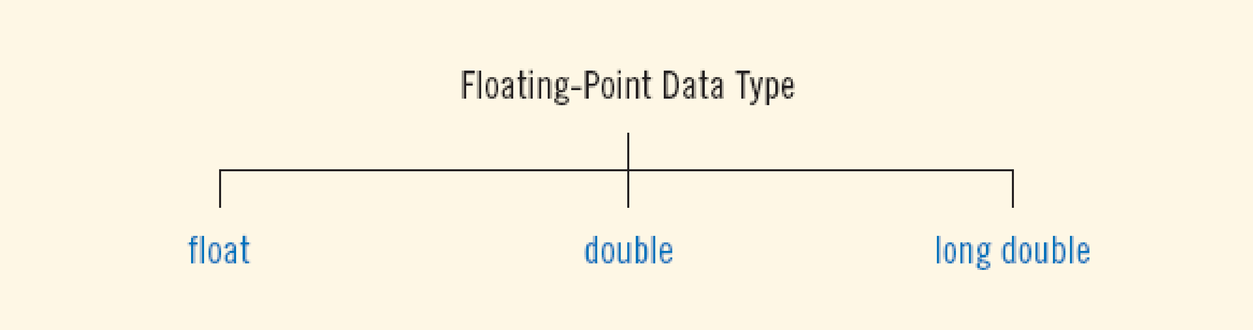
Floating-Point Data Types

- C++ uses scientific notation to represent real numbers (floating-point notation)



Real Number	C++ Floating-Point Notation
75.924	7.592400E1
0.18	1.800000E-1
0.0000453	4.530000E-5
-1.482	-1.482000E0
7800.0	7.800000E3

`Floating-Point` **Data Types**



- `float`: represents any real number
- Range: -3.4E+38 to 3.4E+38 (four bytes)
- `double`: represents any real number
- Range: -1.7E+308 to 1.7E+308 (eight bytes)
- On most newer compilers, data types `double` and `long double` are same

Floating-Point Data Types

- Maximum number of significant digits (decimal places) for float values is 6 or 7
- Maximum number of significant digits for double is 15
- Precision: maximum number of significant digits
  - Float values are called single precision
  - Double values are called double precision

Arithmetic Operators and Operator Precedence

- C++ arithmetic operators:
  - + addition
  - - subtraction
  - * multiplication
  - / division
  - % modulus operator
- +, -, *, and / can be used with integral and floating-point data types
- Operators can be unary or binary

Order of Precedence

- All operations inside of () are evaluated first
- *, /, and % are at the same level of precedence and are evaluated next
- + and – have the same level of precedence and are evaluated last
- When operators are on the same level
  - Performed from left to right (associativity)
- `3 * 7 - 6 + 2 * 5 / 4 + 6` means
  `(((3 * 7) – 6) + ((2 * 5) / 4 )) + 6`

Expressions

- If all operands are integers
  - Expression is called an integral expression
    - Yields an integral result
    - Example: `2 + 3 * 5`
- If all operands are floating-point
  - Expression is called a floating-point expression
    - Yields a floating-point result
    - Example: `12.8 * 17.5 - 34.50`

Mixed Expressions

- Mixed expression:
  - Has operands of different data types
  - Contains integers and floating-point
- Examples of mixed expressions:

```
2 + 3.5
6 / 4 + 3.9
5.4 * 2 - 13.6 + 18 / 2
```

Mixed Expressions

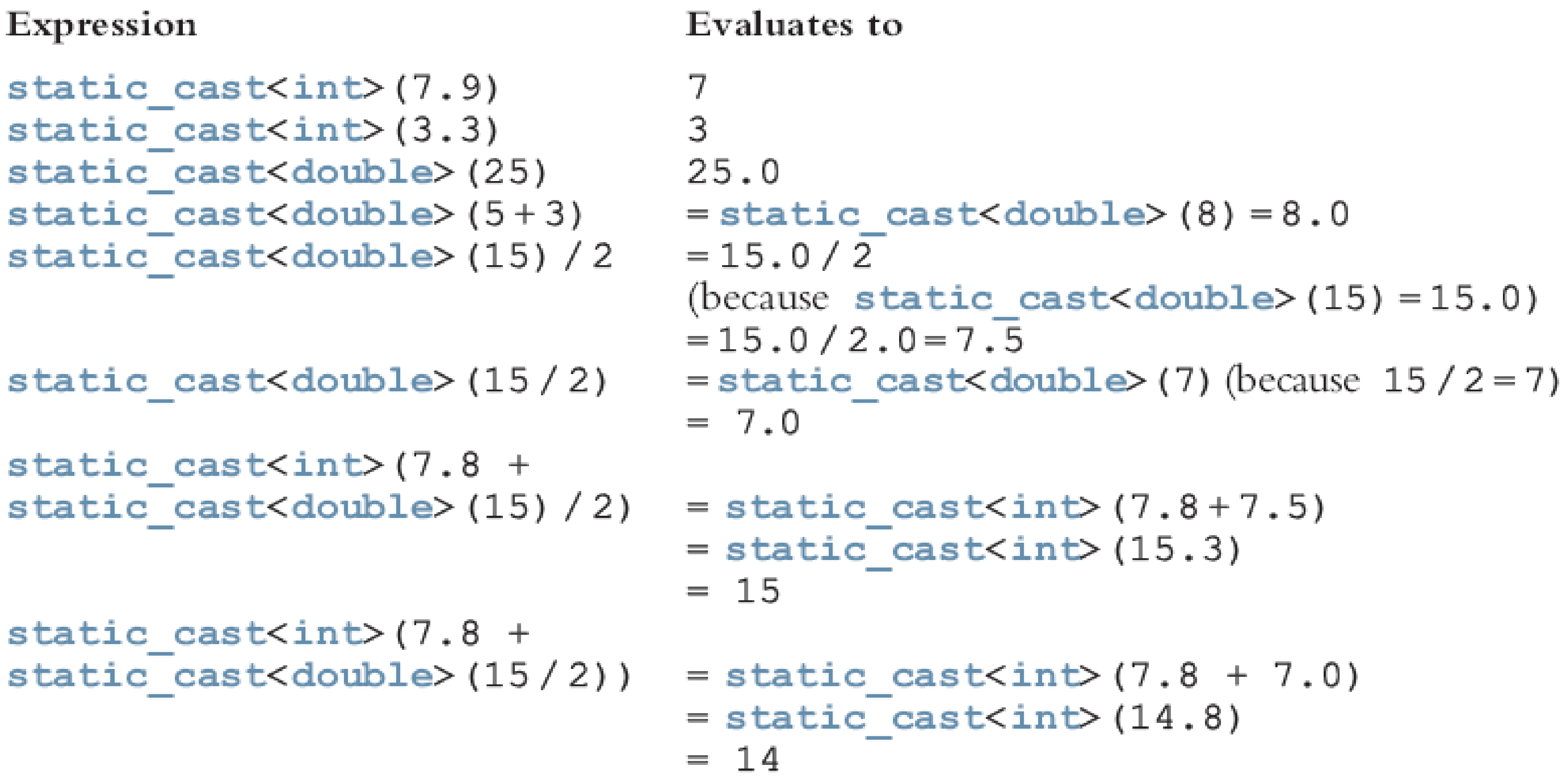
- Evaluation rules:
  - If operator has same types of operands
    - Evaluated according to the type of the operands
  - If operator has both types of operands
    - Integer is changed to floating-point
    - Operator is evaluated
    - Result is floating-point
  - Entire expression is evaluated according to precedence rules

