

Systems Programming

Intro, Getting Started in C

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Yusong Yan

Introductions: Instructor

❖ Justin Hsia (he/him)

- Engineering background (EE, MechE, some Synth Bio), but a teacher at heart
 - Love helping students pursue teaching careers
- Raising a kindergartener and an infant/toddler:
 - Will be sick 🤒 and tired 😩 at various points this quarter
- Interests include ultimate, a cappella, board games, hiking, anime, and more!
 - Learn more about me through the off-topic questions in the lecture posts



Introductions: Teaching Assistants



- Learn more about us on the course website!
- ❖ More than anything, we want you to feel...
 - Comfortable and welcome in this space
 - Able to learn and succeed in this course
 - Comfortable reaching out if you need help or want change

Introductions: Students

- ❖ ~240 students registered, split across two lectures
- ❖ Expected background
 - **Prereq:** CSE 351 – C, pointers, memory model, linker, system calls
 - **Indirect Prereq:** CSE 123 – classes, inheritance, basic data structures, and general good style practices
 - CSE 391 or Linux skills needed for CSE 351 assumed
- ❖ Get to know each other! Help each other out!
 - College is a unique time to get to know lots of different people
 - Forming bonds with classmates makes class more enjoyable and can help with learning

Lecture Outline (1/3)

❖ Course Policies

- <https://courses.cs.washington.edu/courses/cse333/26au/syllabus.html>
- Digest here, but you ***must*** read the full details online

❖ Course Introduction

❖ Getting Started in C

- What do you need to write a C program from scratch?

Staff-Student Communication

- ❖ **Website:** <http://cs.uw.edu/333>
 - Schedule, policies, materials, assignments, etc.
- ❖ **Discussion:** <https://edstem.org/us/courses/101845/>
 - Announcements made here
 - Ask and answer questions – staff will monitor and contribute
- ❖ **Office Hours:** Google Sheet queue (UW login) for both in-person and virtual OHs
- ❖ **1-on-1 Meetings:** can request a limited number of appointments via Google Form (UW login)
- ❖ **Anonymous feedback**

Office Hours

❖ Check Weekly Calendar for scheduled office hours:

- Zoom meeting links are found in the Zoom tab within Canvas

❖ All office hours will use a Google Sheets queue

- Fill out the first 3 columns to enter the queue:

❖ We encourage you to chat with other students if the TAs are busy!

- Keep it high-level; no sharing code or answers
- Trade debugging strategies, tips for using course tools

Weekly Calendar ([Subscribe](#))

< Prev Next > Oct 11 – 17, 2026 Compact Week List

Sun 10/11	Mon 10/12	Tue 10/13	Wed 10/14	Thu 10/15	Fri 10/16	Sat 10/17
	11:30a - 12:20p Lecture A C: Linking, File I/O JHN 102	10a - 11a Office Hours Megan CSE1 Third Floor Breakout	Ex-3 Due	HW1 Due	MeetStf Due	11:30a - 1:30p Office Hours Shrihan CSE1 Third Floor Breakout
	12:30p - 1:30p Office Hours Justin CSE 544	1:30p - 2:30p Office Hours Aadi & Camden CSE2 121	10a - 11a Office Hours Justin Zoom and CSE 544	Section POSIX I/O	10a - 11:30a Office Hours Yusong CSE2 121	1:30p - 2:30p Office Hours Andrew Zoom
	1:30p - 2:20p Lecture B C: Linking, File I/O CSE2 G10	2:30p - 3:30p Office Hours Aadi & Aviel CSE2 121	11:30a - 12:20p Lecture A Buffering, POSIX I/O, System Calls JHN 102	1:30p - 2:30p Office Hours Laura & Yusong CSE2 121	11:30a - 12:20p Lecture A Makefiles, C++ Preview JHN 102	

