

CS107e

Computer Systems from

the Ground Up

Philip Levis,
Peter McEvoy, Sean Konz,
Jane Lange

Spring 2020

<https://cs107e.github.io/>



Phil



Jane



Sean



Peter

Class Meeting Protocol

A CA helps manage questions: everyone is muted.

If you have a question, put a message in chat that you'd like to ask a question.

The CA will interrupt me to tell me there's a question from you and will unmute you.

Class Meeting Protocol 2

I'd like it if you can have video on, so we can see your faces and get to know you, but if you'd rather not, that's OK. If you'd like to keep your video off, then please ask questions so we can at least get to know your voice.

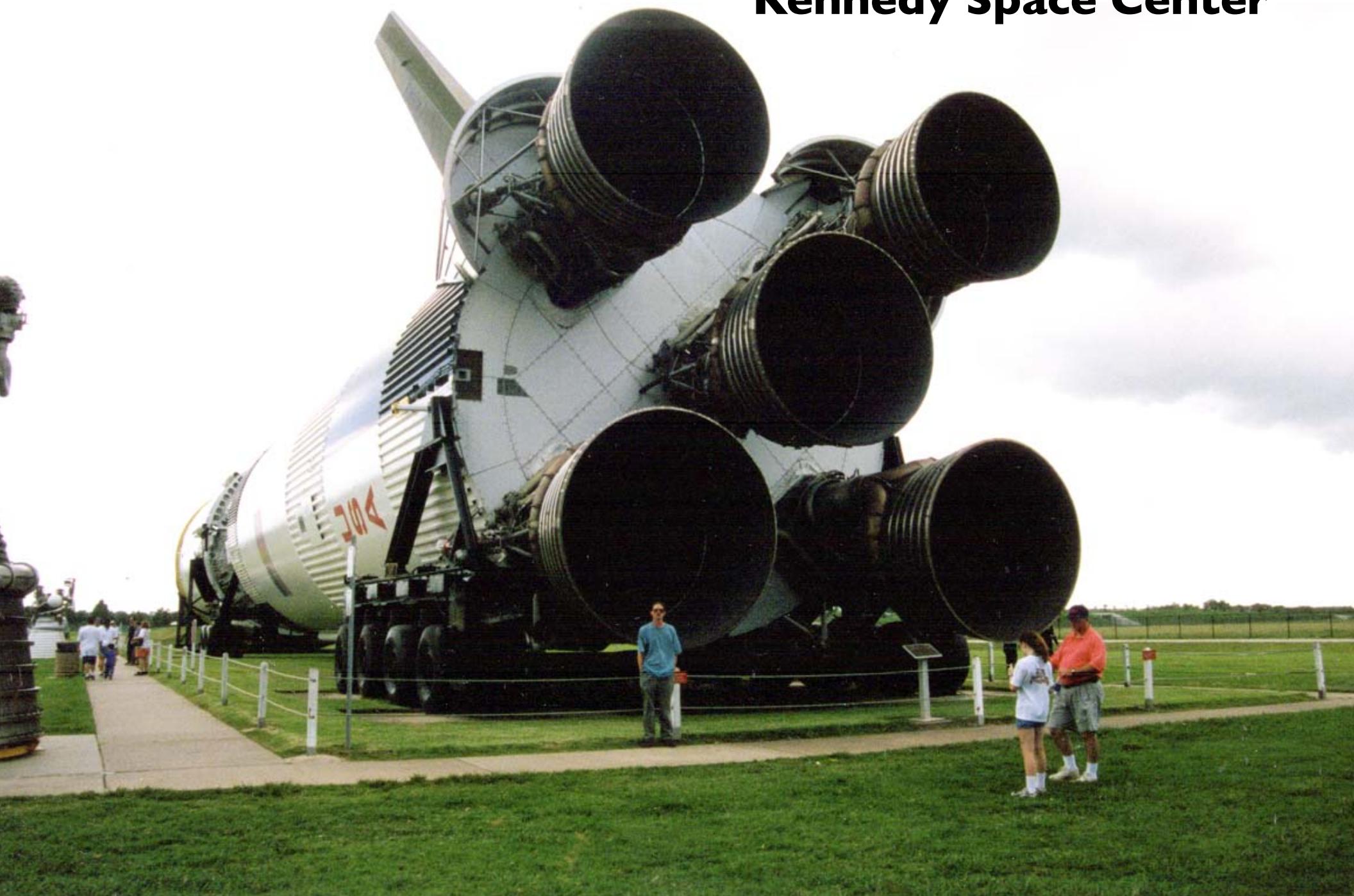
Any Questions?

Learning Goal I

Understand how computers
represent data,
execute programs,
and control peripherals

