601.220 Intermediate Programming

Separate compilation

Outline

- Header files and separate compilation

Separate source files

- Big software projects are typically split among multiple files
- Helper functions might be separated from main, some code grouped together as a library of functions which accomplish related tasks
- Different developers may create/edit/test different pieces

Header files

- But how do we allow different files used within one program to communicate?
  - Must specify definitions and declarations that different files need to use
  - Typically, we use header files (`.h` files) to group together declarations, then `#include` them into appropriate files
  - A separate `.c` source file will contain definitions for those functions declared in a `.h` header file. Typically, functions defined in `file.c` are declared in a function named `file.h`

Header files in C

- When the preprocessor sees a `#include` directive, it inserts the contents of the specified file at that location in the code
  - Generally, the included file contains *declarations* of functions that are used in the code
  - Note that there are two ways to include files
    - `#include <stdio.h>`
    - `#include "myHeader.h"`

Using header files

```c
// functions.c:
#include "functions.h" //including my own header file; use " "

float func1 (int x, float y) {
   return x+y;
}

int func2 (int a) {
   return 2*a;
}


// functions.h:
float func1 (int x, float y);
int func2 (int a);
```

Using header files

```c
// mainFile.c:
#include <stdio.h>
#include "functions.h"

int main() {
   printf("%.2f %d", func1(2,3.0), func2(7));
   return 0;
}
```

```
$ gcc -std=c99 -pedantic -Wall -Wextra mainFile.c functions.c
$ ./a.out
5.00 14
```

Using header files

```c
// mainFile.c:
#include <stdio.h>
//#include "functions.h" //leaving this out!

int main() {
   printf("%.2f %d", func1(2,3.0), func2(7));
   return 0;
}
```

```
$ gcc -std=c99 -pedantic -Wall -Wextra mainFile.c functions.c
mainFile.c:5:22: error: implicit declaration of function 'func1' is invalid in
   printf("%.2f %d", func1(2,3.0), func2(7));
                     ^
mainFile.c:5:36: error: implicit declaration of function 'func2' is invalid in
   printf("%.2f %d", func1(2,3.0), func2(7));
                                   ^
mainFile.c:5:36: note: did you mean 'func1'?
mainFile.c:5:22: note: 'func1' declared here
   printf("%.2f %d", func1(2,3.0), func2(7));
                     ^             ~~~~~
                                   func1
mainFile.c:5:22: warning: format specifies type 'double' but the argument has t
   printf("%.2f %d", func1(2,3.0), func2(7));
```

Checkpoint Question!

Which statement is wrong?

