CSE 5910
Software Foundations

Instructor: Aijun An
aan@cse.yorku.ca
Office: Lassonde 2048
Office Hours: Tue & Thur 2:45pm – 3:30pm

http://www.cse.yorku.ca/course/5910

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Outline

Course Information
- Course content and objective
- Textbook
- Class format
- Marking scheme

Introduction to Computers

Introduction to Programming Languages

Introduction to C++

How to create, compile and run a C++ program

How to create an CSE account and use Linux (in the lab)

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Course Content

C++
- One of the most popular programming languages
  - Used in many fields including quantitative finance
  - Huge code base in place that is hard to replace
- Has both high-level and low-level language features.
  - High-level features make it easy to use for general purpose
  - Low-level features make it powerful and its programs run fast.
- A multi-paradigm programming language, supporting both
  - Object-oriented programming
  - Procedural programming

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Course Objective

Learn how to read, design and write C++ programs

By the end of the course, you should be able to
- Understand C++ programs
- Design programs
- Write modest-sized programs in C++
- Test and debug C++ code

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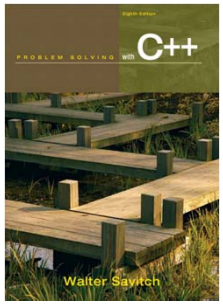
Textbook

Title: Problem Solving with C++ (8th Edition)

Author: Walter Savitch



- The book is written for students without prior programming experience.
- Has self-test exercises with answers.

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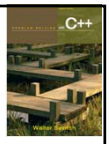
Textbook



The book is sold in the following forms:

- hard copy - $119.70 at York University Bookstore
- eText - $49.95 at York University Bookstore
- hard copy plus MyProgrammingLab with Pearson eText Access Card, 8th Edition - $128.27 at Pearson
- eText with MyProgrammingLab – Instant Access – for Problem Solving with C++, 8/e - $90.10 at CourseSmart

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Class Format

Lectures and Labs

- Time: 11:30am – 3:00pm
- Location: Lassonde 1002 (from the 2nd class)

Lab content:

- Exercise on computers with assistance from the instructor and TA

Format

- The first 2 to 2.5 hours are lectures.
- The last 1-1.5 hour is lab exercise.

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Marking Scheme

The weight distribution of the course components is as follows:

- 30% - Assignments (5 assignments)
- 10% - Labs (1% for each lab)
- 25% - Midterm test (November 9 in class)
  - including written test and lab test
- 35% - Final exam
  - including written test and lab test

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Course Website

http:www.cse.yorku.ca/course/5910

or

https://wiki.cse.yorku.ca/course_archive/2012-13/F/5910/

It contains all the information about the course

- Lecture notes will be posted there.
- Assignments will be posted there.
- How to remotely access the CSE Linux server in order to use the C++ complier.
- Course policies
- ……

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Computer Systems

A computer system contains

- Hardware
  - the collection of physical elements that comprise a computer system
  - Examples: processor, main memory, disk, screen, keyboard, etc.
- Software
  - The collection of programs used by a computer system
  - A computer program is
    - a set of instructions for a computer to follow
  - Examples: text editors, operating systems, etc.

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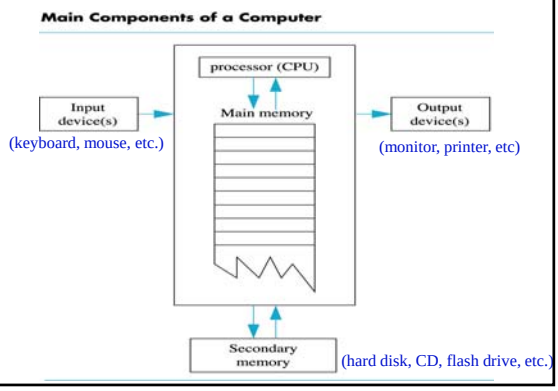
Computer Hardware



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Processor (CPU)

CPU stands for *Central Processing Unit*

It's the brain of the computer

- Follows the instructions in a program
- Perform calculations specified by the program

Typical capabilities of CPU include:

add
subtract
multiply
divide
move data from location to location

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Main Memory

Internal storage area in the computer

- also called memory or RAM (Random Access Memory)

Stores program instructions and data currently being processed by the CPU

Compared to other storage media

- Access to RAM is fast
- Information is not saved when the computer is powered off.