Saturn V

Kennedy Space Center



Command Module

64,000 lbs

Saturn V
6,200,000 lbs

Payload

1.5% of total weight

Falcon 9



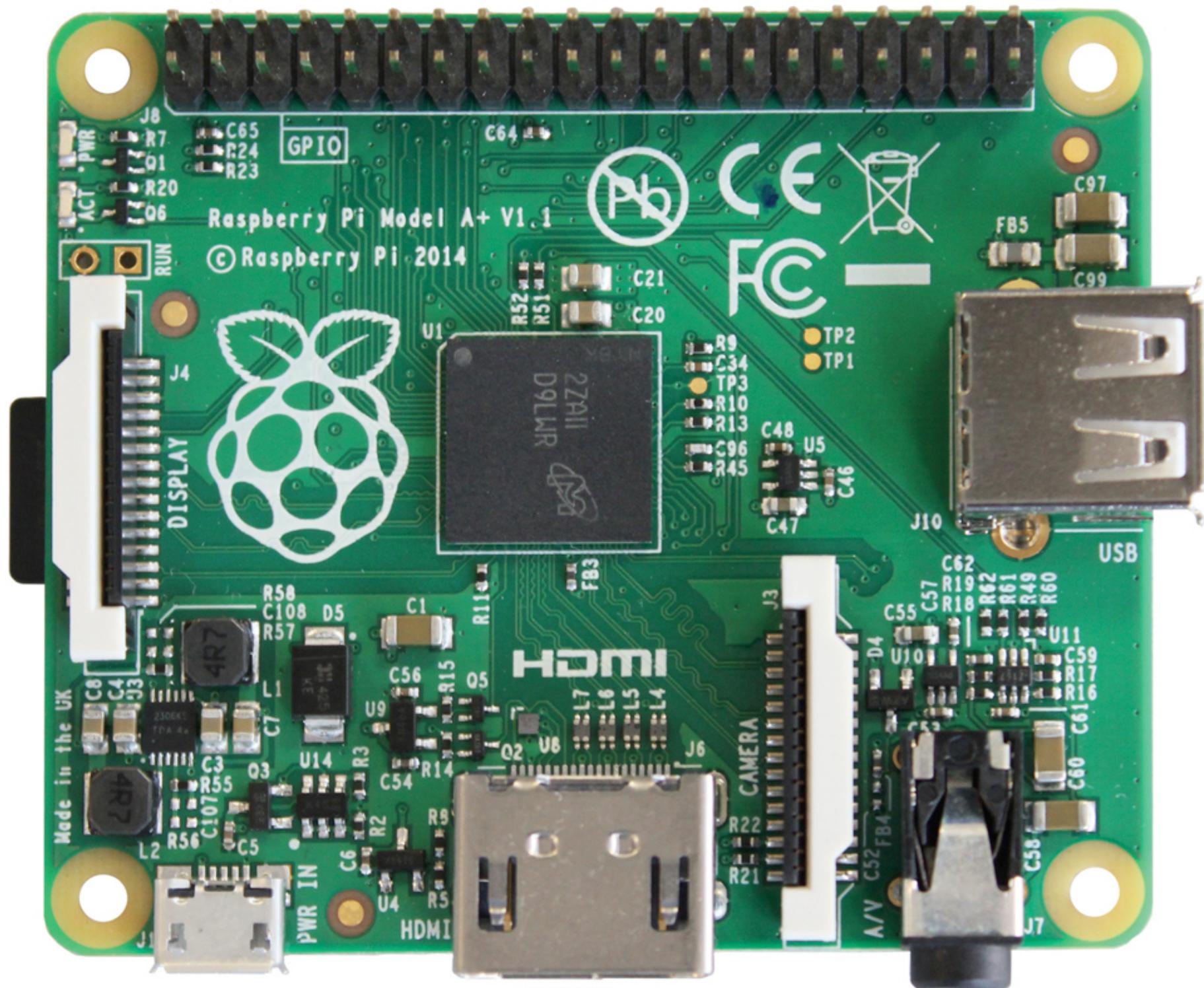


Understanding is Empowering

