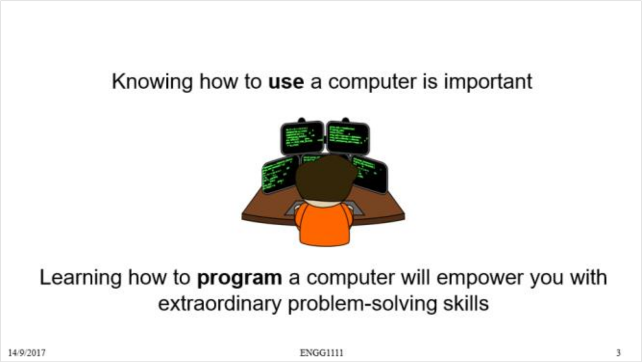
§1 Introduction

ENGG1111

Computer Programming and Applications

Dirk Schnieders

Outline



Knowing how to **use** a computer is important

Learning how to **program** a computer will empower you with extraordinary problem-solving skills

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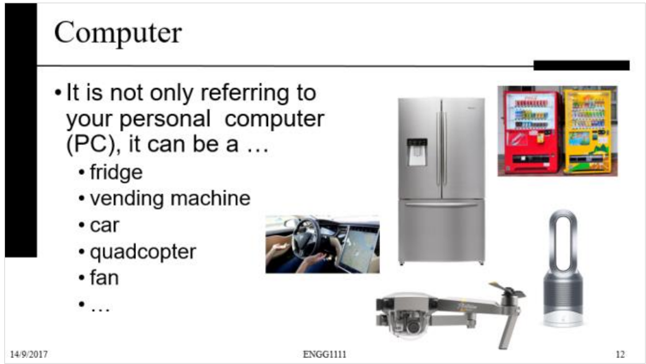

Computer

- It is not only referring to your personal computer (PC), it can be a …
  - fridge
  - vending machine
  - car
  - quadcopter
  - fan
  - …

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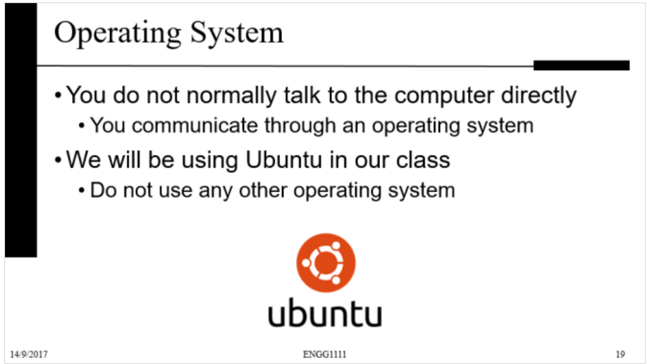

Operating System

- You do not normally talk to the computer directly
  - You communicate through an operating system
- We will be using Ubuntu in our class
  - Do not use any other operating system

ubuntu

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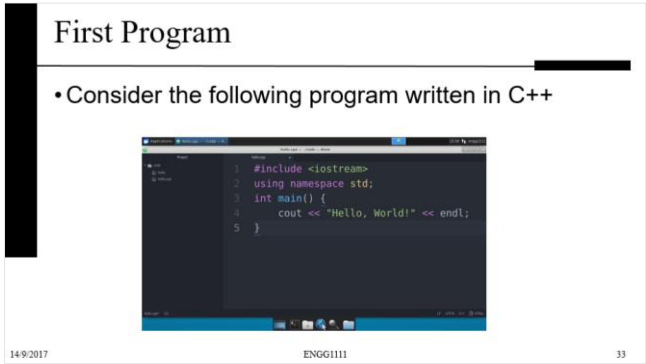

First Program

- Consider the following program written in C++

```
#include <iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```

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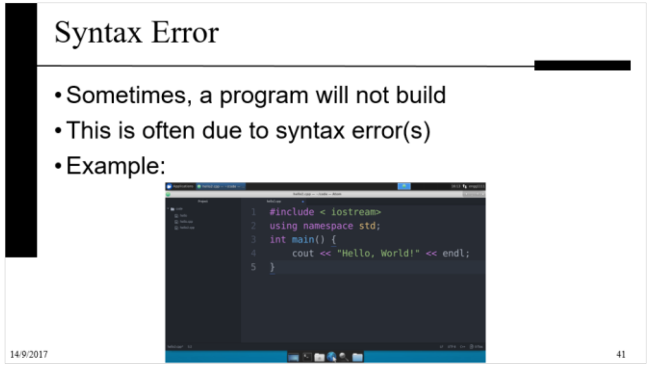

Syntax Error

- Sometimes, a program will not build
- This is often due to syntax error(s)
- Example:

```
#include < iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```

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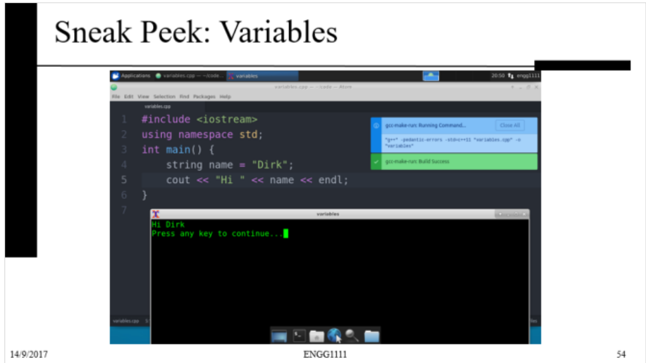

Sneak Peek: Variables

```
#include <iostream>
using namespace std;
int main() {
    string name = "Dirk";
    cout << "Hi " << name << endl;
}
```

gcc-make-run: Running Command...

"g++" -pedantic-errors -std=c++11 "variables.cpp" -o "variables"

gcc-make-run: Build Success

```
Hi Dirk
Press any key to continue...
```

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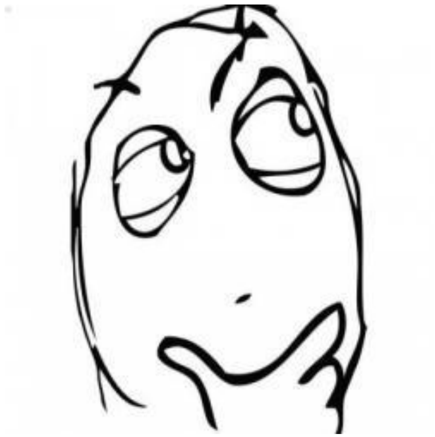
Knowing how to **use** a computer is important

Learning how to **program** a computer will empower you with extraordinary problem-solving skills

I don’t want to major in computer science.

Why do I have to learn to program?



Learn to Code - Code to Learn

- In the process of learning to code (computer programming), you learn many other things
  - You are coding to learn
- In addition to learning mathematical and computational ideas your are also learning strategies for solving problems, designing projects, and communicating ideas
- These skills are useful not just for computer scientists but for everyone

Based on work by Mitchel Resnick

If you like solving problems,
there is a good chance that you will love programming

Coding

- Coding involves the following steps
  1. Problem definition

     Examine, analyze and understand the problem
  2. Algorithm design

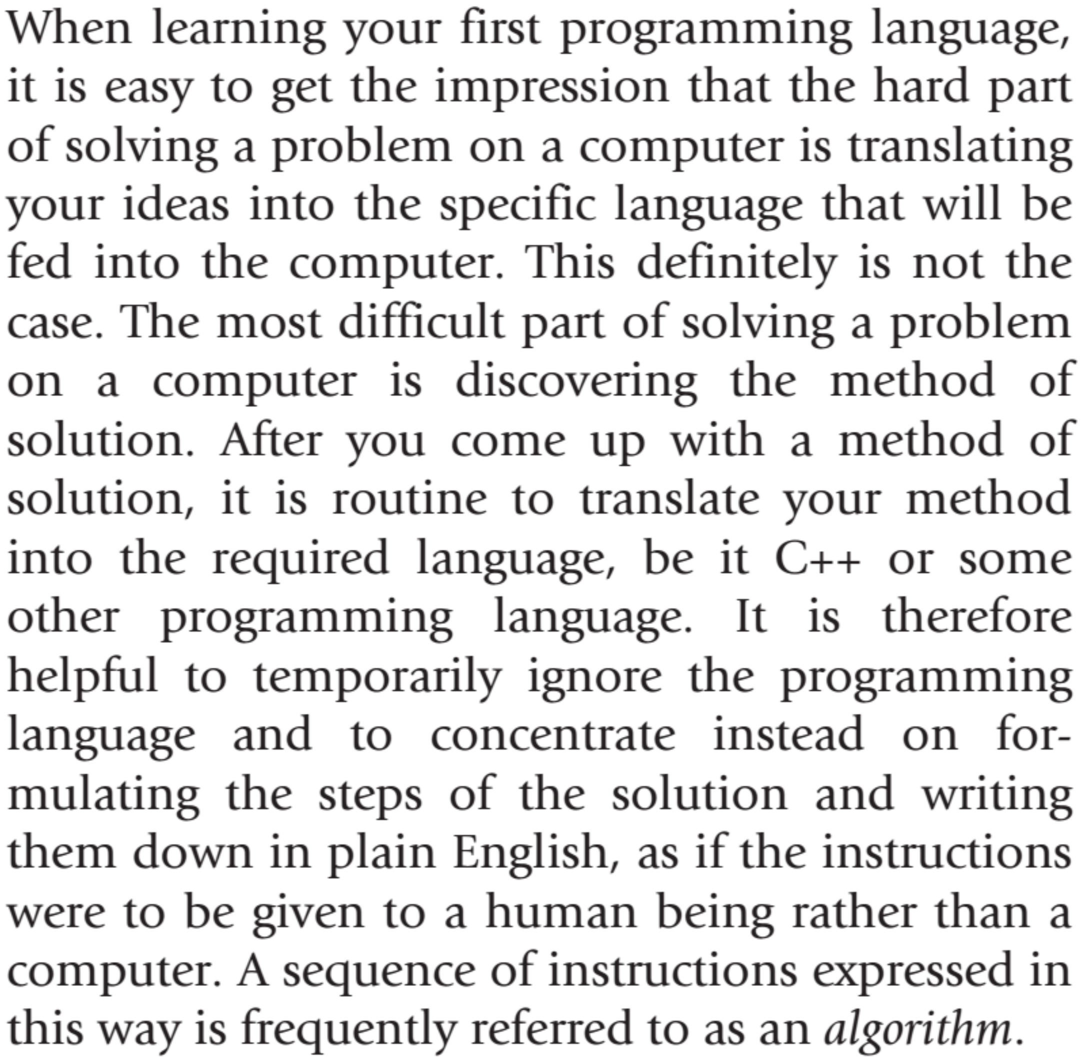
     Devise a solution in the form of an algorithm
  3. Desktop testing

     Check that the solution works under a range of conditions
  4. Translate to code

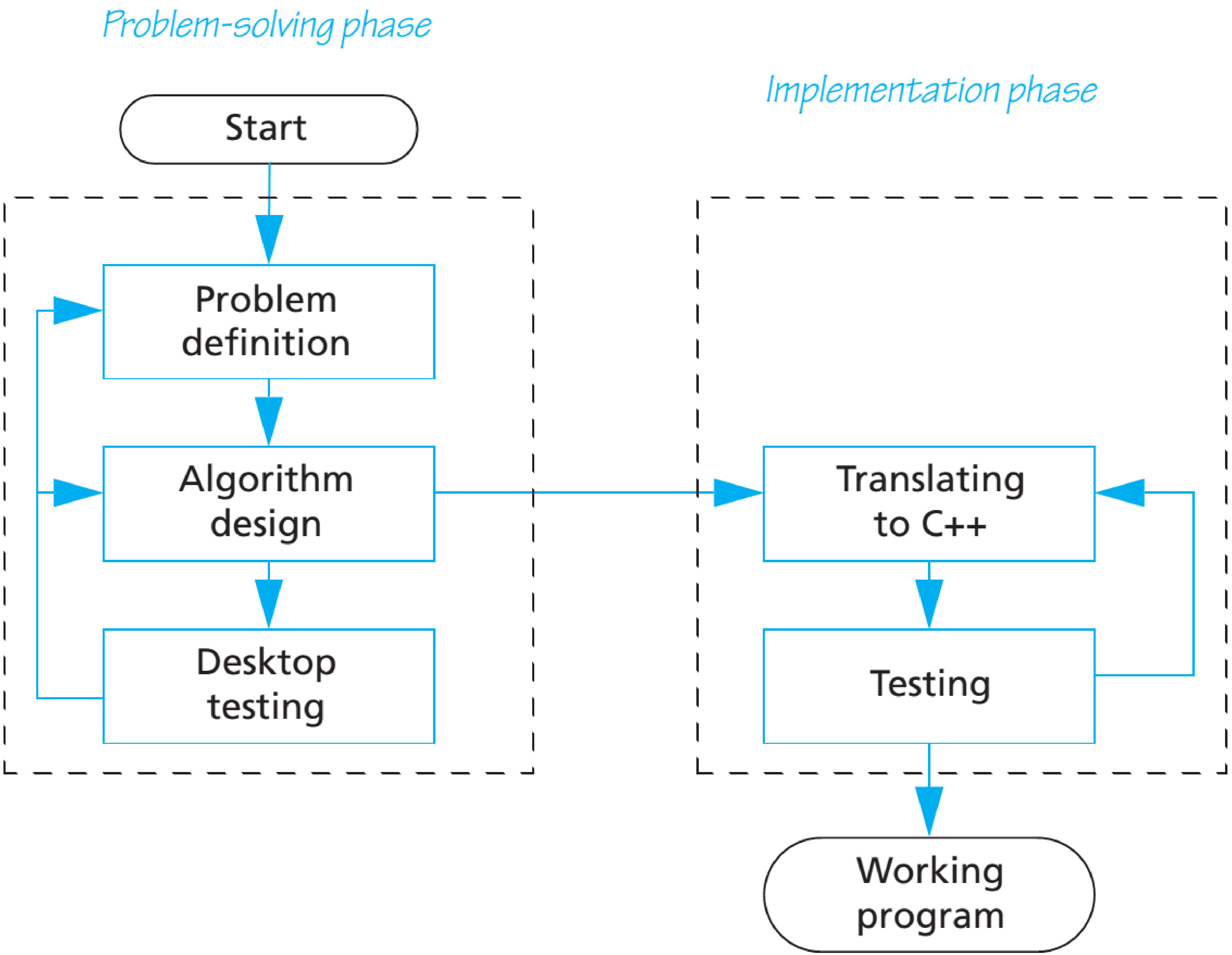
     Translate the solution into a programming language and write the code
  5. Testing

