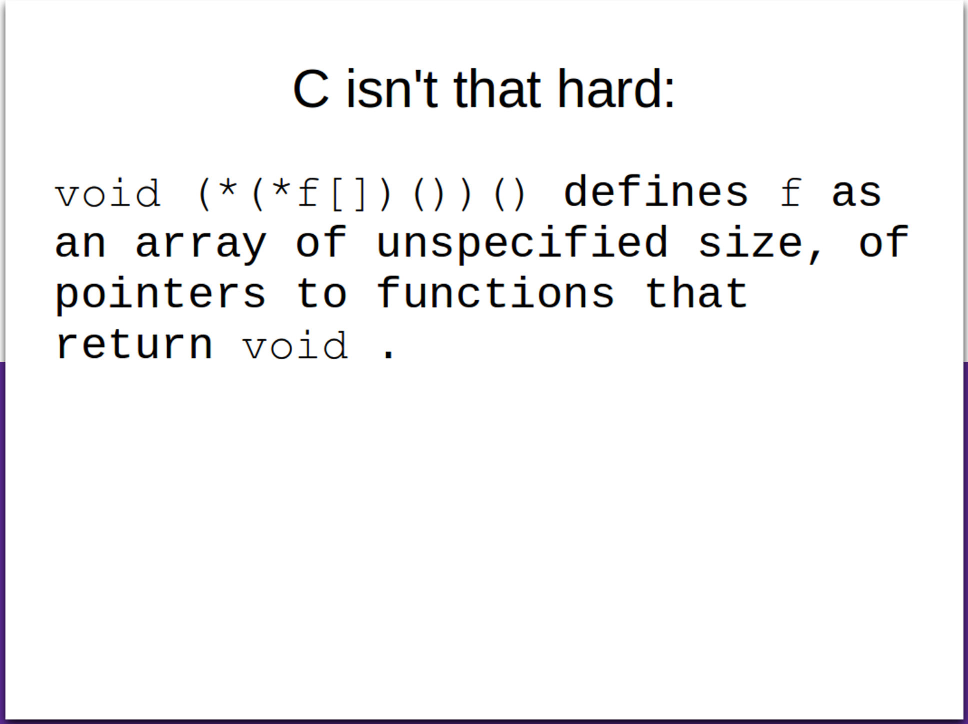
CSE 333
Section 1

C, Pointers, and Gitlab



C isn't that hard:

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

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Logistics

- Homework 0:
    - Due **Monday @ 11:59 PM (01/13)**
    - Meant to acquaint you to your repo and project logistics
    - Must be done individually

TA Intro!

Icebreaker!

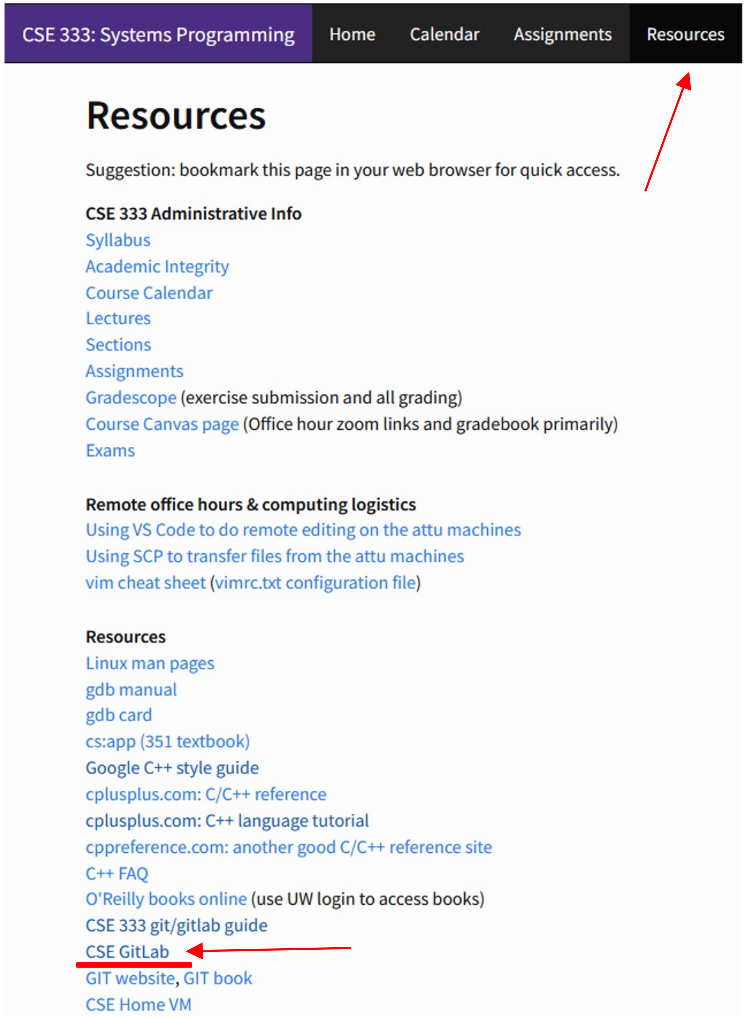
Please turn to the people next to you and share:

- Name, pronouns, year
- What are you excited to learn in CSE 333?
- The largest animal you could take bare-handed in a fight

Setting Up `git`

Accessing Gitlab

- Sign-in using your **CSE NetID @** https://gitlab.cs.washington.edu/
- There should be a repo created for you titled: `cse333-25wi-<netid>`
- Please let us know if you don’t have one!



Resources

Suggestion: bookmark this page in your web browser for quick access.

CSE 333 Administrative Info

Syllabus
Academic Integrity
Course Calendar
Lectures
Sections
Assignments
Gradescope (exercise submission and all grading)
Course Canvas page (Office hour zoom links and gradebook primarily)
Exams

Remote office hours & computing logistics

Using VS Code to do remote editing on the attu machines
Using SCP to transfer files from the attu machines
vim cheat sheet (vimrc.txt configuration file)

Resources

Linux man pages
gdb manual
gdb card
cs:app (351 textbook)
Google C++ style guide
cplusplus.com: C/C++ reference
cplusplus.com: C++ language tutorial
cppreference.com: another good C/C++ reference site
C++ FAQ
O'Reilly books online (use UW login to access books)
CSE 333 git/gitlab guide
CSE GitLab
GIT website, GIT book
CSE Home VM

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 (*i.e.*, use 25wi).

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
    - Gives you stable checkpoint backups in case something goes wrong with your working copy

Using VS Code

- Can install an extension that will allow you to directly edit files on a virtual machine (attu!)
- Will also be helpful to install the C/C++ extension for syntax highlighting
- To set up, visit https://courses.cs.washington.edu/courses/cse333/25wi/resources/VSCode.pdf

Now take some time to set up your environment. TAs will come around to help.

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

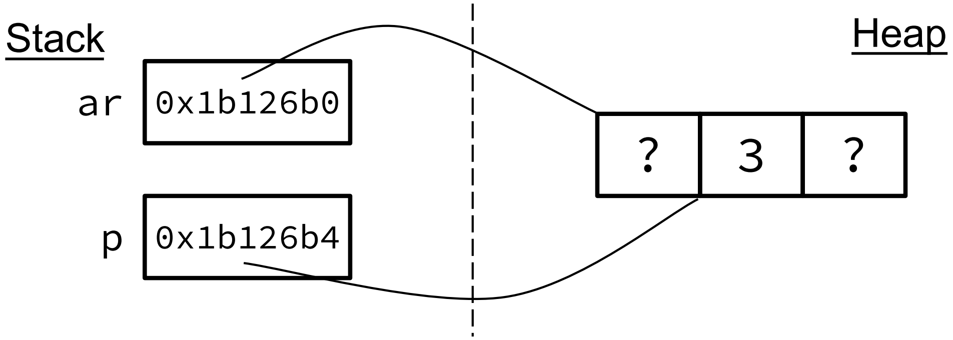
- Common uses:
    - Reference to data allocated elsewhere (*e.g.*, `malloc`, literals, files)
    - Iterators (*e.g.*, data structure traversal)
    - Data abstraction (*e.g.*, head of linked list, function pointers)

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:

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

- Example diagram:



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?