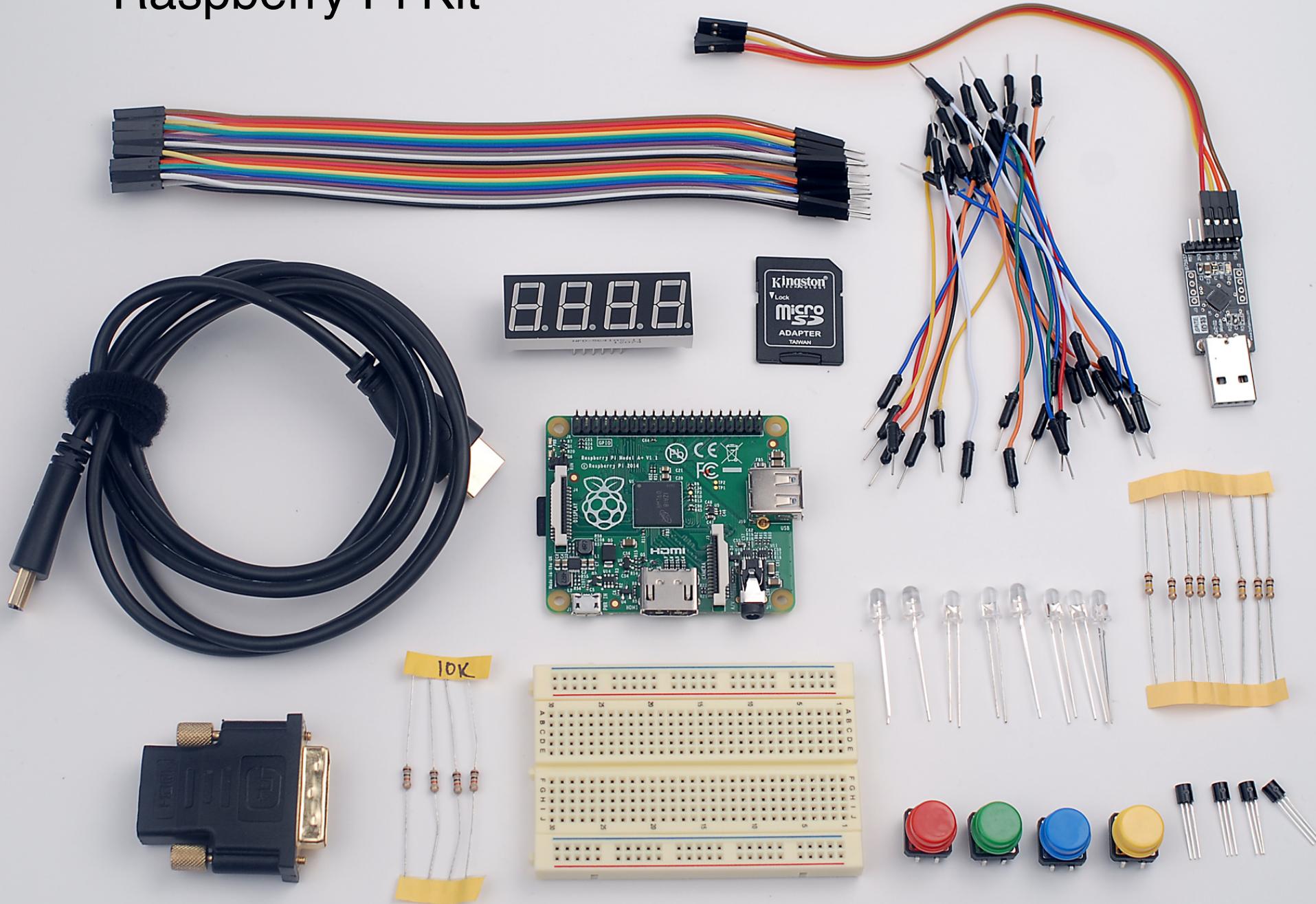
Bare Metal on the Raspberry Pi

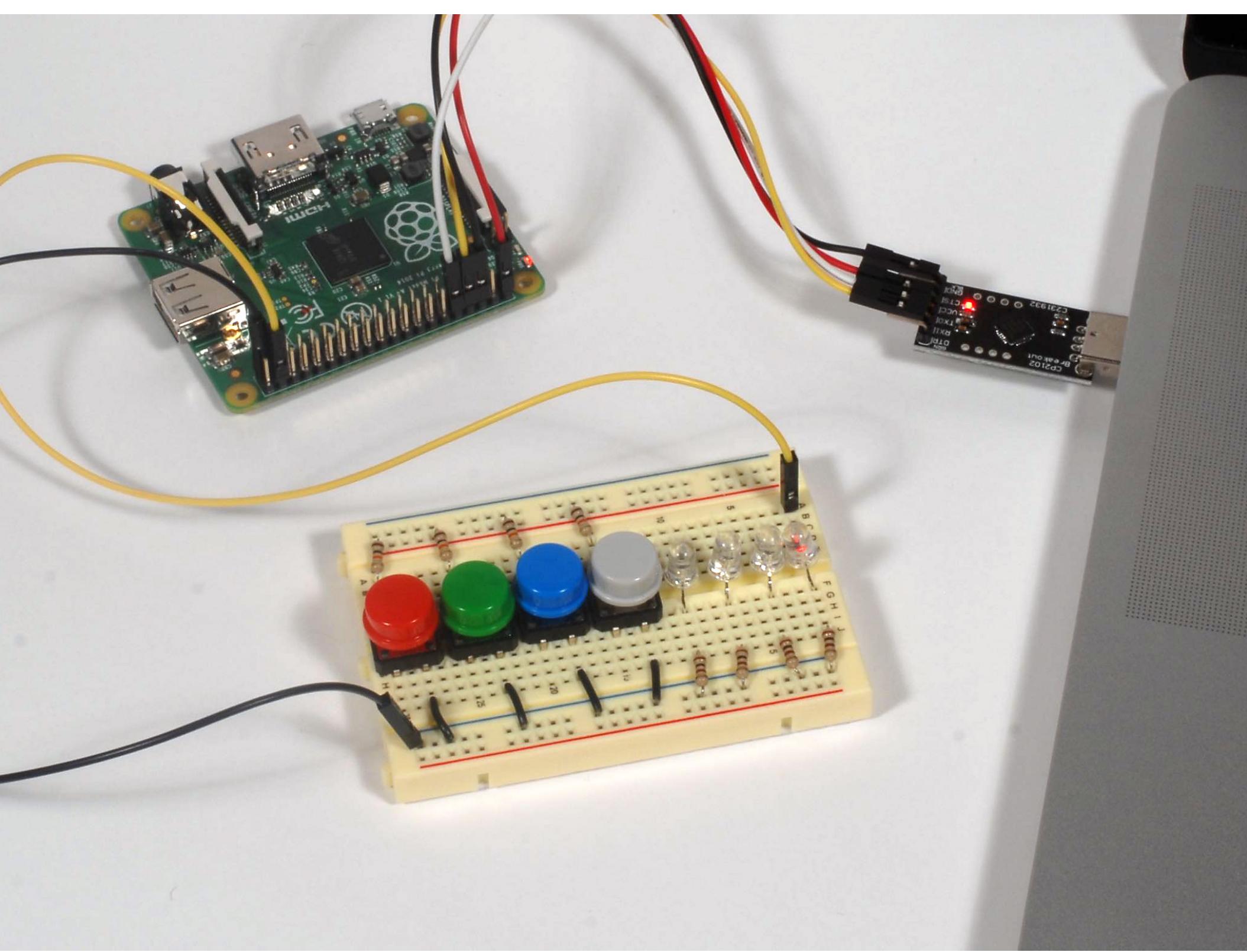
Definition: Bare metal programming involves no operating system (programmer constructs libraries)