Full Name(s)	Category	Description	Time Queued	Staff	Status
Example 1	Concept	What are the advantages and disadvantages of buffering?		Justin	Done
Example 2	Debugging	HW1: valgrind memory leak in Part B from HashTable.		Justin	Done
Example 3	Spec	EX3: what is required for the testing code in main?		Justin	Done
Example 4	Tools	GDB: how do I examine memory on the stack?		Justin	Done

Course Components

- ❖ Lectures (28)
 - Introduce the concepts; take notes!!!
- ❖ Sections (10)
 - Applied concepts, important tools and skills for assignments, exam preparation
- ❖ Exercises (12)
 - Small problems to familiarize you with C/C++ fundamentals; submitted via GitLab
- ❖ Homework (4)
 - Web search server built in progressive steps; submitted via GitLab
- ❖ In-Person Exams (2)
 - **Midterm:** Monday, November 2 from 5:30–6:40 PM
 - **Final:** Wednesday, December 16 from 12:30–2:20 PM

Grading

❖ **Exercises:** 15% total

- Graded on a 9-point scale for correctness and style by autograders and TAs
- Lowest exercise score dropped
- No late work accepted (solutions are released immediately)

❖ **Homework:** 30% total

- Binaries provided if you didn't get the previous part working
- Graded on test suite, manual tests, and style
- Late day system + 6 tokens to avoid penalties

❖ **Exams:** Midterm (25%) and Final (25%)

❖ **Effort, Participation, and Altruism:** 5%

- Many ways to earn credit here; relatively lenient on this

Academic Integrity and Student Conduct

- ❖ We trust you implicitly and will follow up if that trust is violated
 - In short: don't attempt to gain credit for something you didn't do, and don't help others do so, either
- ❖ We are using the Allen School's [“AI as a Reference Tool” policy](#)
 - AI may help with general questions and ungraded work, but not graded assignments or assessments
 - More explanation for why this class still focuses on programming by hand can be found on our [Generative AI webpage](#)
- ❖ If you find yourself in a situation where you are tempted to perform academic misconduct, please reach out to the instructor to explain your situation instead
 - See the [Extenuating Circumstances](#) section of the syllabus



Lecture Outline (2/3)

