Intro, Getting Started in C
CSE 333 Winter 2023

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Zhuochun Liu
Introductions: Course Staff

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

❖ TAs: Adina  Danny  Edward  James  Lahari  Mitchell  Noa  Patrick
  ▪ 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](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](http://cs.uw.edu/333)
  - Schedule, policies, materials, assignments, etc.

❖ **Discussion:**  [https://edstem.org/us/courses/32030](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
Lecture Outline

❖ Course Policies
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❖ Course Introduction

❖ Getting Started in C
  ▪ What do you need to write a C program from scratch?
Layers of Computing Below Programming

Software Applications
(written in Java, Python, C, etc.)

Programming Languages & Libraries
(e.g., Java Runtime Env, C Standard Lib)

Operating System
(e.g., Linux, MacOS, Windows)

Hardware
(e.g., CPU, memory, disk, network, peripherals)
Layers of Computing Below Programming

- **Software Applications**
  - C application
  - C++ application
  - Java application

- **Operating System**
  - (e.g., Linux, MacOS, Windows)

- **Hardware**
  - (e.g., CPU, memory, disk, network, peripherals)

- **HW/SW interface**
  - Operating System

- **OS/App interface**
  - Hardware

- **C standard library (glibc)**
  - C++ STL/boost/standard library
  - JRE
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: ```c
char x[] = "hi\n";
```
  ▪ `string.h` has helpful library/utility functions

❖ **Structs** are collections of fields (variables)
  ▪ The most object-like, but no methods
Generic C Program Layout

```c
#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`
C Syntax: main

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

```c
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!
How much memory would you expect to be allocated for \texttt{argv} & all of its pointed-to arrays?

A. 44 bytes
B. 48 bytes
C. 52 bytes
D. 56 bytes
E. We’re lost...

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

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

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

  ```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;
  }
  ```
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!

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

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

`C compiler goes line-by-line:`
Solution 1: Reverse Ordering

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

```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;
}
```

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*

```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

↑ more on this in Lecture 5
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](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