Bare metal programs boot and startup on their own, and directly control peripherals



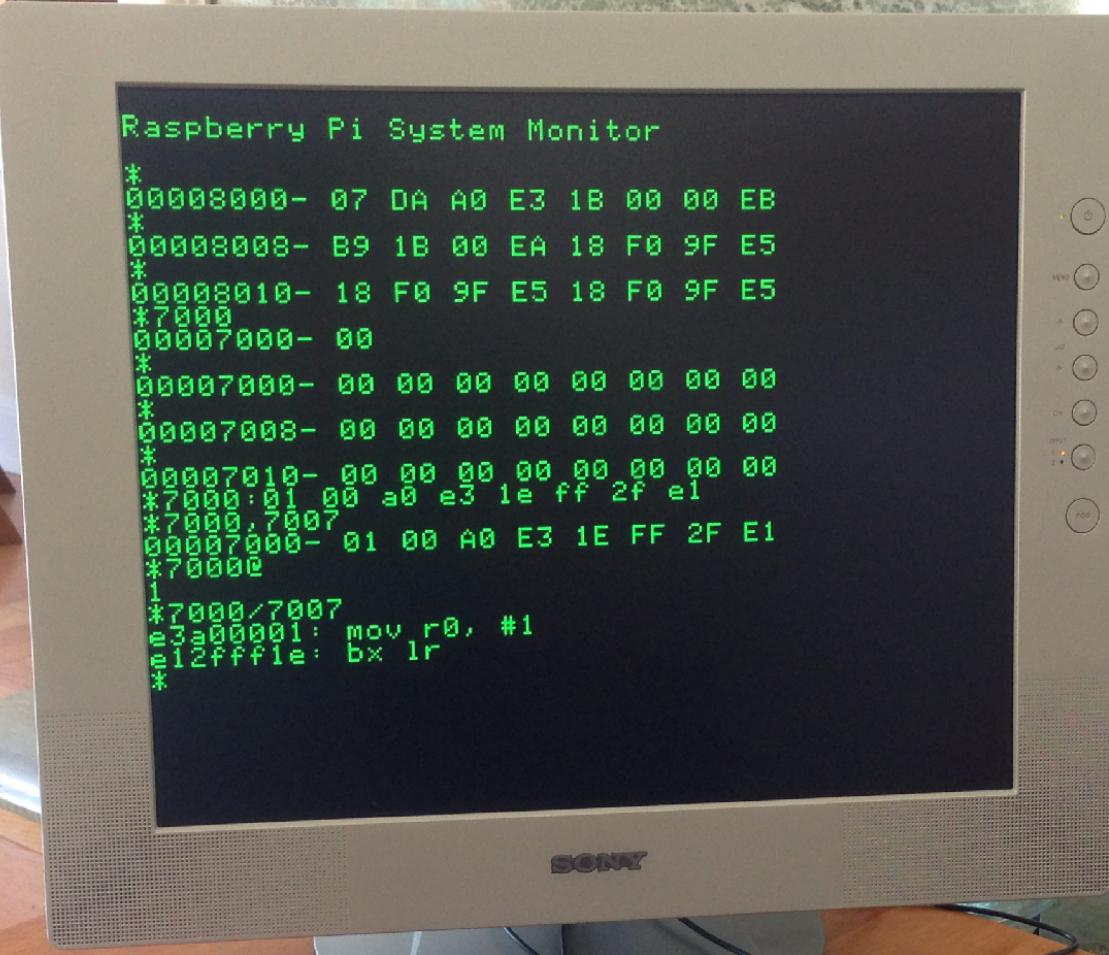
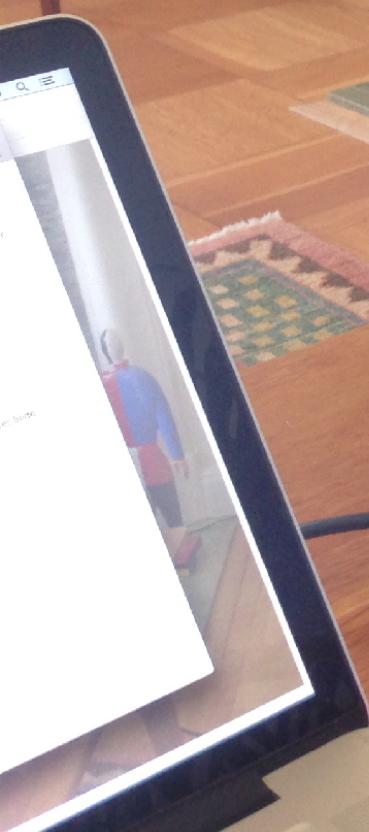
Raspberry Pi Kit





