C isn't that hard:

void (**f[])(())() defines f as an array of unspecified size, of pointers to functions that return void.
Logistics

● Exercise 1:
  ○ Due Friday (tomorrow!) @ 11:00 AM (03/29) – no late exercises accepted

● Homework 0:
  ○ Due Monday @ 10:00 PM (04/01)
  ○ Meant to acquaint you to your repo and project logistics
  ○ Must be done individually
TA Intro
Icebreaker!

Please turn to the people next to you and share:

- Name, pronouns, year
- What are you excited for this summer? Any fun travel plans?
- What are you excited to learn in CSE 333?
Pointer Review
Pointers

- Data type that stores the address of (the lowest byte of) a datum
  - Can draw an arrow in memory diagrams from pointer to pointed to data, particularly if actual value (stored address) is unknown

- Common uses:
  - Reference to data allocated elsewhere (e.g., malloc, literals, files)
  - Iterators (e.g., data structure traversal)
  - Data abstraction (e.g., head of linked list, function pointers)
Pointer Syntax and Semantics

- Declared as `type* name;` or `type *name;`
  - Doesn’t matter, just be consistent
- “Address-of” operator `&` gets a variable’s address
- “Dereference” operator `*` refers to the pointed-to datum

Example code:
```c
int* ar = (int*) malloc(3*sizeof(int)); // reference
int* p = &ar[1]; // iterator
*p = 3;
```

Example diagram:
```
Stack       Heap
ar 0x1b126b0
p 0x1b126b4
    ? 3 ?
```
Output Parameters
Output Parameters

- Recall: the `return` statement in a function passes a single value back through the `%rax` register.

- An **output parameter** is a C idiom that emulates “returning values” through parameters:
  - An output parameter is a pointer (i.e., the address of a location in memory).
  - The function with this parameter must *dereference it* to change the value stored at that location.
  - The new value is “returned” by persisting after the function returns.

- Output parameters are the only way in C to achieve *returning multiple values*.
Exercise 1
Exercise 1

- Which parameters are output parameters?
  quotient and remainder

- What should go in the division blanks?
  &quot and &rem

- What should go in the printf blanks?
  quot and rem

```c
void division(int numerator, int denominator, int* quotient, int* remainder) {
    *quotient = numerator / denominator;
    *remainder = numerator % denominator;
}

int main(int argc, char* argv[]) {
    int quot, rem;
    division(22, 5, _____, _____);
    printf("%d rem %d\n", _____, _____);
    return EXIT_SUCCESS;
}
```
Exercise 1

- Draw out a memory diagram of the beginning of this call to `division`.

```
void division(int numerator, int denominator, int* quotient, int* remainder) {
    *quotient = numerator / denominator;
    *remainder = numerator % denominator;
}

int main(int argc, char* argv[]) {
    int quot, rem;
    division(22, 5, _____, _____);
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```
Exercise 1

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void division(int numerator,  
              int denominator,  
              int* quotient,    
              int* remainder) {
    *quotient = numerator / denominator;  
    *remainder = numerator % denominator;  
}

int main(int argc, char* argv[]) {  
    int quot, rem;  
    division(22, 5, _____, _____);  
    printf("%d rem %d\n", _____, _____);  
    return EXIT_SUCCESS;
}
```
C-Strings
C-Strings

char str_name[size];

- A string in C is declared as an array of characters that is terminated by a null character '\0'.
- When allocating space for a string, remember to add an extra element for the null character.
Initialization Examples

- **Code:**

  ```c
  // list initialization
  char str1[6] = {'H','e','l','l','o','\0'};
  // string literal initialization
  char str2[6] = "Hello";
  ```

- **Memory:**

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>'H'</td>
<td>'e'</td>
<td>'l'</td>
<td>'l'</td>
<td>'o'</td>
<td>'\0'</td>
</tr>
</tbody>
</table>

- **Notes:**
  - Both initialize the array *in the declaration scope* (e.g., on the stack if a local var), though the latter can be thought of as copying the contents from the string literal into the array.
  - The size 6 is *optional*, as it can be inferred from the initialization.
Common String Literal Error

- **Code:**

```c
// pointer instead of an array
char* str3 = "Hello";
```

- **Memory:**

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
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<td>'e'</td>
<td>'l'</td>
<td>'l'</td>
<td>'o'</td>
<td>'\0'</td>
</tr>
</tbody>
</table>

- **Memory Address:**

```
str3 0x402037
```

- **Notes:**
  - By default, using a string literal will allocate and initialize the character array in *read-only* memory (Literals)
Common String Literal Error

- **Code:**
  ```c
  // pointer instead of an array
  char* str3 = "Hello";
  ```

- **Memory:**
  ```
  str3: 0x402037
  index 0 1 2 3 4 5
  value 'H' 'e' 'l' 'l' 'o' '\0'
  ```

- **Notes:**
  - By default, using a string literal will allocate and initialize the character array in `read-only` memory (Literals)
  - What would happen if we executed `str3[0] = 'J';`?
  - Segfault!
Exercise 2
The following code has a bug. What's the problem, and how would you fix it?

```c
void bar(char ch) {
    ch = '3';
}

int main(int argc, char* argv[]) {
    char fav_class[] = "CSE331"
    bar(fav_class[5]);
    printf("%s\n", fav_class);  // should print "CSE333"
    return EXIT_SUCCESS;
}
```
The following code has a bug. What's the problem, and how would you fix it?

```c
void bar_fixed(char* ch) {
    *ch = '3';
}

int main(int argc, char* argv[]) {
    char fav_class[] = "CSE331";
    bar(&fav_class[5]);
    printf("%s\n", fav_class);   // should print "CSE333"
    return EXIT_SUCCESS;
}
```

Modifying the argument `ch` in `bar` will not affect `fav_class` in `main()` because arguments in C are always passed by value.