Type Conversion (Casting)

- Implicit type coercion: when value of one type is automatically changed to another type
- Cast operator: provides explicit type conversion

```
static_cast<dataTypeName>(expression)
```

Type Conversion (Casting)



Expression	Evaluates to
static_cast<int>(7.9)	7
static_cast<int>(3.3)	3
static_cast<double>(25)	25.0
static_cast<double>(5+3)	=static_cast<double>(8) =8.0
static_cast<double>(15) / 2	=15.0 / 2 (because static_cast<double>(15) =15.0) =15.0 / 2.0=7.5
static_cast<double>(15 / 2)	=static_cast<double>(7) (because 15 / 2=7) = 7.0
static_cast<int>(7.8 + static_cast<double>(15) / 2)	= static_cast<int>(7.8+7.5) = static_cast<int>(15.3) = 15
static_cast<int>(7.8 + static_cast<double>(15 / 2))	= static_cast<int>(7.8 + 7.0) = static_cast<int>(14.8) = 14

`string` Type

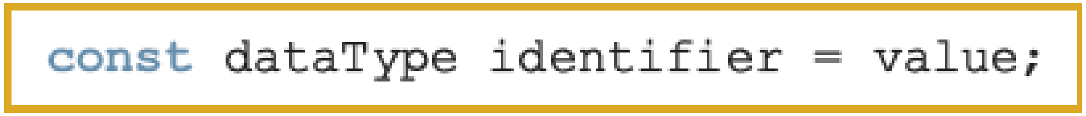
- Programmer-defined type supplied in ANSI/ISO Standard C++ library
- Sequence of zero or more characters
- Enclosed in double quotation marks
- Null: a string with no characters
- Each character has relative position in string
  - Position of first character is 0
- Length of a string is number of characters in it
  - Example: length of `"William Jacob"` is 13

Input

- Data must be loaded into main memory before it can be manipulated
- Storing data in memory is a two-step process:
  - Instruct computer to allocate memory
  - Include statements to put data into memory

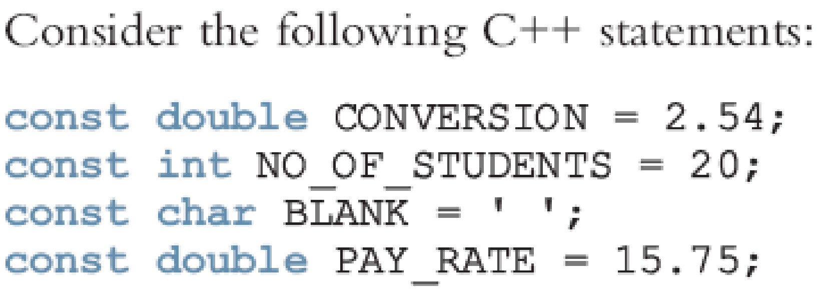
Allocating Memory with Constants and Variables

- Named constant: memory location whose content can’t change during execution
- The syntax to declare a named constant is:



```
const dataType identifier = value;
```

- In C++, `const` is a reserved word



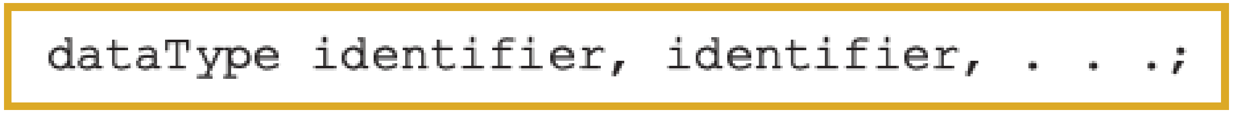
Consider the following C++ statements:

```
const double CONVERSION = 2.54;
const int NO_OF_STUDENTS = 20;
const char BLANK = ' ';
const double PAY_RATE = 15.75;
```