Raspberry Pi Shell

```
Raspberry Pi System Monitor  
*  
00008000- 07 DA A0 E3 1B 00 00 EB  
*  
00008008- B9 1B 00 EA 18 F0 9F E5  
*  
00008010- 18 F0 9F E5 18 F0 9F E5  
*7000  
00007000- 00  
*  
00007000- 00 00 00 00 00 00 00 00  
*  
00007008- 00 00 00 00 00 00 00 00  
*  
00007010- 00 00 00 00 00 00 00 00  
*7000:01 00 a0 e3 1e ff 2f e1  
*7000,7007  
00007000- 01 00 A0 E3 1E FF 2F E1  
*70000  
1  
*7000/7007  
e3a00001: mov r0, #1  
e12fffffe: bx lr  
**
```



**Almost every instruction
will be code you've written!**

Learning Goal 2

Master your tools

Software Tools

UNIX command line: bash, cd, ls, ...

Programming languages: C, ...

gcc

as

ld

binutils: nm, objcopy, objdump, ...

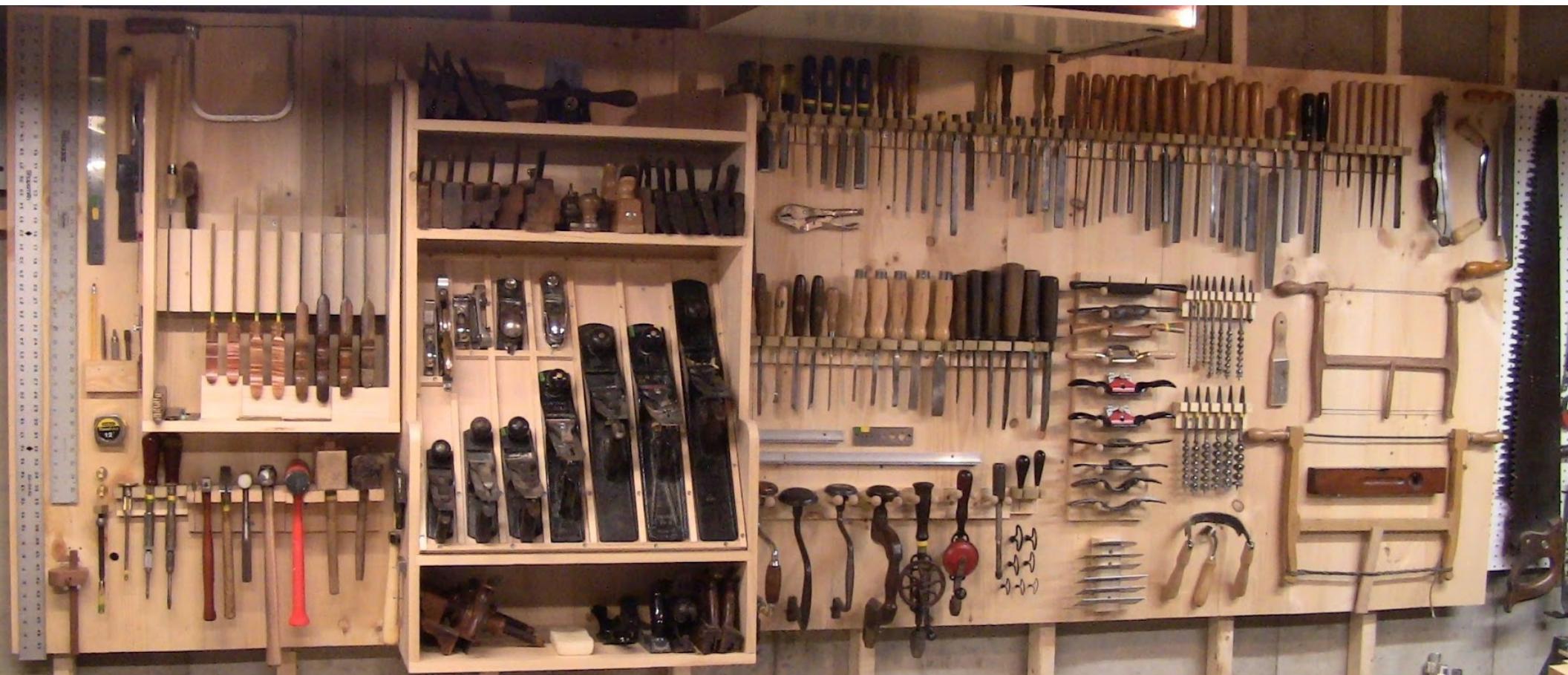
make

git and github.com

documentation: markdown



Different Tools for Different Jobs



<http://dans-woodshop.blogspot.com/>

Organized Development Environment



<http://amhistory.si.edu/juliachild/>

Don't Avoid Activation Energy

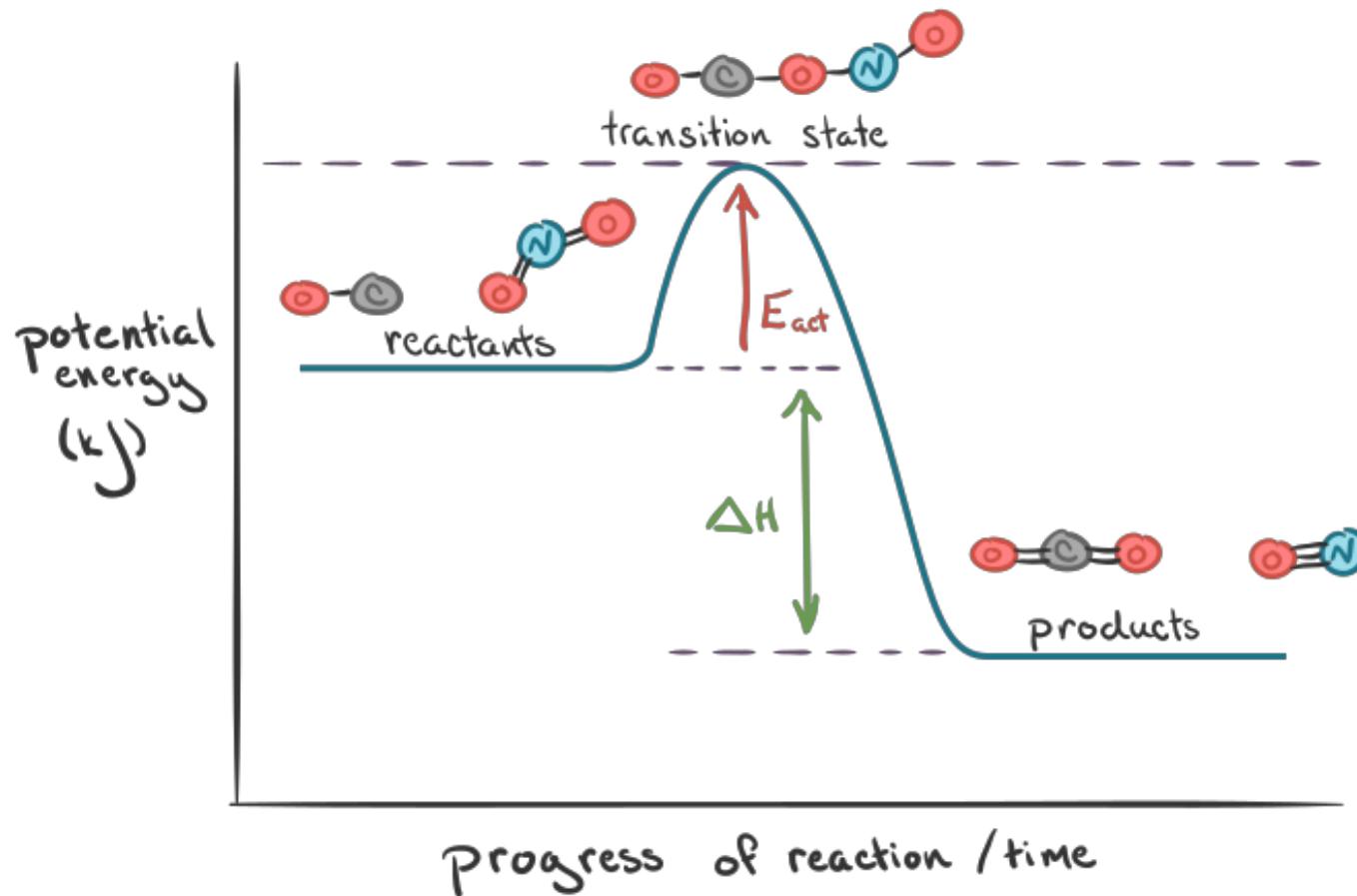


Figure from Khan Academy

<https://www.khanacademy.org/test-prep/mcat/chemical-processes/thermochemistry/a/endothermic-vs-exothermic-reactions>