❖ Course Policies

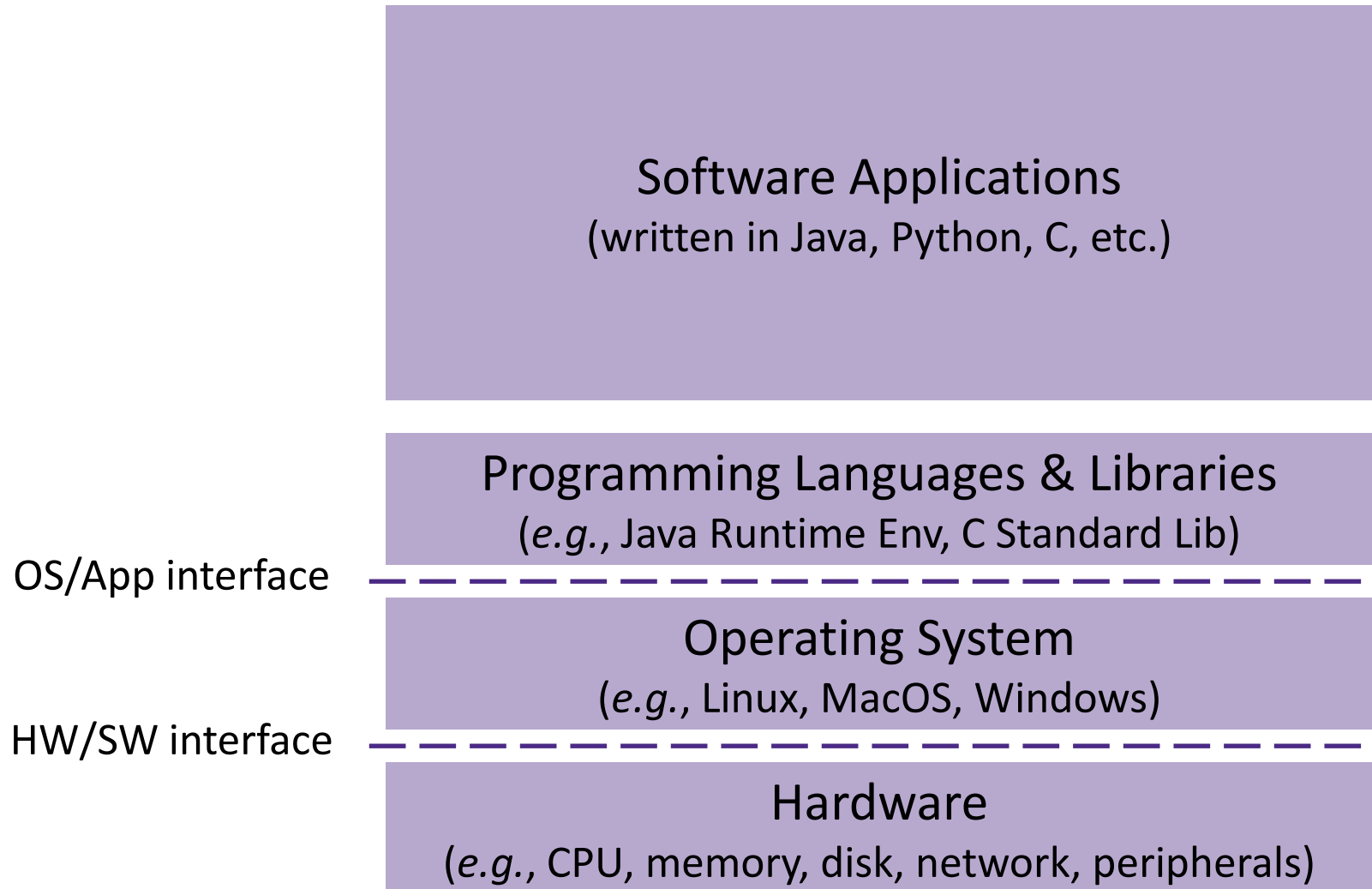
- <https://courses.cs.washington.edu/courses/cse333/26au/syllabus.html>
- Summary here, but you ***must*** read the full details online