     Test your code

Programming and Problem-solving



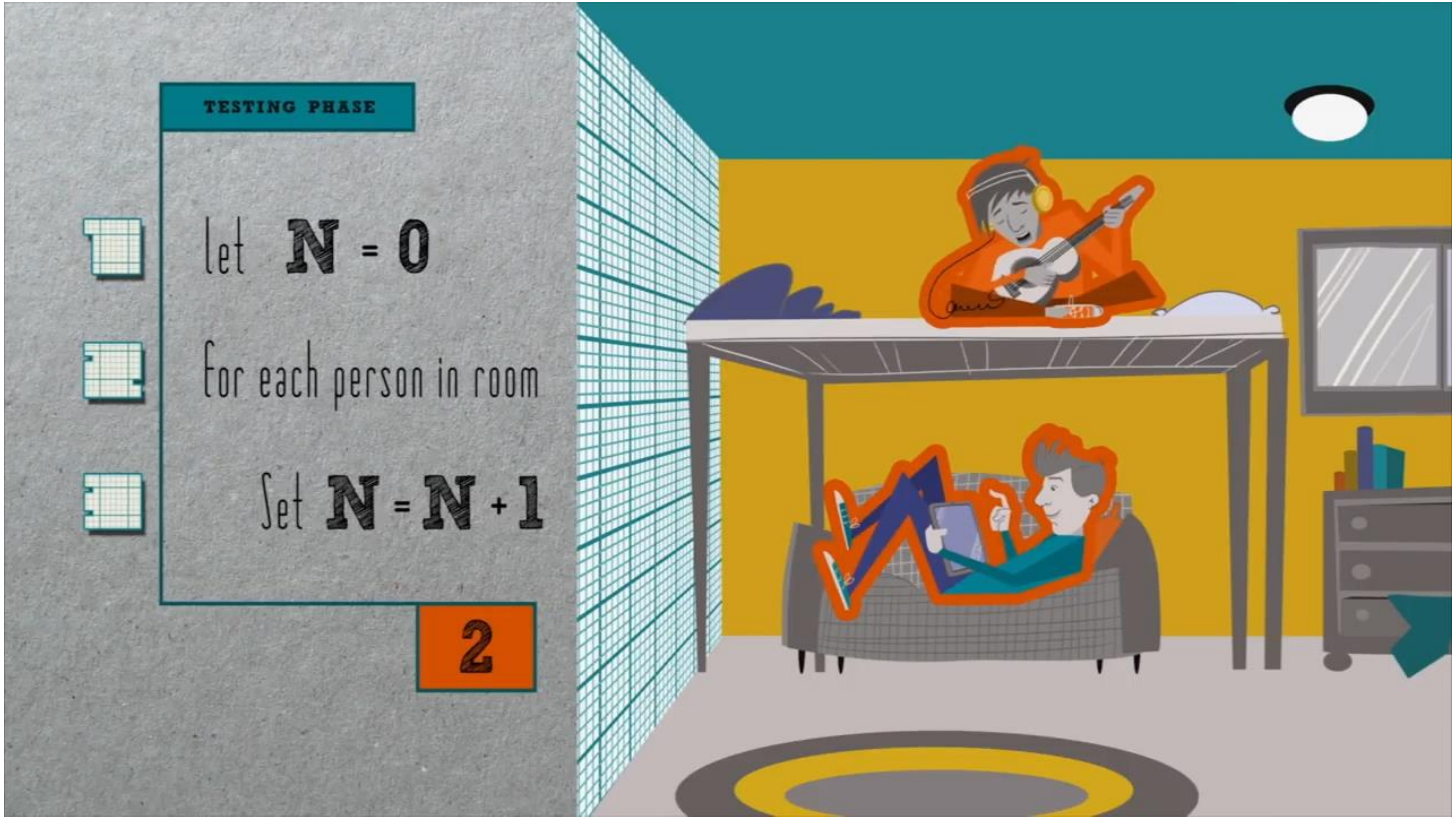
When learning your first programming language, it is easy to get the impression that the hard part of solving a problem on a computer is translating your ideas into the specific language that will be fed into the computer. This definitely is not the case. The most difficult part of solving a problem on a computer is discovering the method of solution. After you come up with a method of solution, it is routine to translate your method into the required language, be it C++ or some other programming language. It is therefore helpful to temporarily ignore the programming language and to concentrate instead on formulating the steps of the solution and writing them down in plain English, as if the instructions were to be given to a human being rather than a computer. A sequence of instructions expressed in this way is frequently referred to as an *algorithm*.


Problem-solving phase
Implementation phase
Start
Problem definition
Algorithm design
Desktop testing
Translating to C++
Testing
Working program

Tip

- Do not skip any steps
    - Even if you initially feel you are solving a trivial problem

What is an Algorithm?



```
let N = 0
For each person in room
    Set N = N + 1
```

Computer

- It is not only referring to your personal computer (PC), it can be a …
  - fridge
  - vending machine
  - car
  - quadcopter
  - fan
  - …

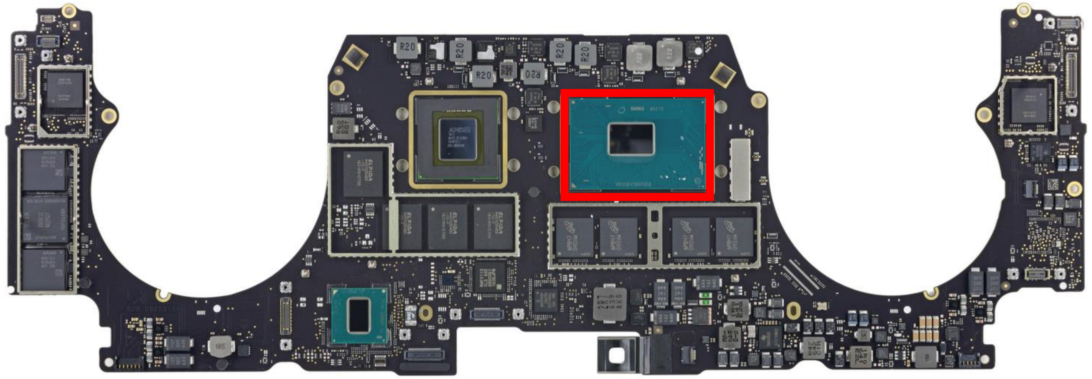
Hardware

- The actual physical parts that make up a computer

2017 MacBook Pro 15"

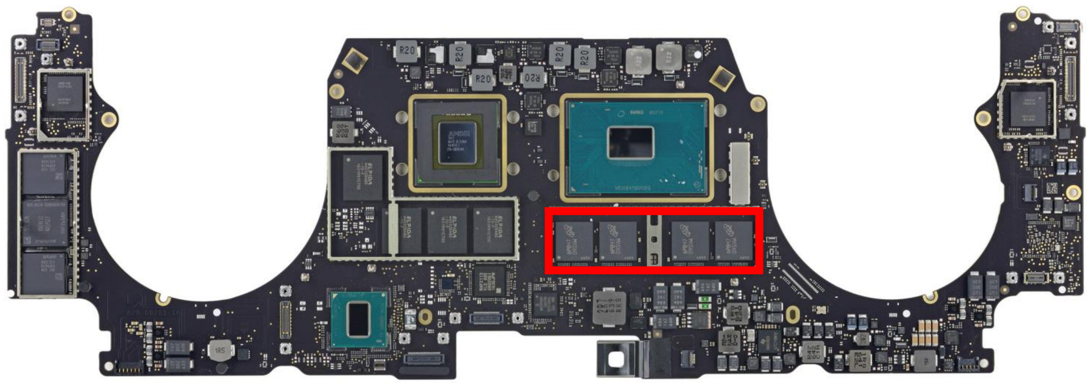
Central Processing Unit (CPU)

- Follows instructions in a program
- Performs simple tasks like
  - Addition, subtraction, multiplication and division
  - Move data from one memory location to another



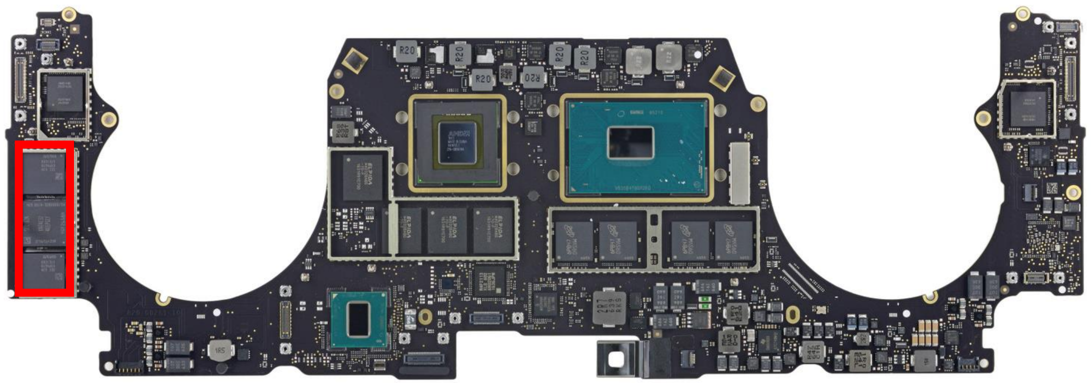
Main memory

- Long list of memory cells
- Each memory cell has an address (a number) that gives its position in the memory
- Each memory cell consists of 8 digits (1 byte)
- Volatile – information will be lost when the computer is switched off



Secondary memory

- Non-volatile – information will not be lost even after the computer is switched off
- For permanent storage of data in units of files
  - E.g., SSD, HDD



Input Device

- Any device that allows a user to input information

Output Device

- Any device that allows a computer to communicate information to the user

Operating System

- You do not normally talk to the computer directly
    - You communicate through an operating system
- We will be using Ubuntu in our class
    - Do not use any other operating system

ubuntu

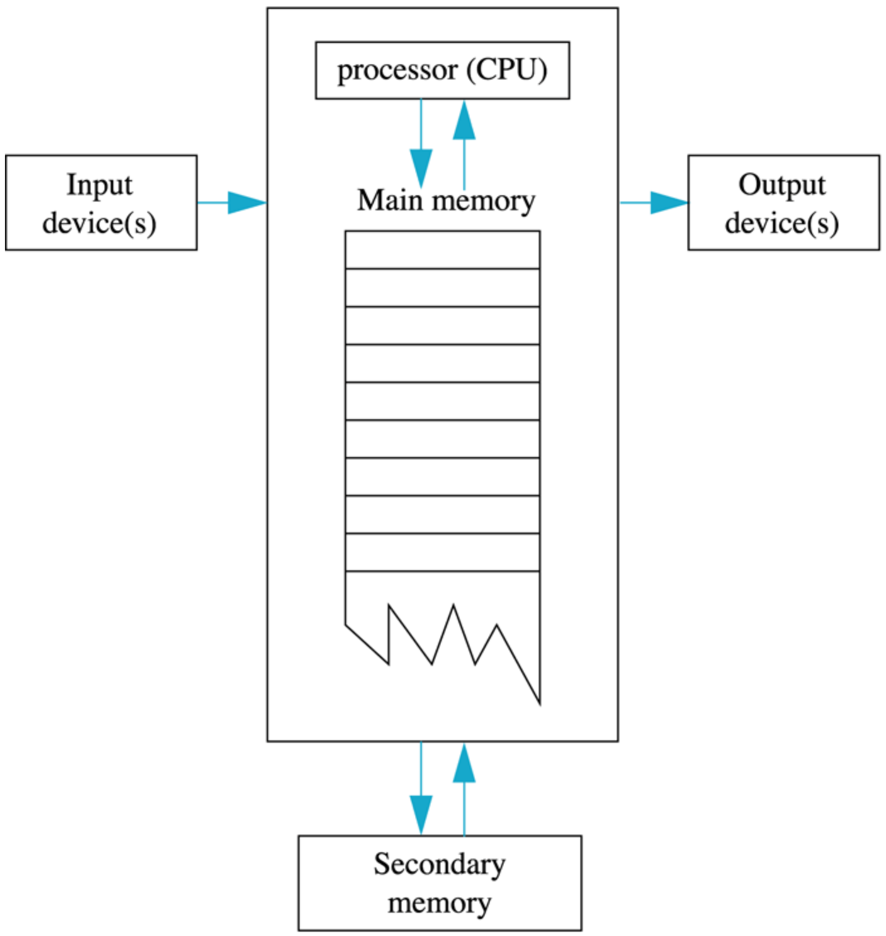
Computer Program

- A computer program is a sequence of instructions for a computer to follow
    - Written to perform a specified task with a computer

Computer Organization

- When a program is being executed
  - The program is loaded into the main memory
  - The CPU reads the program instructions and process the program data
  - The output of the program can be written to the main memory, secondary memory, or displayed through the output device(s)

Main Components of a Computer



Languages

Machine Language	Assembly Language	High-level Programming Language	Human Language
01101001 10101011	LOAD A ADD B STORE C	C=A+B	Write a program that computes the addition of two integers

Machine Language

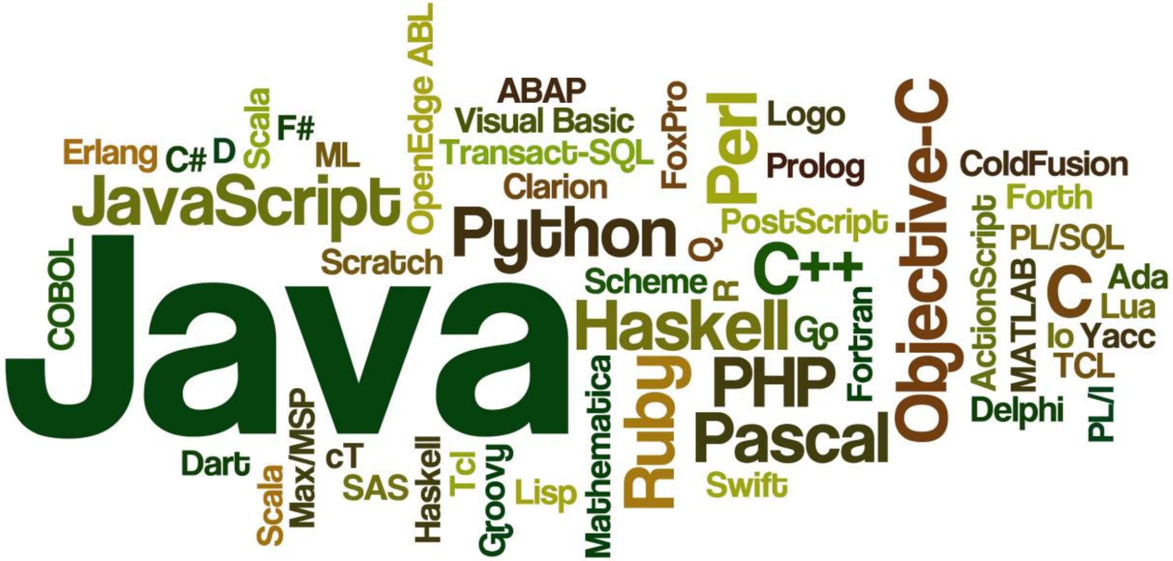
- The CPU can only understand machine language (machine code)
- Low level instruction perform very specific tasks
    - E.g., a load, a jump, or an ALU operation
- Every processor or processor family has its own machine code instruction set
- All practical programs today are written in higher-level languages or assembly language

