CSE 232, Lab Exercise 6

Partner

Choose a partner in the lab to work with on this exercise. Two people should work at one computer. Occasionally switch who is typing.

More Command Line

The following topics are useful information for effectively using the terminal.

Command Completion

One very common mistake in typing in any programming language are small typos that break your program or instruction. One way to avoid them is to use an *auto-completion* feature so you don't have to type out a full name or variable. When you hit the TAB key, the terminal attempts to fill the rest of the command of filename you are typing. If there isn't a unique match (for instance, you are typing: `cp fi` and then hit TAB when there are files with the names `file_01` and `file_02` present), it will fill in as much as it can (in this case `cp file_0`) with the cursor waiting after the 0 for you to type the last part. If you hit TAB again, the terminal will present the potential options that it can autofill with. You can specify more characters until a unique match is found.

Example:

```
cp f<TAB>
cp file_0<TAB>
cp file_02 f<TAB>
cp file_02 file_0<TAB>
cp file_02 file_01
```

I recommend making use of tab completion as the terminal doesn't make typos, and humans do.

History

The terminal remembers each command you type into it in its `history`. When you execute the `history` command, the terminal will report each command run, with a number.

Example:

```
  495  ls
```

```
496  cd ../../
497  ls
498  ls
499  cd ..
500  cp file_02 file_01
501  history
```

You can run a command again by noting its number. For instance, `!500` will run the `cp` command again.

A neat trick is the `!!` command which runs the last command again.

Configuration (.tcshrc and .bashrc)

Sometimes there are CLI commands you always want to run before you get to work. Perhaps, you want your terminal to configure some settings, or tell you how much disk space you have left. To make this easier, there are two config files that your shell looks for (in your HOME directory).

It turns out there are various versions of the CLI interpreter script. One is called tcsh (t-shell for short) the other bash. By default you get a tcsh on your DECS account but you can start either for testing purposes: tcsh or bash.

All interpreters run a startup script when they run for the first time. For tcsh is the .tcshrc (note the dot) and for bash it is .bashrc

Depending on your shell, those run everytime you invoke tcsh/bash. You can use those init scripts to set up your environment

$PATH

Your PATH is a list of directories that the sheel looks in when trying to run a command. The shell looks through every folder in the list (in order) trying to find a program named the same as your command.

You can see your path by 'echo'ing it to the screen with:

```
echo $PATH
```

In the BASH and tcsh shells it outputs something like:

```
/soft/linux/bin:/bin:/usr/bin:/usr/sbin:/usr/X11R6/bin:/usr
/cpssbin:/soft/linux/bin:/usr/X11R6/bin:/usr/local/bin:
```

This means if I try to run `say_hello Josh`, it looks in `/soft/linux/bin` for an executable called `say_hello`, and if it can't find it, if then looks in `/bin`, then in `/usr/sbin`, and so on before giving up.

Sometimes it is useful to add other directories to this path (often for programs you want to call from the command line). You do so by adding the directory to the PATH. Example, I want to add the folder `~/bill_programs/` to my PATH because it has useful programs to run at the command line.

```
setenv PATH $PATH\:~/bill_programs # for tcsh in labs

export PATH=$PATH:~/bill_programs # for bash
```

However, this change to the PATH will only last as long as your terminal session lasts (when you log out it is gone.) You want to add that line to the appropriate config file (.tcshrc or .bashrc) config file if you want that in your path for future sessions.

 Add the Desktop to your PATH and echo your PATH for the TA.

The Problem

We are going to work on two things:

1. First time coding vectors
2. Understanding how we can break our program out into different files and create one executable from those files

We start with the second part. However, look for your programming tasks (there are two) to accomplish at the end of this file. Don't forget!!!

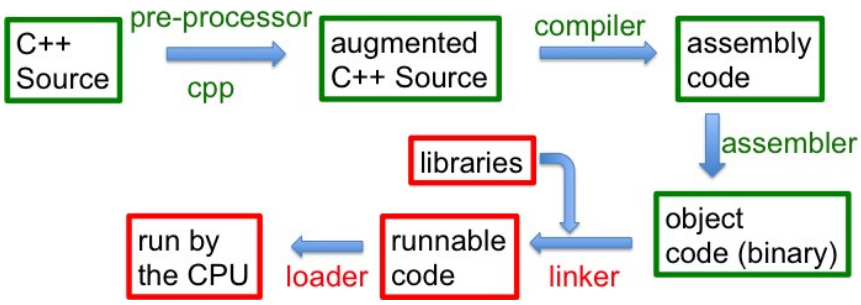
Separate Compilation of Files

Why?

Imagine that you write a really useful function (which hopefully you will today). You would like to package the function up individually so you could use it in other programs. The hard way to accomplish that would be to have to copy that function into every new program where you might want to use it. A better idea would be to place that function in its own separate file, and then compile any new program and your trusty function into one executable. That would be lovely!

How?

