University of Windsor
Faculty of Science
School of Computer Science

COMP-2650
Computer Architecture I: Digital Design
Winter 2022

Lab#	Date	Title	Due	Grade Release
Lab02	Week 02	**Programming Environment Setup**	Feb. 02, 2022, Wednesday 4 AM EDT	Feb. 07, 2022

The objectives of the first lab will be for you to set up a programming environment, specifically to have an integrated development environment (IDE) installed and functioning on your local drive in the lab or on your own desktop or laptop computer. Also, you will be developing on the program specification of the lab assignments that you will be gradually completing throughout this term.

Step 1. Environment Setup

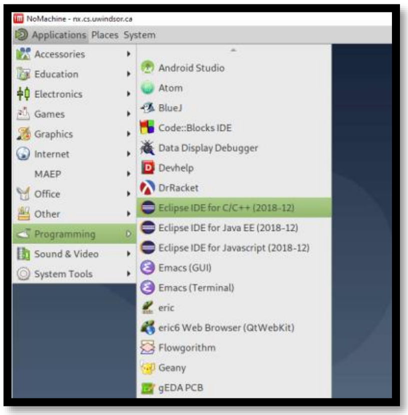
In computer engineering, there are hardware description languages (HDL) such as VHDL and Verilog that are specialized computer languages used to describe the structure and behavior of electronic circuits, and most commonly, digital logic circuits. However, in computer science and this course mainly, we rely on schematic-based design methods that create a representation of functionality. We literally use pen and paper to draw circuits and gates. Therefore, we do not cover any HDL. We instead simulate the circuit's functionality via writing programs using a general-purpose programing language to make sure that our designed circuit is working correctly.

We will use C as the programming language. C++ is an extension to the C and has more features. We are not using those features in this course and, therefore, C++ is similar to C for us. Although we create C++ projects, we only use C language. This way, you will see some limitations of C language and will be motivated to move on to C++ language in future.

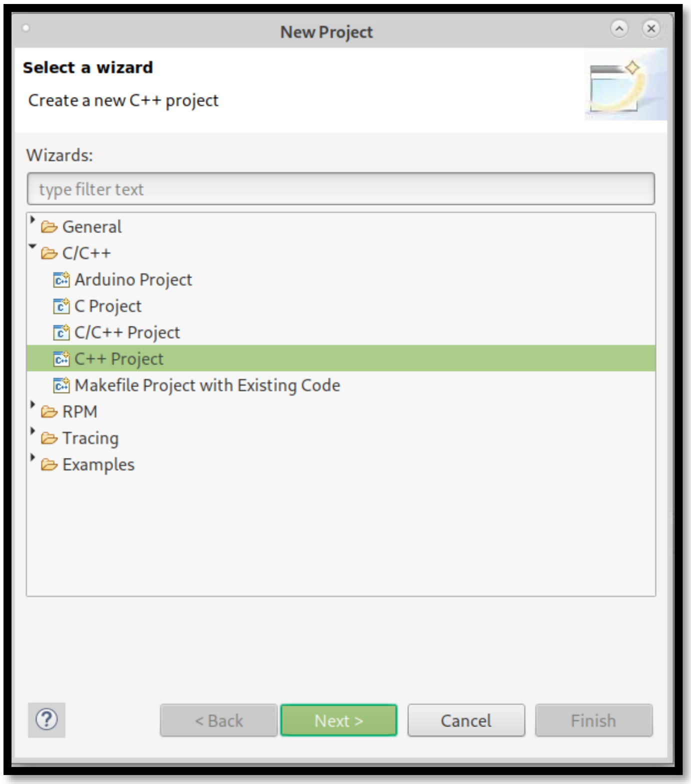
For IDE, we use Eclipse as the programming environment throughout the lab manual. You are however free to adopt any programming environment such as NetBeans, CodeBlocks or text editors like nano or vim. Eclipse is free and open-source. Go to the download page and grab the binary for your platform. When installing Eclipse, remember to choose Eclipse IDE for C/C++ Developers. Eclipse is a Java-based platform without C/C++ compilers. So, you have to install the following as well:

- Java (jdk)
- Cygwin or minGW for GCC compiler

You can also connect to computer systems available in the school to work remotely using this link. Therein, Eclipse as well as Code::Blocks have already been installed and are ready to use. Make sure you can start up a `Hello World` project in C++ and run it in Eclipse. Here's a quick test for you to try and create a new C/C++ project using remote computers in the school using Eclipse:



Now, you can create a C/C++ project:



New Project

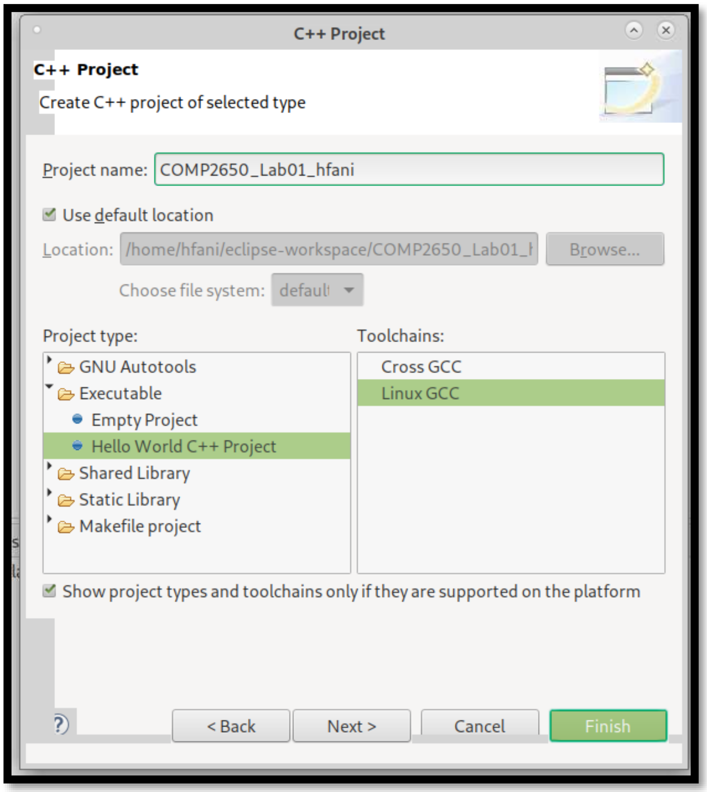
Select a wizard

Create a new C++ project

Wizards: type filter text

Next, depending on the operating in your computer, you select the compiler. Do NOT select the `Cross GCC`.

On Linux:



C++ Project

C++ Project

Create C++ project of selected type

Project name: COMP2650_Lab01_hfani

☑ Use default location

Location: /home/hfani/eclipse-workspace/COMP2650_Lab01_I

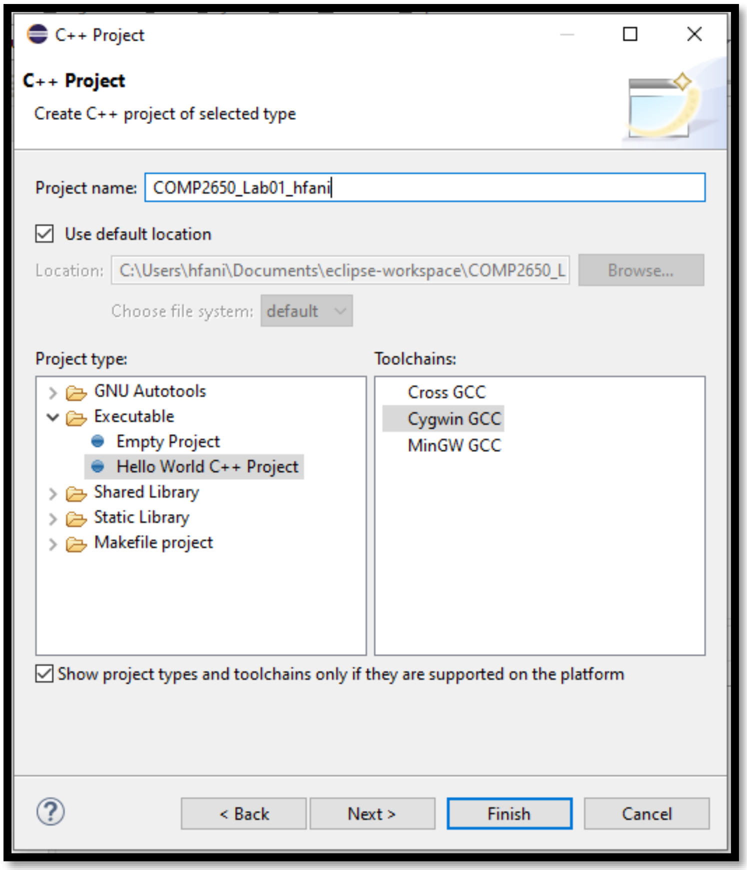
Choose file system: default

Project type: Hello World C++ Project

Toolchains: Linux GCC

☑ Show project types and toolchains only if they are supported on the platform

On Windows:



C++ Project

C++ Project

Create C++ project of selected type

Project name: COMP2650_Lab01_hfani

☑ Use default location

Location: C:\Users\hfani\Documents\eclipse-workspace\COMP2650_L

Choose file system: default

Project type:

- GNU Autotools
- Executable
  - Empty Project
  - Hello World C++ Project
- Shared Library
- Static Library
- Makefile project

Toolchains:

- Cross GCC
- Cygwin GCC
- MinGW GCC

☑ Show project types and toolchains only if they are supported on the platform

Step2. Writing the First Program

Now, let's write a quick program that accepts two Boolean values and returns the AND of them. Recall from math, the truth table for AND operation, also shown as '∧' or '&' is as follows:

x	y	x AND y	x ∧ y	x & y
false	false	false	false	false
false	true	false	false	false
true	false	false	false	false
true	true	true	true	true

We know that C++ language has a type for Boolean values, called `bool`, that accept `false` and `true`. However, C language does not have it. So, we can use the standard type `int` for our program and use 0 for `false` and 1 for `true` values.

```
int main(void) {
    setbuf(stdout, NULL);#This is needed to stop I/O buffer due to eclipse's bug!
    int x;
    int y;
    scanf("%d", &x);
    scanf("%d", &y);
    printf("%d AND %d is %d", x, y, x & y);
    return 0;
}
```

Let's build the project and run the program by clicking the build icon 🔨 to see it's working fine according to the above truth table. Depending on what computer system and folder you created the program, you see the build messages similar to the followings in the `Console` tab:

```
12:27:03 **** Incremental Build of configuration Debug for project COMP2650_Lab02_hfani ****
make all
Building file: ../src/COMP2650_Lab02_hfani.cpp
Invoking: Cygwin C++ Compiler
g++ -O0 -g3 -Wall -c -fmessage-length=0 -MMD -MP -MF"src/COMP2650_Lab02_hfani.d" -
MT"src/COMP2650_Lab02_hfani.o" -o "src/COMP2650_Lab02_hfani.o" "../src/COMP2650_Lab02_hfani.cpp"
../src/COMP2650_Lab02_hfani.cpp: In function 'int main(int, char**)':
../src/COMP2650_Lab02_hfani.cpp:5:19: error: 'scanf' was not declared in this scope
     scanf("%d", &x);
                   ^
../src/COMP2650_Lab02_hfani.cpp:7:42: error: 'printf' was not declared in this scope
     printf("%d AND %d is %d", x, y, x & y);
                                          ^
make: *** [src/subdir.mk:20: src/COMP2650_Lab02_hfani.o] Error 1
"make all" terminated with exit code 2. Build might be incomplete.

12:27:03 Build Failed. 3 errors, 0 warnings. (took 419ms)
```

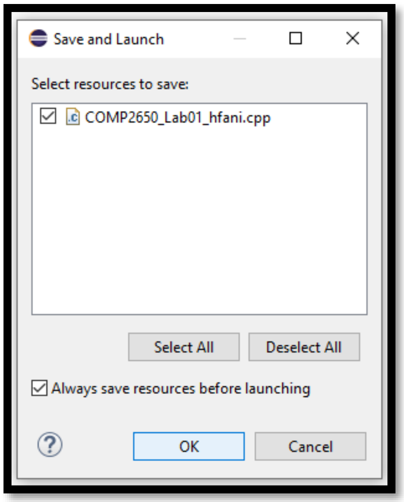
As you can see, the build failed for our program due to 2 errors in finding `scanf` and `printf` functions. Because the linker could not find the declaration for these functions. Recall from the C++ program language course, we know that these two functions are in the standard I/O library in `stdio.h`. Let's include this library and built the program again:

```
#include <stdio.h>
int main(void) {

    int x;
    int y;
    scanf("%d", &x);
    scanf("%d", &y);
    printf("%d AND %d is %d", x, y, x & y);
    return 0;
}
```

```
12:28:47 **** Incremental Build of configuration Debug for project COMP2650_Lab02_hfani ****
make all
Building file: ../src/COMP2650_Lab02_hfani.cpp
Invoking: Cygwin C++ Compiler
g++ -O0 -g3 -Wall -c -fmessage-length=0 -MMD -MP -MF"src/COMP2650_Lab02_hfani.d" -
MT"src/COMP2650_Lab02_hfani.o" -o "src/COMP2650_Lab02_hfani.o" "../src/COMP2650_Lab02_hfani.cpp"
Finished building: ../src/COMP2650_Lab02_hfani.cpp

Building target: COMP2650_Lab02_hfani.exe
Invoking: Cygwin C++ Linker
g++  -o "COMP2650_Lab02_hfani.exe"  ./src/COMP2650_Lab02_hfani.o
Finished building target: COMP2650_Lab02_hfani.exe
12:28:48 Build Finished. 0 errors, 0 warnings. (took 1s.179ms)
```

The last message shows that the project has been built successfully with no error.