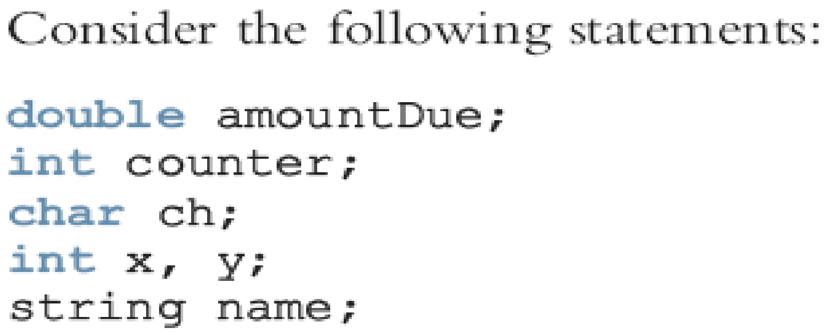
Allocating Memory with Constants and Variables

- Variable: memory location whose content may change during execution

- The syntax to declare a named constant is:



```
dataType identifier, identifier, . . .;
```



Consider the following statements:

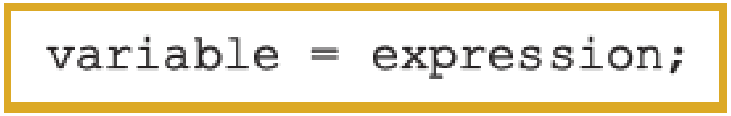
```
double amountDue;
int counter;
char ch;
int x, y;
string name;
```

Putting Data into Variables

- Ways to place data into a variable:
  - Use C++’s assignment statement
  - Use input (read) statements

Assignment Statement

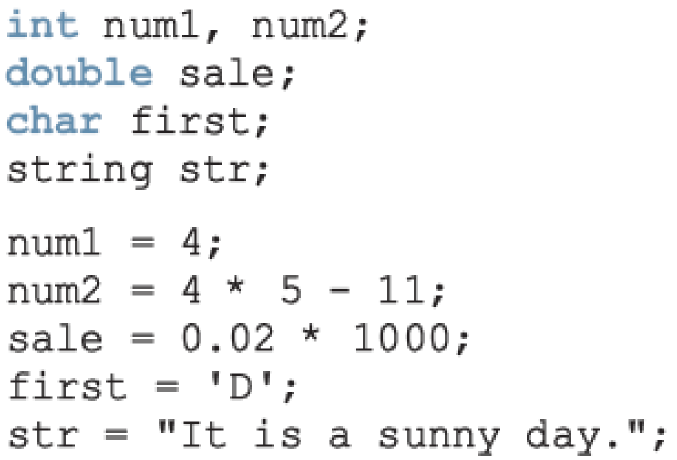
- The assignment statement takes the form:



```
variable = expression;
```

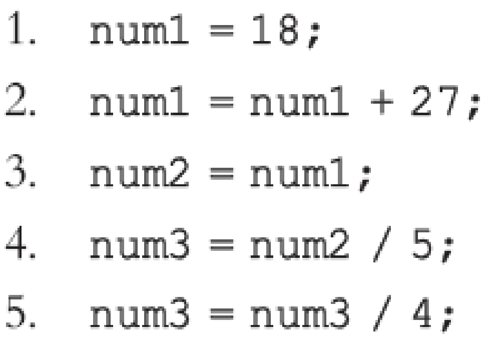
- Expression is evaluated and its value is assigned to the variable on the left side
- In C++, = is called the assignment operator

Assignment Statement



```
int num1, num2;
double sale;
char first;
string str;

num1 = 4;
num2 = 4 * 5 - 11;
sale = 0.02 * 1000;
first = 'D';
str = "It is a sunny day.";
```



```
1.  num1 = 18;
2.  num1 = num1 + 27;
3.  num2 = num1;
4.  num3 = num2 / 5;
5.  num3 = num3 / 4;
```

Saving and Using the Value of an Expression

- To save the value of an expression:
  - Declare a variable of the appropriate data type
  - Assign the value of the expression to the variable that was declared
    - Use the assignment statement
- Wherever the value of the expression is needed, use the variable holding the value

Declaring & Initializing Variables

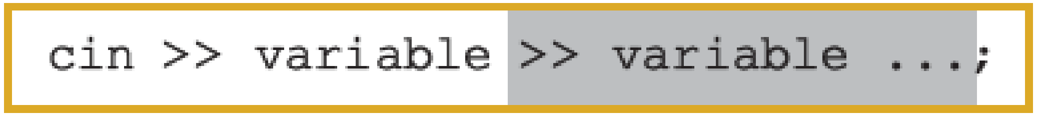
- Variables can be initialized when declared:

```
int first=13, second=10;
char ch=' ';
double x=12.6;
```

- All variables must be initialized before they are used
  - But not necessarily during declaration

Input (Read) Statement

- `cin` is used with >> to gather input



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

- The stream extraction operator is >>
- For example, if miles is a double variable

```
cin >> miles;
```

  - Causes computer to get a value of type `double`
  - Places it in the variable `miles`

