CS107e
Computer Systems from the Ground Up

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https://cs107e.github.io/

https://edstem.org/us/courses/21299/

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Liana

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Learning Goal 1

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

OK

```
int counter;
int calc() {...}
```

```
int a = 20;
unsigned int b = 6;
if (a < b) {...}
```

Not OK

```
int calc() {
  int counter;
  ...
}
```

```
int a = -20;
unsigned int b = 6;
if (a < b) {...}
```

OK

```
int counter;
int calc() {...}
```

Not OK

```
int calc() {
   int counter;
   ...
}
```

```
int a = 20;
unsigned int b = 6;
if (a < b) {...}
```

```
int a = -20;
unsigned int b = 6;
if (a < b) {...}
```

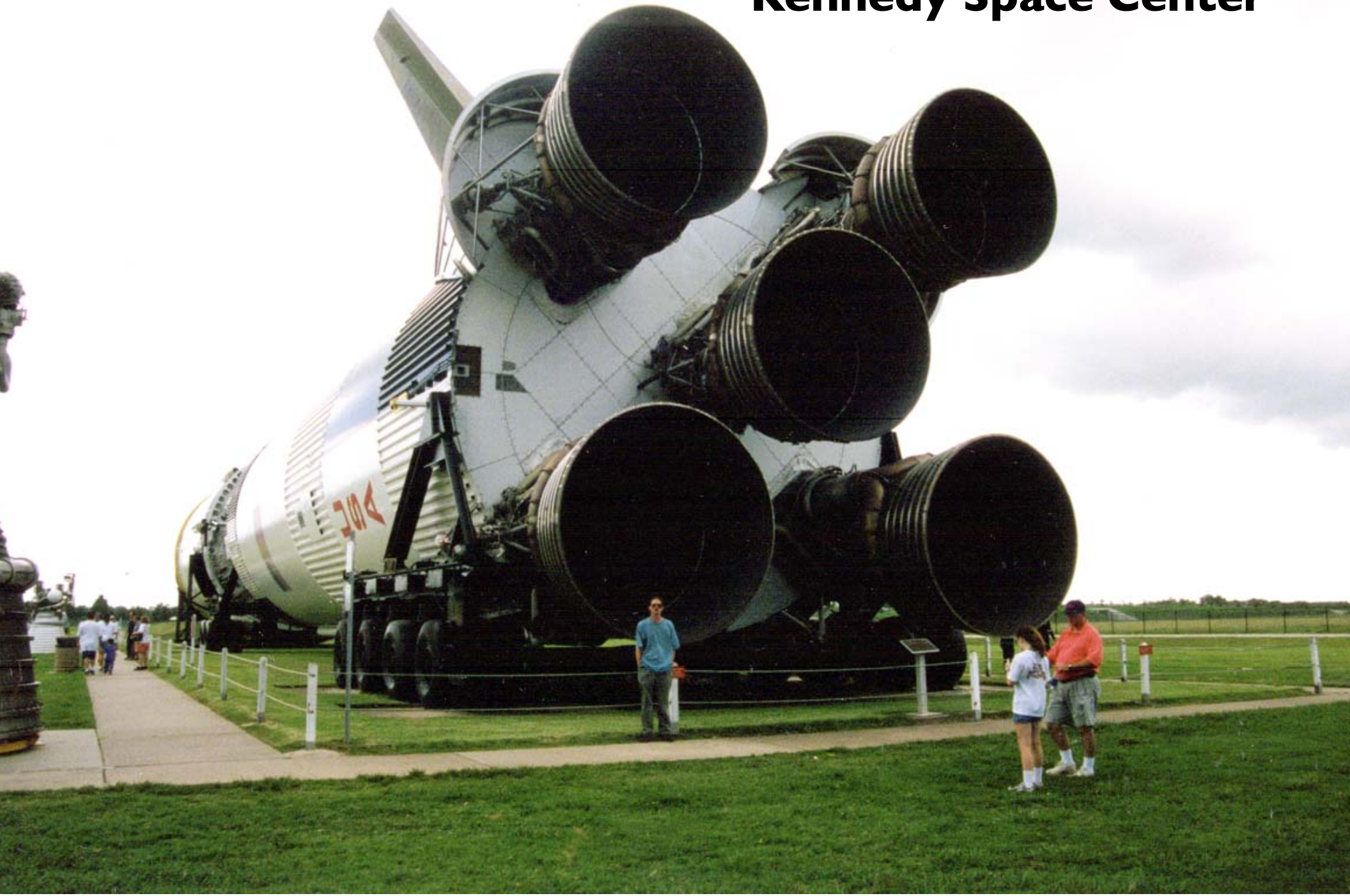
Why?

