Lecture 01
Introduction

CS211 – Fundamentals of Computer Programming II

Branden Ghena – Fall 2021

Slides adapted from:
Jesse Tov

Northwestern

Welcome to CS211

- In brief: become a **better** and **broader** programmer

- First half
  - C programming
  - Unix shell

- Second half
  - C++ programming

- Introduces students to industry-standard languages and tools
- Builds foundational software design skills at a medium scale

Questions in class

- Please ask questions!!!
  - It’s not just you who doesn’t understand something.

- You can always ask questions verbally during class
  - Raise hands to grab my attention and I’ll call on you

- Bonus option: realtime-lecture-questions in Campuswire
  - We’ll have it monitored by staff in real time during lecture
  - Ask questions and they’ll either give answers or alert me (or both)

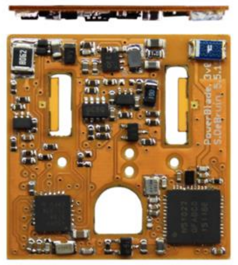
  - In Campuswire: “# Rooms” on left. Then “#realtime-lecture-questions”.

COVID

- We’re all figuring this out together
  - Please be patient and empathetic, and we will be too
- Masks in class/office hours are **mandatory**
- If you are sick, do not come to class
  - We’ll be flexible with deadlines if we need to be
  - Lectures are being recorded automatically
- Contact me (via Campuswire) and we’ll figure it out

Branden Ghena (he/him)

- Assistant Faculty of Instruction
- Education
  - Undergrad: Michigan Tech
  - Master's: University of Michigan
  - PhD: University of California, Berkeley
- Research
  - Resource-constrained sensing systems
  - Low-energy wireless networks
  - Embedded operating systems
- Teaching
  - Computer Systems
    - 211: Fundamentals of Programming II
    - 213: Intro to Computer Systems
    - 343: Operating Systems
    - CE346: Microprocessor System Design
    - 397: Wireless Protocols for the IoT



Tock

Things I love

twitch

Today’s Goals

- Discuss **why** we teach (and require) this class
- Describe how this class is going to function
- Introduction to working in Unix shell (command line)

Outline

- **Why?**
- Course Overview
- Unix Shell

C - the most important programming language

- Old (1972), but nowhere near the first programming language
  - FORTRAN, LISP, ALGOL, COBOL, Basic, B, and many others came first

- Right time, right place, right capability
  - Enables both low-level control and (relatively) high level thinking
  - Fast, efficient, and highly portable

- Inspired everything that has come since
  - C syntax is copied partially or completely in MANY other languages
  - Lessons learned from using C inspired improvements to make programming easier

C++ - an evolutionary addition to C

- Additional features on top of C
    - Most important: classes to support Object Oriented Programming
    - Also includes a significant amount of libraries that C does not

- Enables more complicated software design
    - Manages which part of code can access which things at which times
    - Manages how things are named and referred to
    - Manages errors to help software respond to them

Things written in C/C++

- All major modern operating systems are partially or entirely C
    - Windows, Linux, MacOS, Android, iOS
- Scientific computing (mix of C and C++)
    - Mathematica, MATLAB, various scientific libraries
- Video game engines (often C++)
    - Unreal Engine, Unity, CryEngine
- Embedded control systems (usually C, occasionally C++)
    - Cars, Airplanes, Satellites and Rovers, Thermostats, Webcams, …

Upsides to C and C++

- You are in charge of everything
  - You can do anything you want without constraints

- Capable of directly interacting with hardware ("systems language")
  - Grab exactly as much memory as you need and manage it yourself
  - Makes it incredibly fast (~100x faster than Python)
  - Makes it incredibly efficient (no memory is wasted)

- These lead to the languages being very widely used
  - Top five programming languages for decades include C and C++

Downsides to C and C++

- You are in charge of everything
  - And nothing is taken care of for you

- Things you "can't" do are *undefined behavior*
  - To enable portability, the languages just straight-up don't say what happens if you violate the rules
  - The computer could do *anything*