Assembly Language

- A low-level programming language
- Defined by the hardware manufacturer, so every kind of computer has its own unique assembler language
- Need to translate to machine code for CPU to execute
    - The translation program is called an assembler

High-level Programming Language

- Resemble human languages
    - Use more complex instructions
    - Need to translate to machine code for CPU to execute
    - The translation program is called a compiler



C++

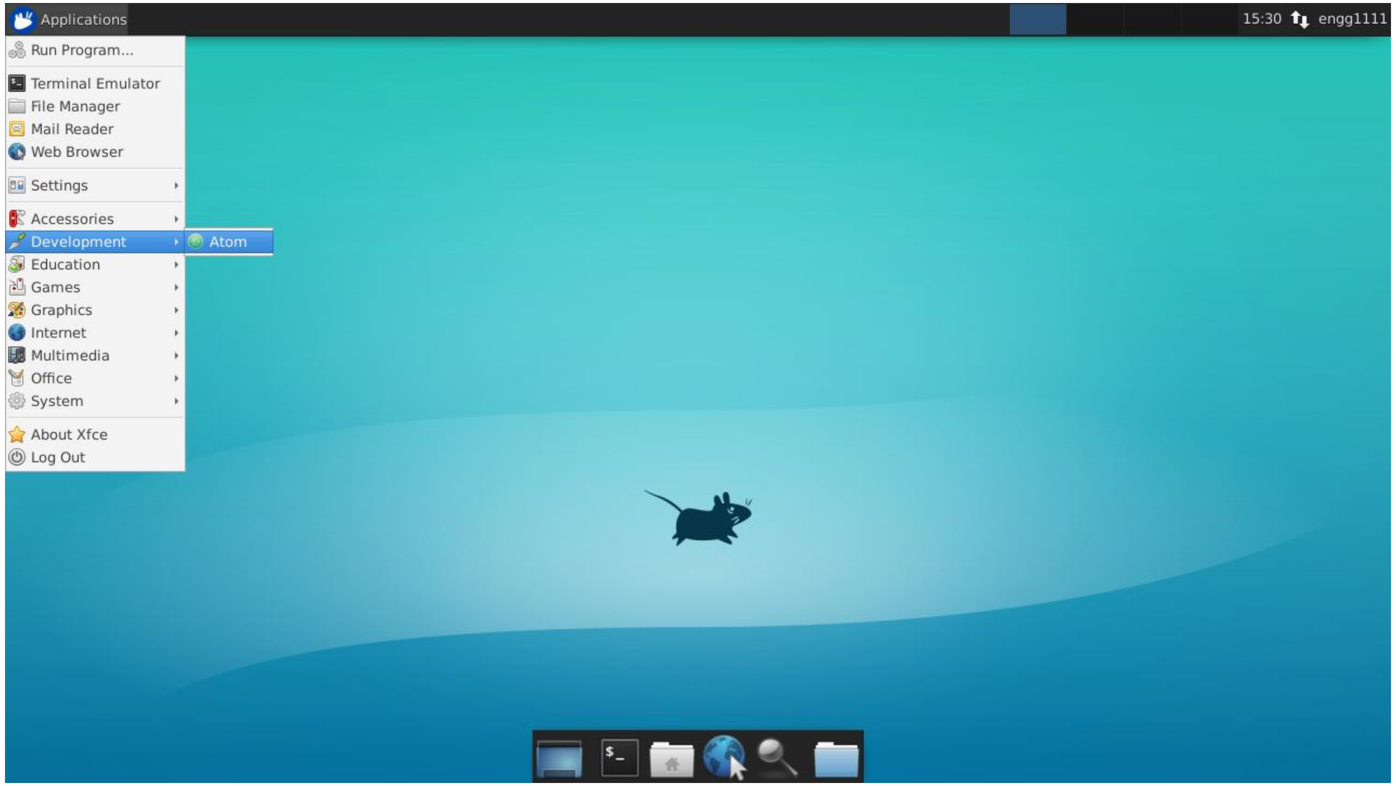
- In this course we will be using the C++ programming language
- C++ is a popular, industrial-strength language
- If you master general programming concepts using C++, you can apply them to many other languages

Text Editor

- A word-processor like program used for typing in and editing the source code of a program
  - E.g., Notepad, Emacs, vi, pico, Sublime Text, ATOM
- C++ files are saved as *.cpp
  - Always save your C++ file with the ending cpp

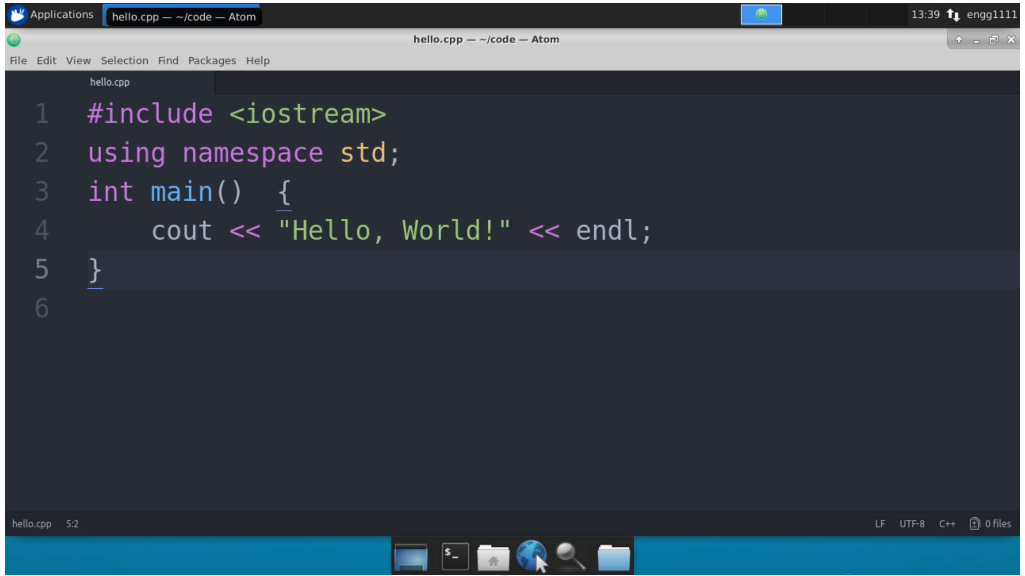
Text Editor

- In this course we are using ATOM
- In Ubuntu, you can start is as follows



Text Editor - Syntax Highlighting

- ATOM supports syntax highlighting for C++
  - I.e., different colours are assigned to keywords, literals, variables, etc.



```
#include <iostream>
using namespace std;
int main()  {
    cout << "Hello, World!" << endl;
}

```

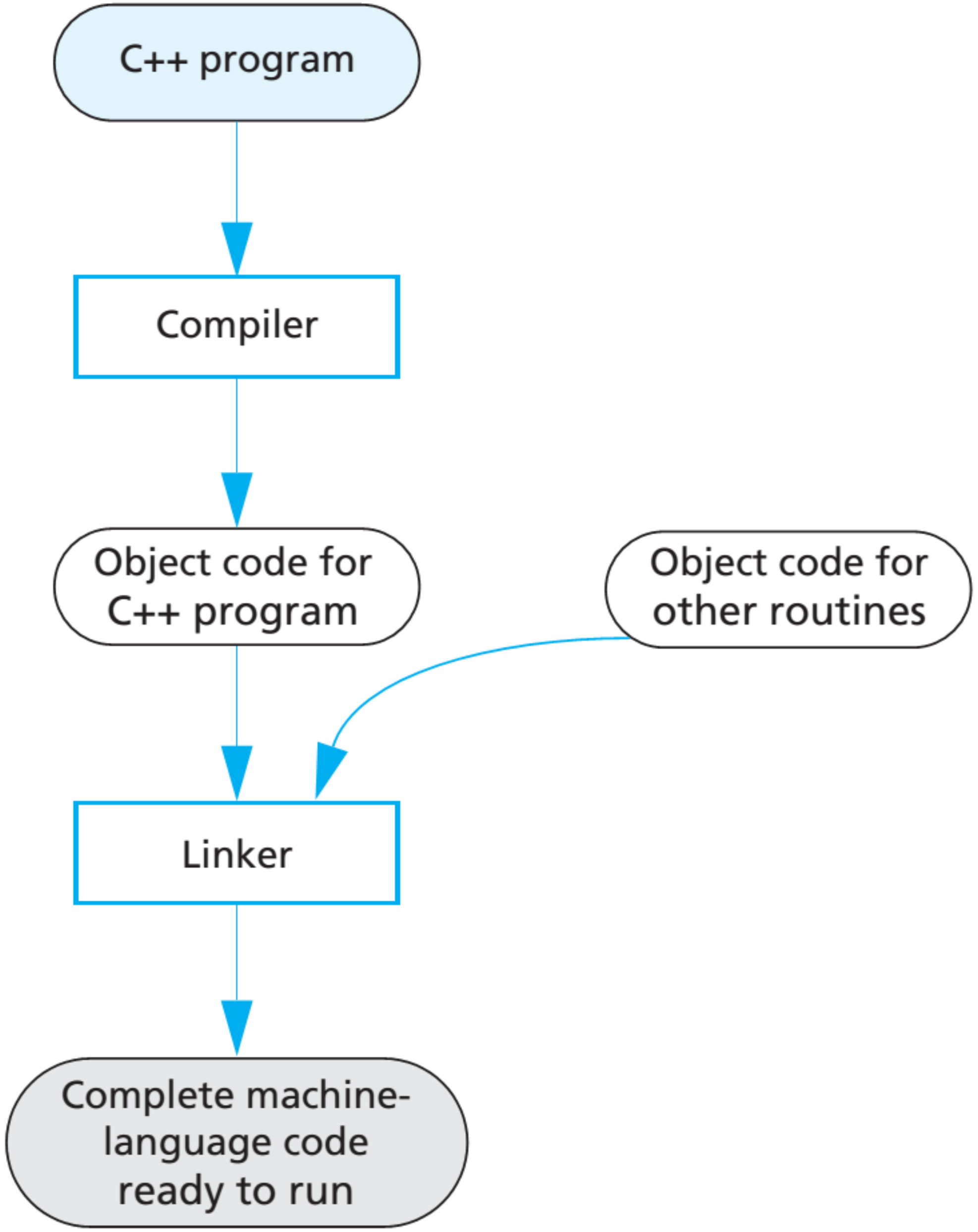
- Note that the highlighting does not affect the meaning of the source itself and is not saved with the file
- If you save your file as *.cpp, ATOM create the syntax highlighting automatically

Compiler

- Computers can only understand programs written in low-level languages (simple instructions), which may differ from one kind of computers to another
- A compiler is a program that translates a high-level language program, such as a C++ program, into a machine-language program that a computer can directly understand and execute
- The input program is called the source program or source code, and the translated version is called the object program or object code

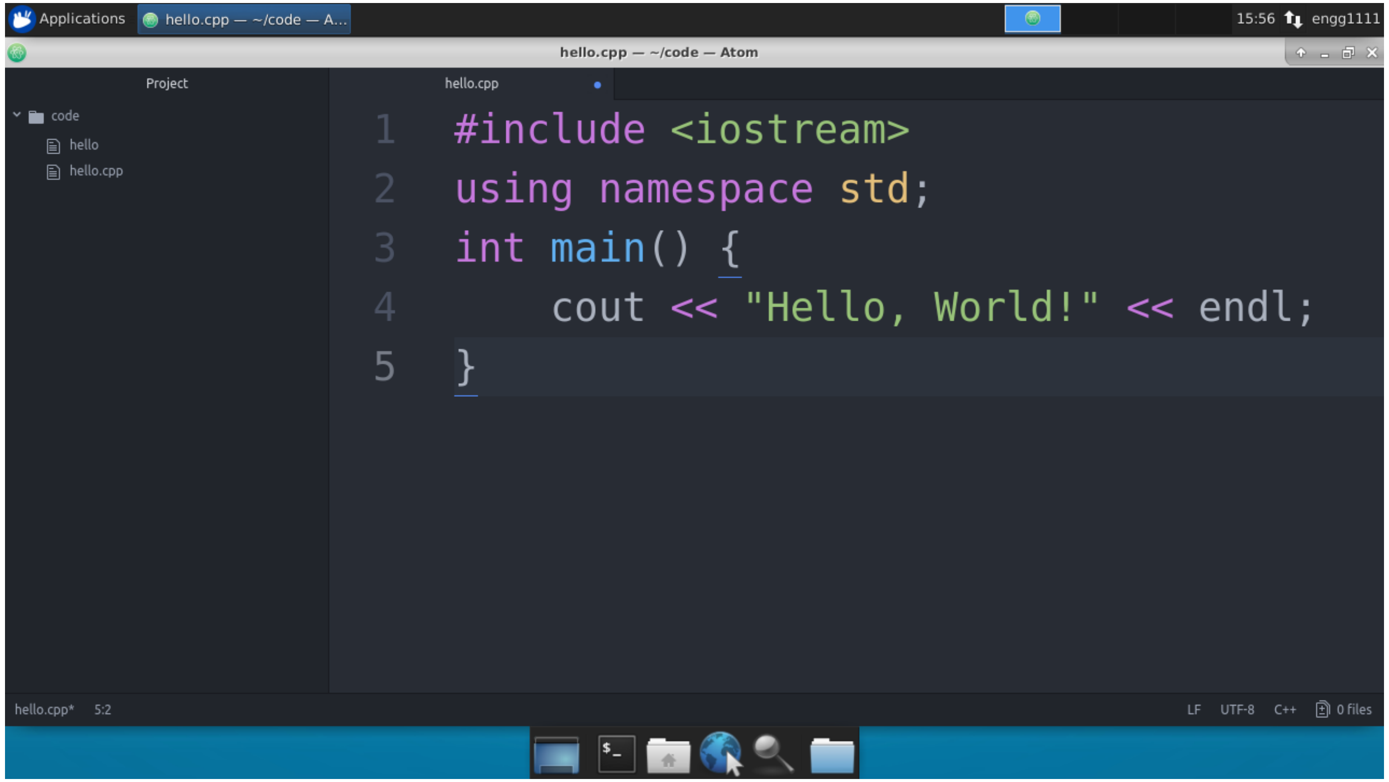
Linker

- When writing a program, we can make use of some routines that have been written by someone else (e.g., routines for handling I/O, trigonometric functions)
- Such routines have been compiled into object code and a collection of such pre-compiled routines is called a library
- A linker is a program that combines (links) the object code of your program with those of the routines from a library to produce an executable
- We are going to use g++ in this course as the driver for compiler and linker