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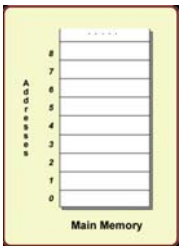
Main Memory

Can be considered as an array of boxes, each of which holds a single byte of information

- A byte contains 8 bits. A bit is a binary digit (0 or 1)
- Each box has an address
- *Random access*:
  - Given an address, CPU can directly obtain the information at that address.



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Secondary Memory

Stores programs and data in the forms of files

Files cannot be directly processed by CPU.

- A file must be loaded into the main memory to be processed.

Slower to access than main memory

Often requires *sequential access*

- read through the file from the beginning in the order in which it is stored

The information on the secondary memory is not lost when the system is powered off.

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Types of Secondary Memory

Hard disk

- Fast (but slower than main memory)
- Usually fixed in the computer and not normally removed

Floppy disk

- Slow
- Easily shared with other computers

Compact disk

- Slower than hard disks
- Easily shared with other computers
- Can be read only or re-writable

Flash memory

- Slower than hard disks
- Easily shared with other computers

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Computer Program

A sequence of instructions written to perform a specified task on a computer

Two forms of a program:

- Executable program
  - Binary code (consists of 0s and 1s).
  - Can be directly executed by the computer
- Source code
  - Written in a *programming language* (human understandable)
  - Need to be either converted into an executable program by a *compiler* or may be executed with the aid of an *interpreter*.

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Computer Software

A collection of programs and related data

Types of software (according to functionalities)

- System software
  - the programs used to operate and manage computer hardware
  - Examples: operating systems (Windows, Mac OS, Linux), device drivers, utilities, etc.
- Programming tools
  - Used to create, translate, combine, debug and maintain programs
  - Examples: compilers, interpreters, linkers, debuggers, text editors.
- Application software
  - Designed to help the user to perform specific tasks
  - Examples: Word processors, web browsers, accounting, financial analysis, computer games, media plays, etc.

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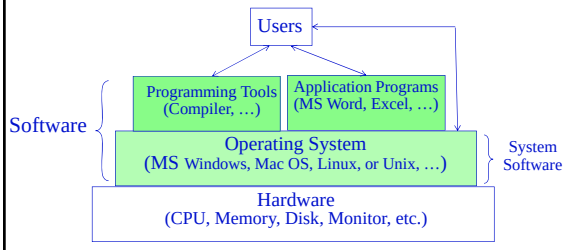
Computer Software Structure



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Operating System

The most important system program that

- manages and allocates computer hardware resources
- allows us to communicate with the hardware
- responds to user requests to run other programs

Common operating systems include:

- Windows, MAC OS, Unix, Linux, DOS, etc.
- We are going to use Linux in this course.

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Programming Languages

An artificial language designed to write computer programs

Common programming languages include

C, C++ , Java, Pascal, Visual Basic, FORTRAN, Perl, COBOL, Lisp, Scheme, Ada, C#, Python, MATLAB

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Programming Languages

Programming languages can be classified along multiple axes:

- High-level or low-level
- Compiled, interpreted or just-in-time compiled
- Procedural, object-oriented, etc.

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High-level vs. Low-level

Low-level language

- deals more with direct hardware interaction, and thus
- is more suitable for programs like device drivers code that really needs access to the hardware.
- difficult to port to other platforms.
- must be converted into executable machine code (zeros and ones)

Example: assembly language

- An assembly language command such as

ADD X Y Z

might mean add the values found at x and y in memory, and store the result in location z.

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High-level vs. Low-level

High-level language

- resembles human languages
- is designed to be easy to read and write
- takes less time to develop a program
- generally portable among different platforms
- must be translated to zeros and ones for the CPU to execute a program

Examples:

C, C++ , Java, Pascal, Visual Basic, FORTRAN, Perl, COBOL, Lisp, Scheme, Ada, C#, Python, MATLAB

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Compiled vs. Interpreted

Compiled language

- Programs need to be translated into an executable machine code by a *compiler* and later executed.
- The executable program runs faster.
- Example: C, C++, Fortran

Interpreted language

- Programs can be executed immediately with the aid of an *interpreter*
- Program runs slower
- Example: Perl, MATLAB, Basic

Just-in-time compiled language

- Program is first compiled into portable byte code, which can later be executed with the aid of an interpreter.
- Slower than the compiled, but faster than the purely interpreted.
- Example: Java

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Procedural vs. object-oriented

Procedural:

- Program consists of a set of functions or procedures
- Examples: C, C++, Visual Basic, MATLAB, ….