- Backwards compatibility means features are only ever added
  - You'll see this especially in C++, C just has less features total
  - C++ feels like a bunch of things stapled together
    - And there's an amazing programming language hiding in there

Analogies for programming languages

- Python
  - Great beginner’s car you can drive without a license
  - Unless you want to go really fast or on bad terrain, you may never need another car

- C
  - A racing car that goes incredibly fast but breaks down every fifty miles

- C++
  - A souped-up version of the C racing car with dozens of extra features that only breaks down every 250 miles
  - But when it breaks down, nobody can figure out what went wrong

http://users.cms.caltech.edu/~mvanier/hacking/rants/cars.html

So why teach C and C++?

- You’ll learn a lot more about programming
    - Syntax and ideas from C inspired a lot of other languages
    - Feels very different from Racket or Python

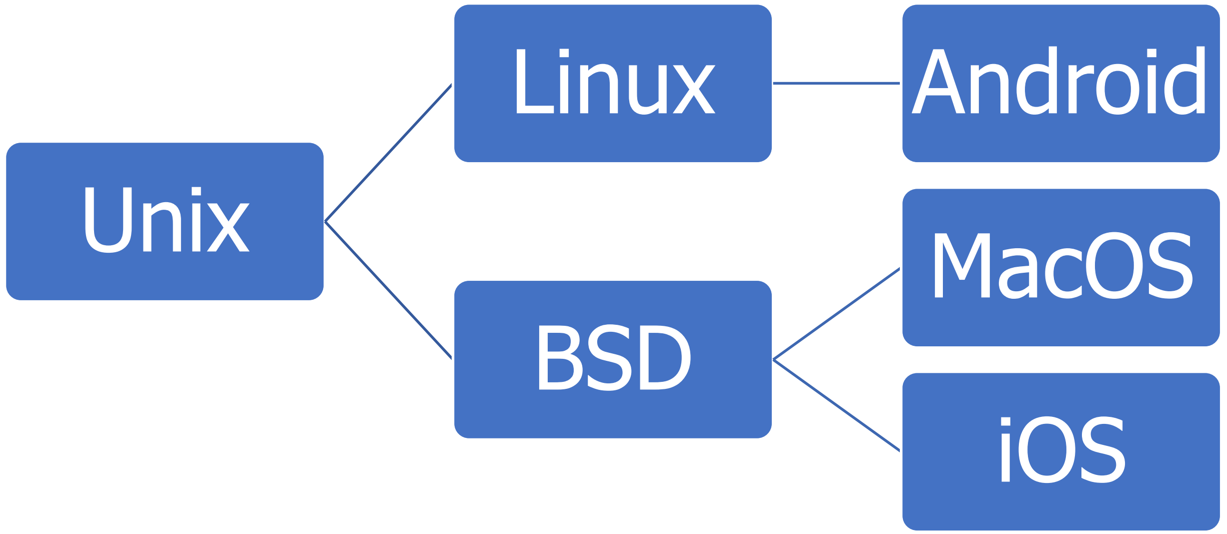
- You’ll become a better programmer
    - You’re going to run into a lot of errors and problems in this class
    - Hopefully they teach you to better design and plan your code

- Prepare you to dig deeper into computer systems
    - A “systems language” is needed to interact directly with hardware
    - Major options: Pascal, C, C++, Ada, Rust

Unix

- A wildly popular operating system in the 1970s and 80s

- Today refers to the *family* of operating systems inspired or grown from Unix
  - Particular design style for "everything is a file"
  - Various tools the OS is expected to provide
  - Command line interface, also known as a "shell"



C and Unix were born together

- Operating systems used to be written in assembly
  - Basic instructions specific to a certain processor family (see CS213)
  - So supporting a new computer type meant rewriting all of your software