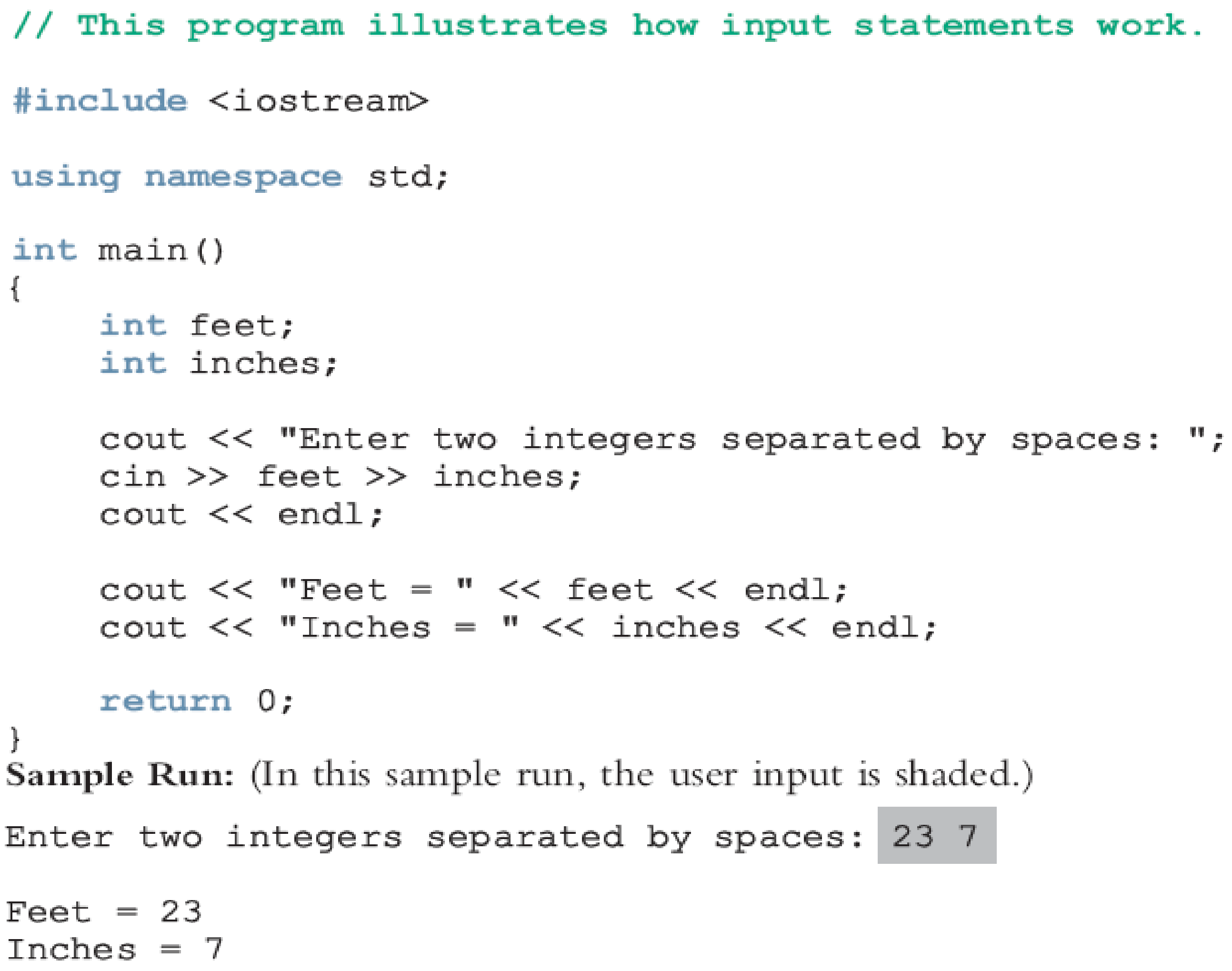
Input (Read) Statement

- Using more than one variable in `cin` allows more than one value to be read at a time
- For example, if `feet` and `inches` are variables of type `int`, a statement such as:

```
  cin >> feet >> inches;
```

  - Inputs two integers from the keyboard
  - Places them in variables `feet` and `inches` respectively

Input (Read) Statement



```
// This program illustrates how input statements work.

#include <iostream>

using namespace std;

int main()
{
    int feet;
    int inches;

    cout << "Enter two integers separated by spaces: ";
    cin >> feet >> inches;
    cout << endl;

    cout << "Feet = " << feet << endl;
    cout << "Inches = " << inches << endl;

    return 0;
}
```

Sample Run: (In this sample run, the user input is shaded.)

```
Enter two integers separated by spaces: 23 7

Feet = 23
Inches = 7
```

Variable Initialization

- There are two ways to initialize a variable:

```
int feet;
```

  - By using the assignment statement

```
feet = 35;
```

  - By using a read statement

```
cin >> feet;
```

Increment & Decrement Operators

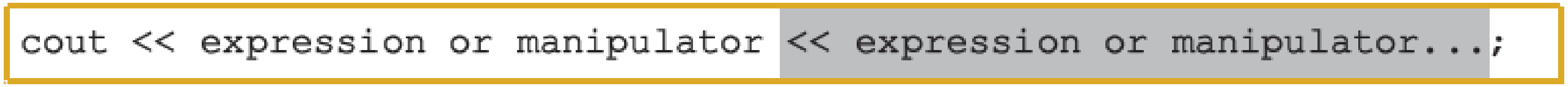
- Increment operator: increment variable by 1
  - Pre-increment: `++variable`
  - Post-increment: `variable++`
- Decrement operator: decrement variable by 1
  - Pre-decrement: `--variable`
  - Post-decrement: `variable—`
- What is the difference between the following?

```
x = 5;
y = ++x;
```

```
x = 5;
y = x++;
```

Output

- The syntax of `cout` and << is:

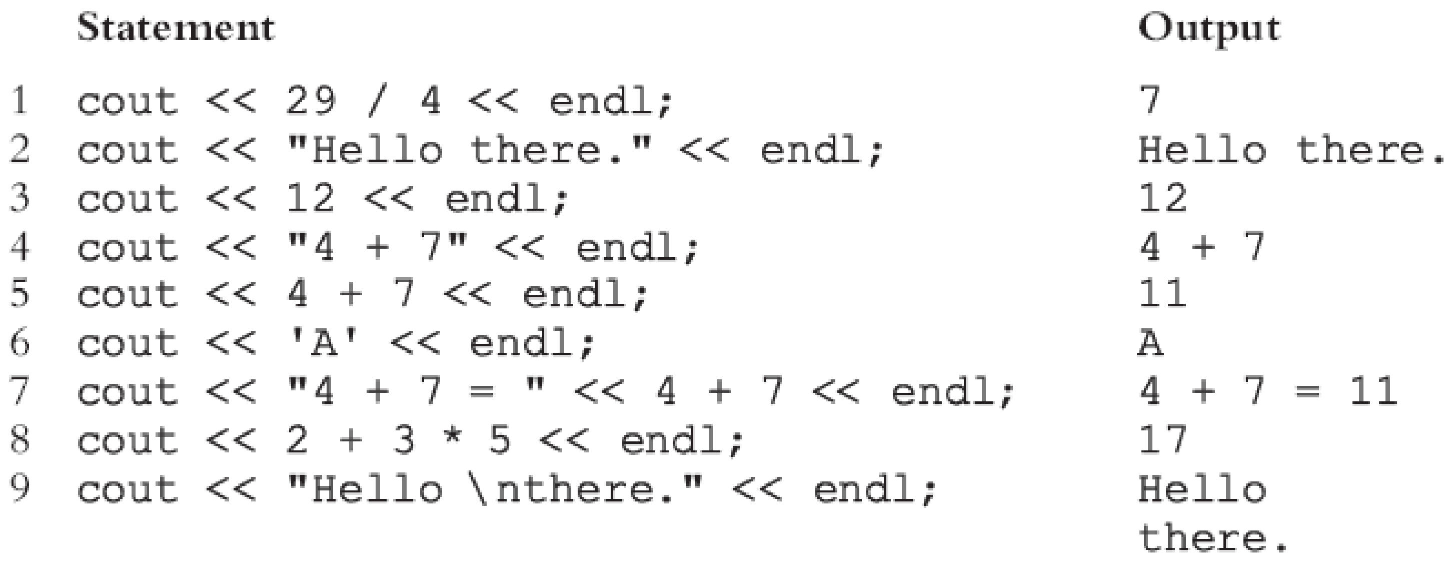


```
cout << expression or manipulator << expression or manipulator...;
```

  - Called an output statement
- The stream insertion operator is <<
- Expression evaluated and its value is printed at the current cursor position on the screen

Output

- A manipulator is used to format the output
  - Example: `endl` causes insertion point to move to beginning of next line



	Statement	Output
1	`cout << 29 / 4 << endl;`	`7`
2	`cout << "Hello there." << endl;`	`Hello there.`
3	`cout << 12 << endl;`	`12`
4	`cout << "4 + 7" << endl;`	`4 + 7`
5	`cout << 4 + 7 << endl;`	`11`
6	`cout << 'A' << endl;`	`A`
7	`cout << "4 + 7 = " << 4 + 7 << endl;`	`4 + 7 = 11`
8	`cout << 2 + 3 * 5 << endl;`	`17`
9	`cout << "Hello \nthere." << endl;`	`Hello` `there.`

Output

- The new line character is '\n'
  - May appear anywhere in the string

```
cout << "Hello there.";
cout << "My name is James.";
```

- Output:

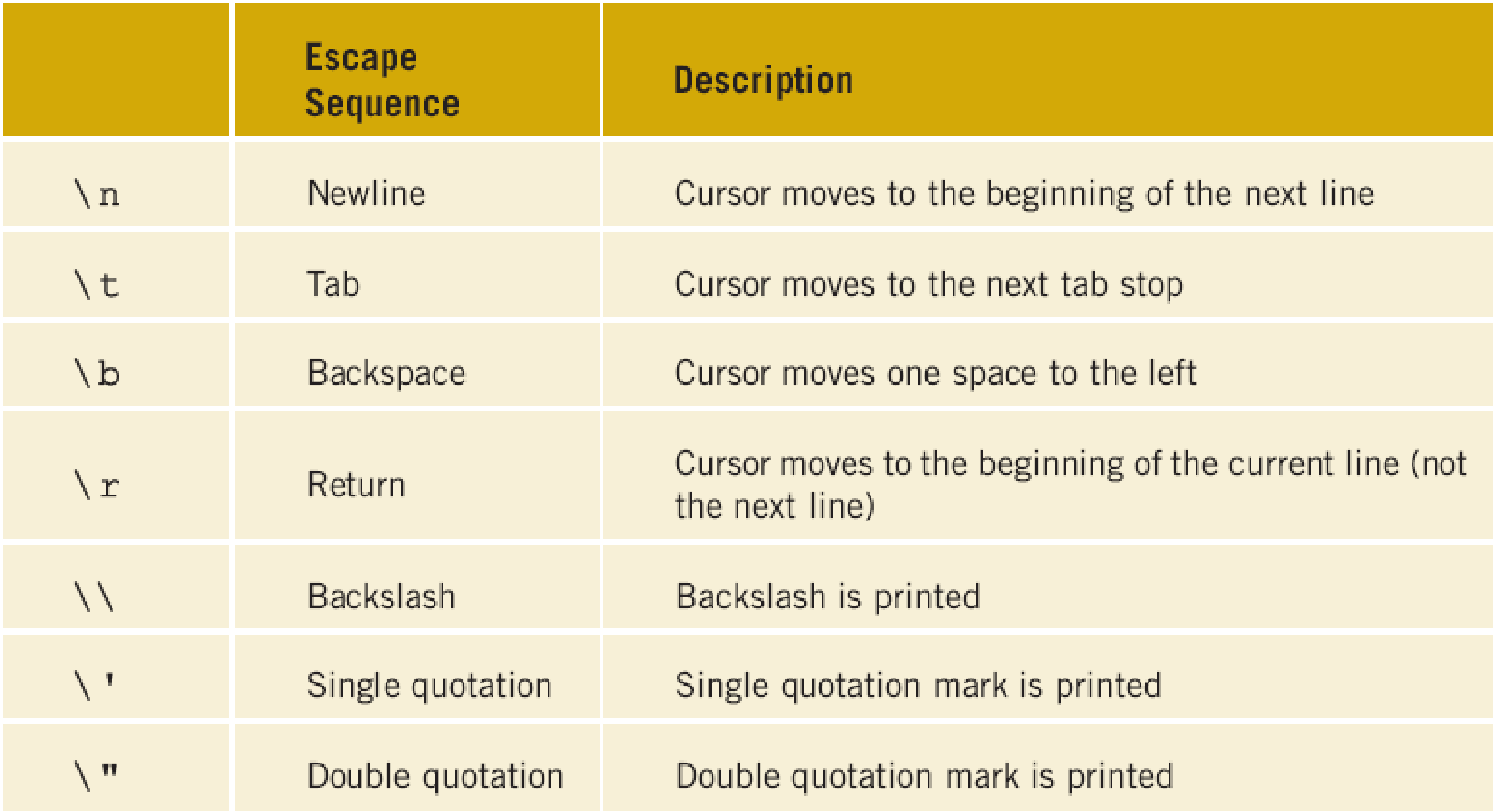
```
Hello there.My name is James.
```

```
cout << "Hello there.\n";
cout << "My name is James.";
```