❖ Course Introduction

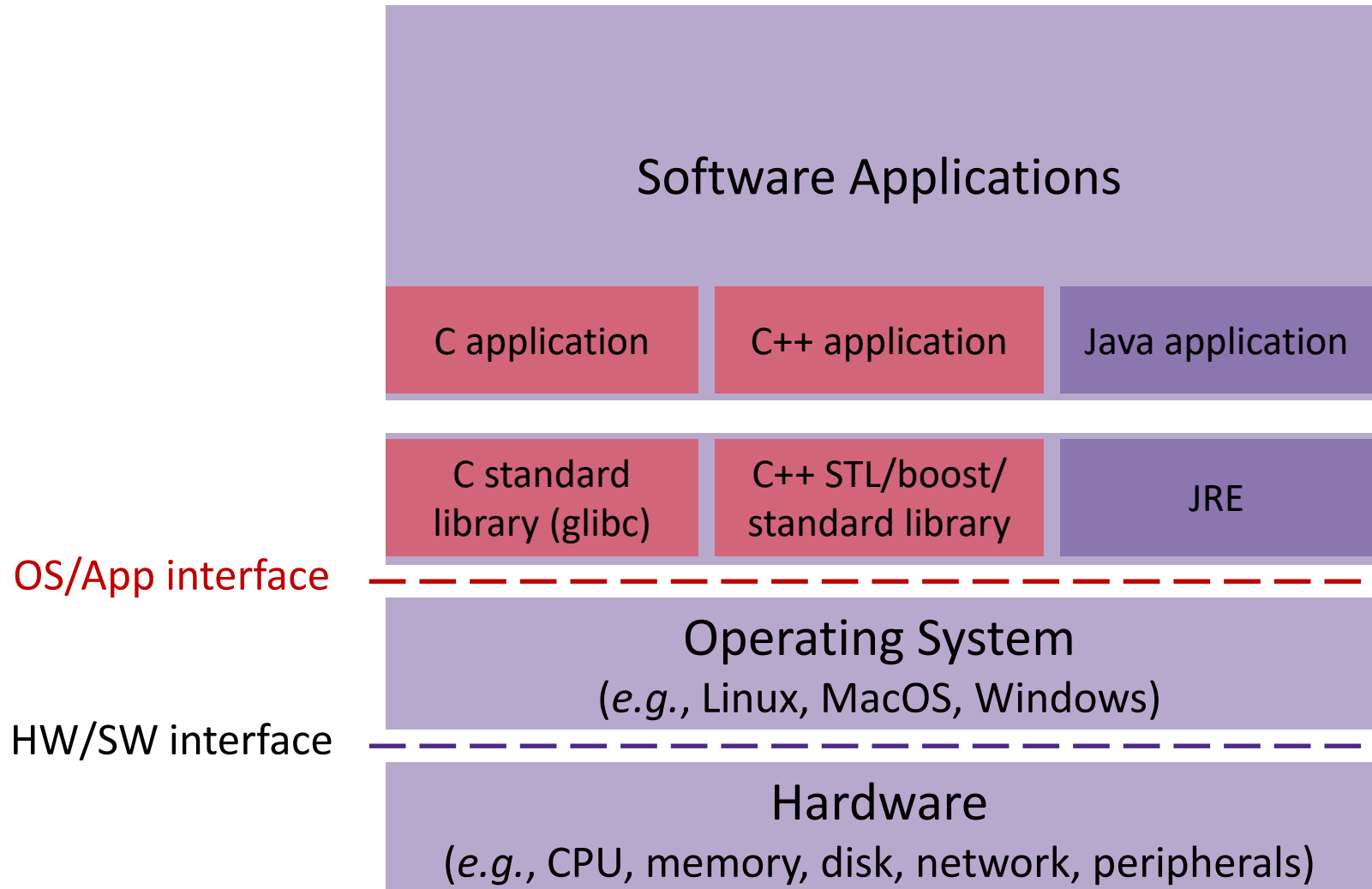
❖ Getting Started in C

- What do you need to write a C program from scratch?

Lower Computing Layers (1/2)



Lower Computing Layers (2/2)



Systems Programming

- ❖ **The programming skills, engineering discipline, and knowledge you need to build a system**
 - **Programming:** C / C++ / Rust / Zig / ...
 - **Discipline:** testing, debugging, performance analysis
 - **Knowledge:** long list of interesting topics
 - Concurrency, networking, OS interfaces and semantics, techniques for consistent data management, distributed systems algorithms, ...
 - Most important: A deep(er) understanding of the “layer below”



Discipline?!?

- ❖ Cultivate good habits, encourage clean code
 - Coding style conventions
 - Unit testing, code coverage testing, regression testing
 - Reading/writing documentation (code comments, design docs)
 - Code reviews

- ❖ Will take you a lifetime to learn, but oh-so-important, especially for systems code
 - Avoid write-once, read-never code
 - Treat assignment submissions in this class as production code
 - Comments must be updated, no commented-out code, no extra (debugging) output

Style Grading in 333

- ❖ A **style guide** is a “set of standards for the writing, formatting, and design of documents” – in this case, code
- ❖ No style guide is perfect
 - Inherently limiting to coding as a form of expression/art
 - Rules should be motivated (*e.g.*, consistency, performance, safety, readability), even if not everyone agrees
- ❖ In 333, we will use a [subset of the Google C++ Style Guide](#)
 - Want you to experience adhering to a style guide
 - Hope you view these more as *design decisions* to be considered rather than rules to follow to get a grade
 - We acknowledge that judgments of language implicitly encode certain values and not others

Lecture Outline (3/3)

❖ Course Policies

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❖ Course Introduction

❖ Getting Started in C

- What do you need to write a C program from scratch?