A. We use double quotation marks with `#include` to include our own header files, e.g. `#include "myHeader.h"`

B. Generally, a header file only contains the declarations not the actual implementations

C. The compiler needs full function definition in order to produce the object file(s)

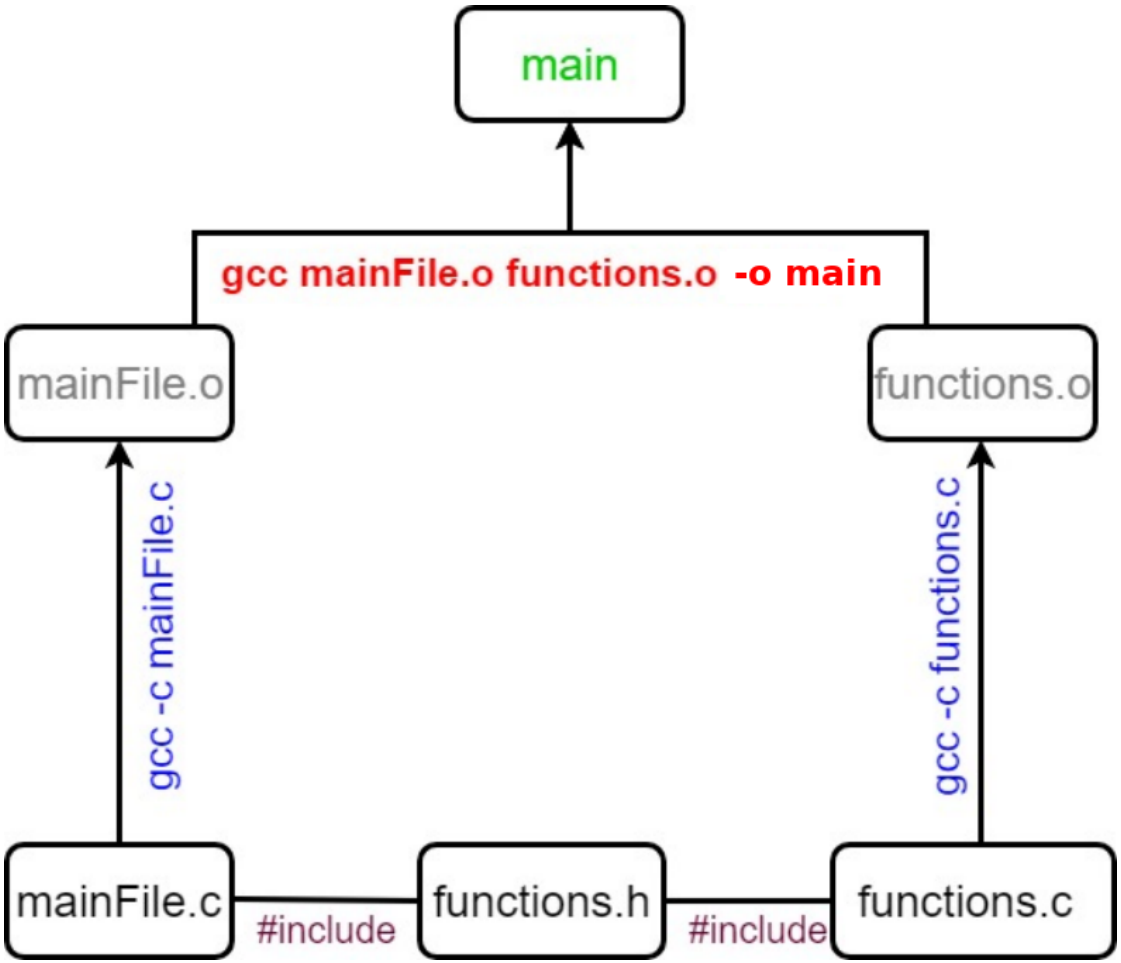
D. When declaring a function, it is optional to write the names of the parameters

E. None of the above

Compiling and Linking

- Until now, we've used one `gcc` command to perform compilation and linking steps for us
  - *compiling* translates source files (`.c` files) into intermediate object files (`.o` files)
  - *linking* combines `.o` files into one executable file called `a.out` (Recall that we can optionally specify the executable name with `-o flag`)

Compiling and Linking



Using header files

```c
// mainFile.c:
#include <stdio.h>
#include "functions.h"  //put header file back in

int main() {
   printf("Calling functions..."); //added this line
   printf("%.2f %d", func1(2,3.0), func2(7));
   return 0;
}
```

```
$ gcc -std=c99 -pedantic -Wall -Wextra mainFile.c functions.c
$ ./a.out
Calling functions...5.00 14
```

- The gcc command above recompiled `functions.c`, even though nothing changed in it

Compiling and Linking

- But a change to one source file doesn't always necessitate re-compiling all source files! Just re-compile what changed (and anything that depends on it), and then re-link
  - To separate compiling from linking, we can use the `-c` flag with `gcc` to indicate that we want to compile a source file to create an object file, and then separately run `gcc` on the resulting object files once all have compiled.
  - `gcc -c` command generates an object file with `.o` extension

Compiling and Linking Separately

- Compile source functions.c to create object file functions.o:
  - `gcc -std=c99 -pedantic -Wall -Wextra -c functions.c`
- Compile source mainFile.c to create object file mainFile.o:
  - `gcc -std=c99 -pedantic -Wall -Wextra -c mainFile.c`
- Link two object files to create executable named main:
  - `gcc -o main mainFile.o functions.o`
- Run the resulting executable file:
  - `./main`

Using header files

```c
// mainFile.c:
#include <stdio.h>
#include "functions.h"  //put header file back in

int main() {
   printf("Calling functions..."); //added this line
   printf("%.2f %d", func1(2,3.0), func2(7));
   return 0;
}
```

```
$ gcc -std=c99 -pedantic -Wall -Wextra -c functions.c
$ gcc -std=c99 -pedantic -Wall -Wextra -c mainFile.c
$ gcc -o main mainFile.o functions.o
$ ./main
Calling functions...5.00 14
```

Using header files

```c
// mainFile.c:
#include <stdio.h>
#include "functions.h"  //put header file back in

int main() {
   //removed the line that was here, so now re-compile this
   printf("%.2f %d", func1(2,3.0), func2(7));
   return 0;
}
```

```
$ gcc -std=c99 -pedantic -Wall -Wextra -c mainFile.c
$ gcc -o main mainFile.o functions.o
$ ./main
5.00 14
```

- No need to recompile the functions.c code.