Intro, Getting Started in C

CSE 333 Winter 2023

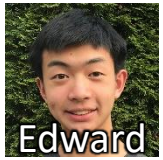
Instructor: Justin Hsia

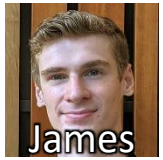
Teaching Assistants:

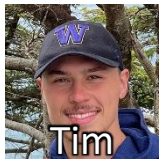
Adina Tung
Danny Agustinus
Edward Zhang
James Froelich
Lahari Nidadavolu
Mitchell Levy
Noa Ferman
Patrick Ho
Paul Han
Saket Gollapudi
Sara Deutscher
Tim Mandzyuk
Timmy Yang
Wei Wu
Yiqing Wang
Zhuochun Liu

Introductions: Course Staff

- Your Instructor: just call me Justin
  - CSE Associate Teaching Professor
  - Raising a toddler, will be tired
- TAs:







  - Available in section, office hours, and discussion board
- 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

- ~200 students registered, split across two lectures
- Expected background
  - **Prereq:** CSE 351 – C, pointers, memory model, linker, system calls
  - **Indirect Prereq**: CSE 143 – 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!
  - Working well with others is a valuable life skill
  - Take advantage of partner work, where permissible, to *learn*, not just get a grade
    - Good chance to learn collaboration tools and tricks

Lecture Outline

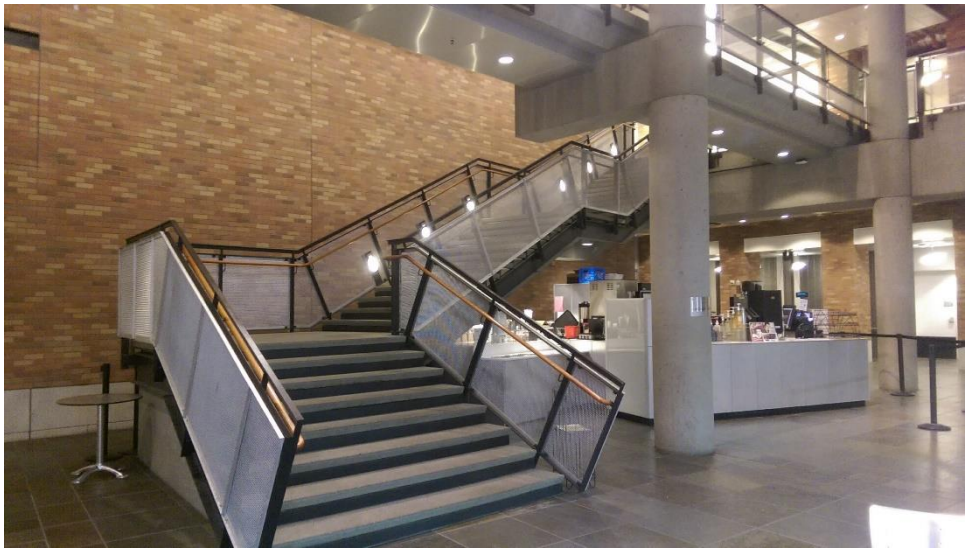
- **Course Policies**
  - https://courses.cs.washington.edu/courses/cse333/23wi/syllabus.html
  - Digest here, but you ***must*** read the full details online
- Course Introduction
- Getting Started in C
  - What do you need to write a C program from scratch?

Communication

- **Website:** http://cs.uw.edu/333
  - Schedule, policies, materials, assignments, etc.
- **Discussion:** https://edstem.org/us/courses/32030
  - Announcements made here
  - Ask and answer questions – staff will monitor and contribute
- **Office Hours:** Google Sheet queue for both in-person and virtual OHs, which are spread throughout the week
- **1-on-1 Meetings:** can request a limited number of appointments via Google Form
- **Anonymous feedback**

In-Person Office Hours

- Allen 3rd floor breakout
  - Up the stairs in the CSE Atrium (Allen Center, not Gates)



  - At the top of two flights, the open area with the whiteboard wall is the 3rd floor breakout!