Don't Avoid Activation Energy

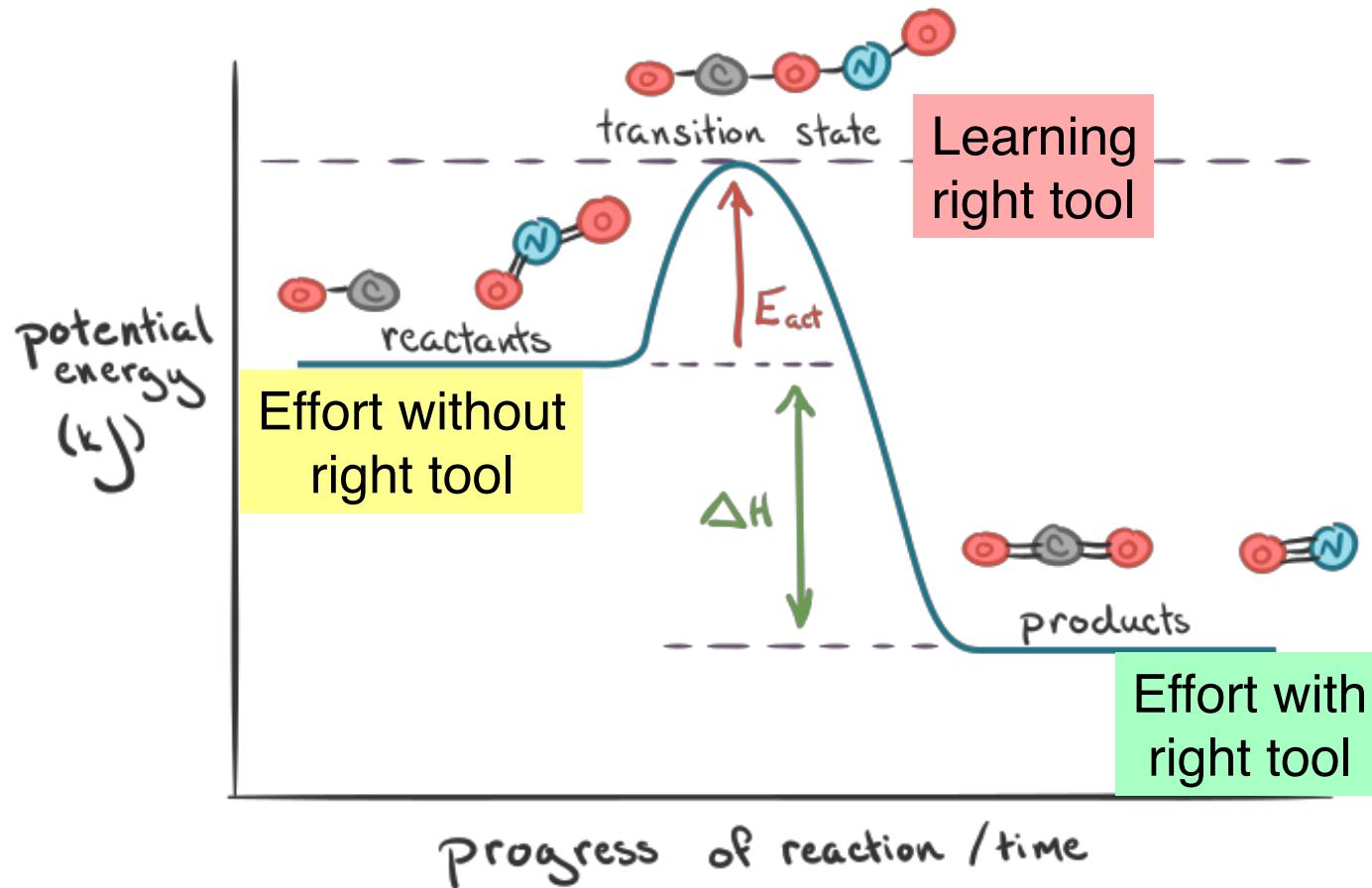


Figure from Khan Academy

<https://www.khanacademy.org/test-prep/mcat/chemical-processes/thermochemistry/a/endothermic-vs-exothermic-reactions>

Hyperbolic Discounting

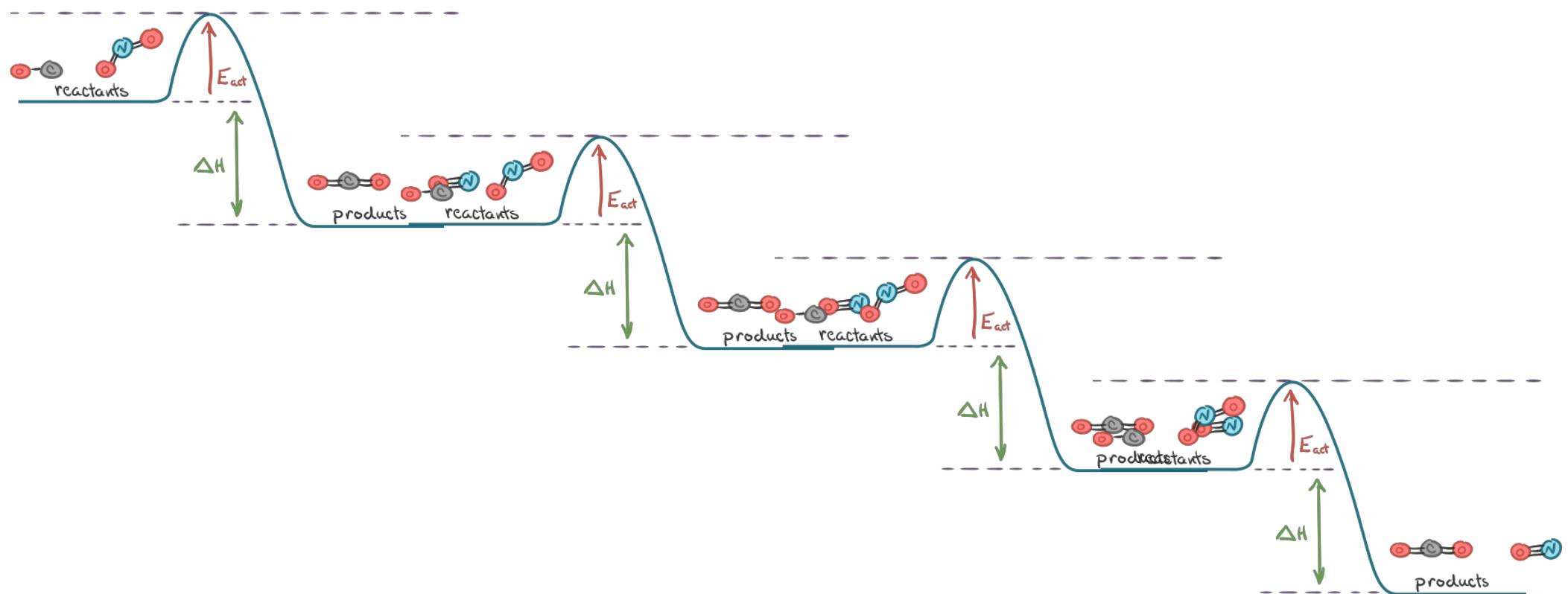


Hyperbolic Discounting



A close-up photograph showing a person's hands working on a piece of wood. The person is using a chisel to shape a dark, rectangular block of wood that is resting on a larger, lighter-colored wooden board. The background shows a workshop environment with various tools and equipment. A bottle of water is visible on the right side.

Practice, Practice, Practice



It never ends... 1000x improvements possible!

Jeff Dean
Mark Horowitz over dinner
Radio SPI bug

Figure from Khan Academy

<https://www.khanacademy.org/test-prep/mcat/chemical-processes/thermochemistry/a/endothermic-vs-exothermic-reactions>

Debugging and Troubleshooting



Course Topics

cs107e.github.io

§ I Bare Metal Programming

1. ARM processor and memory architecture
2. ARM assembly language and machine code
3. C
4. Functions
5. Serial communication
6. Linking and loading
7. Memory allocation

§2 Personal Computer

- I. Keyboard**
- 2. Graphics**
- 3. Interrupts**

Goal: Build Raspberry Pi shell

§3 Additional Topics

- 1. Sensors**
- 2. Performance**
- 3. Towards Linux and beyond**

And a special guest lecture!