C Data Structures Review

- ❖ C does not support objects!
- ❖ **Arrays** are contiguous chunks of memory
 - No implicit initialization; declaration just gives you “mystery data”
 - Don’t know their own length, so **no bounds checking**
- ❖ **C-strings** are null-terminated arrays of characters
 - Example: `char x[] = "hi\n";`
 - `string.h` has helpful library/utility functions
 - Documentation: <http://www.cplusplus.com/reference/cstring/>
- ❖ **Structs** are collections of fields (variables)
 - The most object-like, but no methods



Generic C Program Layout

```
#include <system_files>
#include "local_files"

#define macro_name macro_expr

/* declare functions */
/* declare external variables & structs */

int main(int argc, char* argv[]) {
    /* the innards */
}

/* define other functions */
```

C Syntax: `main` (1/2)

- ❖ To get command-line arguments in `main`, use:

```
int main(int argc, char* argv[])
```

- ❖ What does this mean?

- `argc` contains the number of strings on the command line (the executable name counts as one, plus one for each argument)
- `argv` is an array containing *pointers* to the arguments as strings, “null-terminated” with a NULL pointer (in modern C standards)

- ❖ Example: `$ ./foo hello 87`

- `argc = 3`
- `argv[0] = "./foo", argv[1] = "hello", argv[2] = "87", argv[3] =  $\emptyset$`

C Syntax: `main` (2/2)

- ❖ To get command-line arguments in `main`, use:

```
int main(int argc, char* argv[])
```

- ❖ Advantages:

- Easy to implement – keyboard presses are passed as characters
- Flexible – can handle any number of arguments

- ❖ Disadvantages:

- Input checking needed by the programmer to prevent user misuse
 - Common C idiom is to print back usage messages
- Data conversion might be needed if argument is not intended as characters
 - See Exercise 1!

pollev.com/cse333

How much memory would you expect to be allocated for `argv` & all of its pointed-to arrays?

```
$ cp -r dir1 dir2
```

- A. 48 bytes
- B. 52 bytes
- C. 56 bytes
- D. 60 bytes
- E. 64 bytes
- F. We're lost...

Printing in C

❖ `int printf(const char* format, ...);`

- Can check documentation to learn about (1) parameters, (2) the return value, and (3) *error handling*: <https://www.cplusplus.com/reference/cstdio/printf/>
- Very important to use the correct format specifier for the value you want to print; otherwise, implicit casting will occur

- | specifier | Output | Example |
|-----------|--|--------------|
| d or i | Signed decimal integer | 392 |
| u | Unsigned decimal integer | 7235 |
| o | Unsigned octal | 610 |
| x | Unsigned hexadecimal integer | 7fa |
| X | Unsigned hexadecimal integer (uppercase) | 7FA |
| f | Decimal floating point, lowercase | 392.65 |
| F | Decimal floating point, uppercase | 392.65 |
| e | Scientific notation (mantissa/exponent), lowercase | 3.9265e+2 |
| E | Scientific notation (mantissa/exponent), uppercase | 3.9265E+2 |
| g | Use the shortest representation: %e or %f | 392.65 |
| G | Use the shortest representation: %E or %F | 392.65 |
| a | Hexadecimal floating point, lowercase | -0xc.90fep-2 |
| A | Hexadecimal floating point, uppercase | -0XC.90FEP-2 |
| c | Character | a |
| s | String of characters | sample |
| p | Pointer address | b8000000 |



Error Handling

❖ Errors and Exceptions

- C does not have exception handling (no try/catch)
- Errors are returned as **integer error codes** from functions
 - Because of this, error handling is ugly and inelegant
 - For readability, `CONSTANT_NAMES` are defined to abstract away the actual integer values – need to look up in documentation
- Global variable **`errno`** holds value of last system error

