Intro to Programming & C++

Unit 1

Sections 1.1-3 and 2.1-10, 2.12-13, 2.15-17

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1.1 Why Program?

Computer – programmable machine designed to follow instructions

Program – instructions in computer memory to make the computer do something

Programmer – person who writes instructions (programs) to make computer perform a task

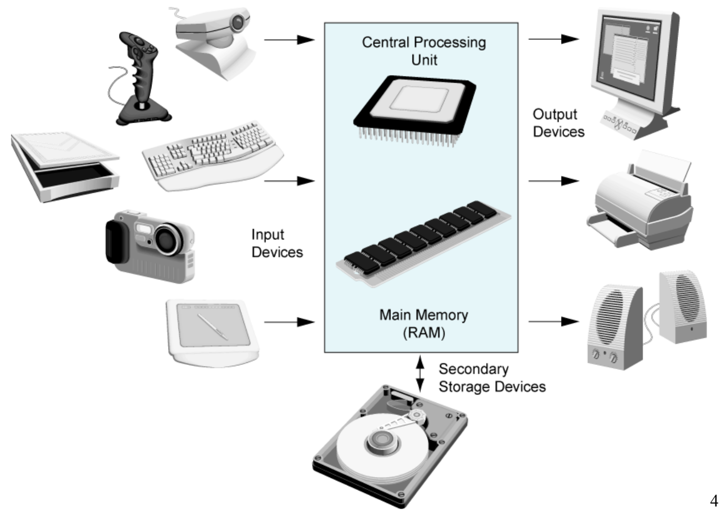
SO, without programmers, no programs; without programs, a computer cannot do anything

1.2 Computer Systems: Hardware and Software

- Hardware:
  the physical components that a computer is made of.

- Software:
  the programs that run on a computer

Hardware Components Illustrated



Hardware Components

- **Central Processing Unit** (CPU)
  - **Arithmetic Logic Unit** (math, comparisons, etc)
  - **Control Unit** (processes instructions)
- **Main Memory** (RAM): Fast, expensive, volatile
- **Secondary Storage**: Slow, cheap, long-lasting
- **Input Devices**: keyboard, mouse, camera
- **Output Devices**: screen, printer, speakers

Software

- Programs that run on the hardware
- Operating Systems (System software):
  - programs that manage the computer hardware and the programs that run on them.
  - Unix, MS-DOS, Linux, Windows, Mac OS X
  - Time machine, printer drivers, compilers
- Application Programs (Apps):
  - Solve specific problems and provide services to the user
  - Word, Excel, iTunes, Firefox, Angry Birds, Photoshop

1.3 Programs and Programming Languages

- A program is a set of instructions that the computer follows to perform a task
- An algorithm:
  - A set of well-defined steps for performing a task or solving a problem.
  - A step by step ordered procedure that solves a problem in a finite number of precise steps.
- An algorithm can be in any language (English, C++, machine code, etc).

Example (algorithm)

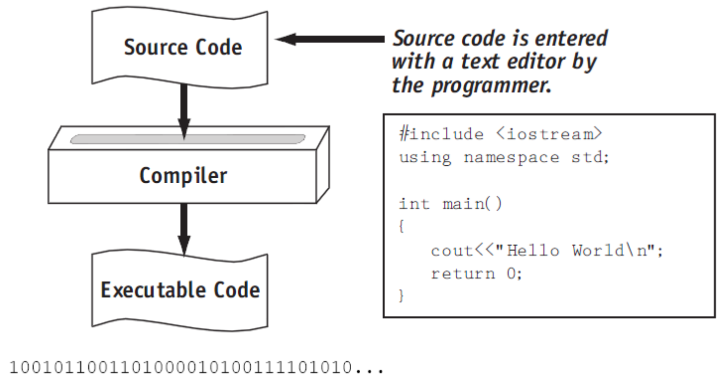
1. Display on screen: “how many hours did you work?”
2. Wait for user to enter number, store it in memory
3. Display on screen: “what is your pay rate (per hour)?”
4. Wait for user to enter rate, store it in memory
5. Multiply hours by rate, store result in memory
6. Display on screen: “you have earned $xx.xx” where xx.xx is result of step 5.