Administration

Weekly Cadence

Each week has a focus topic

Pair of coordinated lectures on Fri and Mon

Mandatory lab on Wednesdays

Assignment handed out Wed evening (after lab),
YEAH hours on Thu, assignment due following Tue at
6 pm (before Tue lab)

Laboratories

Attendance is **mandatory**

Do exercises and complete check-list

Leave lab ready for assignment: walks you through tricky bit (hardware/software interface) to get you started

Philosophy: lots-of-help, hands-on, collaborative

Course lab fee: \$75 (your RPi kit)

Assignments

7 assignments

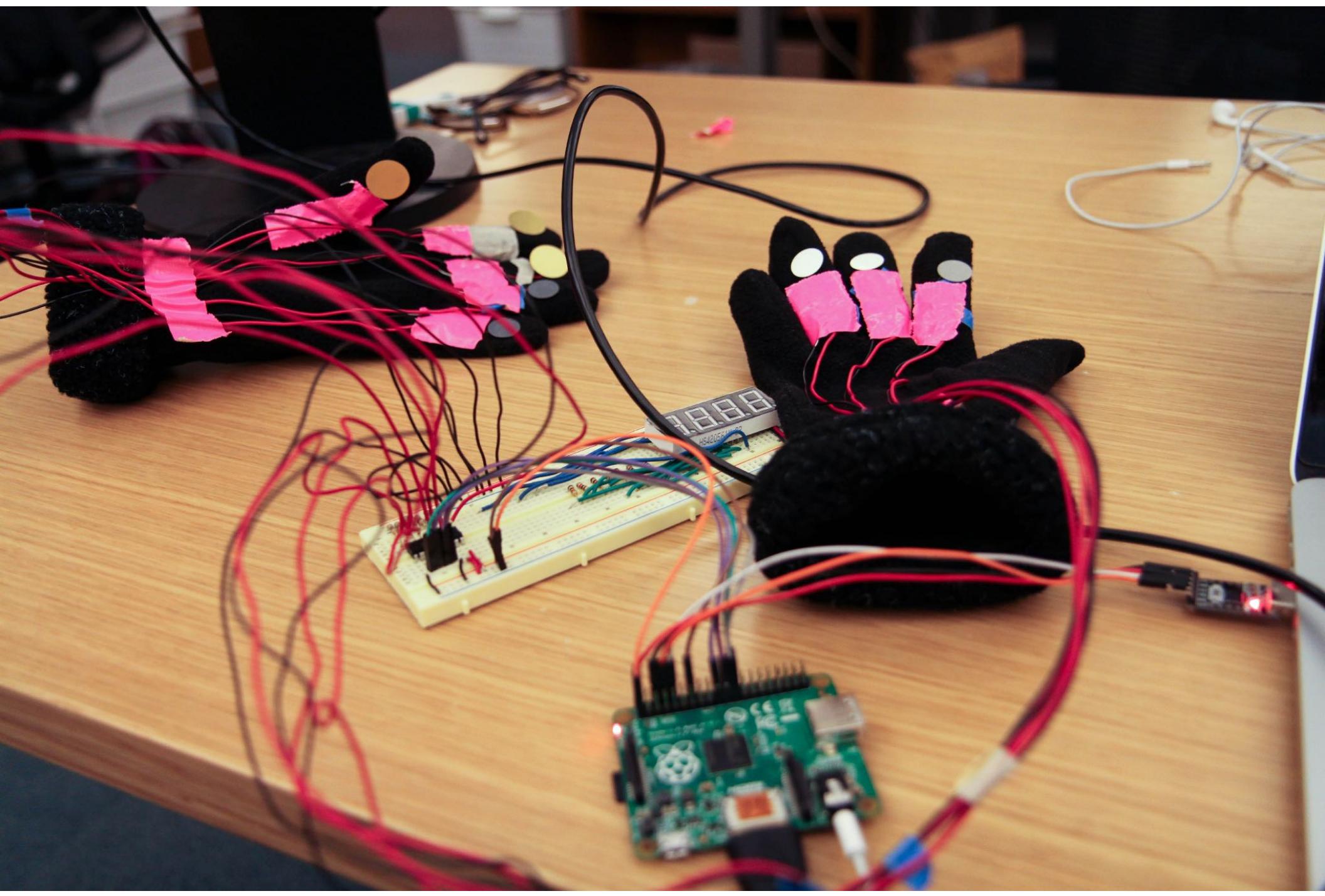
- **Build** on each other

Two parts for each assignment

- Basic (required, tight spec, guided steps)
- Extension (optional, opportunity for your exploration/creativity)

Final project demonstrations on Wednesday, June 10

- Scaled back due to lack of exam period, physical lab resources
- Encourage you to play with some hardware (e.g. sensors)

