

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 .
```

Logistics

- Exercise 1:
 - Due **Friday @ 10:00 AM (4/4)**
- Homework 0:
 - Due **Monday @ 11:59 PM (4/7)**
 - 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: `cse333-25sp-
<netid>`
- Please let us know if you don't have one!

CSE 333: Systems Programming Home Calendar Assignments Resources

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 25sp).

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/cse333/25sp/resources/VSCode.pdf>

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

Pointer Review

Pointers

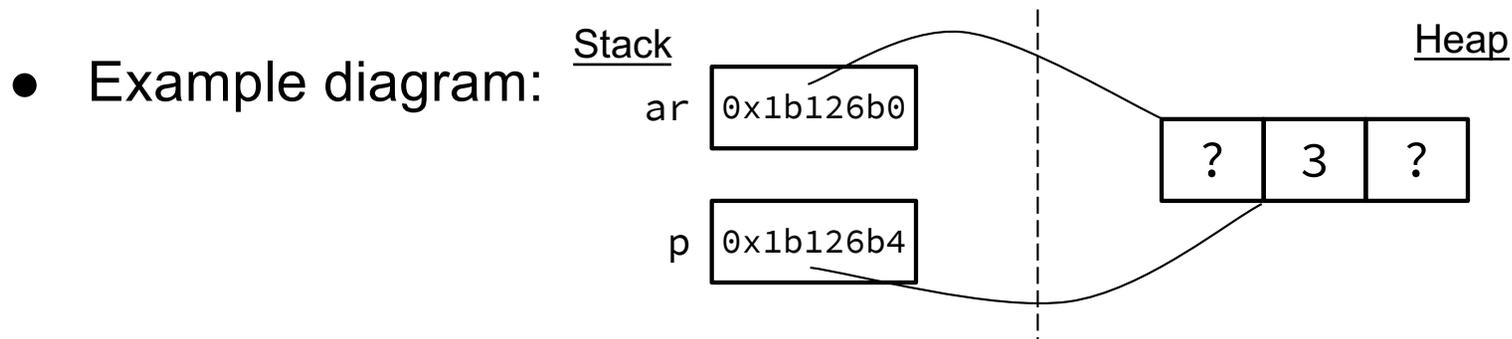
- Data type that stores the address of (the lowest byte of) a datum
 - Can draw an arrow in memory diagrams from pointer to pointed to data, particularly if actual value (stored address) is unknown
- Common uses:
 - Reference to data allocated elsewhere (*e.g.*, `malloc`, literals, files)
 - Iterators (*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;
```



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

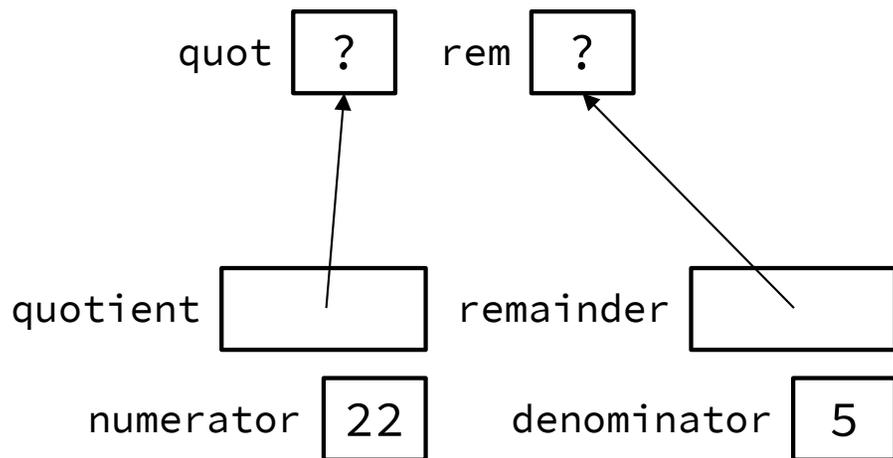
- Which parameters are output parameters?
quotient and remainder
- What should go in the `division` blanks?
" and &rem
- What should go in the `printf` blanks?
quot and rem

```
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:

```
// 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:

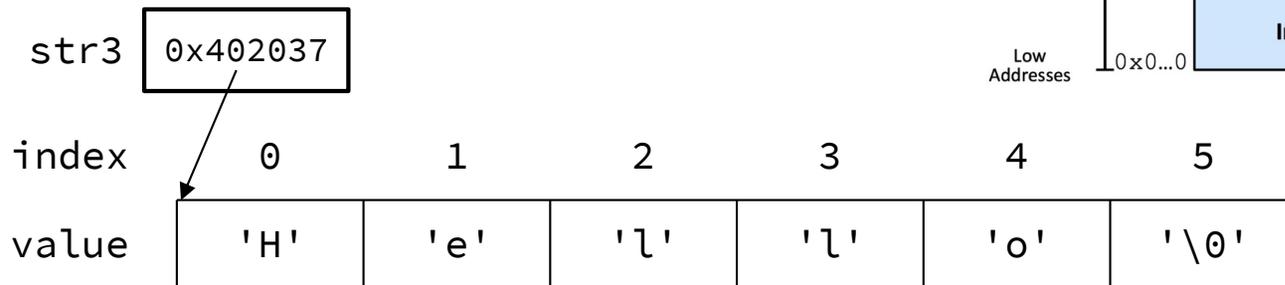
- Both initialize the array *in the declaration scope* (e.g., on the stack if a local var), though the latter can be thought of as copying the contents from the string literal into the array
- The size 6 is *optional*, as it can be inferred from the initialization

Common String Literal Error

- Code:

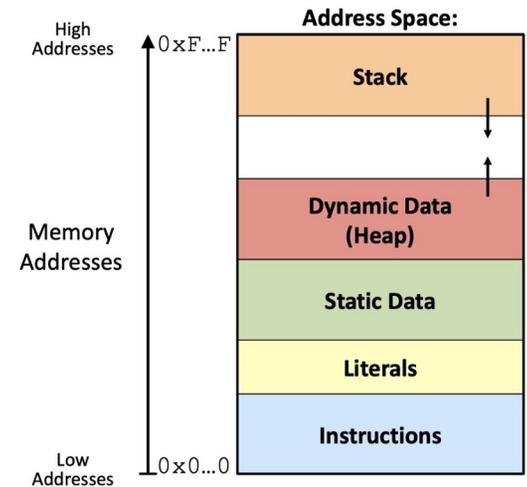
```
// pointer instead of an array  
char* str3 = "Hello";
```

- Memory:



- Notes:

- By default, using a string literal will allocate and initialize the character array in *read-only* memory (Literals)

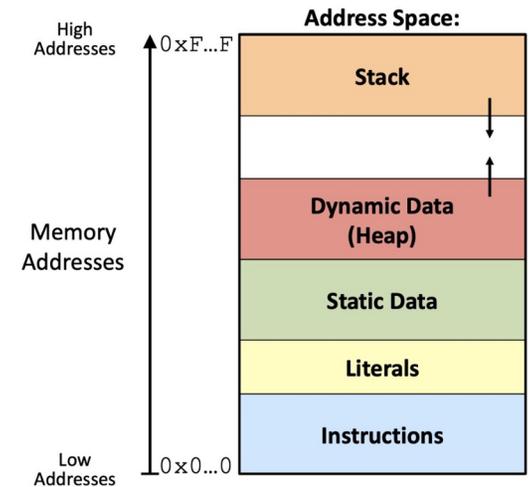
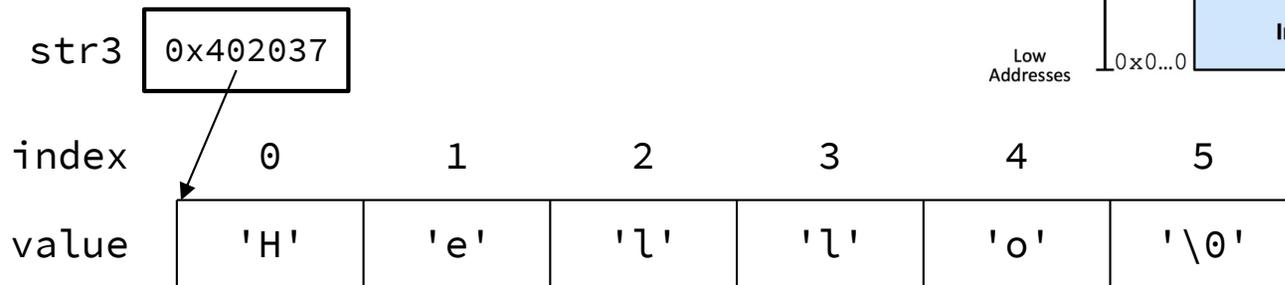


