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`

file names should match: one has .h extension, the other has .c extension. The .h file contains the functions declarations, and the .c file contains the definitions (i.e., actual implementation of the declared functions)

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>` ← use angle brackets when including C libraries
    - `#include "myHeader.h"` ← use quotation marks when including your own (i.e., user defined) header files

Using header files

NOTE: functions.h should be included in functions.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;
}
```

function definitions go inside the .c file

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

function declarations go inside the .h file

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;
}
```

include the .h file (not the .c file!)

func1 and func2 are declared in functions.h and defined (i.e., implemented) in functions.c. We can use them here because we included functions.h in mainFile.c

```
$ 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;
}
```

cannot be used anymore because the header file that contains the declarations (i.e., function.h) is not included

```
$ gcc -std=c99 -pedantic -Wall -Wextra mainFile.c functions.c
mainFile.c: In function ‘main’:
mainFile.c:5:22: warning: implicit declaration of function ‘func1’ [-Wimplicit-
    printf("%.2f %d", func1(2,3.0), func2(7));
                      ^~~~~
mainFile.c:5:36: warning: implicit declaration of function ‘func2’ [-Wimplicit-
    printf("%.2f %d", func1(2,3.0), func2(7));
                                    ^~~~~
mainFile.c:5:15: warning: format ‘%f’ expects argument of type ‘double’, but ar
    printf("%.2f %d", func1(2,3.0), func2(7));
            ~~~^      ~~~~~~~~~~~~
            %.2d
```

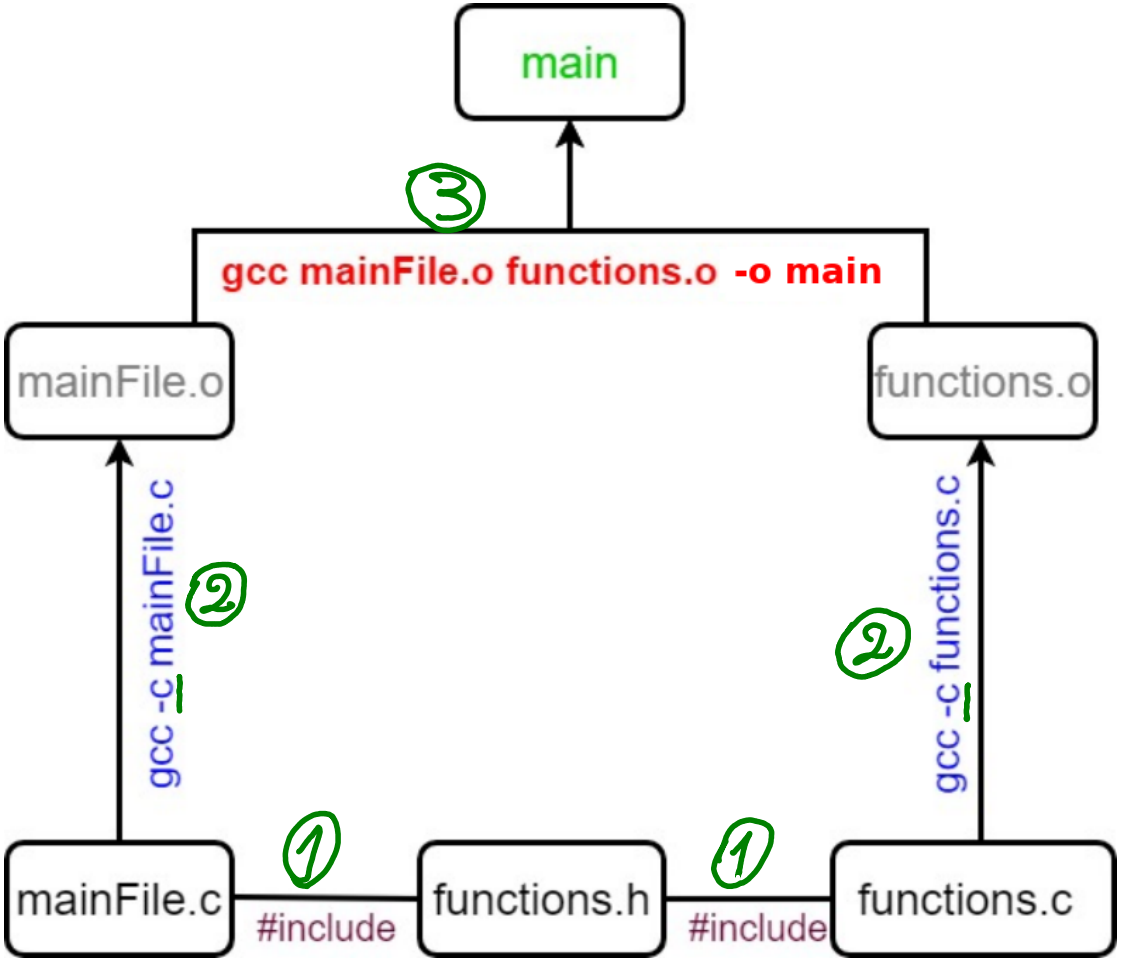
Compiling and Linking

- 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)

    each .c file gets translated to a separate .o file. For example, main.c gets translated by the compiler to main.o

  - *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



1. include function.h in both functions.c and mainFile.c

2. use -c to compile .c file(s) into .o file(s); that is use -c switch to separately produce functions.o and mainFile.o

3. Once you have the .o files, go ahead and combine them into one executable named "main" using the -o switch. This last step is called "linking", done by the linker

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
```

separate compilations for functions.c and mainFile.c

linking

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.