C++ program
Compiler
Object code for C++ program
Object code for other routines
Linker
Complete machine-language code ready to run

First Program

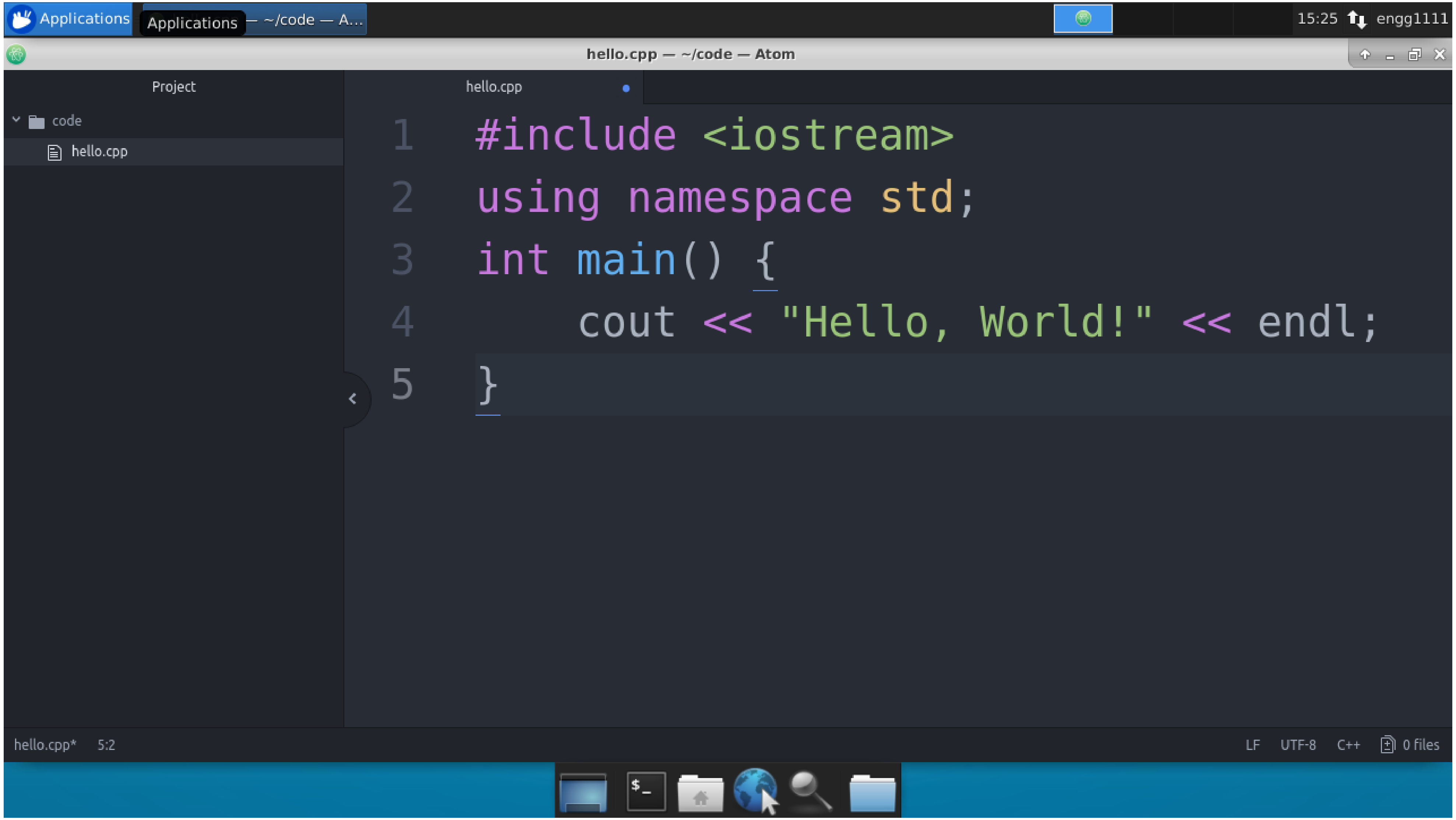
- Consider the following program written in C++



```
#include <iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```

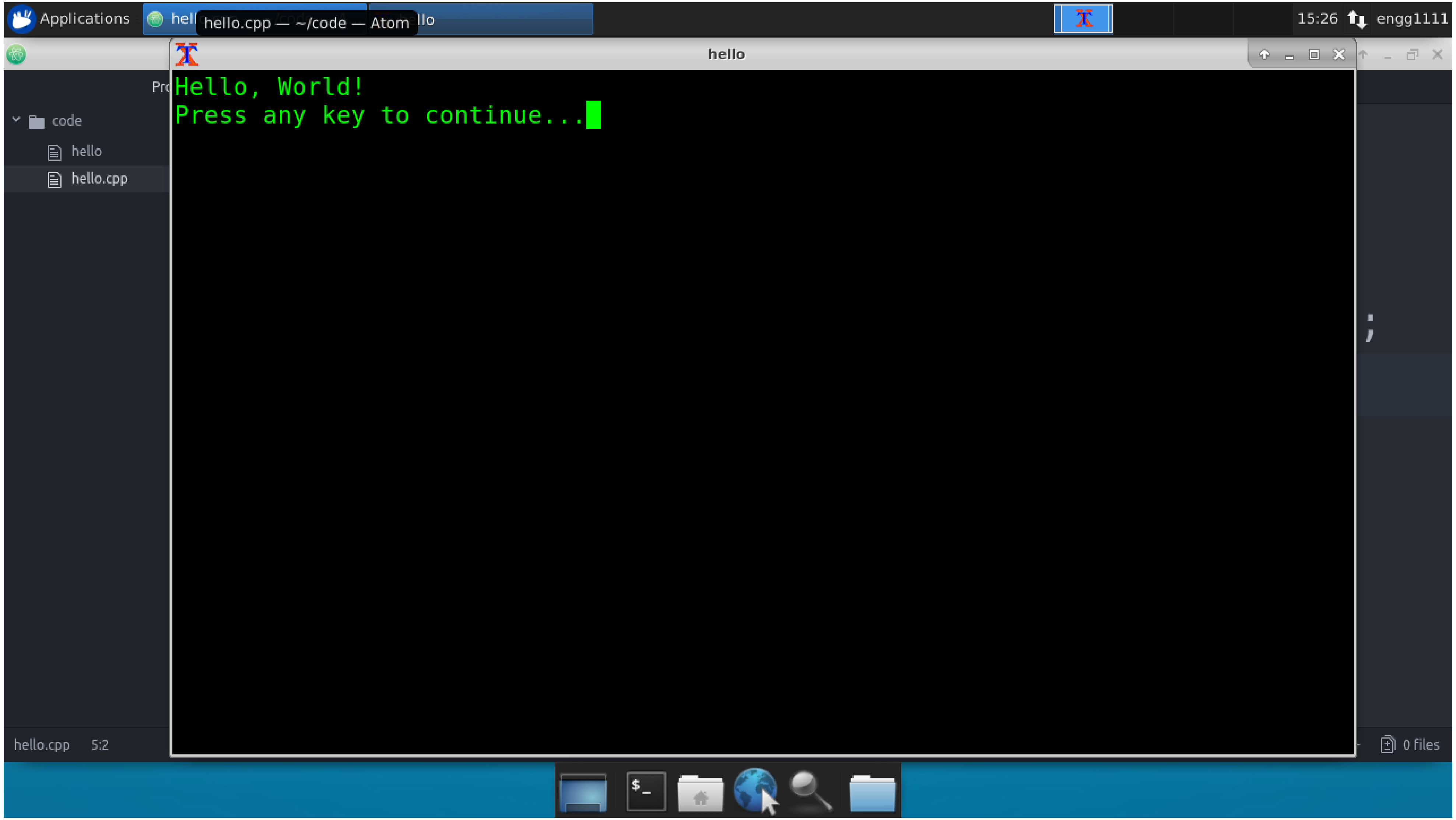
Building an Executable

[redacted]



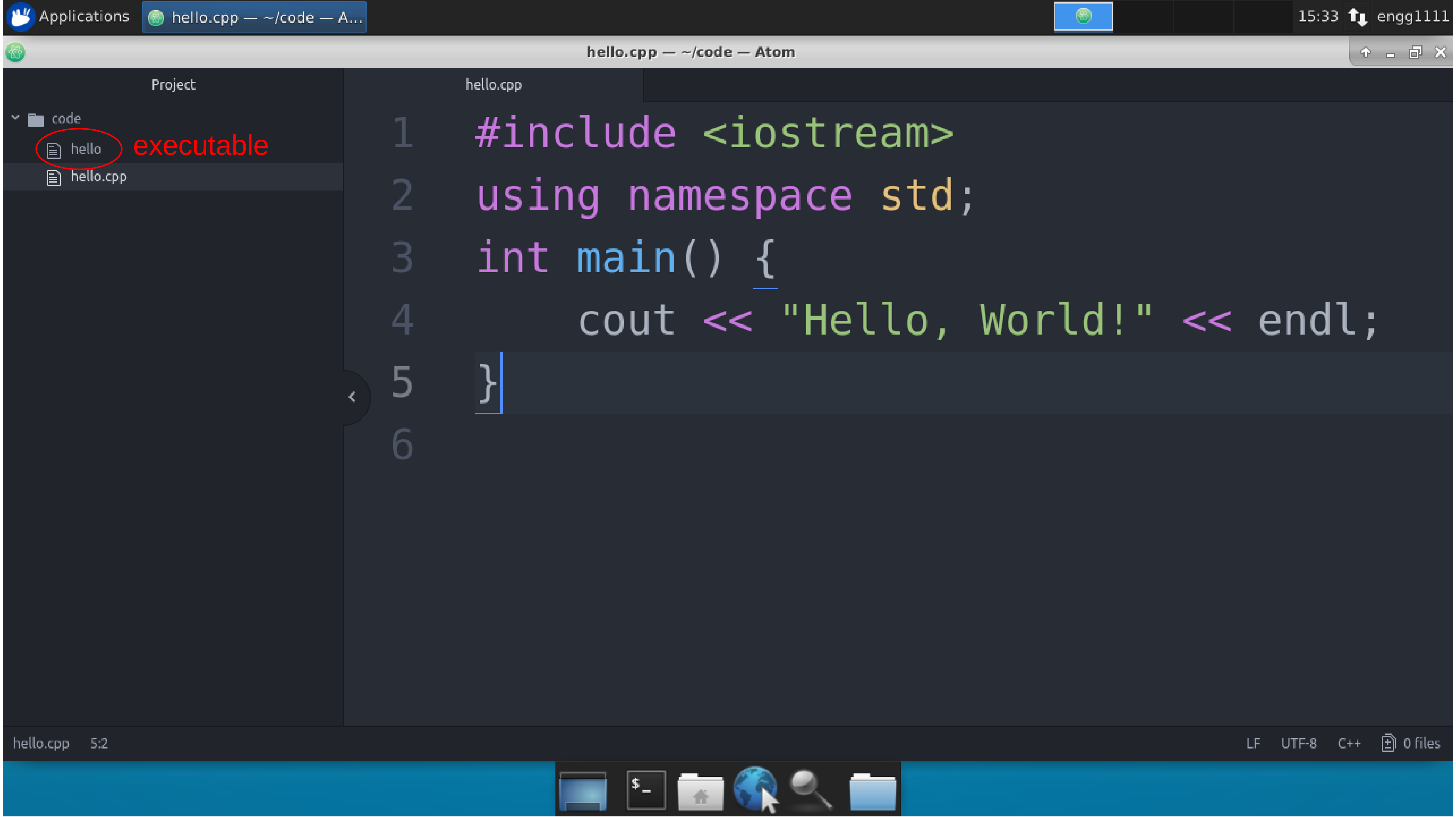
```
#include <iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```