❖ Status codes and signals

- Processes exit (e.g., **`return`** from **`main`**) with status code
 - Standard codes in `stdlib.h`: **`EXIT_SUCCESS`** (zero), **`EXIT_FAILURE`** (non-zero)
- “Crashes” trigger signals from OS (e.g., `SIGSEGV` for segfault)

Function Definitions

❖ Generic format:

```
ReturnType FuncName(type param1, ..., type paramN) {  
    // statements  
}
```

■ Example:

```
// sum of integers from 1 to max  
int sumTo(int max) {  
    int i, sum = 0;  
  
    for (i = 1; i <= max; ++i) {  
        sum += i;  
    }  
  
    return sum;  
}
```

Function Ordering

❖ You *shouldn't* call a function that hasn't been declared yet

■ Example:

```
int main(int argc, char** argv) {  
    printf("sumTo(5) is: %d\n", sumTo(5));  
    return EXIT_SUCCESS;  
}  
  
// sum of integers from 1 to max  
int sumTo(int max) {  
    int i, sum = 0;  
  
    for (i = 1; i <= max; ++i) {  
        sum += i;  
    }  
    return sum;  
}
```

Note: code examples from slides are posted on the course website for you to experiment with!

sum_badorder.c

Solution 1: Reverse Ordering

- ❖ Simple solution; however, imposes ordering restriction on writing functions (who-calls-what?)

- Example:

```
// sum of integers from 1 to max
int sumTo(int max) {
    int i, sum = 0;

    for (i = 1; i <= max; ++i) {
        sum += i;
    }
    return sum;
}

int main(int argc, char** argv) {
    printf("sumTo(5) is: %d\n", sumTo(5));
    return EXIT_SUCCESS;
}
```

sum_betterorder.c



Solution 2: Function Declaration

- ❖ Teaches the compiler the arguments and return types; function definitions can then be in a logical order
 - Function comment usually by the *prototype*

- Example:

```
// sum of integers from 1 to max
int sumTo(int max); // func prototype

int main(int argc, char** argv) {
    printf("sumTo(5) is: %d\n", sumTo(5));
    return EXIT_SUCCESS;
}

int sumTo(int max) {
    int i, sum = 0;
    for (i = 1; i <= max; ++i) {
        sum += i;
    }
    return sum;
}
```

Function Declaration vs. Definition

- ❖ C/C++ make a careful distinction between these two
- ❖ **Definition:** The thing itself
 - *e.g.*, code for function, variable definition that creates storage
 - Must be **exactly one** definition of each thing (no duplicates)
- ❖ **Declaration:** Description of a thing
 - *e.g.*, function prototype, external variable declaration
 - Often in header files and incorporated via `#include`
 - Should also `#include` declaration in the file with the actual definition to check for consistency
 - Needs to appear in **all files** that use that thing
 - Should appear before first use

To-do List (1/2)

- ❖ Check access: Canvas, Ed Discussion, Gradescope, Poll Everywhere
 - All user IDs should be your **uw.edu** email address
- ❖ Explore the website *thoroughly*: <http://cs.uw.edu/333>
 - In particular, the syllabus and generative AI policy
- ❖ Computer setup: CSE lab or SSH into attu
 - [Husky OnNet](#) VPN when you're off campus (required as of 26wi)
 - Check for GitLab repo NOW, then follow [the GitLab guide](#) to clone and add SSH key *before* Section 1 tomorrow
 - See the [text editors page](#) for how to configure vim or VS Code for use in this class
 - You will want to get comfortable navigating and editing multiple files *simultaneously*

To-do List (2/2)

- ❖ Pre-Quarter Survey (Canvas) due Friday @ 11:59 PM
- ❖ **Exercise 1 is due at 11 AM on Monday**
 - Find exercise spec on website, submit via GitLab (demo during Section 1)
 - Sample solution will be posted Monday afternoon
 - **Hint:** look at documentation for [stdlib.h](#), [string.h](#), and [inttypes.h](#)