In order to modify `fav_class` in `main()`, we need to pass a pointer to a character (char*) into `bar` and then dereference it:

```c
void bar_fixed(char* ch) {
    *ch = '3';
}
```
Function Pointers
Function Pointers

- Pointers can store addresses of functions
  - Functions are just instructions in read-only memory, their names are pointers to this memory.
- Used when performing operations for a function to use
  - Like a comparator for a sorter to use in Java
  - Reduces redundancy

```c
int one() { return 1; }
int two() { return 2; }
int three() { return 3; }

int get(int (*func_name)()) {
    return func_name();
}

int main(int argc, char* argv[]) {
    int res1 = get(one);
    int res2 = get(two);
    int res3 = get(three);
    printf("%d, %d, %d\n", res1, res2, res3);
    return EXIT_SUCCESS;
}
```
Setting Up git
gcc 11

- CSE Lab machines and the attu cluster use gcc 11.
- As such we’ll be using gcc 11 this quarter
- To verify that you’re using gcc 11 run:
  - gcc -v or
  - gcc --version
- If you use the CSE Linux home VM, you should use the newer version even if you have an older one installed.
Git Repo Usage

● Try to use the command line interface (not Gitlab’s web interface)

● Only push files used to build your code to the repo
  ○ No executables, object files, etc.
  ○ Don’t always use `git add .` to add all your local files

● Commit and push when an individual *chunk of work* is tested and done
  ○ Don’t push after every edit
  ○ Don’t only push once when everything is done
Using VS Code

- Can install an extension that will allow you to directly edit files on a virtual machine (atta!)
- Will also be helpful to install the C/C++ extension for syntax highlighting
- To set up, visit https://courses.cs.washington.edu/courses/cse333/24sp/resources/VSCode.pdf
git/Gitlab Reference

We have a page that details how to (1) set up Gitlab and (2) use git to manage your repo:
- https://courses.cs.washington.edu/courses/cse333/24sp/resources/git_tutorial.html

We asked you to attempt your Gitlab setup ahead of time:
- If you didn’t, please do so now on your CSE Linux environment setup
- If you did and ran into issues, we’ll walk around to help you now
Accessing Gitlab

- Sign-in using your **CSE NetID** @ https://gitlab.cs.washington.edu/
- There should be a repo created for you titled: `cse333-24sp-<netid>`
- Please let us know if you don’t have one!
SSH Key Generation

**Step 1a)** See if you have an existing SSH key
- Run `cat ~/.ssh/id_rsa.pub`
- If you see a long string starting with `ssh-rsa` or `ssh-dsa` go to Step 2

**Step 1b)** Generate a new SSH key
- If you don't have an existing SSH key, you'll need to create one
- Run `ssh-keygen -t rsa -C "<netid>@cs.washington.edu"` to generate a new key
- Hit enter to skip creating a password
  - git docs suggest creating a password, but it’s overkill for CSE333
Adding your SSH key to Gitlab

Step 2) Copy your SSH key
- Run `cat ~/.ssh/id_rsa.pub`
- Copy the complete key starting with `ssh-` and ending with your username and host
  (i.e. `<netid>@cs.washington.edu`)

Step 3) Add your SSH key to Gitlab
Adding your SSH key to Gitlab

Step 3) Add your SSH key to Gitlab

- Navigate to your ssh-keys page (click on your avatar in the upper-right, then “Preferences,” then “SSH Keys” in the left-side menu)
- Paste into the “Key” text box and give a “Title” to identify what machine the key is for
- Click the green “Add key” button below “Title”
Setting up git

- The git command looks for a file named `.gitconfig` in your home directory. Some commands like `commit` and `push` expect certain options to be set and will produce verbose messages if not.
- If you have not already configured git, enter the following commands (once) in a terminal window to set these values:

  ```bash
  git config --global user.name "<your name>"
  git config --global user.email <your netid>@cs.washington.edu
  git config --global push.default simple
  ```
First Commit

1. **git clone <repo url from project page>**
   a. Clones your repo

2. **touch README.md**
   a. Creates an empty file called README.md

3. **git status**
   a. Prints out the status of the repo: you should see 1 new file README.md

4. **git add README.md (or: git stage README.md)**
   a. Stages a new file/updated file for commit.

   `git status: README.md staged for commit`

5. **git commit -m "First Commit"**
   a. Commits all staged files with the provided comment/message.

   `git status: Your branch is ahead by 1 commit`

6. **git push**
   a. Publishes the changes to the central repo.

   *You should now see these changes in the web interface (may need to refresh).*

   *Might need `git push -u origin master` on first commit (only), but would be unusual for this to happen*