Now, let's run the program by clicking the run icon in the toolbar ▶. If this is the first run of the program, you see two dialogs in order to select the program file and the type of application. Select the options as follow:

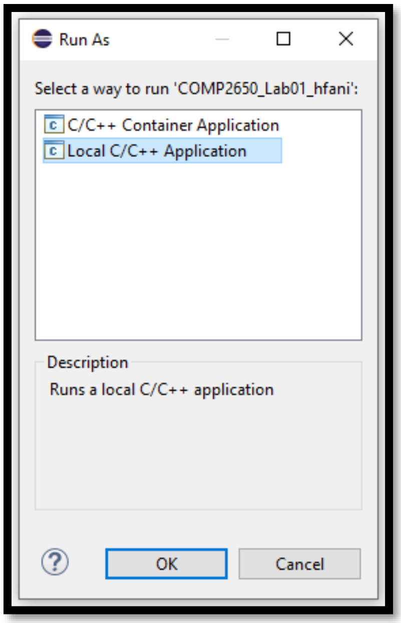


Save and Launch

Select resources to save:

☑ COMP2650_Lab01_hfani.cpp

☑ Always save resources before launching



Run As

Select a way to run 'COMP2650_Lab01_hfani':

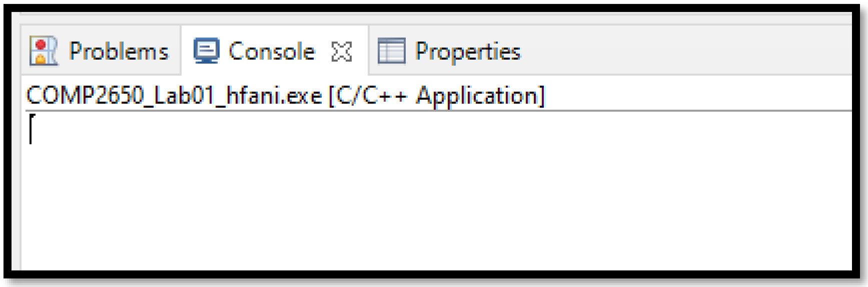
C/C++ Container Application

Local C/C++ Application

Description

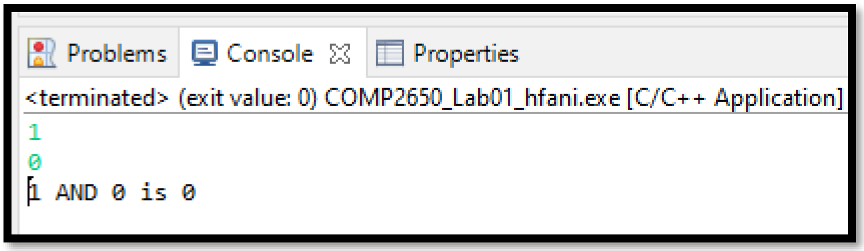
Runs a local C/C++ application

In the `Console` tab, our program is running and waiting for the inputs, instructed by lines #06 and #07 of the program:



```
COMP2650_Lab01_hfani.exe [C/C++ Application]
```

When entering the Boolean values, the program outputs the AND result:



```
<terminated> (exit value: 0) COMP2650_Lab01_hfani.exe [C/C++ Application]
1
0
1 AND 0 is 0
```

Do run the program and try different inputs, e.g., `1 AND 1`, `0 AND 0`, `0 AND 1`, and check whether the program correctly calculates the AND operation.

Step 3. Lab Assignment

You should complete the above program that firstly outputs a menu of commands as follows:

```
Enter the command number:
   0) Exit
   1) AND
   2) OR
```

Based on the chosen number of commands by the user, the program should then ask for the input(s). For instance, if a user selects (1), the program should accept two inputs as follows:

```
   x =
   y =
```

When the user enters the two Boolean values (0 or 1), the program should

1) apply the `AND` command on the input `x` and `y`
2) print the result
3) comes back to the main menu. If the user selects (0), the program ends.
4) Restrict the user to enter inputs within the range {0,1}. For instance, if the user enters 2, -1, …, print out an error message and come back to ask for new inputs.

Deliverables

You will prepare and submit the program in one single zip file `lab02_{UWinID}.zip` containing the following items:

1. The code file (`main.c` or `main.cpp`) and executable file (`main.exe` in windows or `main` in unix/mac)
2. The result of the four commands in the file `results.png/jpg`. Simply make a screenshot of the results.
3. [Optional and if necessary] A readme document in a txt file `readme.txt`. It explains how to build and run the program as well as any prerequisites that are needed. *Please note that if your program cannot be built and run on our computer systems, you will lose marks.*

(90%) `lab02_hfani.zip`

- (80%)
    - o `main.c or main.cpp` => Must be compiled and built with no error!
    - o `main.exe or main`
- (10%) `results.jpg/png`
- (Optional) `readme.txt`

(10%) `Files Naming and Formats`

Please follow the naming convention as you lose marks otherwise. Instead of UWinID, use your own UWindsor account name, e.g., mine is hfani@uwindsor.ca, so, `lab02_hfani.zip`