Remember this picture?



g++ (the underlying compiler) does all of these steps rather invisibly. To take advantage of it we need multiple files

Header Files

If we are going to define a function in one file and use the function in a main file, we are going to have to find a way to inform the main file about the **types** of the function. That is, we have to tell the main file:

- the function's **name**
- the **type** the function returns
- the **type** of the parameters the function uses
    - the **name** of each parameter is **unimportant**. It can be given, changed in the main function or just left out. All that matters is each parameter's **type**

If we tell the main function this information, that is enough for the C++ compiler to check that the function is being used correctly in main, and by correctly I mean that main is using all the types correctly in calling the function, even though it does not yet have available the actual function code.

Providing this information is the job of a *header file*. Header files that users write typically end in `.h`, and are used to indicate the type information of a some C++ elements (of functions, or classes, or some other C++ thing). This header file is used by the compiler to make sure that, whoever is using this function, they are at least using the types correctly. Thus without the function itself, we can know that we followed the compiler rules and used the correct types.

Example

Make a new directory/folder, call it lab6_1, as you have been doing all along (either with your File Browser and the Create Folder dropdown or with the command line command `mkdir`).

In 232 browser for lab6 are 3 files: `main.cpp, extra.cpp, extra.h` Copy these files to your desktop (easiest, right click each file, then Save As into your lab6_1 directory/folder).

In your editor you can now Open -> Other Documents each of the three files. Should look something like the below, with the three tabs (for the three files) each opened.

To build a final executable ***inside the lab6_1 directory***, you can do the following in the command line

```
g++ -std=c++11 -Wall  -g *.cpp
```

That means, it will compile all (* means all names, *.cpp means all files ending in .cpp) the `.cpp` files and build an executable.

Two warnings!

1) It's nice that by typing `*.cpp` compile all the files, but if you have too many files (from different projects, things you are working on temporarily etc.) it won't work. You can do it from the command if you'd prefer with a list of files. You can even name your executable using the –o modifier to be something than the dreaded `a.out`

```
g++ -std=c++11 -Wall -g file1.cpp file2.cpp file3.cpp
```

2) We ***never*** compile a `.h` file. That doesn't make any sense. All a `.h` file provides is a list of declarations to be used by other files. It is never compiled and would not show up in the list of files to compile (shown above)


Show your TA that you got the three files, made a project, compiled and ran it.

The Files

- `extra.cpp`. It defines the function `extra` which will be used in the `main` program.
- `extra.h`. This is the header file. Notice that is only really provides the ***declaration*** of the function.

    - In the declaration, the names of the parameters are not required, only their types.
    - Note that the function declaration ***ends in a ;*** (semicolon). Don't forget!!!
    - There are some weird # statements, we'll get to that.
- `main.cpp`. This is the `main` program. Notice that it has the following statement in it:

  ```
  #include "extra.h"
  ```

  This means that the `main` program is "including" the declaration of the function so that the compiler may check the type use of `extra` by `main`. Notice the quotes. When the `include` uses quotes, it is assumed that the `.h` file is in the same directory as the other files. `include` with <> means get includes from the "standard include place". Since it is our include file, we need to use quotes for it.

Weird # in headers

Anything beginning with # is part of the pre-processor. This controls aspects of how the compilation goes. In this case, we are trying to prevent a multiple definition error. What if we wanted to use `extra` in a more than one file? Your expectation is that every file that wants to use `extra` should include the `extra.h` file for compilation to work, and you would be correct. Sort of. Remember that you cannot declare a variable more than once, and the same goes for a function. You should only declare it once. In making one executable from many files, it is possible that, by including `extra.h` in multiple files, we would declare the `extra` function multiple times for this single executable. C++ would complain. However, it would be weird to have to do this in some kind of order where only one file included `extra.h` and assume the rest would have to assume it is available.

The way around this involves the pre-processor. Basically there are three statements we care about:

```
#ifndef some_variable_we_make_up
#define some_variable_we_make_up
```

… all the ***declarations*** in this .h file

```
#endif
```

This means. "If the pre-processor variable we indicate (`some_variable_we_make_up`) is not defined (`#ifndef`), go ahead and define it (`#define`) for this compilation and do everything else up to the `#endif`, meaning include the declarations in the compilation. If the variable is already defined, skip everything up to the `#endif`, meaning skip the declarations"

Thus whichever file pulls in the header file first, defines the pre-processor variable and declares the function for the entire compilation. If some other file also includes the header file later in the compilation, the pre-processor variable is already defined so the declarations are not included.

Programming Task 1

Make a new a new directory called `splitter`. We want to add three new files to the project: `splitter-main.cpp splitter-functions.cpp splitter-functions.h`

- Make a new file then save as `splitter-main.cpp`
- Now make the `splitter-functions.cpp` and the `splitter-functions.h` file.
- You should have three file tabs at the top now.