- Unix development started in 1969 by Ken Thompson and Dennis Ritchie
  - Developed at Bell Labs, which was a computing research powerhouse

- C language was created in 1972 by Dennis Ritchie to write Unix programs
  - And they quickly rewrote the whole OS in C as well
  - This made the OS simpler to modify and easier to **port** to new systems
  - Unix became *enormously* popular due in part to its portability

Unix shell

- Text-based interface to a computer
  - Compare to graphical interfaces that need a mouse

- Necessary for remote interactions with many computers
  - Cloud servers
  - Specialized “headless” hardware

- Can be incredibly efficient and powerful
  - Find all JPEG files in this folder and change to be PNGs
  - **`mogrify –format png *.jpg`**

So why teach Unix shell?

- Many future classes are going to require you to work on a specialized computer that is shared by the class
  - More resources, specific capabilities, etc.

- Add another basic computing tool to your skillset
  - You might not use shell every day
  - But maybe you might

- You get to feel like a “hacker”

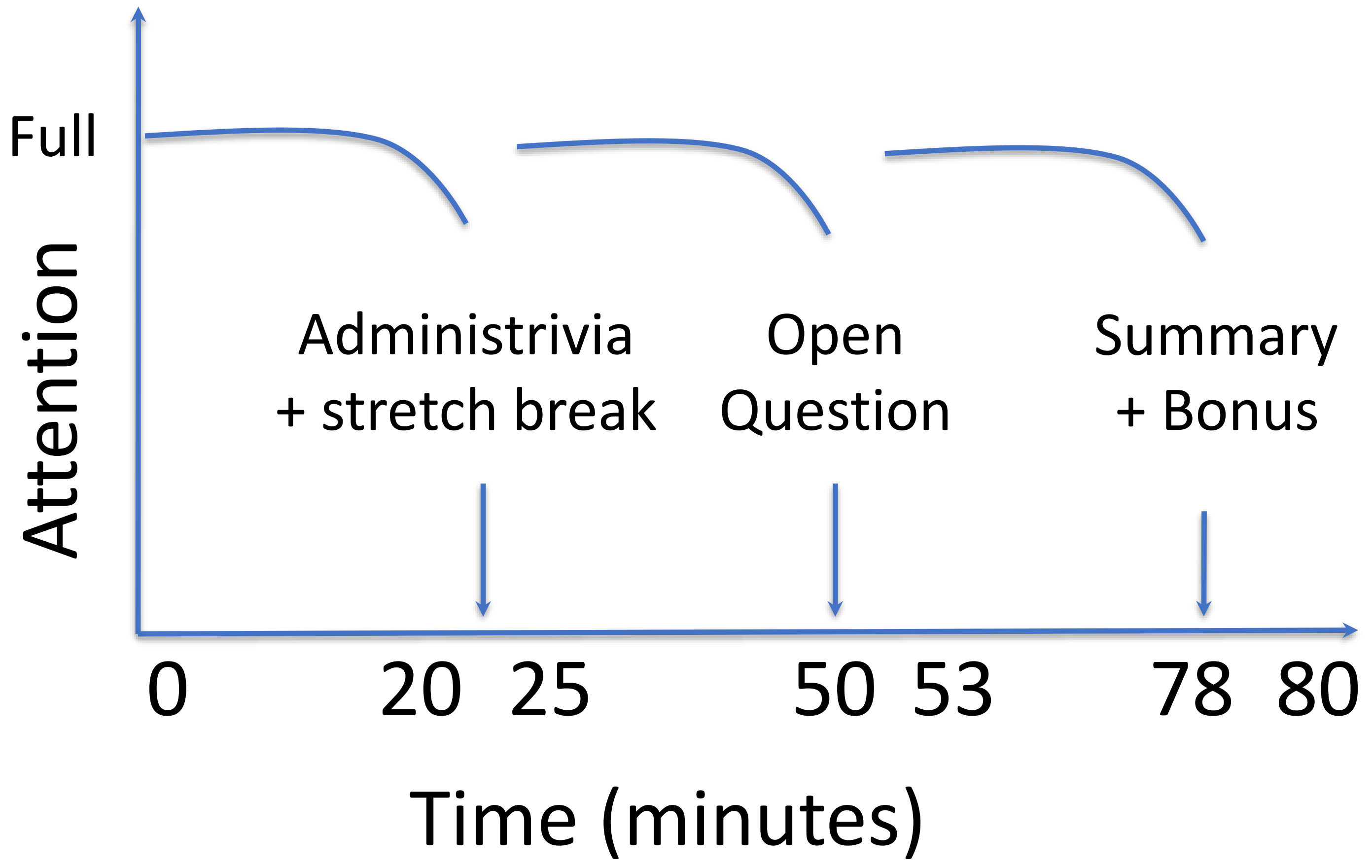
So, why CS211?