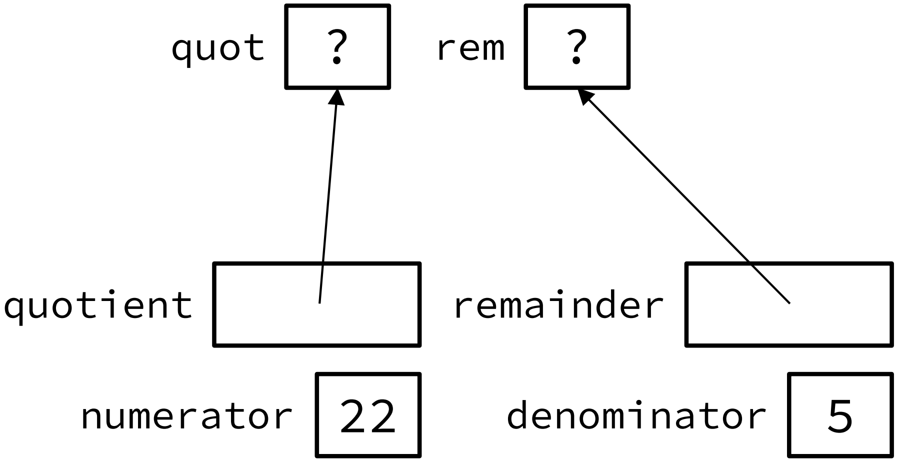
  quot and rem

```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, _____, _____);
  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:

index	0	1	2	3	4	5
value	'H'	'e'	'l'	'l'	'o'	'\0'

- 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

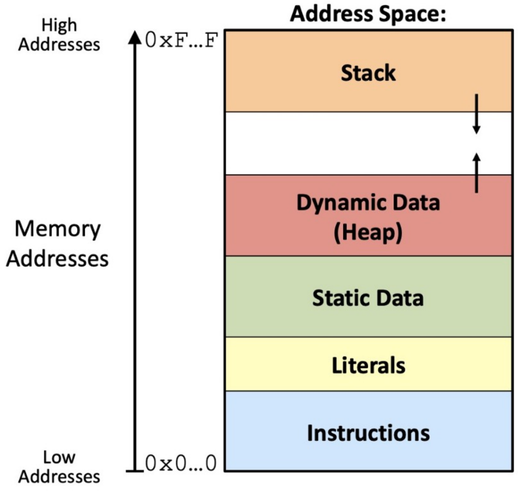
- Code:

```
// 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)

Common String Literal Error

- Code:

```c
// pointer instead of an array
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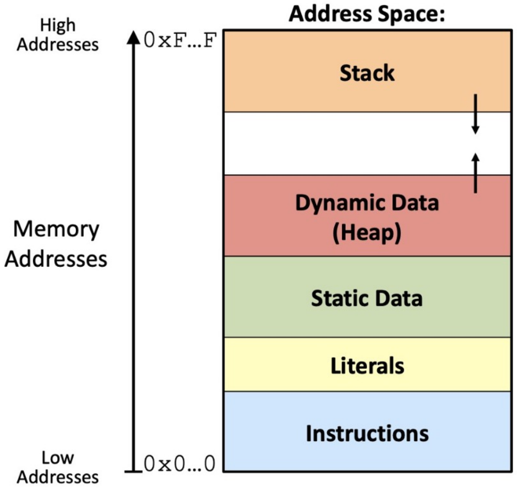
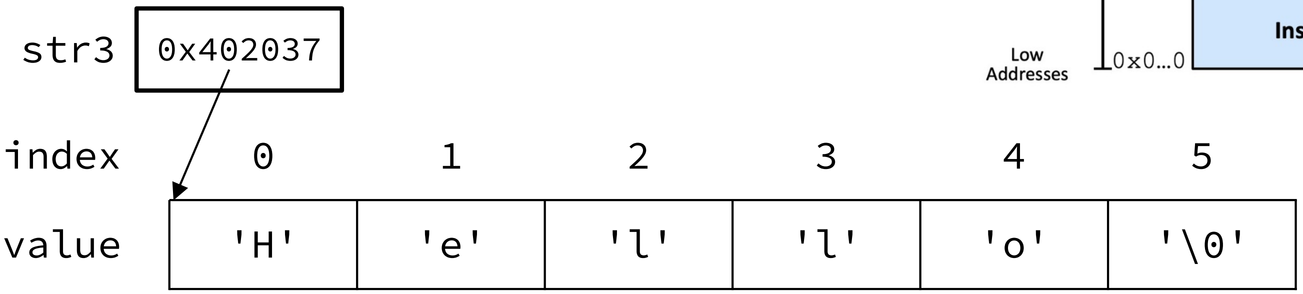


- Memory:



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!

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;
}
```

Exercise 2

A prefix sum over an array is the running total of all numbers in the array up to and including the current number. For example, given the array {1, 2, 3, 4}, the prefix sum would be {1, 3, 6, 10}.