Building an Executable



```
Hello, World!
Press any key to continue...
```

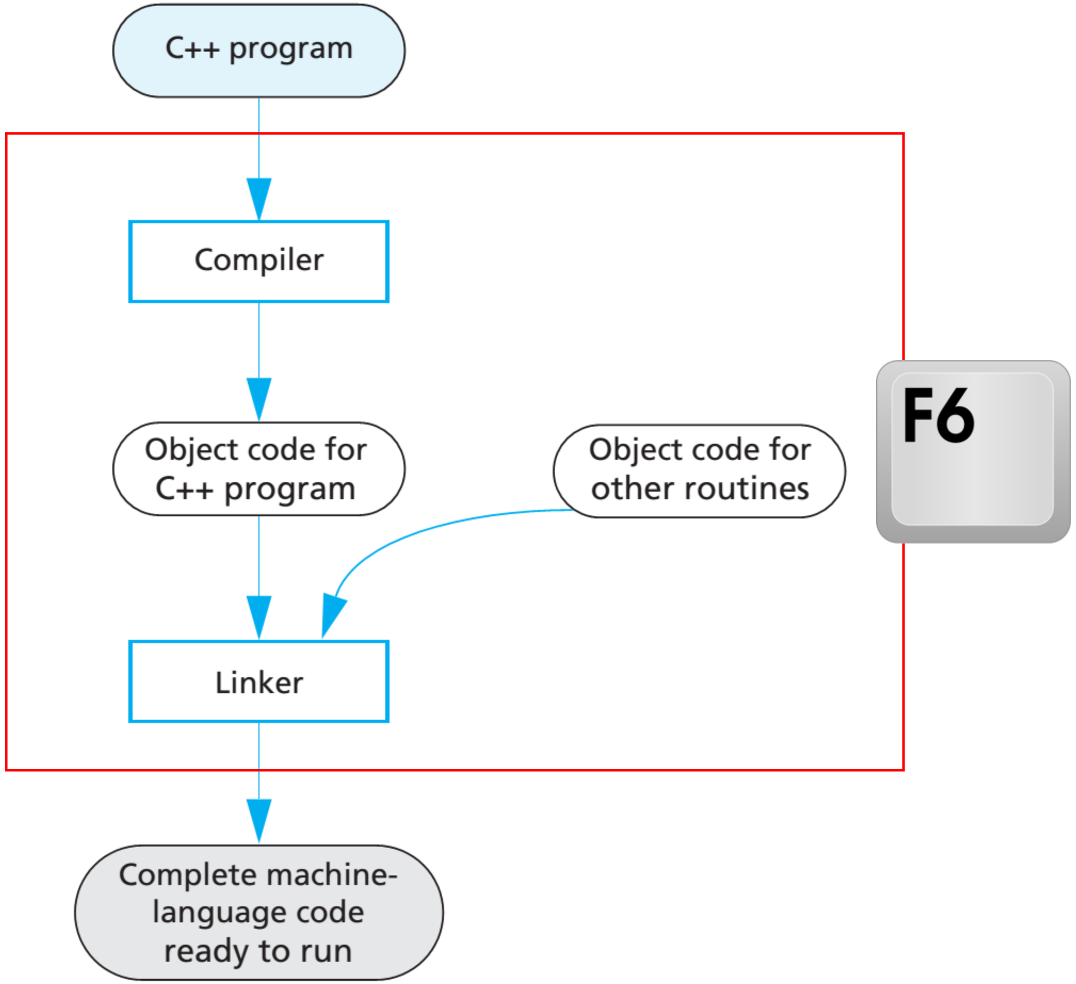
F6



executable

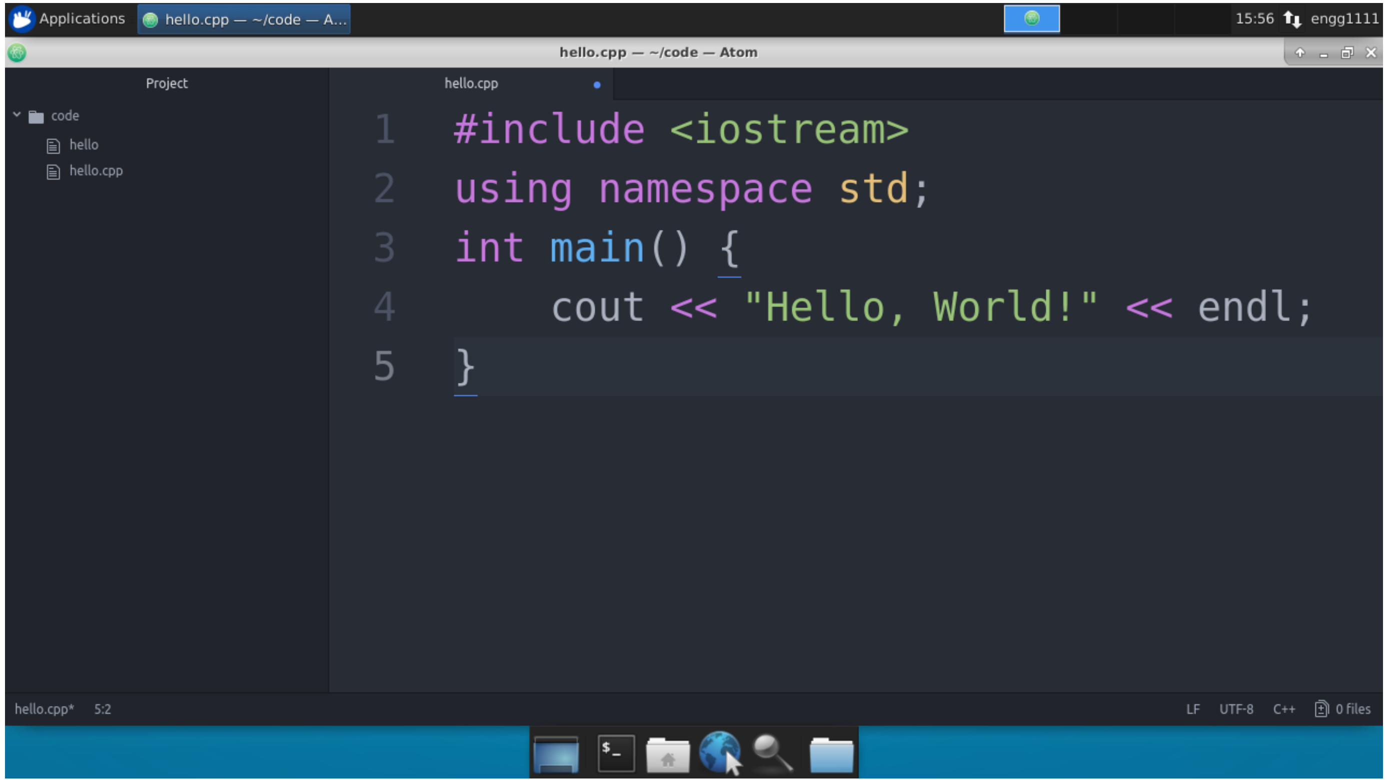
```cpp
#include <iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```

Building an Executable


C++ program
Compiler
Object code for C++ program
Object code for other routines
Linker
Complete machine-language code ready to run
F6

First Program

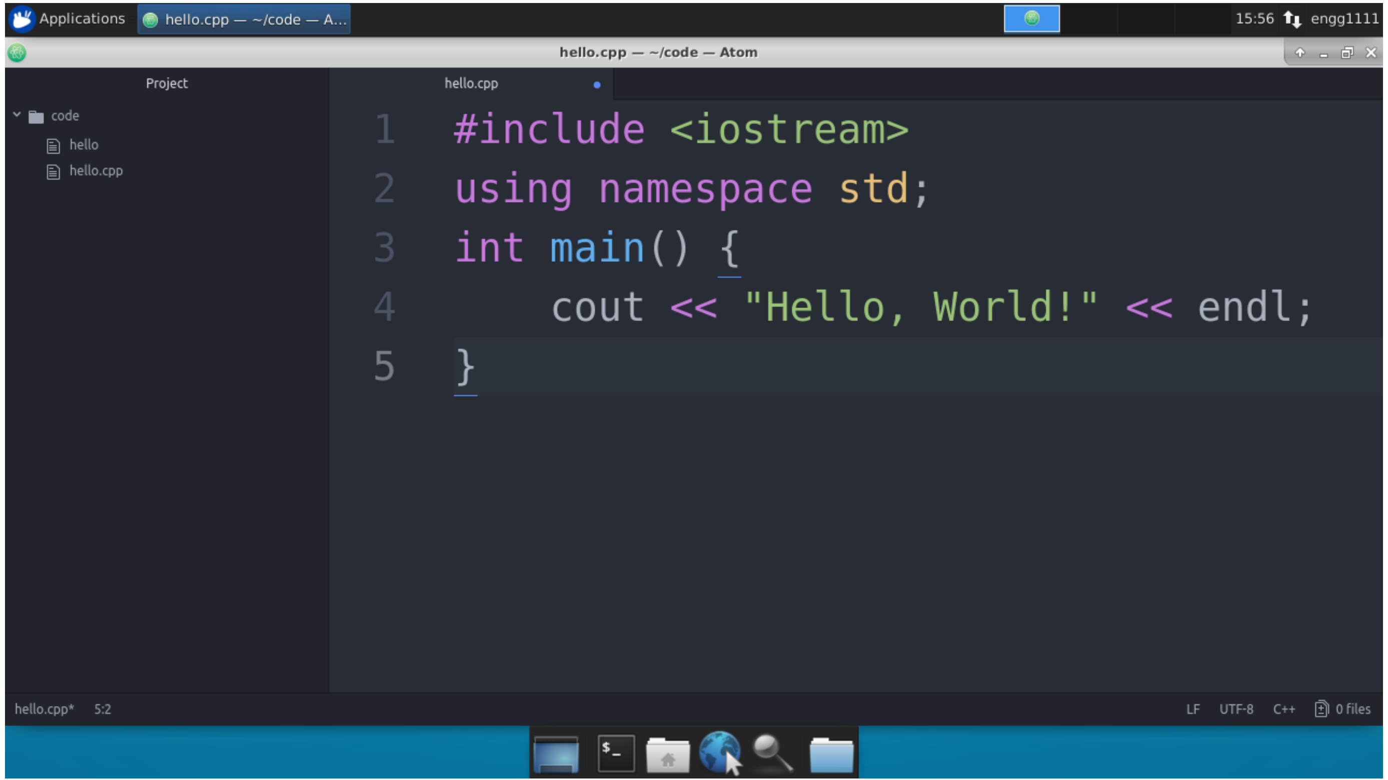
- For now we will consider lines 1, 2 and 3 to be rather complicated way of saying “The program starts here.”



```
1  #include <iostream>
2  using namespace std;
3  int main() {
4      cout << "Hello, World!" << endl;
5  }
```

First Program

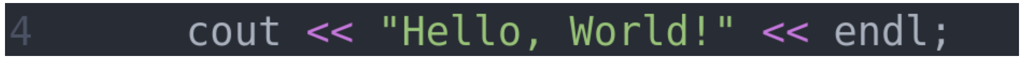
- Line 5 simply means “The program ends here.”



```
1  #include <iostream>
2  using namespace std;
3  int main() {
4      cout << "Hello, World!" << endl;
5  }
```

First Program

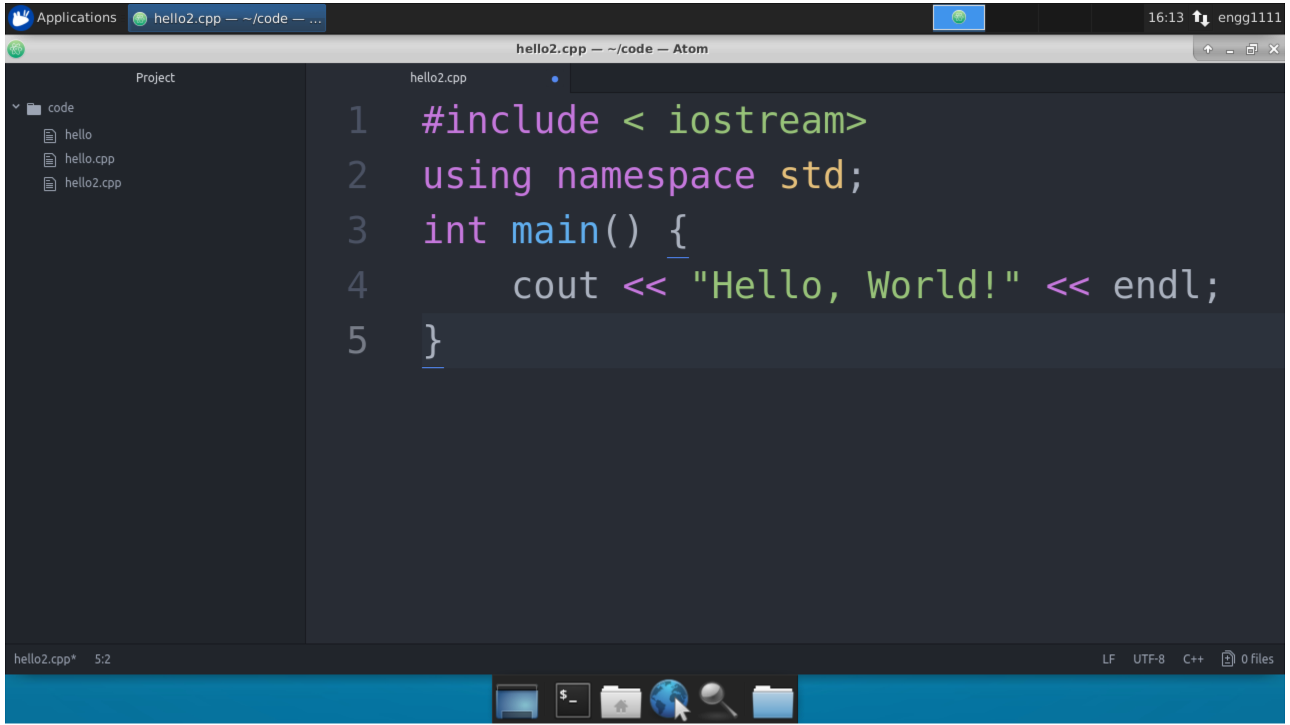
- Line 4 is a single statement
  - Usually statements fit in exactly one line
  - Each statement ends with a semicolon
  - Multiple statements are executed sequentially
- cout << is used to output on the screen
- A sequence of characters enclosed by a pair of double quotes forms a string literal, e.g., “Hello, World!”
- << endl is used to produce a newline
- The complete statement will print Hello, World! to the screen followed by a newline



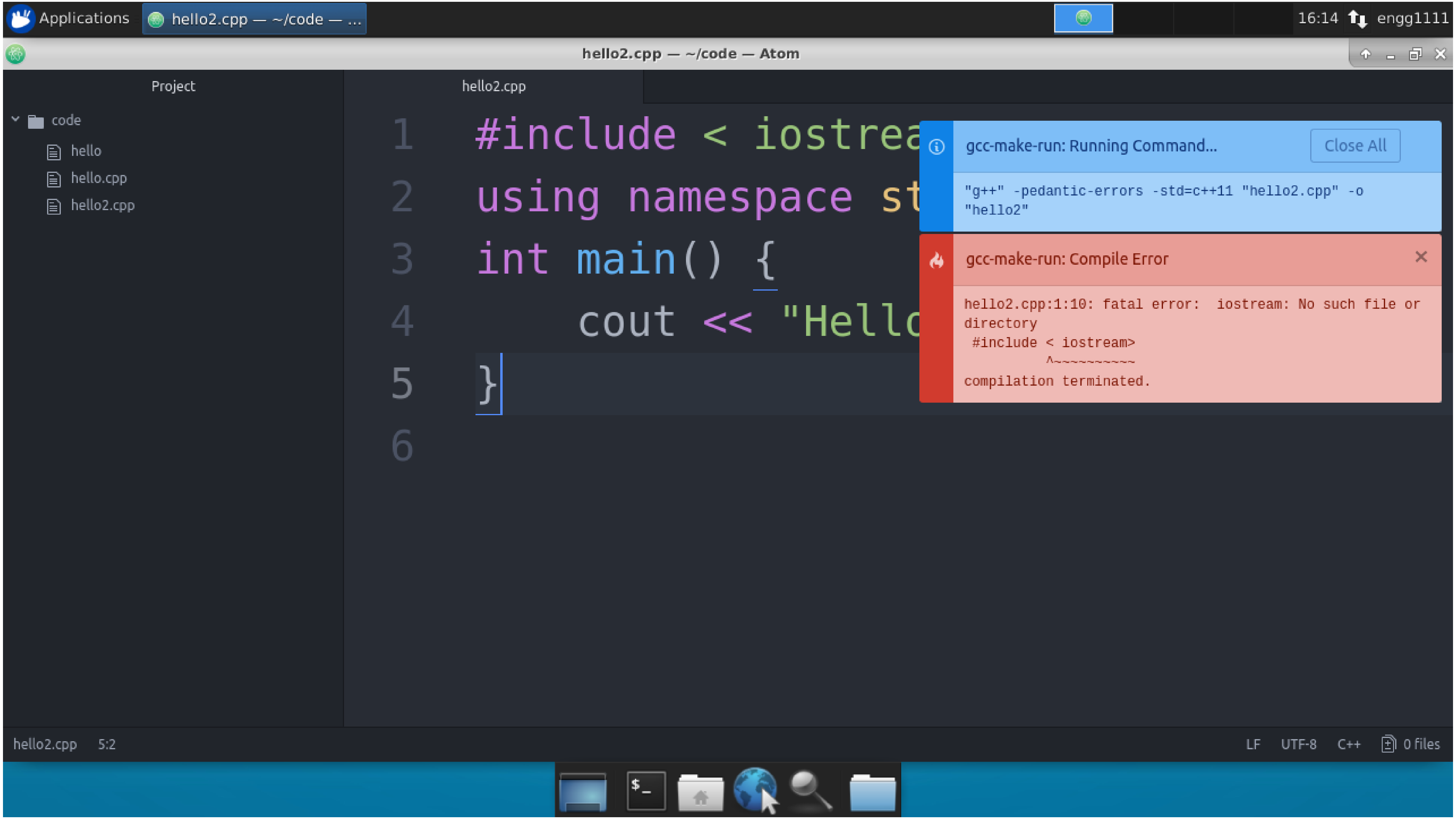
```
4       cout << "Hello, World!" << endl;
```

Syntax Error

- Sometimes, a program will not build
- This is often due to syntax error(s)
- Example:



```cpp
#include < iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}
```



```
#include < iostrea
using namespace st
int main() {
    cout << "Hello
}
```

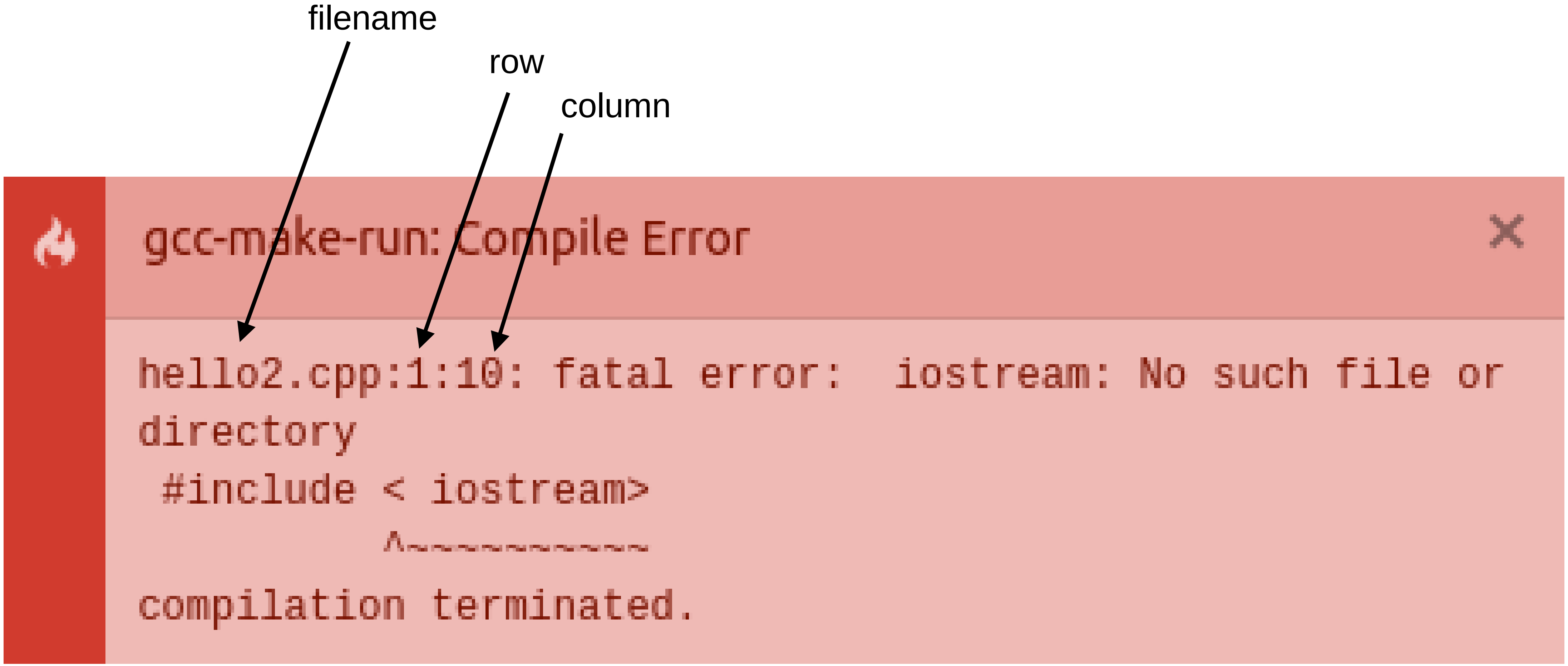
gcc-make-run: Running Command...

```
"g++" -pedantic-errors -std=c++11 "hello2.cpp" -o
"hello2"
```

gcc-make-run: Compile Error

```
hello2.cpp:1:10: fatal error:  iostream: No such file or
directory
 #include < iostream>
          ^~~~~~~~~~~
compilation terminated.
```

Understanding Compiler Error



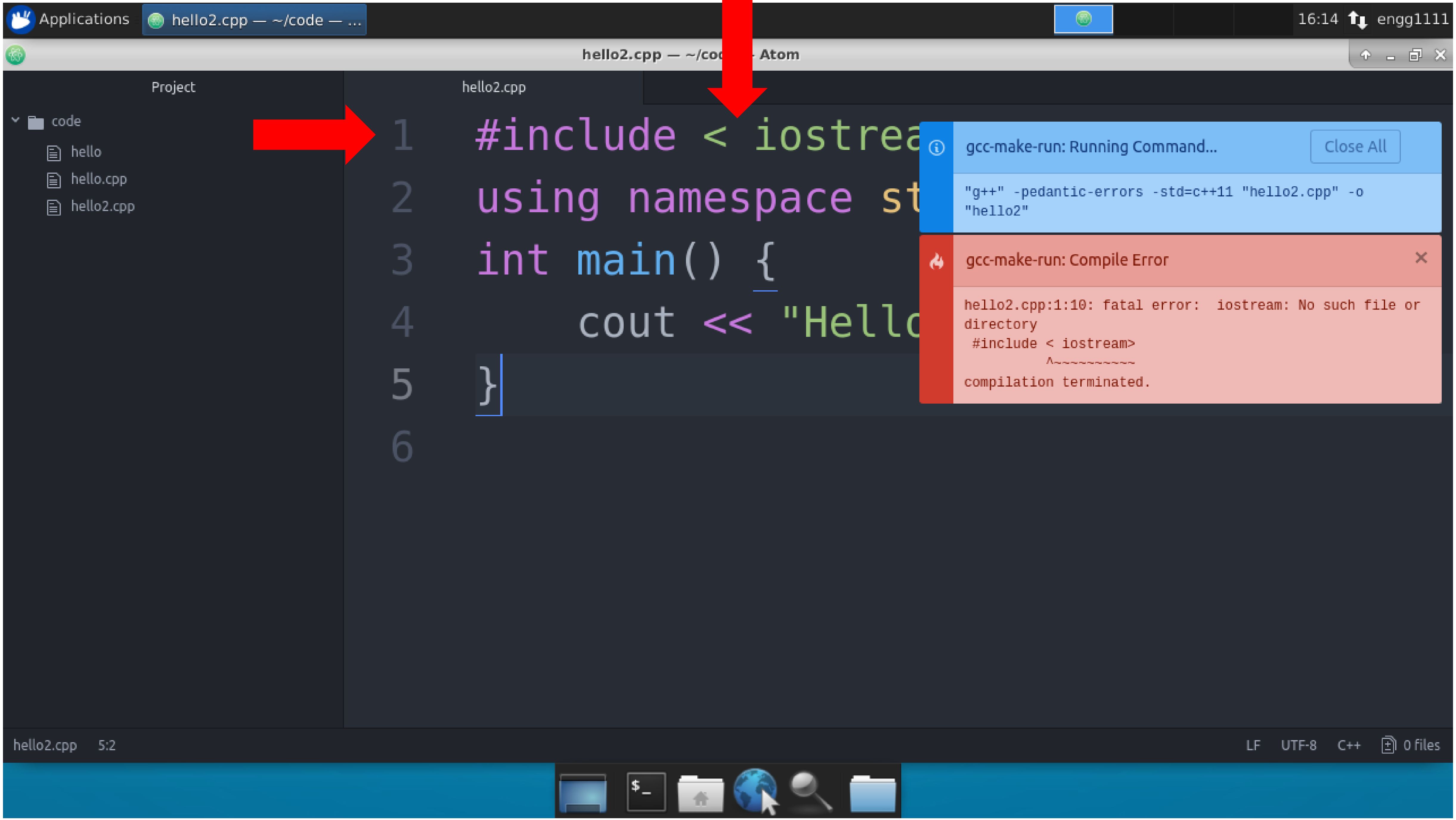
filename

row

column

gcc-make-run: Compile Error

```
hello2.cpp:1:10: fatal error:  iostream: No such file or
directory
 #include < iostream>
          ^~~~~~~~~~~
compilation terminated.
```



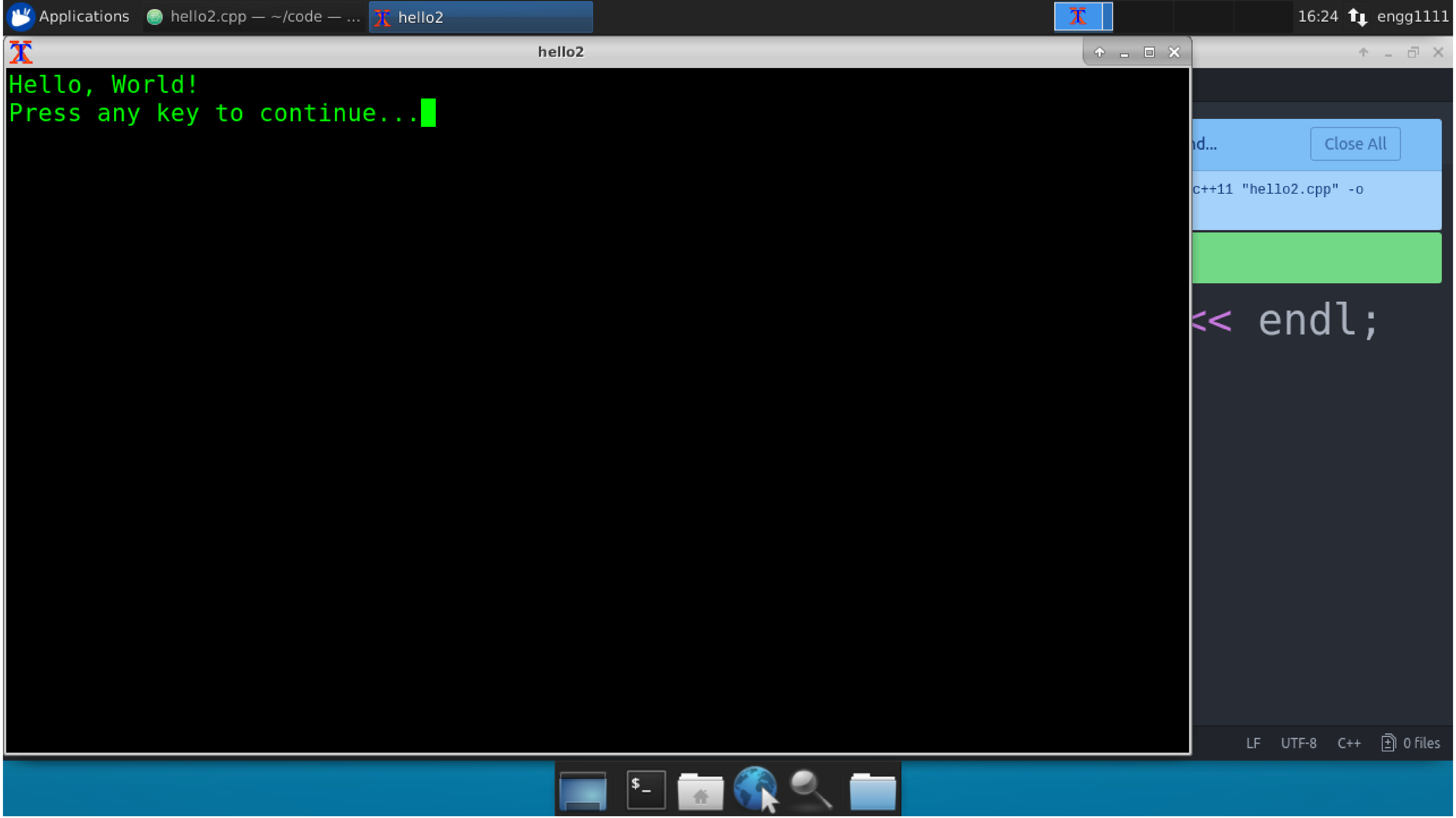
```
#include < iostrea
using namespace st
int main() {
    cout << "Hello
}
```

gcc-make-run: Running Command...