- It’s going to make you a **much** better programmer

- It’s going to teach you a bunch of new skills

- It’s going to enable you to succeed in future classes

Architecture of a lecture



Outline

- Why?
- **Course Overview**
- Unix Shell

Lectures

- Tuesdays and Thursdays here!
  - Please don’t sit in the balcony, it’ll be impossible to hear you
- In general, questions are gonna be tough with masks
  - Solution: chatroom in Campuswire
  - You can also ask questions out loud!
- Lectures should be recorded
  - In Canvas under the Panopto tab a few hours after class

Grade composition

Category	Count	Total Value
Labs	5 (likely)	5%
Quizzes	4	10%
Homework	6	60%
Final project	1	25%

Labs

- Small, guided practice sessions to help you learn
  - Teach you a new skill/language

- Two parts
  - **Lab guide** will walk you through doing some things
  - **Lab assessment** on Canvas will ask a few short questions about it
    - Should be easy if you did the lab

- These are not formal assignments or quizzes
  - You may work with others on them

Quizzes

- Multiple quizzes instead of a big exam
  - Should be four total
  - Each is roughly 15-20 minutes

- Quizzes cover mainly material from the last two weeks
  - But build upon knowledge from the entire course

- More details on these to come

Homeworks

- Programming assignments with about a week to complete it
  - This is where you’ll learn the most in class

- First four are C, last two are C++

- Homeworks 1 and 5 are on your own
- Other homeworks are with a partner of your choosing

- These are serious. Be careful about academic integrity on these

Final Project

- A bigger homework, where you get to choose what you want to do
  - Done with a partner of your choosing

- Make an "interactive program" (usually a game)
  - Examples: Pacman, Tetris, Two-dots, Checkers, Desert Bus

- This is your chance to do something interesting and fun!
- Can be a significant amount of work though

Relative homework difficulties

Homework	**Difficulty**
Hw01	2
Hw02	5
Hw03	7
Hw04	11
Hw05	6
Hw06	9
Final Project	10ish*

← Hw04 is the last in C
one week break
Hw05 is the first in C++

* But really it's up to you

Late Policy

- You can submit *homeworks* late
- 10% penalty to maximum grade per day late
    - Example: three days late means maximum grade is 70%
- Quizzes and labs cannot be submitted late
- Final project cannot be submitted late without instructor permission

Slip Days

- Slip days let you turn in a homework late and receive no penalty

- Each student gets **3 slip days**
  - Apply to **homeworks only**
  - You don’t need to tell us you’re using them, we’ll just automatically apply them at the end of the year
  - Be sure to coordinate about them on partner assignments

- Examples:
  - Turn in hw01 three days late
  - Turn in hw04 two days late and hw06 one day late
  - Turn in hw02 four days late with only a one-day penalty

Collaboration in CS211, three levels:

1. **Partner Collaboration**
   - Your code and the other student's code are identical because you share it and work on it together
   - ONLY for registered partners on specified homeworks