Note: Computer does not speak English, it only understands its own “machine language”

Programming Languages

- Machine Language:
  - Instructions are encoded as a sequence of 1's and 0's
  - Machine specific
- Low Level Languages: Assembly Language
  - Letters and digits (codes)
  - Direct correspondence to Machine Language
- High Level Languages (like C++):
  - Words, symbols, numbers
  - Easier for humans to read and use
  - Must be translated to Machine Code

Translation Process



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

int main()
{
   cout<<"Hello World\n";
   return 0;
}
```

Tony Gaddis, Starting out with C++: From Control Structures Through Objects 7th ed.

2.1 The Parts of a C++ Program

```
// sample C++ program
#include <iostream>
using namespace std;

int main()
{
     cout << "Hello, world!";
     return 0;
}
```

Parts of a C++ Program

- Comment: `//…`
  - ignored by compiler
  - notes to human reader
- Preprocessor Directive: `#include <iostream>`
  - compiler inserts contents of file iostream here
  - required because `cout` is defined in iostream
- `using namespace std;`
  - allows us to write `cout` instead of `std::cout`

Parts of a C++ Program

- `int main ()`
  - start of function (group of statements) named `main`
  - the starting point of the program
- `{}`
  - contains the body of the function
- `cout << “Hello, world!”;`
  - statement to display message on screen
- `return 0;`
  - quit and send value 0 to OS (means success!)

2.2 The `cout` Object

- `cout`: short for “console output”
  - a stream object: represents the contents of the screen
- <<: the stream insertion operator
  - use it to send data to `cout` (to be output to the screen)

```
cout << “This is an example.”;
```

- when this instruction is executed, the console (screen) looks like this:

```
This is an example.
```

Note: the “ ” do not show up in the output

The `endl` manipulator

- `endl`: short for “end line”
  - send it to cout when you want to start a new line of output.

```
cout << “Hello ” << endl << “there!”;
```

- or you can use the newline character: `\n`

```
cout << “Hello \nthere!”;
```

- Either way the output to the screen is:

```
Hello
there!
```

more examples

```
cout << “Hello ” << “there!”;
```

```
Hello there!
```

```
cout << “Hello ”;
cout << “there!”;
```

```
Hello there!
```

```
cout << “The best selling book on Amazon\n is \”The Help\””;
```

```
The best selling book on Amazon
 is ”The Help”
```

2.3 The `#include` Directive

- Inserts the contents of another file into the program.

```
#include <iostream>
```

- For example, `cout` is not part of the core C++ language, it is defined in the iostream file.
- Any program that uses the cout object must contain the extensive setup information found in iostream.
- The code in iostream is C++ code.

2.4 Variables and Literals

- Variable: named location in main memory
- A variable definition has a name and a datatype
  - <datatype> <identifier>;
  - The data type indicates the kind of data it can contain.
  - The identifier is a name of your choosing.
- A variable must be defined before it can be used!!
- Example variable definitions:
  - `int someNumber;`
  - `char firstLetter;`

Literals

- A literal represents a constant value used in a program statement.
- Numbers: `0, 34, 3.14159, -1.8e12,` etc.
- Strings (sequence of keyboard symbols):
  - `“Hello”, “This is a string”`
  - `“100 years”, “100”, “Y”,` etc.
- NOTE: These are different: `5` `“5”`

2.5 Identifiers

- An identifier is a name for some program element (like a variable).
- Rules:
  - May not be a keyword (see Table 2.4 in the book)
  - First character must be a letter or underscore
  - Following characters must be letters, numbers or underscores.
- Identifiers are case-sensitive:
  - `myVariable` is not the same as `MyVariable`

2.12 Variable Assignments and Initialization

- An **assignment statement** uses the = operator to store a value in an already defined variable.
  - `someNumber = 12;`
- When this statement is executed, the computer stores the value 12 in memory, in the location named “someNumber”.
- The variable receiving the value must be on the left side of the = (the following does NOT work):
  - `12 = someNumber;  //This is an ERROR`

Example program using a variable

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

int main()  {
   int number;

   number = 100;
   cout << “The value of the number is “
        << number  << endl;
   return 0;
}
```

output screen:

```
The value of the number is 100
```

Variable Initialization

- To initialize a variable means to assign it a value when it is defined:
  - `int length = 12;`
- You can define and initialize multiple variables at once (and change them later) :

```
int length = 12, width = 5, area;
area = 35;
length = 10;
area =40;
```