```
"g++" -pedantic-errors -std=c++11 "hello2.cpp" -o
"hello2"
```

gcc-make-run: Compile Error

```
hello2.cpp:1:10: fatal error:  iostream: No such file or
directory
 #include < iostream>
          ^~~~~~~~~~~
compilation terminated.
```



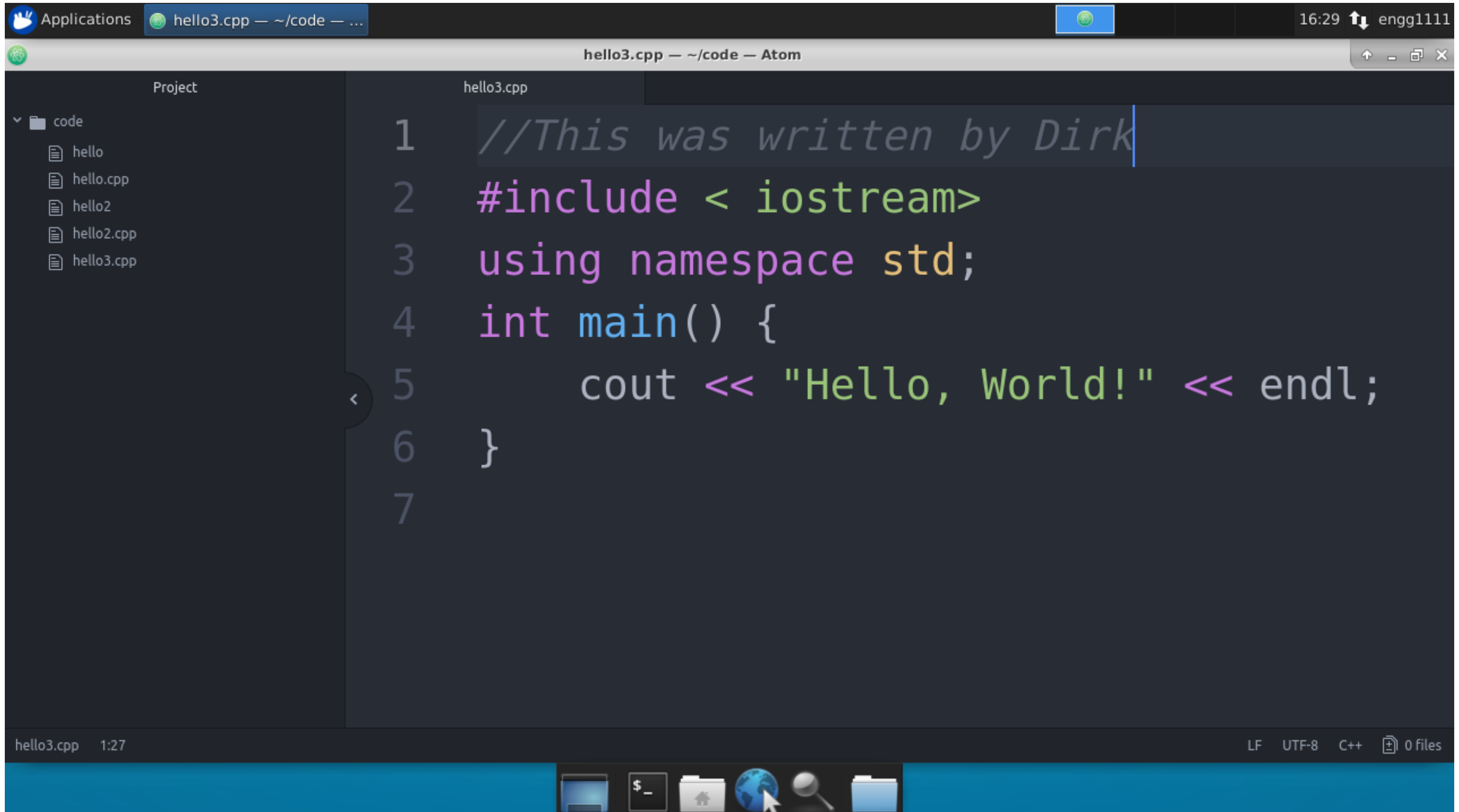
```
Hello, World!
Press any key to continue...
```

```
c++11 "hello2.cpp" -o
```

```
<< endl;
```

Comment

- A double slash indicates a comment line
  - Any text after // till the end of the line will be ignored by the compiler
- Example:

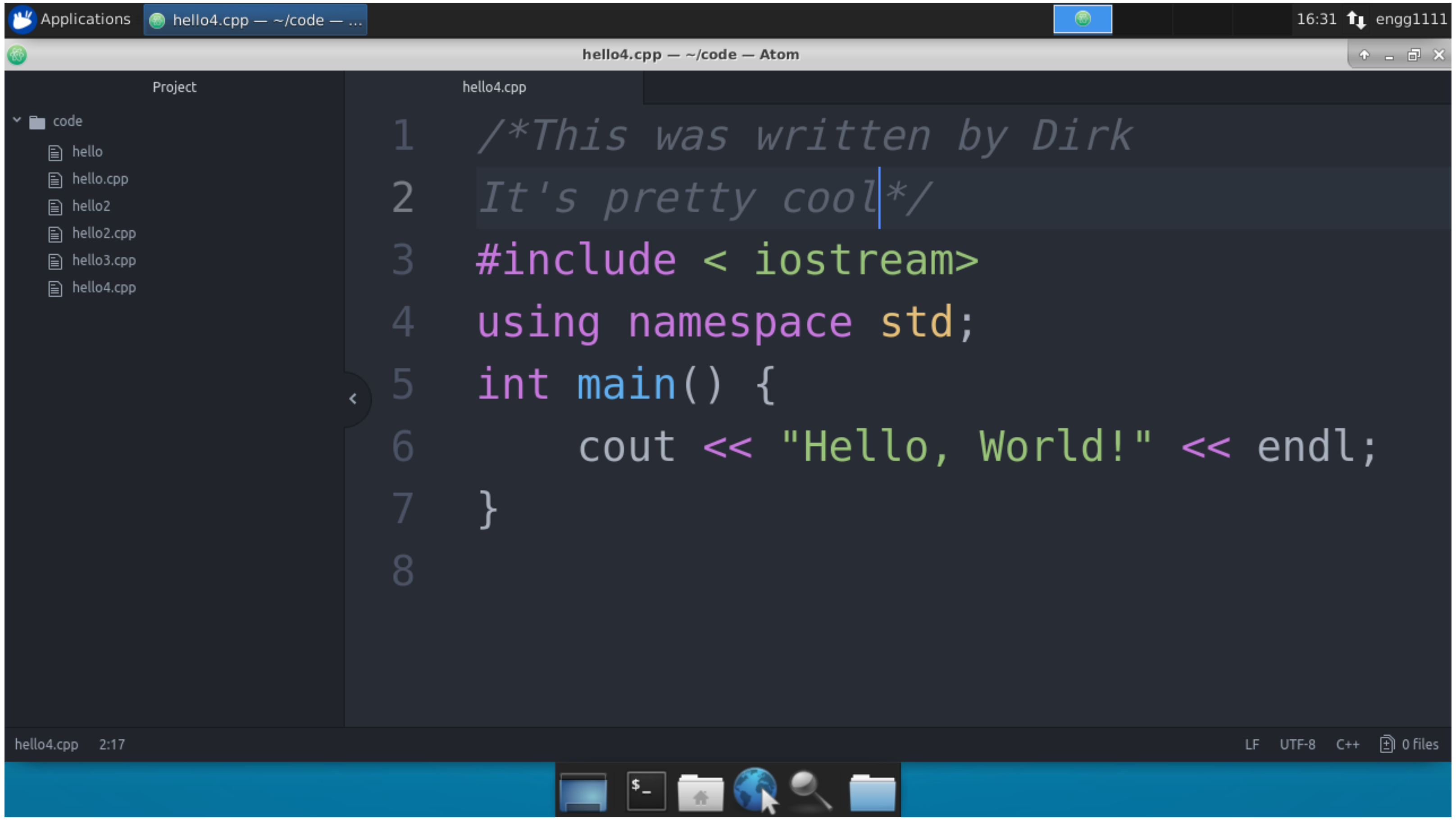


```
//This was written by Dirk
#include < iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}

```

Comment

- A multi-line comment is bounded by /* */
- Example:

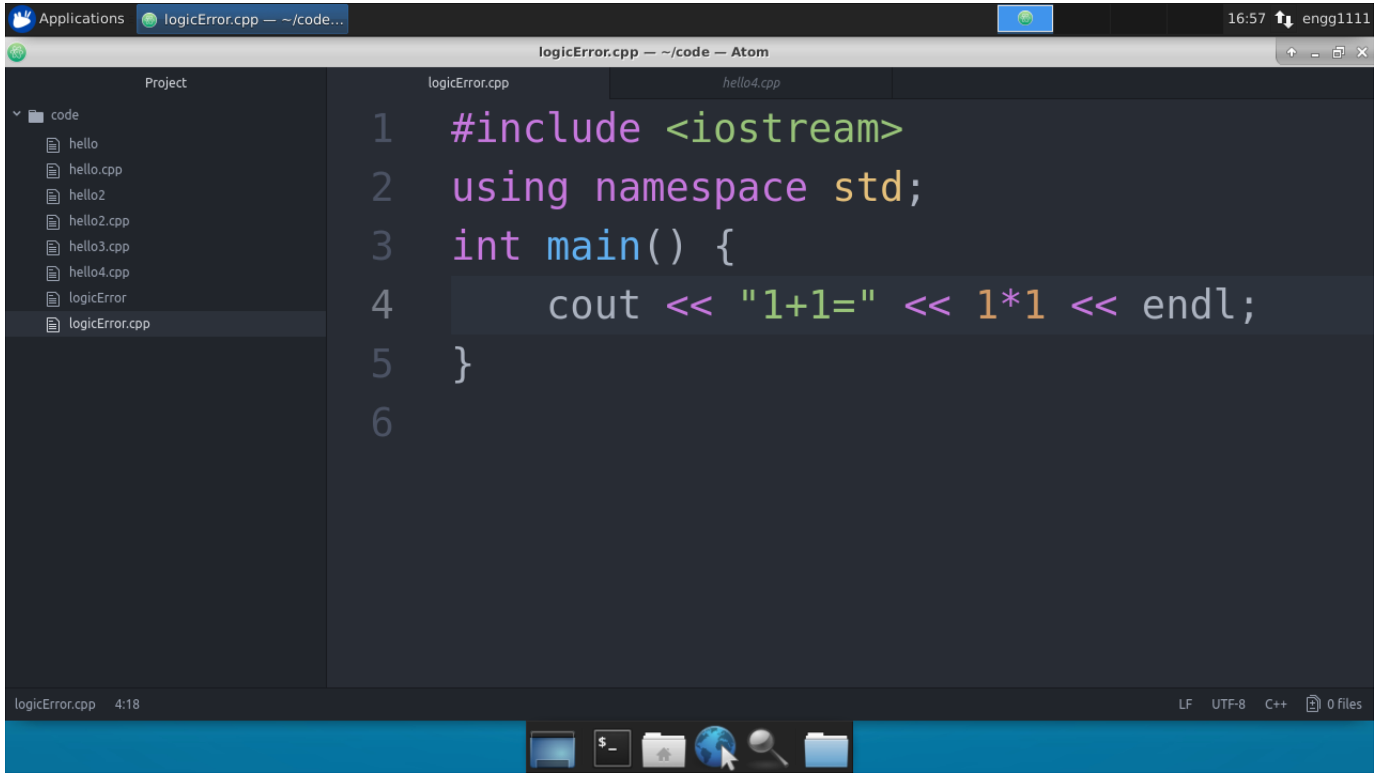


```
/*This was written by Dirk
It's pretty cool*/
#include < iostream>
using namespace std;
int main() {
    cout << "Hello, World!" << endl;
}

```

Logic Error

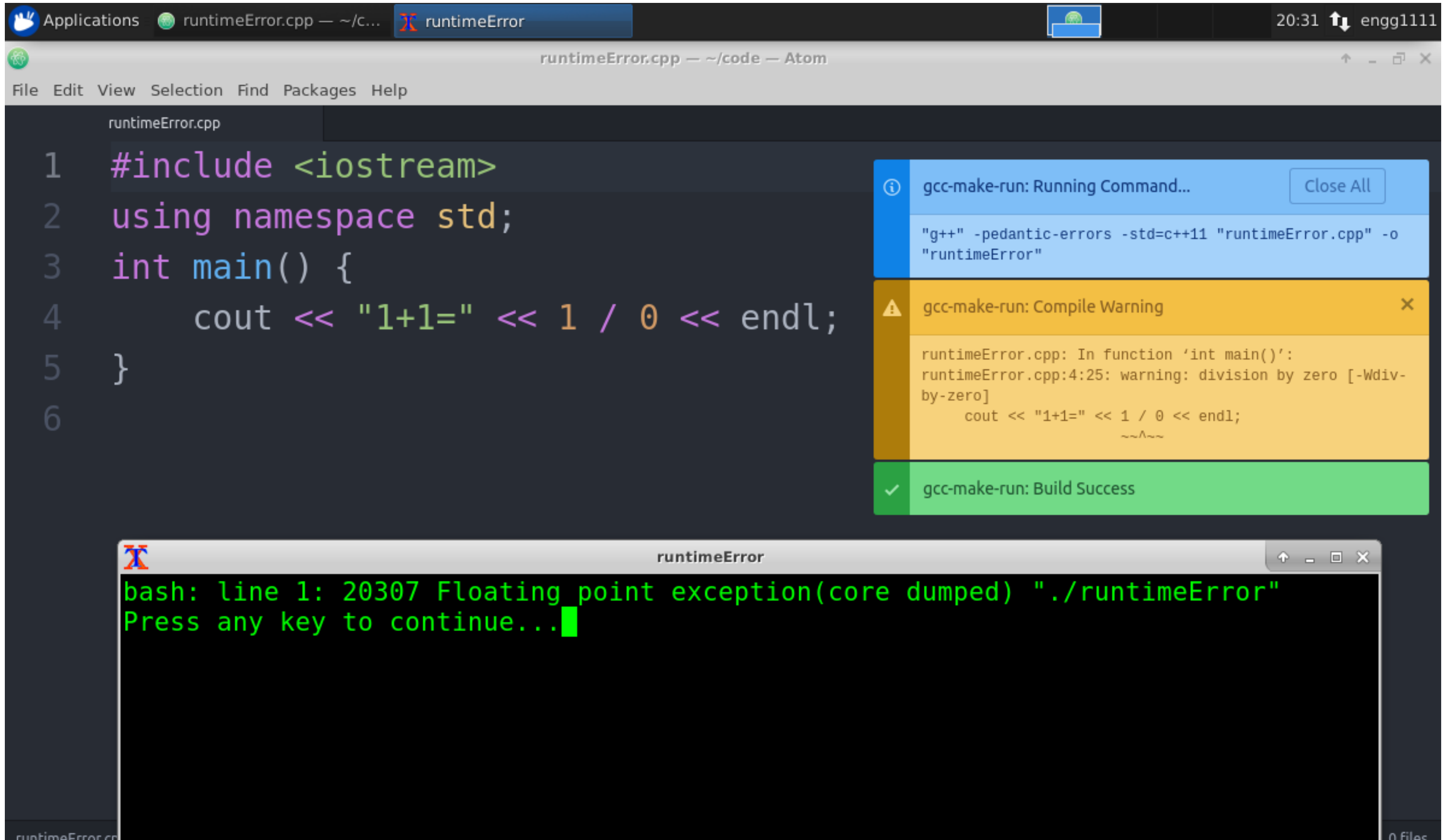
- Sometimes, a program will compile and run successfully but has logic error(s)
- Example:



```
#include <iostream>
using namespace std;
int main() {
	cout << "1+1=" << 1*1 << endl;
}
```

Runtime Error

- Sometimes, a program will compile successful (with or without warning) but does not run
- Example:


Applications
runtimeError.cpp — ~/c...
runtimeError
20:31
engg1111
runtimeError.cpp — ~/code — Atom
File Edit View Selection Find Packages Help
runtimeError.cpp
Close All
runtimeError

```cpp
#include <iostream>
using namespace std;
int main() {
    cout << "1+1=" << 1 / 0 << endl;
}

```

gcc-make-run: Running Command...