- Output :

```
Hello there.
My name is James.
```

Output



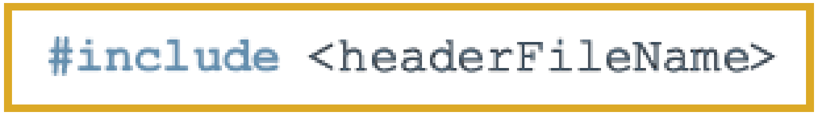
	Escape Sequence	Description
`\n`	Newline	Cursor moves to the beginning of the next line
`\t`	Tab	Cursor moves to the next tab stop
`\b`	Backspace	Cursor moves one space to the left
`\r`	Return	Cursor moves to the beginning of the current line (not the next line)
`\\`	Backslash	Backslash is printed
`\'`	Single quotation	Single quotation mark is printed
`\"`	Double quotation	Double quotation mark is printed

Preprocessor Directives

- C++ has a small number of operations
- Many functions and symbols needed to run a C++ program are provided as collection of libraries
- Every library has a name and is referred to by a header file
- Preprocessor directives are commands supplied to the preprocessor
- All preprocessor commands begin with #
- No semicolon at the end of these commands

Preprocessor Directives

- Syntax to include a header file:



```
#include <headerFileName>
```

- For example:

```
#include <iostream>
```

  - Causes the preprocessor to include the header file `iostream` in the program

namespace and Using cin and cout in a Program

- cin and cout are declared in the header file iostream, but within std namespace
- To use cin and cout in a program, use the following two statements:

```
#include <iostream>
using namespace std;
```

Using the `string` Data Type in a Program

- To use the `string` type, you need to access its definition from the header file `string`
- Include the following preprocessor directive:

```
#include  <string>
```