Course Components

- Lectures (26) – two less than normal!!!
  - Introduce the concepts; take notes
- Sections (10)
  - Applied concepts, important tools and skills for assignments, clarification of lectures, exam review and preparation
- Programming Exercises (12)
  - One due roughly every 4-5 days
  - We are checking for: correctness, memory issues, code style/quality
- Programming Project (0+4)
  - Warm-up, then 4 "homework" that build on each other
- Take-home Exams (2)
  - **Midterm:** Thursday, February 9 – Saturday, February 11
  - **Final:** Monday, March 13 – Wednesday, March 15

Grading

- **Exercises:** 30% total
  - Submitted via Gradescope (under your UW email)
  - Graded on correctness and style by autograders and TAs
- **Projects:** 43% total
  - Submitted via GitLab; must tag commit that you want graded
  - Binaries provided if you didn't get previous part working
  - Graded on test suite, manual tests, and style
- **Exams:** Midterm (12%) and Final (12%)
  - Take-home; short answer questions based on assignments
- **Effort, Participation, and Altruism:** 3%
  - Many ways to earn credit here, relatively lenient on this

Academic Integrity and Student Conduct

- I 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
- This does ***not*** mean suffer in silence – learn from the course staff and peers, talk, share ideas; *but* don't share or copy work that is supposed to be yours
  - Partners allowed this quarter on programming assignments!
- If you find yourself in a situation where you are tempted to perform academic misconduct, please reach out to Justin to explain your situation instead
  - See the Extenuating Circumstances section of the syllabus