2. **Close Collaboration**
   - You communicate about code however you see fit
   - ONLY acceptable for labs

3. **Arms-Length Collaboration**
   - You discuss problems and solutions at a high level
   - MAY NOT read, write, look at, record, or transcribe code
   - MAY NOT have the code up on screen during collaboration
   - MUST cite your sources, both arms-length collaborators and other resources

Refer to syllabus for the official version of this policy

Academic Honesty

- In CS211, we take cheating very seriously

- Cheating is when you:
  - Engage in an inappropriate level of collaboration
    - Such as look at another student’s code

  - Enable another student, *present or future*, to cheat
    - Such as letting a CS211 student read your code next year

  - Fail to cite your sources (friend, Stack Overflow, etc.)
    - Such as you get a big hint and don’t acknowledge where it came from in a code comment

Academic Honesty

- **Please do not cheat in CS211**

1. If you don’t write code, you won’t learn!

2. Cheating on code is super easy to catch!!
    - No, like really really easy
    - All suspected cheating is reported to the relevant dean for investigation
    - Last time I taught it was 8 cases

- If you are unsure about a situation, ask the staff on Campuswire

Getting Help – Campuswire

- Post questions here
  - Staff and I monitor and answer questions
  - You can also answer each other! (or note that you have the same issue)

- I’ll also post useful or interesting notes here

- Do NOT email me. Post to Campuswire instead
  - I won’t see your email until way later and then I’ll feel guilty about it

Getting Help – Office Hours

- Course Staff
  - 2 graduate TAs, and 16 Peer Mentors (the most staff *ever*)

- Office Hours
  - We’re going to host a TON of office hours
  - Mix of remote and in-person
  - Details to follow, schedule on Canvas homepage

Getting Help – Request a Meeting

- Lecture is my side gig

- My main job is helping students succeed

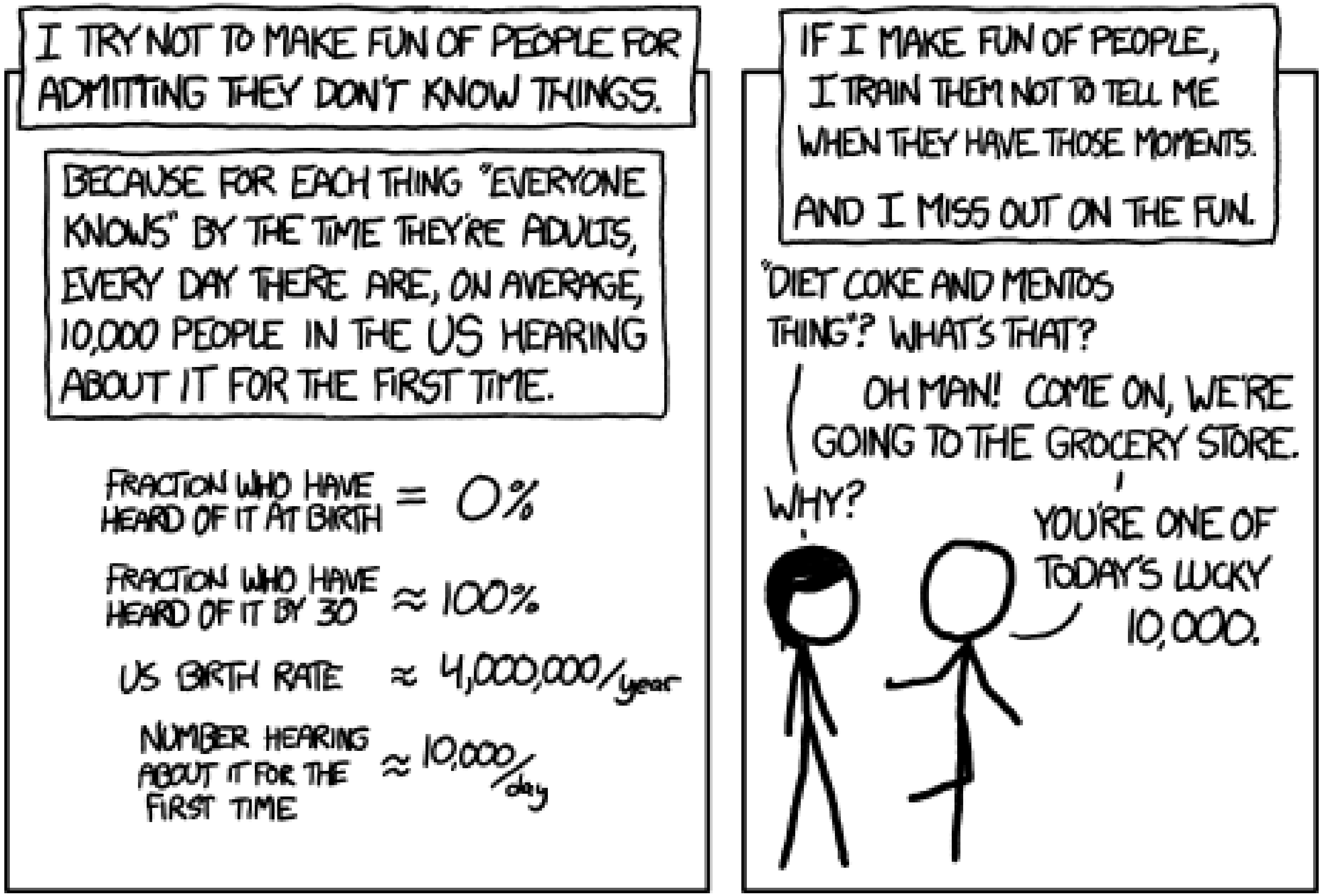
- If you are struggling, reach out and I will meet with you
  - Course material
  - Homework
  - Other stuff going on in your life