Function split

The split function should take in a `string` and return a `vector<string>` of the individual elements in the string that are separated by the separator character (default `' '`, space). Thus

`"hello mom and dad"` → `{"hello", "mom", "and", "dad"}`

- Open `splitter-functions.h` and store the function ***declaration*** of `split` there. The declaration should be:

```
vector<string> split (const string &s,
                      char separator=' ');
```

- As discussed, default parameter values ***go in the header file only***. The default does not occur in the definition if it occurred in the declaration.
- This header file should wrap all declarations using the `#ifndef, #define, #endif` as discussed above. Make up your own variable name.

- Open `splitter-functions.cpp` and write the ***definition*** of the function `split`. You ***must*** include the `splitter-functions.h` here using quotes as previously indicated.
- Make sure the definition matches the declaration in `splitter-functions.h`. The parameter names do not matter but the types do. Make sure the function signature match for the declaration and definition.
- You can ***compile*** `splitter-functions.cpp` (not build, at least not yet) to see if it is well-formed for C++. You can do so with the `-c` flag. This will not build an executable, but instead a `.o` file. The `.o` file is the result of compilation but before building an executable, an in-between stage.

```
g++ -std=c++11 -Wall -c functions-splitter.cpp
```

Function print_vector
This function prints all the elements of `vector<string> v` with each element of the vector on a separate line. The `ostream out` provided as a **reference parameter** (it must be a reference). Note `out` and `v` are passed by reference.

- `print_vector` : Store the declaration in `splitter-functions.h` then place function definition in `print-vector` in `splitter-functions.cpp`. The declaration should look a lot like the below:

```
void print_vector (ostream &out, const vector<string> &v);
```

- compile the function (not build, compile using the `-c` flag) to make sure it follows the rules.

Function main
Write the `main` function and place it in `splitter-main.cpp`.

- In `main.cpp` make sure you `#include "splitter-functions.h"` (note the quotes), making those functions available to main. Write a `main` function that:
- The operation of `main` is as follows:
  - prompts for a string to be split
  - prompts for the single character to split the string with
  - splits the string using the `split` function which returns a vector
  - prints the vector using the `print_vector` function
- compile (not build) main to see that it follows the rules

Build the executable
Build the project using

g++ -std=c++11 -Wall -g *.cpp.

and run the executable.

Little g++ tip
If you want to name your executable something other than a.out (so you can keep track of things), you can use the –o flag to set the name. Below we explicitly compile everything (not *.cpp, but we name the files explicitly) and create an executable named.

```
g++ -std=c++11 -Wall -g -c -o splitter splitter-main.cpp splitter-functions.cpp
```

Testing on Mimir
You can test your functions on Mimir, `Lab06-split`. The only thing we pay attention to is `splitter/splitter-functions.cpp` file. We ignore any other files in the submitted directory (header, main) and will test using our stuff. Mimir will only pay

attention function definitions file. This is the advantage of local work. You write your own main and header, then we test to see if the definitions do what they are supposed to.

Assignment Notes

1. Couple ways to do the split function
    1. `getline`
        i. `getline` takes a delimiter character as a third argument. In combination with an input string stream you can use `getline` to split up the string and `push_back` each element onto the vector.
        ii. example `getline(stream, line, delim)` gets the string from the stream (`istream`, `ifstream`, `istringstream`, etc.) up to the end of the line or the delim character.
    b. string methods `find` and `substr`. You can use the `find` method to find the delim character, extract the split element using `substr`, and `push_back` the element onto the vector.
    2. Default parameter value. The default parameter value needs to be set at **declaration time**, which means that the default value for a function parameter should be in the header file (the declaration). If it is in the declaration, it is not required to be in the definition, and by convention should not be.

Programming Task 2

Let's play a little more with vectors. Let's write a function that can add and subtract the elements of two vectors.

1. Create a new directory in your `lab6` directory called `vecops`
    a. three files again: `vecops-main.cpp, vecops-functions.cpp, vecops-functions.h`
1. The `vecops-functions.h` has the following function signatures:

```
a. vector<long> vector_ops(const vector<long>& v1,
                           const vector<long>& v2,
                           char op)
b. void print_vector (ostream &out, const
                      vector<long> &v);
```

Reuse `print_vector` from the previous problem, but make it a vector of longs instead of a vector of strings

2. In `vecops-functions.cpp` write the function `vector_ops` to do the following:
    a. find the shorter of the two vectors
    b. for each element in both vectors, up to the length of the shorter vector
        i. if the op is `'+'`, add each element into a new vector (to be returned)
        ii. if the op is `'-'`, subtract the shorter vector element from the longer vector element into a new vector.

iii. after the operation, copy the remaining elements from the longer vector in the result vector
iv. if op is something else, return an empty `vector<long>`

3. Write a `vecops-main.cpp` and test your function by sending in two vectors and printing the result

Testing on Mimir

Again, can test your functions on Mimir, `Lab06-vecops`. You can only submit the `vecops-functions.cpp` file. We provide the header and the main, and will test using our stuff. You just supply the function definitions. This is the advantage of local work. You write your own main and test, then just submit the `vecops-functions.cpp` to test.