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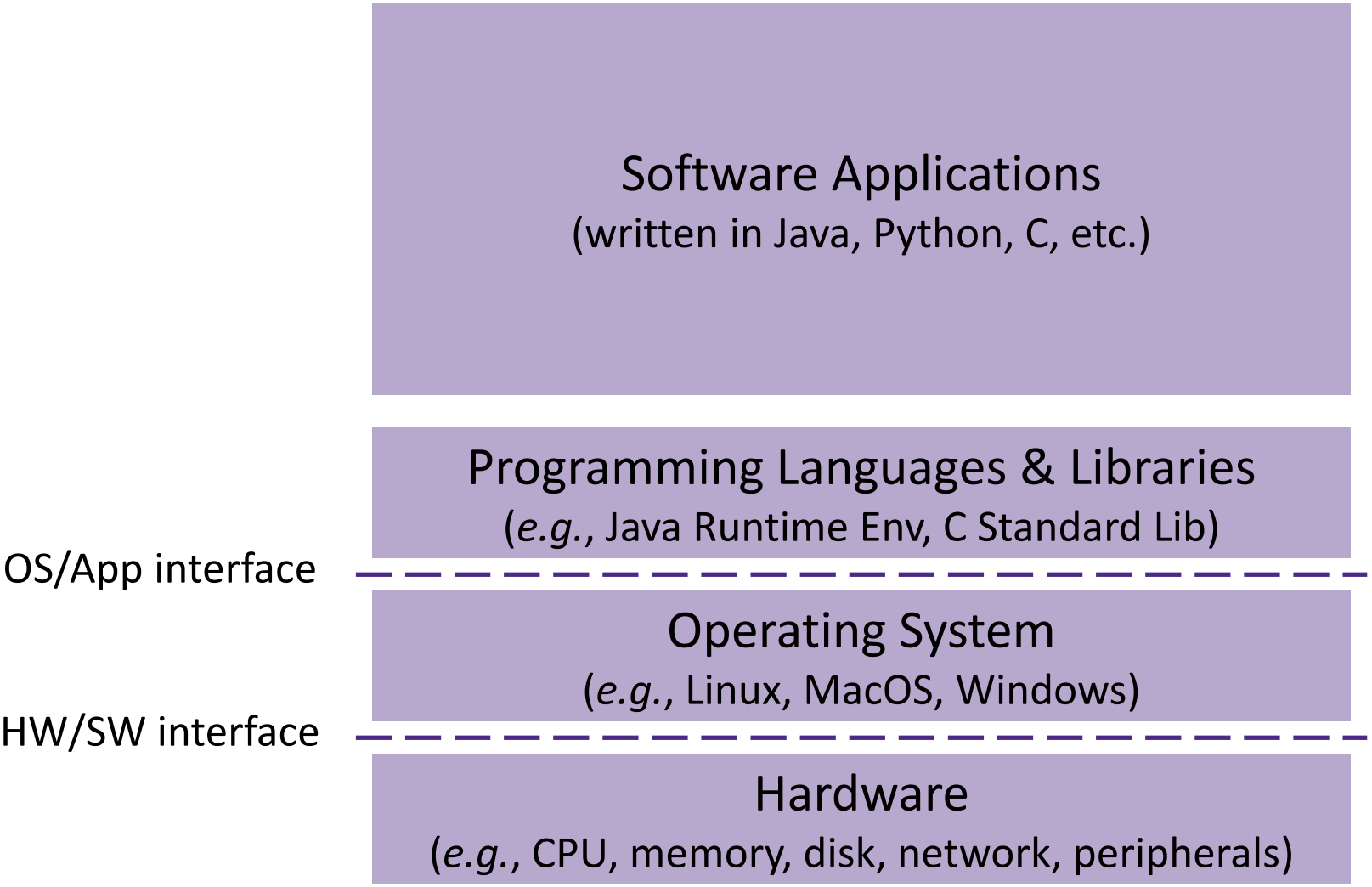
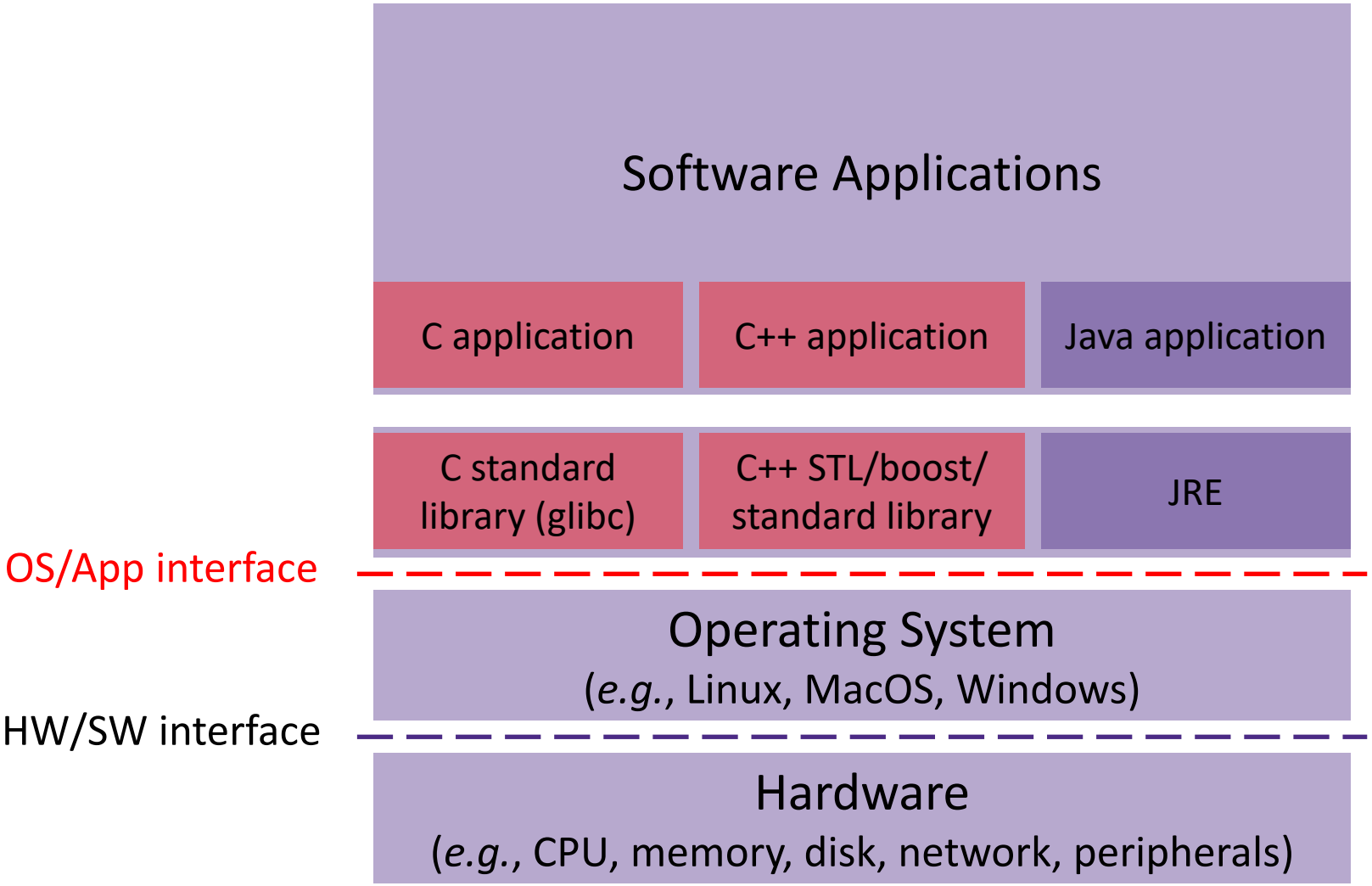
Layers of Computing Below Programming