Advice

- Submit assignments early and often!

- If you find this course difficult, that’s because it **is** difficult.
- However, nobody fails unless they give up.
- You belong here and can succeed here.
- Be kind to each other.

Break + relevant xkcd


I TRY NOT TO MAKE FUN OF PEOPLE FOR ADMITTING THEY DON'T KNOW THINGS.
BECAUSE FOR EACH THING "EVERYONE KNOWS" BY THE TIME THEY'RE ADULTS, EVERY DAY THERE ARE, ON AVERAGE, 10,000 PEOPLE IN THE US HEARING ABOUT IT FOR THE FIRST TIME.
FRACTION WHO HAVE HEARD OF IT AT BIRTH = 0%
FRACTION WHO HAVE HEARD OF IT BY 30 ≈ 100%
US BIRTH RATE ≈ 4,000,000/year
NUMBER HEARING ABOUT IT FOR THE FIRST TIME ≈ 10,000/day
IF I MAKE FUN OF PEOPLE, I TRAIN THEM NOT TO TELL ME WHEN THEY HAVE THOSE MOMENTS.
AND I MISS OUT ON THE FUN.
"DIET COKE AND MENTOS THING"? WHAT'S THAT?
OH MAN! COME ON, WE'RE GOING TO THE GROCERY STORE.
WHY?
YOU'RE ONE OF TODAY'S LUCKY 10,000.

https://xkcd.com/1053/

Outline

- Why?
- Course Overview
- **Unix Shell**

How do you get a Unix shell?

- Have a MacOS or Linux computer (or set up WSL)

- Install Virtualbox and Linux
  - Installing Ubuntu is free and only takes twenty minutes

- Log in to a class server remotely!
  - This is what we'll do for CS211
  - Lab01 teaches you how to do this

Command line interfaces

- Text-based commands

- Positives
  - It’s easy to be precisely clear about what you want and how things are configured

- Negatives
  - How do you remember everything?