Object-oriented:

- Program consists of classes and objects
- Examples: Java, C++, Python, ….

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Introduction to C++

A high-level programming language with some low-level constructs

- High-level constructs (such as branching and looping statements, functions and objects) make it easy to write programs
- Low-level constructs (such as pointers) make it possible to manipulate hardware, such as direct access to main memory.

A compiled language

A multi-paradigm language

- Supporting both procedural and object-oriented programming

C++ programs generally run

- faster than Java, C# and other high-level language programs,
- but slower than C programs.

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Introduction to C++

Where did C++ come from?

- Derived from the C language
  - C is a procedural language. C++ can be considered C with objects.
- C was derived from the B language
- B was derived from the BCPL language

Why the '++'?

- ++ is an operator in C++ and results in a cute pun

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C++ History

C developed by Dennis Ritchie at AT&T Bell Labs in the 1970s.

- Used to write and maintain UNIX operating systems
- Many commercial applications written in C

C++ developed by Bjarne Stroustrup at AT&T Bell Labs in the 1980s.

- Overcame several shortcomings of C
- Incorporated object oriented programming
- C remains a subset of C++

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A Sample C++ Program

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

int main()
{
  cout << "Hello\n";
  cout << "This is my first C++ program!\n";

  return 0;
}
```

A **simple** C++ program begins this way

It ends this way

Main part of the program with 2 ***output statements***

Output of this program when it runs:

```
Hello
This is my first C++ program!
```

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Another Sample C++ Program with Input

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

int main()
{
  int number1, number2;
  int sum;

  cout << "Please input two numbers: ";
  cin >> number1 >> number2;
  sum = number1 + number2;
  cout << "The sum of these two number is ";
  cout << sum << "\n";

  return 0;
}
```

A **simple** C++ program begins this way

Variable declarations

Input statement

Assignment statement

It ends this way

Output of this program when it runs:

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Layout of a Simple C++ Program

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

int main()
{
  Variable Declarations;

  Statement 1;
  Statement 2;
  ……
  Statement last;

  return 0;
}
```

Directives

Every C++ program must contain a **`main()`** function. Braces{ and } mark the beginning and end of the main function.

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Explanation of Code (1)

The **`#include`** directive:

```
#include<iostream>
```

- It tells the compiler where to find information about certain items (such as **`cout`** and **`cin`**) used in the program.
- **`iostream`** is the name of a library file that contains the definitions of **`cin`** and **`cout`**

The **`using`** directive:

```
using namespace std;
```

- It says the names defined in **`iostream`** are to be interpreted in namespace **`std`** (to be explained later in the course).
- **`std`** stands for "standard".

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Explanation of Code (2)

Variable declaration line

```
int number1, number2;
int sum;
```

- Declare three variables to hold integers
- **int** means integers

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Explanation of Code (3)

Output statements:

```
cout << "Hello\n";
cout << "This is my first C++ program!\n";
cout << "Please input two numbers: ";
cout << "The sum of these two number is ";
cout << sum << "\n";
```

- **cout** (see-out) used for output to the monitor
  - Think of **cout** as a name for the monitor
- **<<** is the ***insertion*** operator
  - It inserts the data that follows it into the monitor.
  - **"<<"** points to where the data is to end up
  - Can use more than one **"<<"** in one output statement
- '**\n**' causes a new line to be started on the monitor

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Explanation of Code (4)

Input statement:

```
cin >> number1 >> number2;
```

- **cin** (see-in) used for input from the keyboard
  - Think of **cin** as a name for the keyboard
- "**>>**" is called the ***extraction*** operator
  - It extracts data from the keyboard
  - "**>>**" points from the keyboard to a variable where the data is stored

When the program runs, the above input statement takes two numbers from the keyboard, separated by space, tab or newline.

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Explanation of Code (5)

Assignment statement:

```
sum = number1 + number2;
```

- Performs a computation
- **+** is used for addition
- '**=**' causes variable **sum** to get a new value based on the calculation shown on the right of the equal sign

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Program Layout and Style

Compiler accepts almost any pattern of line breaks and indentation

Example 1:

```
cout << "Hello\n";
```

is the same as

```
cout    <<"Hello\n";
```

Eaxmple 2:

```
cin >> number1 >> number2;
sum = number1 + number2;
```

is the same as:

```
cin >> number1 >> number2; sum = number1 + number2;
```

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Program Layout and Style (Cont'd)

Programmers format programs so they are easy to read

- Use only one statement per line
- Indent statements
- Place opening brace '{' and closing brace '}' on a line by themselves

Variables are declared before they are used

- Typically variables are declared at the beginning of the program
- Statements and declarations end with a semi-colon

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Creating a C++ program

You can create a C++ program (source code) with a text editor

There are many text editors:
- On Linux: **`nedit`**, **`nano`**, **`pico`**, **`emacs`**, **`vi`**, etc
- On Windows: Notepad, WordPad, etc.
- On Mac: TextEdit

With a text editor, type in the program and save it in a file
- The file should have an extension name **`cpp`** , for example,

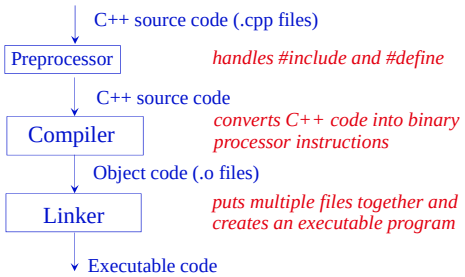
  `program1.cpp`

- The prefix of the file can be named using letters, digits and underscores (in Linux).

Compiling a C++ program

A C++ source code needs to be converted to machine code (i.e., executable program) to be run by CPU

A C++ executable program is built in three stages:



C++ Compiler on Linux

Compiler: **`g++`**
- It does all the three steps: preprocessing, compiling and linking

How to use **`g++`**: on Linux command line, type
- **`g++ program1.cpp`**

  This will generate an executable program named **`a.out`** in the current directory.
- **`g++ program1.cpp -o program1`**

  or
- **`g++ –o program1 program1.cpp`**

  This will generate an executable program named **`program1`** in the current directory.

Running a C++ Executable Program

On a Linux command line, type the name of the executable program. For example,

- **`a.out`**

  This will invoke the **`a.out`** program.

- **`program1`**

  This will invoke the **`program1`** program.

.

Debugging a Program

Bug
- A mistake in a program

Debugging
- Eliminating mistakes in programs
- Term used when a moth caused a failed relay on the Harvard Mark 1 computer. Grace Hopper and other programmers taped the moth in logbook stating:

  "First actual case of a bug being found."

Types of Program Errors

Syntax errors
- Violation of the grammar rules of the language
- Discovered by the compiler
  - Error messages may not always show correct location of errors
- Example: miss a semicolon (;) at the end of a statement

Run-time errors
- Error conditions detected by the computer at run-time
- Example: divide a number by zero

Logic errors
- Errors in the program's algorithm
- Most difficult to diagnose
- Computer does not recognize an error

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Lab 1

Create a CSE account

Use Linux commands

Use Text Editor on Linux to Create a C++ program
- nedit
- nano (http://mintaka.sdsu.edu/reu/nano.html)

Compile a C++ program

Run a C++ program

Remove login instructions

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Home Exercises

Practice remote login from your home computer or laptop to the CSE Linux Server
- Instructions are at

https://wiki.cse.yorku.ca/course_archive/2012-13/F/5910/accessmatlab

Practice creating, compiling and running a C++ program
- from home through remove login

Read Chapter 1 and do as many self-test exercise questions in Chapter 1 as possible

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Home Exercises (Cont'd)

Write, compile and run a program that outputs:

```
     Hello
Hello     Hello
     Hello
```

Write, compile and run a program that outputs:

```
  XXX
 X   X
X
X
X
X
 X   X
  XXX
```

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