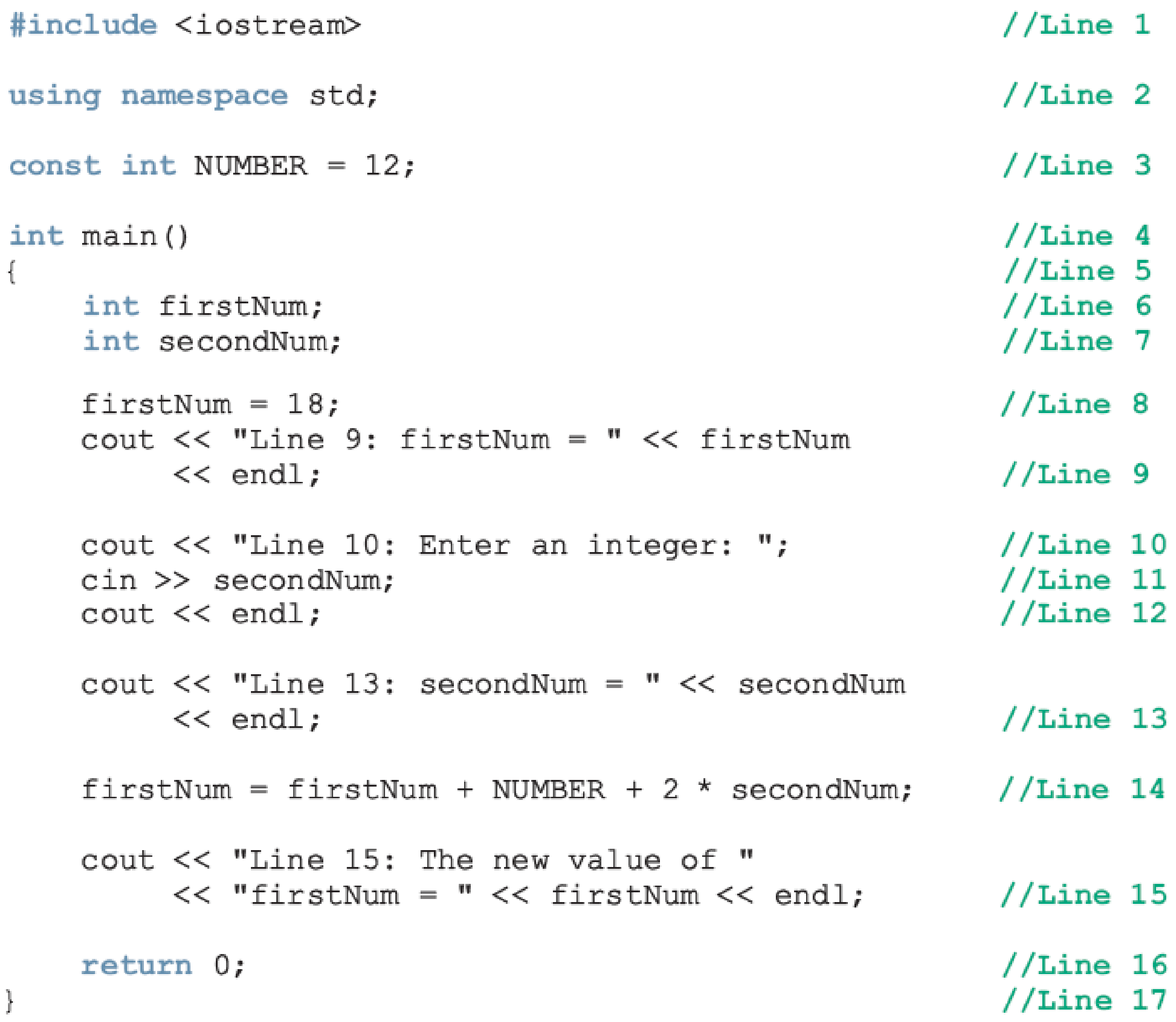
Creating a C++ Program

- C++ program has two parts:
  - Preprocessor directives
  - The program
- Preprocessor directives and program statements constitute C++ source code (.cpp)
- Compiler generates object code (.obj)
- Executable code is produced and saved in a file with the file extension .exe

Creating a C++ Program

- A C++ program is a collection of functions, one of which is the function `main`
- The first line of the function `main` is called the heading of the function:

  `int` main()
- The statements enclosed between the curly braces ({ and }) form the body of the function
  - Contains two types of statements:
    - Declaration statements
    - Executable statements



```
#include <iostream>                                      //Line 1

using namespace std;                                     //Line 2

const int NUMBER = 12;                                   //Line 3

int main()                                               //Line 4
{                                                        //Line 5
    int firstNum;                                        //Line 6
    int secondNum;                                       //Line 7

    firstNum = 18;                                       //Line 8
    cout << "Line 9: firstNum = " << firstNum
         << endl;                                        //Line 9

    cout << "Line 10: Enter an integer: ";               //Line 10
    cin >> secondNum;                                    //Line 11
    cout << endl;                                        //Line 12

    cout << "Line 13: secondNum = " << secondNum
         << endl;                                        //Line 13

    firstNum = firstNum + NUMBER + 2 * secondNum;        //Line 14

    cout << "Line 15: The new value of "
         << "firstNum = " << firstNum << endl;           //Line 15

    return 0;                                            //Line 16
}                                                        //Line 17
```

Creating a C++ Program

Sample Run:

```
Line 9: firstNum = 18
Line 10: Enter an integer: 15

Line 13: secondNum = 15
Line 15: The new value of firstNum = 60
```

Program Style and Form

- Every C++ program has a function `main`
- It must also follow the syntax rules
- Other rules serve the purpose of giving precise meaning to the language

Syntax

- Errors in syntax are found in compilation

```
int x;       //Line 1
int y        //Line 2: error
double z;    //Line 3

y = w + x;   //Line 4: error
```

Use of Blanks

- In C++, you use one or more blanks to separate numbers when data is input
- Used to separate reserved words and identifiers from each other and from other symbols
- Must never appear within a reserved word or identifier

Use of Semicolons, Brackets, and Commas

- All C++ statements end with a semicolon
  - Also called a statement terminator
- { and } are not C++ statements
- Commas separate items in a list

Semantics

- Possible to remove all syntax errors in a program and still not have it run
- Even if it runs, it may still not do what you meant it to do
- For example,

  `2 + 3 * 5` and `(2 + 3) * 5`

  are both syntactically correct expressions, but have different meanings

Naming Identifiers

- Identifiers can be self-documenting:
  - `CENTIMETERS_PER_INCH`
- Avoid run-together words :
  - `annualsale`
  - Solution:
    - Capitalize the beginning of each new word
      - `annualSale`
    - Inserting an underscore just before a new word
      - `annual_sale`

Prompt Lines

- Prompt lines: executable statements that inform the user what to do

```
cout << "Please enter a number between 1 and 10 and "
     << "press the return key" << endl;
cin >> num;
```

Documentation

- A well-documented program is easier to understand and modify
- You use comments to document programs
- Comments should appear in a program to:
  - Explain the purpose of the program
  - Identify who wrote it
  - Explain the purpose of particular statements

Form and Style

- Consider two ways of declaring variables:
  - Method 1

```
int feet, inch;
double x, y;
```

  - Method 2

```
int a,b;double x,y;
```

- Both are correct; however, the second is hard to read

More on Assignment Statements

- C++ has special assignment statements called compound assignments
  `+=`, `-=`, `*=`, `/=`, and `%=`
- Example:

```
x  *=  y;
```

Programming Example: Convert Length

- Write a program that takes as input a given length expressed in feet and inches
  - Convert and output the length in centimeters
- Input: length in feet and inches
- Output: equivalent length in centimeters
- Lengths are given in feet and inches
- Program computes the equivalent length in centimeters
- One inch is equal to `2.54` centimeters

Programming Example: Convert Length

- Convert the length in feet and inches to all inches:
  - Multiply the number of feet by 12
  - Add given inches
- Use the conversion formula (1 inch = 2.54 centimeters) to find the equivalent length in centimeters

Programming Example: Convert Length

- The algorithm is as follows:
  - Get the length in feet and inches
  - Convert the length into total inches
  - Convert total inches into centimeters
  - Output centimeters

Programming Example: Variables and Constants

- Variables

```
int feet;          //variable to hold given feet
int inches;        //variable to hold given inches
int totalInches;   //variable to hold total inches
double centimeters;   //variable to hold length in
                      //centimeters
```

- Named Constant

```
const double CENTIMETERS_PER_INCH = 2.54;

const int INCHES_PER_FOOT = 12;
```

Programming Example: Main Algorithm

- Prompt user for input
- Get data
- Echo the input (output the input)
- Find length in inches
- Output length in inches
- Convert length to centimeters
- Output length in centimeters