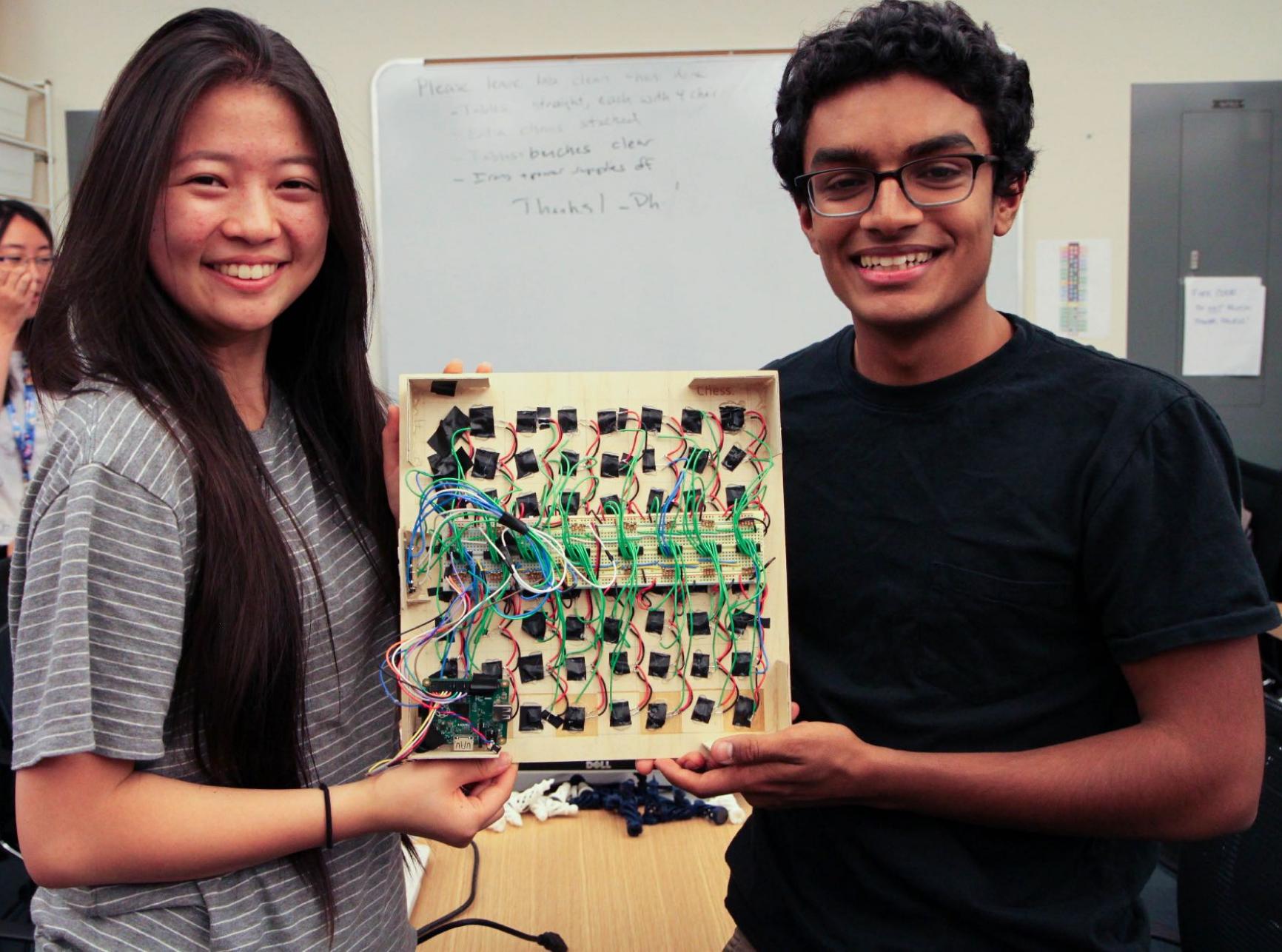




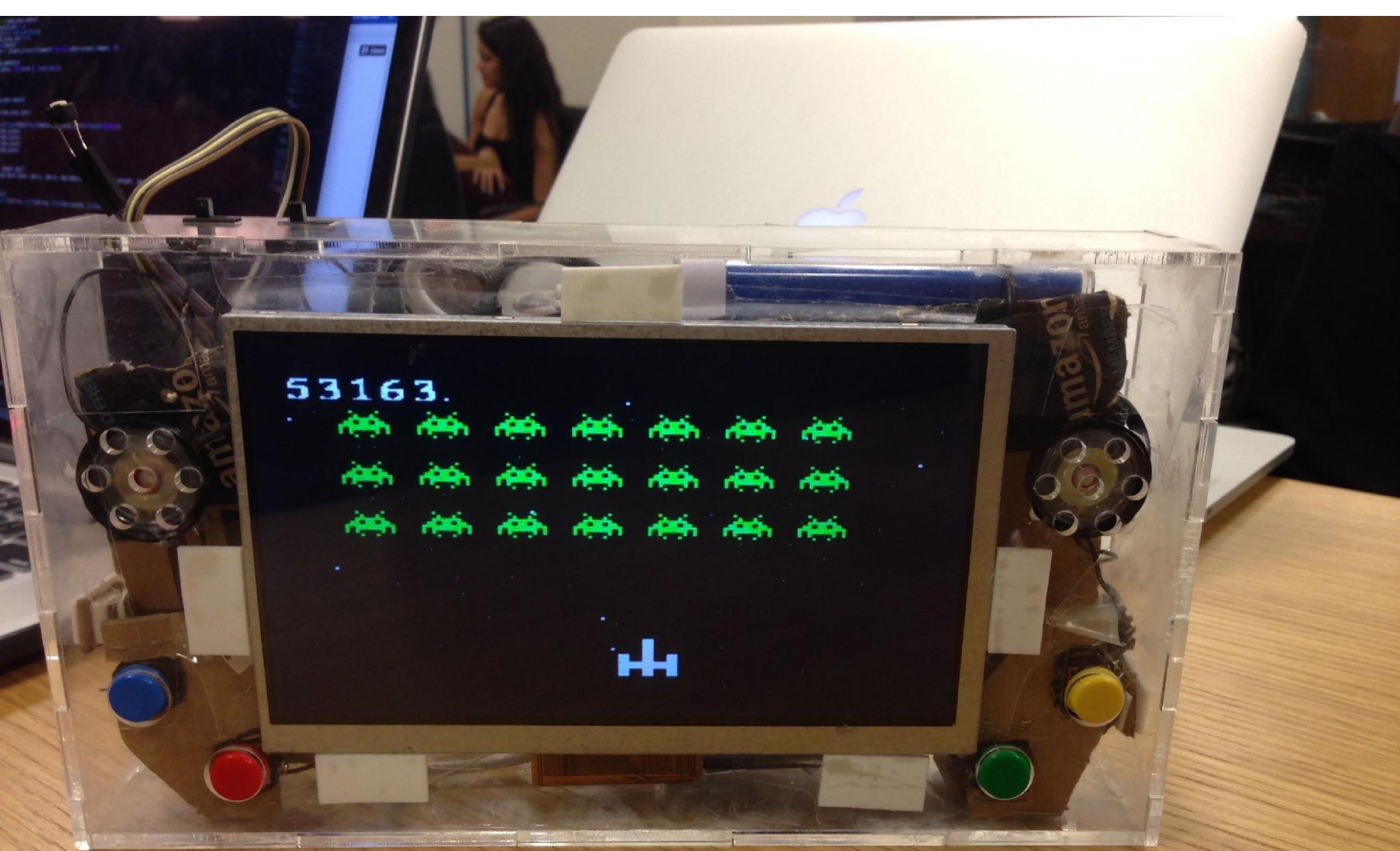


Please leave box clean - no dust
- Tables straight, each with 4 chairs
- Extra chairs stacked
- Tissue boxes clear
- Irons & paper supplies off

Thanks! - Dh







First Week

Assignment 0

TODOs

- Join forum piazza.com/stanford/spring2020/cs107e
- Read and understand our guides on basic topics (electricity, numbers, unix)
- Create github account and send us your GitHub id
- Install/setup your development environment
- Submit your lab preference (we will do our best to get you the lab you want)

Number Representations

Binary representation

Hexadecimal

Bit operators

Guide: <https://cs107e.github.io/guides/numbers/>

Basic Electricity

Voltage and current

Ohms Law : $V = I R$

Power : $P = IV$

Driving an LED

Transistor switches

Breadboarding

Guide: <https://cs107e.github.io/guides/electricity/>

Unix Command Line

Moving around the file system

Creating, moving, and deleting files

Compiling and running programs

Profiles and paths

Guide: <https://cs107e.github.io/guides/unix/>

Watch cs107 UNIX videos!