```
"g++" -pedantic-errors -std=c++11 "runtimeError.cpp" -o
"runtimeError"
```

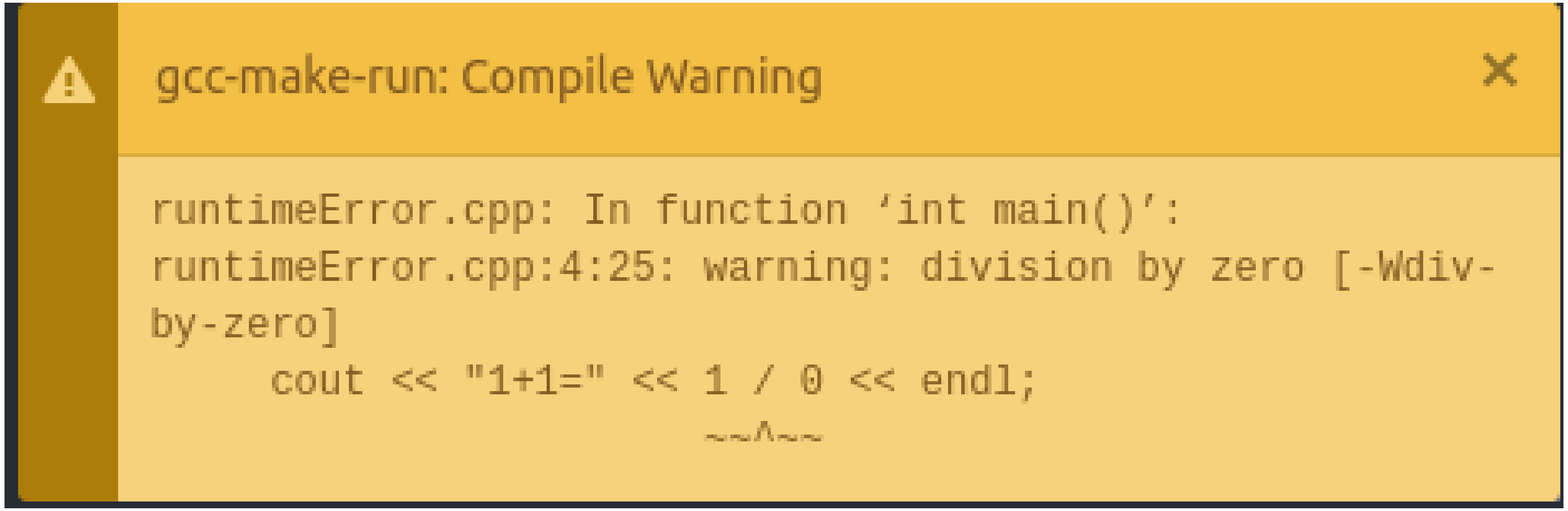
gcc-make-run: Compile Warning

```
runtimeError.cpp: In function ‘int main()’:
runtimeError.cpp:4:25: warning: division by zero [-Wdiv-
by-zero]
     cout << "1+1=" << 1 / 0 << endl;
                         ~~^~~
```

gcc-make-run: Build Success

```
bash: line 1: 20307 Floating point exception(core dumped) "./runtimeError"
Press any key to continue...
```

Compiler Warning



```
runtimeError.cpp: In function ‘int main()’:
runtimeError.cpp:4:25: warning: division by zero [-Wdiv-
by-zero]
     cout << "1+1=" << 1 / 0 << endl;
                       ~~^~~
```

Warning vs. Error

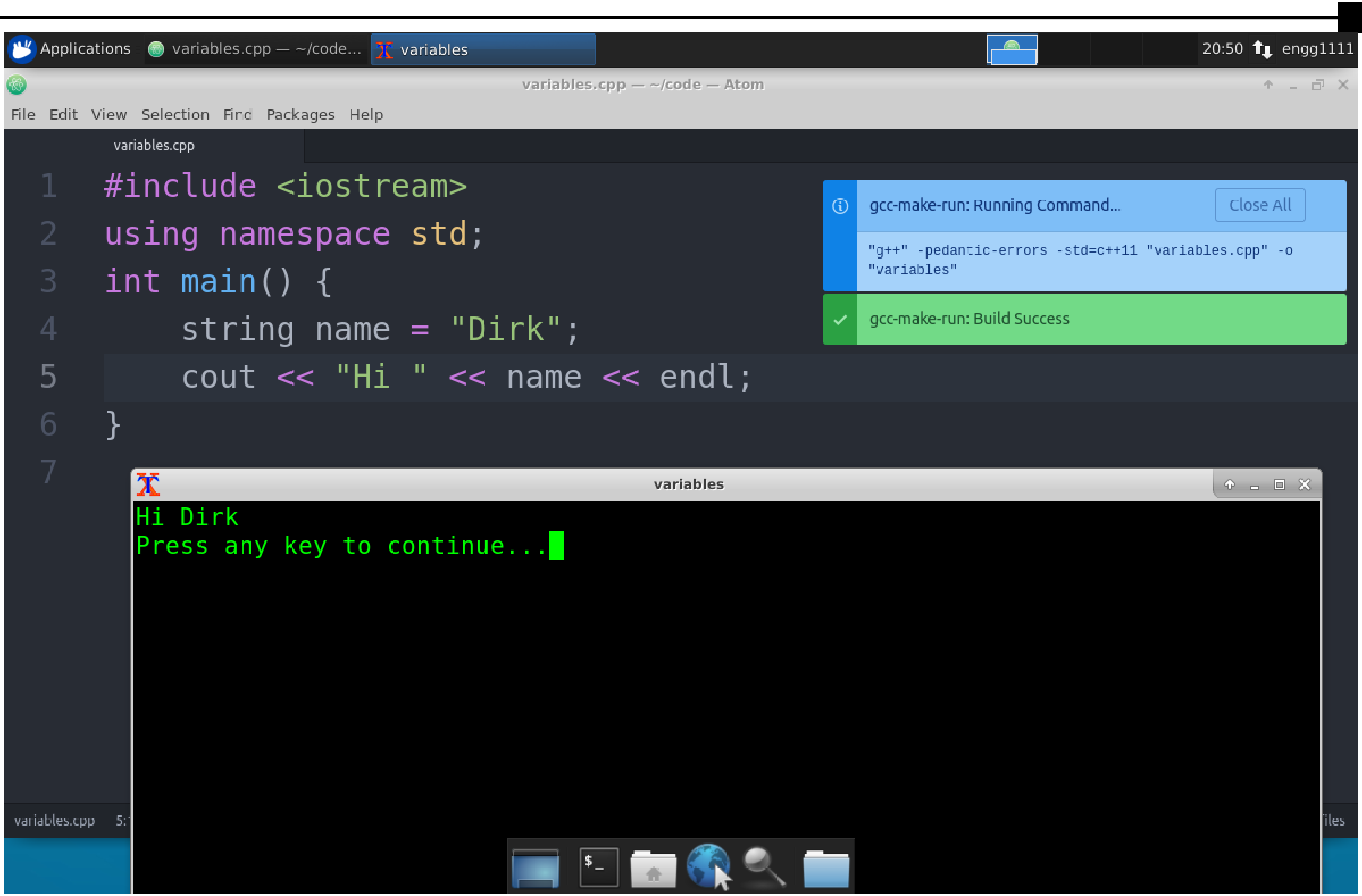
- A direct violation of the syntax rule will result in a compiler error
- A compiler warning usually indicates a likely mistake but is not a violation of the syntax rule
- At this point, you should treat every warning as if it was an error

Do not assume your untested program is correct

Testing & Debugging

- A mistake in a program is called a bug, and the process of eliminating bugs is called debugging
- Syntax errors can be discovered relatively easily based on the error messages reported by the compiler during compilation
- Runtime and logic errors can only be discovered during program execution
- Carefully designed test cases (inputs with expected outputs) are used to catch any possible runtime and logic errors
    - We will use various test cases to test your assignment submissions

Sneak Peek: Variables



```cpp
#include <iostream>
using namespace std;
int main() {
    string name = "Dirk";
    cout << "Hi " << name << endl;
}
```

gcc-make-run: Running Command...

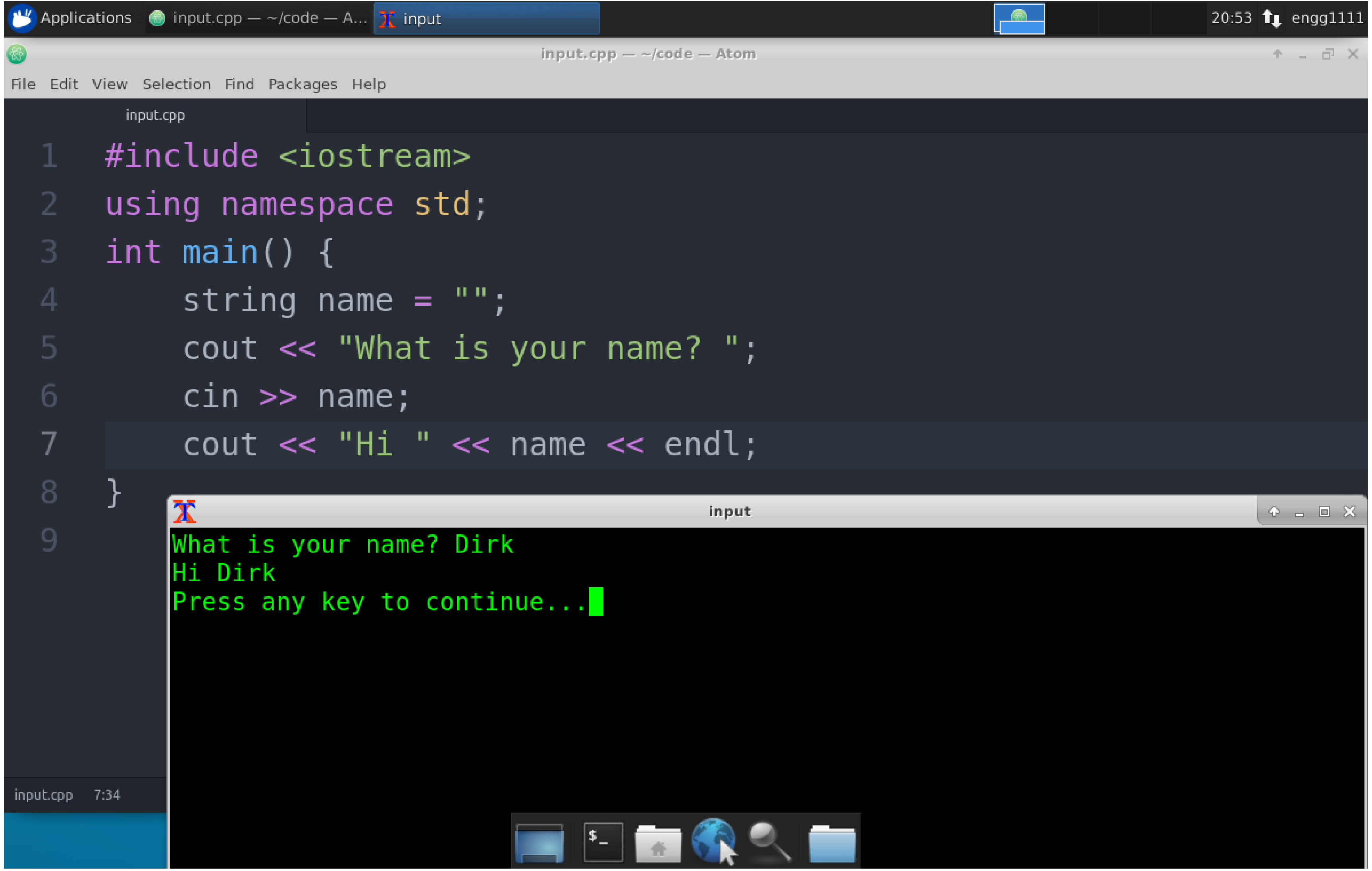
```
"g++" -pedantic-errors -std=c++11 "variables.cpp" -o
"variables"
```

gcc-make-run: Build Success

variables

```
Hi Dirk
Press any key to continue...
```

Sneak Peek: Input



```cpp
#include <iostream>
using namespace std;
int main() {
    string name = "";
    cout << "What is your name? ";
    cin >> name;
    cout << "Hi " << name << endl;
}
```

```
What is your name? Dirk
Hi Dirk
Press any key to continue...
```