Layers of Computing Below Programming



Systems Programming

- **The programming skills, engineering discipline, and knowledge you need to build a system**
  - **Programming:** C / C++
  - **Discipline:** testing, debugging, performance analysis
  - **Knowledge:** long list of interesting topics
    - Concurrency, 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

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- **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`

- 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 (more on pointers later)

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

C Syntax: `main`

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

Poll Everywhere

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. 44 bytes
B. 48 bytes
C. 52 bytes
D. 56 bytes
E. 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 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 found in `stdlib.h`:
      `EXIT_SUCCESS` (usually 0) and `EXIT_FAILURE` (non-zero)
  - "Crashes" trigger signals from OS (*e.g.*, `SIGSEGV` for segfault)

Function Definitions

- Generic format:

```
returnType fname(type param1, …, type paramN) {
    // statements
}
```

```
// 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

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

sum_badorder.c

```
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;
}
```

Solution 1: Reverse Ordering

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

sum_betterorder.c

```c
// 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;
}
```

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*

sum_declared.c

```
// 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

333 Workflow Aids/Upgrades

- See **Linux → Text Editors** on website for how to configure vim or VS Code for use in this class
  - From vi/vim, can compile and execute code without ever leaving the editor using "`:! <cmd>`"
  - For VS Code, can connect to attu remotely and take advantage of the IDE features
  - From either text editor, you will want to get comfortable navigating and editing multiple files *simultaneously*

- We will learn the basics of Makefiles to simplify the compilation steps into the command `make`

To-do List

- Make sure you're registered on Canvas, Ed Discussion, Gradescope, and Poll Everywhere (all uw.edu email address)
- Explore the website *thoroughly*: http://cs.uw.edu/333
- Computer setup: CSE lab, attu, or *23wi* CSE Linux VM
- Pre-Quarter Survey (Canvas) due Friday @ 11:59 pm
- Exercise 1 is due Monday @ 11 am
  - Find exercise spec on website, submit via Gradescope
  - **Hint:** look at documentation for `stdlib.h`, `string.h`, and `inttypes.h`
- Homework 0 (Gitlab) is due Monday @ 11:59 pm
  - Gitlab email sent when repos created – no action needed
  - Make a private Ed post if you don't have a repo or the hw0 files