- Reality
  - There will be a few dozen commands you’ll memorize (after practice)
  - And you’ll learn how to look up everything else

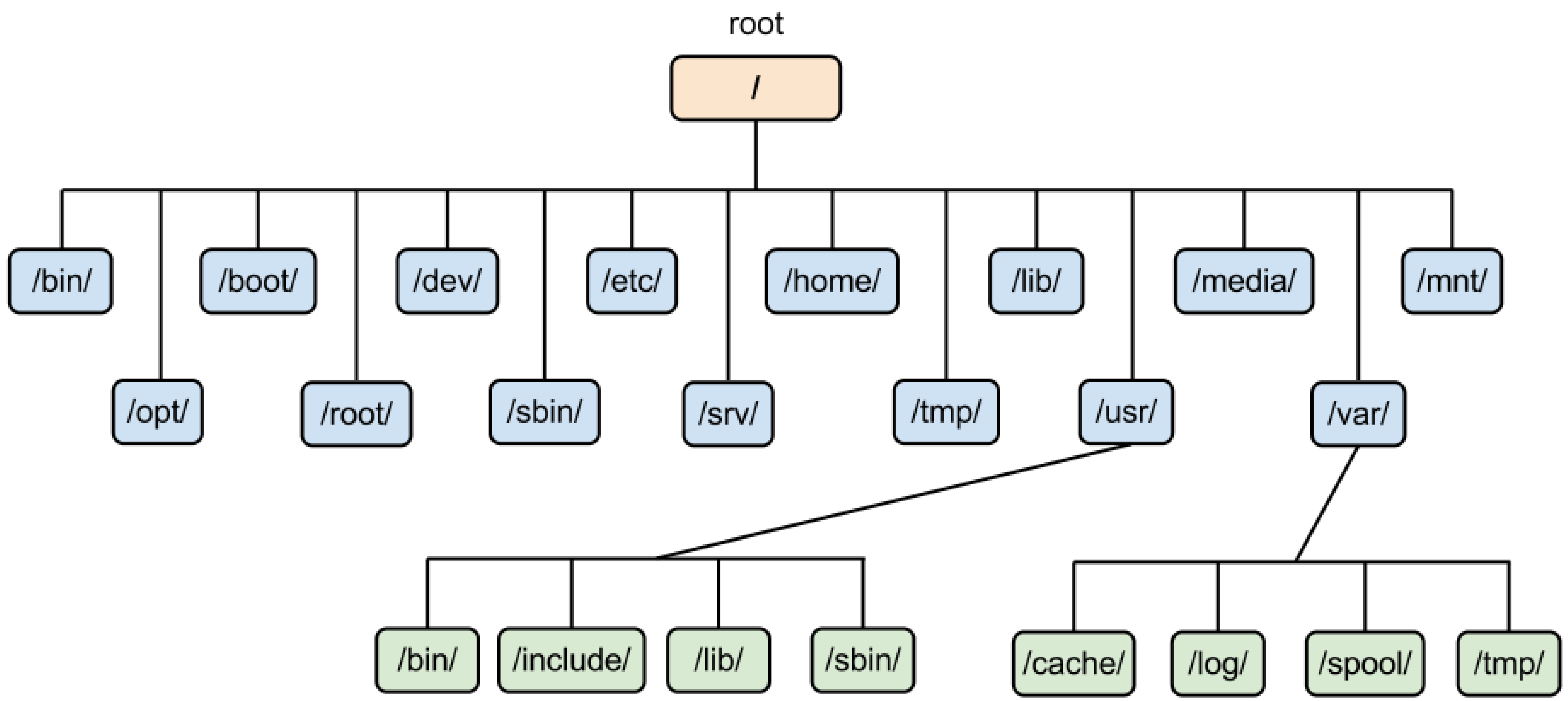
Live code demo!!!