Write a function to compute the prefix sum of an array given a pointer to its first element, the pointer to the first element of the output array, and the length both arrays (assumed to be the same).

A prefix sum over an array is the running total of all numbers in the array up to and including the current number. For example, given the array {1, 2, 3, 4}, the prefix sum would be {1, 3, 6, 10}.

Write a function to compute the prefix sum of an array given a pointer to its first element, the pointer to the first element of the output array, and the length both arrays (assumed to be the same).

```
void prefix_sum(int *input, int *output, int length) {
  if (length == 0) {
    return;
  }
  output[0] = input[0];


  for (int i = 1; i < length; i++) {
    output[i] = output[i - 1] + input[i];
  }
}
```

Exercise 3 (bonus)

The following code has a bug. What’s the problem, and how would you fix it?

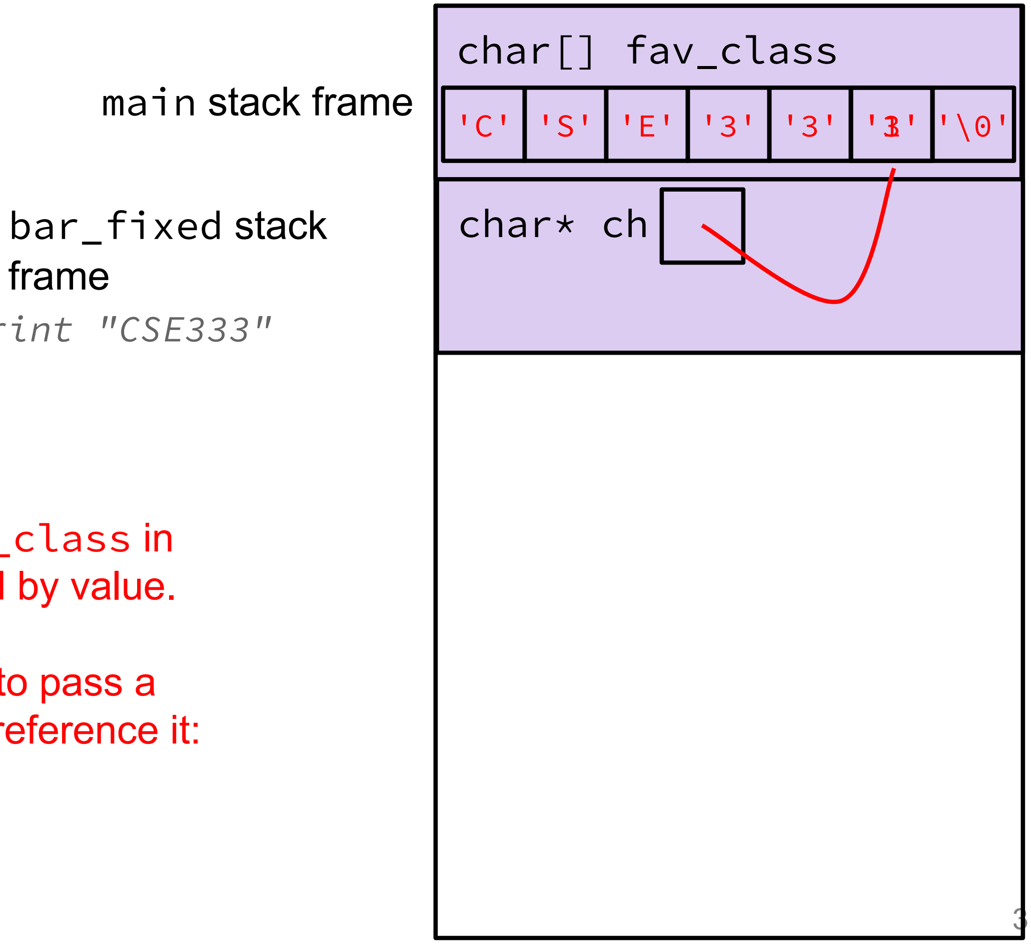
```
void bar(char ch) {
  ch = '3';
}

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?

```
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;
}
```



main stack frame

char[] fav_class

'C'	'S'	'E'	'3'	'3'	'3'	'\0'

bar_fixed stack frame

char* ch

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:

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