Data Types

- Variables are classified according to their data type.
- The data type determines the kind of information that may be stored in the variable.
- A data type is a set of values.
- Generally two main (types of) data types:
  - Numeric
  - Character-based

C++ Data Types

- `int, short, long`
  - whole numbers (integers)
- `float, double`
  - real numbers (with fractional amounts, decimal points)
- `bool`
  - logical values: true and false
- `char`
  - a single character (keyboard symbol)
- `string`
  - any text, a sequence of characters

2.6 Integer Data Types

- Whole numbers such as 12, 7, and -99
- Typical ranges (may vary on different systems):

Data Type:	Range of values:
short	-32,768 to 32,767
unsigned short	0 to 65,535
int	-2,147,483,648 to 2,147,483,647
unsigned int	0 to 4,294,967,295
long	-2,147,483,648 to 2,147,483,647
unsigned long	0 to 4,294,967,295

- Example variable definitions:

```
short dayOfWeek;
unsigned long distance;
int xCoordinate;
```

2.9 Floating-Point Data Types

- Real numbers such as 12.45, and -3.8
- Typical ranges (may vary on different systems):

Data Type:	Range of values:
float	+/- 3.4e +/- 38 (~7 digits of precision)
double	+/- 1.7e +/- 308 (~15 digits of precision)
long double	+/- 1.7e +/- 308 (~15 digits of precision)

- Floating-point literals can be represented in
  - Fixed point (decimal) notation:
    `31.4159` `0.0000625`
  - E (scientific) notation:
    `3.14159E1` `6.25e-5`

Example program using floating-point data types

```
// 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;
}
```

output screen:

```
The Sun is 1.49598e+11 meters away.
The Sun's mass is 1.989e+30 kilograms.
```

2.10 The `bool` Data Type

- The values true and false.
- Literal values: `true, false`
- (false is equivalent to 0, true is equivalent to 1)

```
int main() {
   bool boolValue;
   boolValue = true;
   cout << boolValue << endl;
   boolValue = false;
   cout << boolValue << endl;
   return 0;
}
```

output screen:

```
1
0
```

2.7 The `char` Data Type

- All the keyboard and printable symbols.
- Literal values: `'A' '5' '?' 'b'`
  - characters are indicated using single quotes
- Numeric value of character from the ASCII character set is stored in memory:

CODE:

```
char letter;
letter = 'C';
cout << letter << endl;
```

MEMORY:

```
letter
67
```

OUTPUT:

```
C
```

Appendix B shows the ASCII code values

Special characters

- Newline: `'\n'`
- Double quote: `'\"'`.
- These can occur in strings:
  - `"Hello\nthere"`
  - `"she said \"boo\" very quietly"`
- See textbook for more
- It's a backslash (\), not a slash (/)

2.8 The C++ `string` class

- Sequences of characters
- Requires the string header file: `#include <string>`
- To define `string` variables in programs:

```
string firstName, lastName;
```

- To assign literals to variables:

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

- To display via `cout`

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

OUTPUT:

```
George Washington
```

2.13 Scope

- The scope of a variable is the part of the program in which the variable can be accessed.
- A variable cannot be used before it is defined.

```
// 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;
}
```

2.15 Comments

- Used to document parts of the program
- Intended for humans 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 and Multi-Line Comments

- 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 */

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

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

2.16 Named Constants

- Named constant : variable whose value 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;
```

Note: initialization required.

- Often named in uppercase letters (see style guidelines)

2.17 Programming Style

- The visual organization of the source code
- Includes the use of spaces, tabs, and blank lines
- Includes naming of variables, constants.
- Includes where to use comments.
- Purpose: improve the readability of the source code

Programming Style

Common elements to improve readability:

- Braces `{ }` aligned vertically
- Indentation of statements within a set of braces
- Blank lines between declaration and other statements
- Long statements intentionally broken up over multiple lines.

See the Style Guidelines on the class website.
You must follow these in your programming assignments.