Commands for moving between directories

- Directory structure and moving through it
  - `ls`
    - Lists files in the current directory
  - `cd`
    - Change directory
  - `pwd`
    - Prints the path of the current directory

- Mis-typing something
  - “Command not found” means you tried to run something invalid
  - `fish: `<u>`somecommandyoumistyped`</u>`: command not found...`

Directory structure in Linux



- Example: `/usr/bin/` is the path to user-installed programs

Special paths

`.`	the current directory
`..`	the parent of the current directory
`../../`	the parent of the parent of the current directory
`../../../`	and so on…
`-`	the previous directory you were in before the current one
`~/`	the home directory of the current user (your home)
`~cs211`	the home directory of the user cs211 (works for any user, but you'll probably won't interact with other users)
`/`	the root directory (analogous to `C:\` on windows)

Relative vs absolute paths

- Relative paths are relative to the current directory
    - `../`
    - `src/`
    - `../../code/src/../build/`

- Absolute paths have the full path name to the location
    - `/home/branden/`
    - `/home/branden/cs213/code/`
    - `/home/branden/cs213/code/src/../build/`

Wildcard in path names

- Sometimes you’re not sure exactly what the name is
  - Or there might be multiple files that you want to interact with simultaneously

- The wildcard symbol, *, replaces any number of characters in a path name

- Examples

`ls /home/*/`	List all files in all user’s home directories
`ls ~/cs21*/`	List all files in any directory starting with cs21
`ls code/src/*.c`	List all files that end with “.c” in code/src/

Tab Completion

- Typing takes tooooooooo looooooonnnnggg
  - Solution, let the computer guess what you’re trying to type

- Pressing tab while part-way through typing just about anything in terminal will tab-complete it for you
  - As long as you have typed enough characters so that only one option remains, it will complete it
  - If multiple options remain, it will stop trying

Command flags

- `man`
  - Opens the manual pages for a program
  - Example: `man ls`

- Flags are configurations for a command that change what it does
  - `ls –l` lists files in the current directory in a vertical list with details
  - `ls –t` sorts the ls output by most recently modified
  - `ls –l –t` does both

- You can type multiple flags after a single dash
  - `ls –lt` is equivalent to `ls –l -t`

Searching for things

- `grep –r “text” *`
  - Explanation
    - Grep prints lines matching a pattern
    - The pattern in this case is “text”
    - `–r` means search recursively, i.e. in this directory and all subdirectories
    - * means to search in any file in the current directory
  - Summary
    - Search all the files here and below for the word “text”

Working with files

- `cat path`
  - Prints out the contents of the file
- `mv path1 path2`
  - Moves a file from path1 to path2
- `cp path1 path2`
  - Copies a file from path1 to path2
- `rm path`
  - Deletes (removes) a file

Editing files

- There are many different terminal text editors
  - And there are holy wars about why one is *best*
  - **There is no best. Just use whatever you like**

- Example editors
  - Vim, Emacs, Nano

- In CS211, I’ll be teaching you using the Micro text editor
  - Occasionally I’ll open vim by accident. Someone yell at me when I do
  - https://micro-editor.github.io/

Editing with Micro

- micro filename
  - Opens micro, editing filename

- Works just like any text editor you've used
  - Mouse moves the cursor around, as do the arrow keys
  - Typing makes text appear
    - (This isn't true in some shell editors, looking at you vim)

Ctrl-s	save the file
Ctrl-o	open a file
Ctrl-q	quit

Build a C file if there's enough time

- Lab01

- https://nu-cs211.github.io/cs211-files/lab/lab01.pdf

Don’t be overwhelmed!!!!

- You have plenty of time to learn this
- Lab01 guides you through the same kinds of commands I did today, step by step
- Practice is the only thing that will really help
  - And CS211 will give you plenty of practice

Helpful guides

- Great lecture notes on using the shell
  - https://swcarpentry.github.io/shell-novice/

- Tool to explain various shell commands
  - https://explainshell.com/

- Tool to explain how to use various shell commands
  - Just type the command into the box at the top
  - https://tldr.ostera.io/

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