Programming Example: Putting It Together

- Program begins with comments
- System resources will be used for I/O
- Use input statements to get data and output statements to print results
- Data comes from keyboard and the output will display on the screen
- The first statement of the program, after comments, is preprocessor directive to include header file `iostream`

Programming Example: Putting It Together

- Two types of memory locations for data manipulation:
  - Named constants
    - Usually put before `main`
  - Variables
- This program has only one function (`main`), which will contain all the code
- The program needs variables to manipulate data, which are declared in `main`

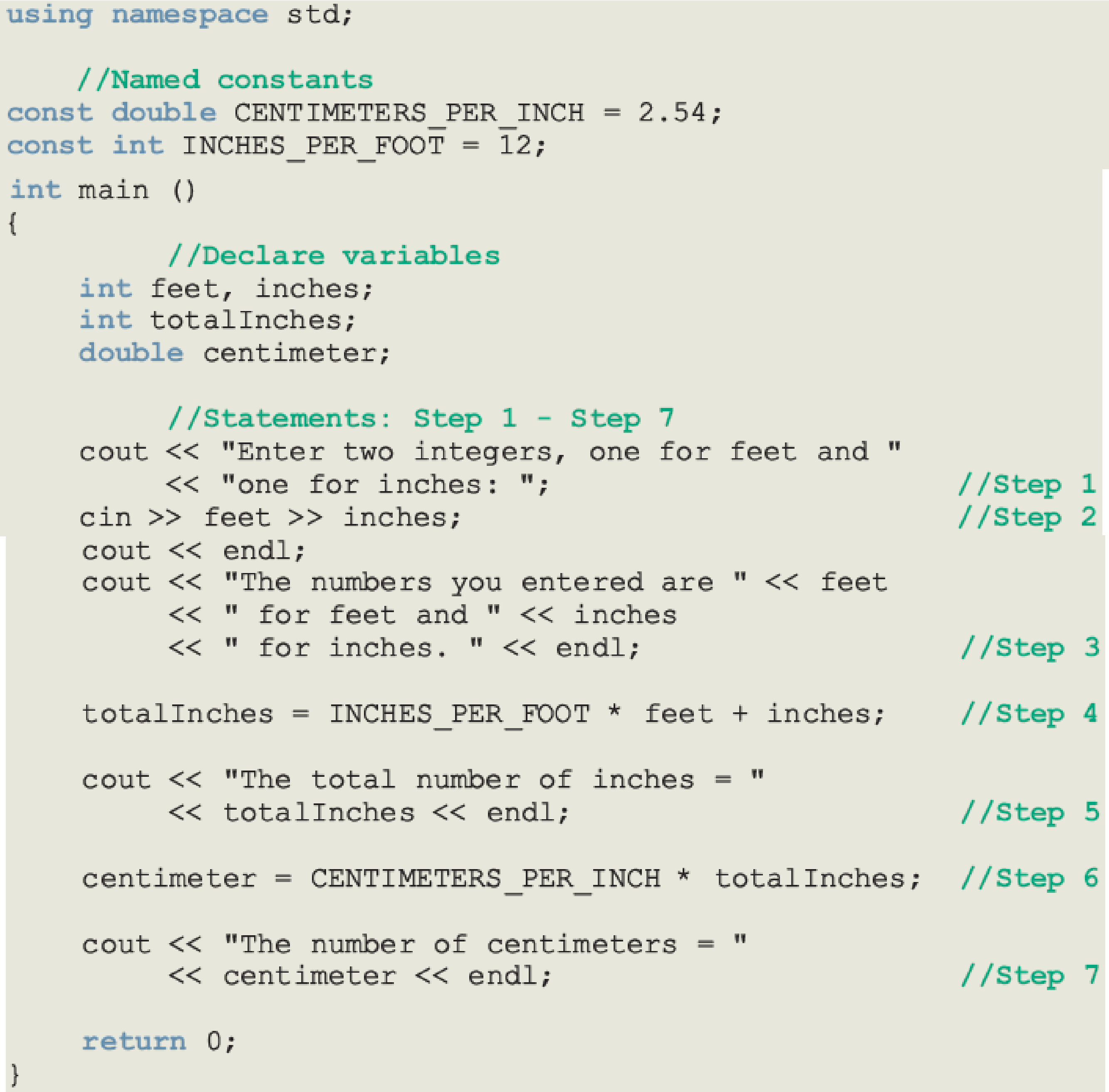
Programming Example: Body of the Function

- The body of the function `main` has the following form:

```
int main ()
{
    declare variables
    statements
    return 0;
}
```

Programming Example: Writing a Complete Program

- Begin the program with comments for documentation
- Include header files
- Declare named constants, if any
- Write the definition of the function `main`



```
using namespace std;

    //Named constants
const double CENTIMETERS_PER_INCH = 2.54;
const int INCHES_PER_FOOT = 12;

int main ()
{
         //Declare variables
    int feet, inches;
    int totalInches;
    double centimeter;

         //Statements: Step 1 - Step 7
    cout << "Enter two integers, one for feet and "
         << "one for inches: ";                         //Step 1
    cin >> feet >> inches;                              //Step 2
    cout << endl;
    cout << "The numbers you entered are " << feet
         << " for feet and " << inches
         << " for inches. " << endl;                    //Step 3

    totalInches = INCHES_PER_FOOT * feet + inches;     //Step 4

    cout << "The total number of inches = "
         << totalInches << endl;                        //Step 5

    centimeter = CENTIMETERS_PER_INCH * totalInches;   //Step 6

    cout << "The number of centimeters = "
         << centimeter << endl;                         //Step 7

    return 0;
}
```

Programming Example: Sample Run

```
Enter two integers, one for feet, one for inches: 15 7

The numbers you entered are 15 for feet and 7 for inches.
The total number of inches = 187
The number of centimeters = 474.98
```

Thanks!