Common String Literal Error

- Code:

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

- Memory:



- 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

```
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];

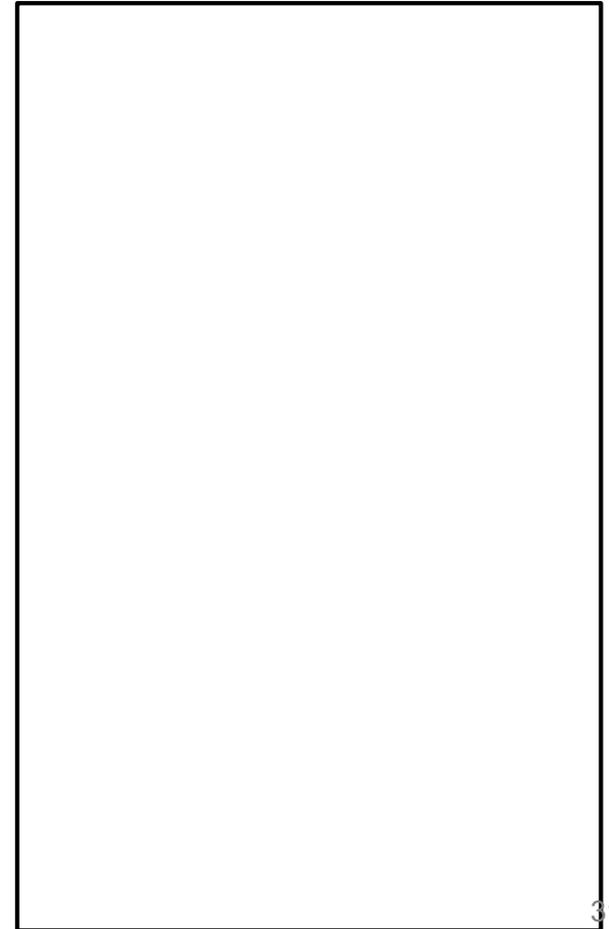
    for (int i = 1; i < length; i++) {
        output[i] = output[i - 1] + input[i];
    }
}
```

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;
}
```



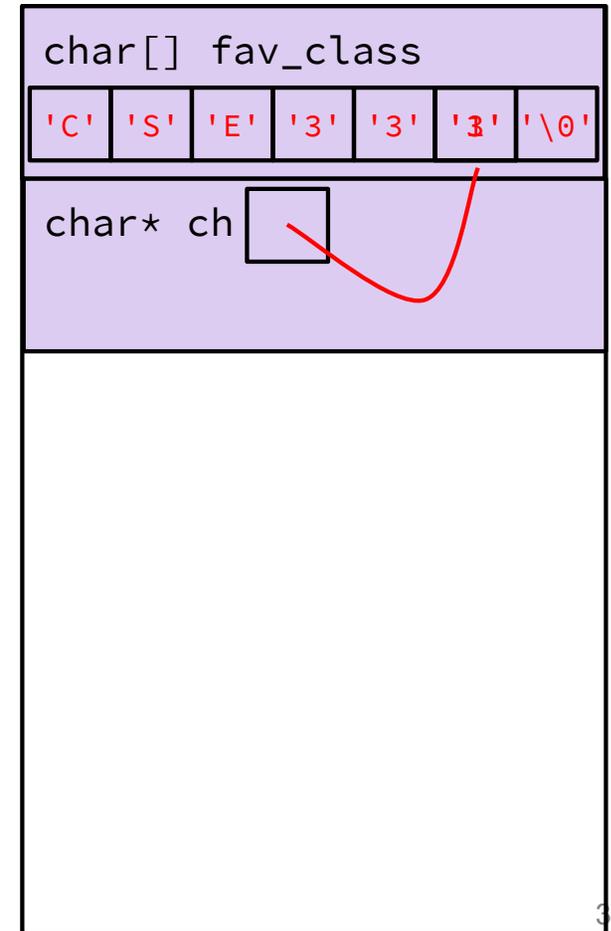
The following code has a bug. What's the problem, and how would you fix it?

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

main stack frame

```
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;  
}
```

bar_fixed stack frame



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';  
}
```