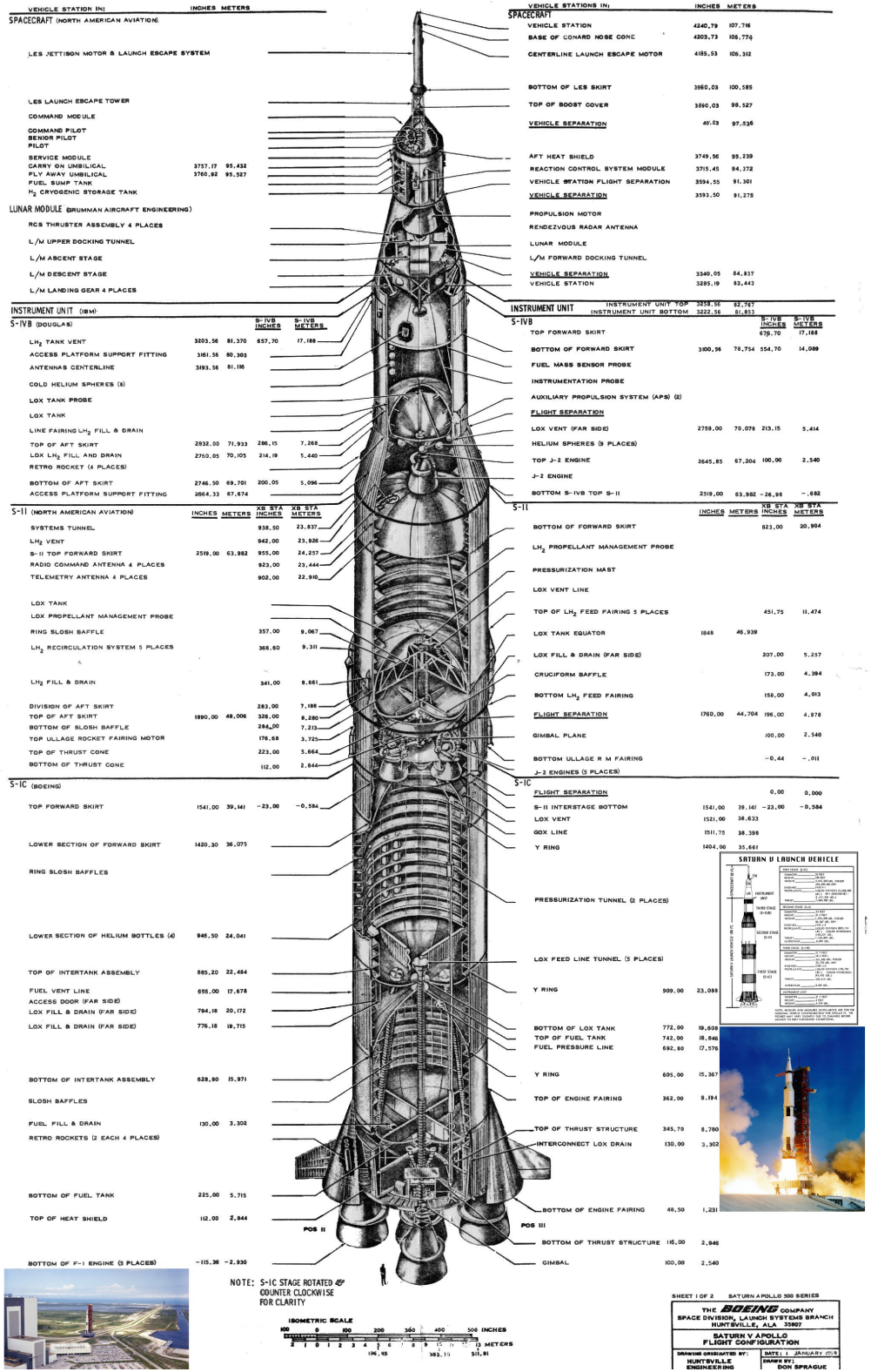
```
int main() {
    ...
}
```

How does your program start at the first instruction of main()?
Or does it really?

Understanding is Empowering

Saturn V
Kennedy Space Center





Command Module
64,000 lbs

Saturn V
6,200,000 lbs

Payload
1.5% of total weight


Falcon 9

Engineer for Excellence!

Perseverance!

First steps are often the hardest

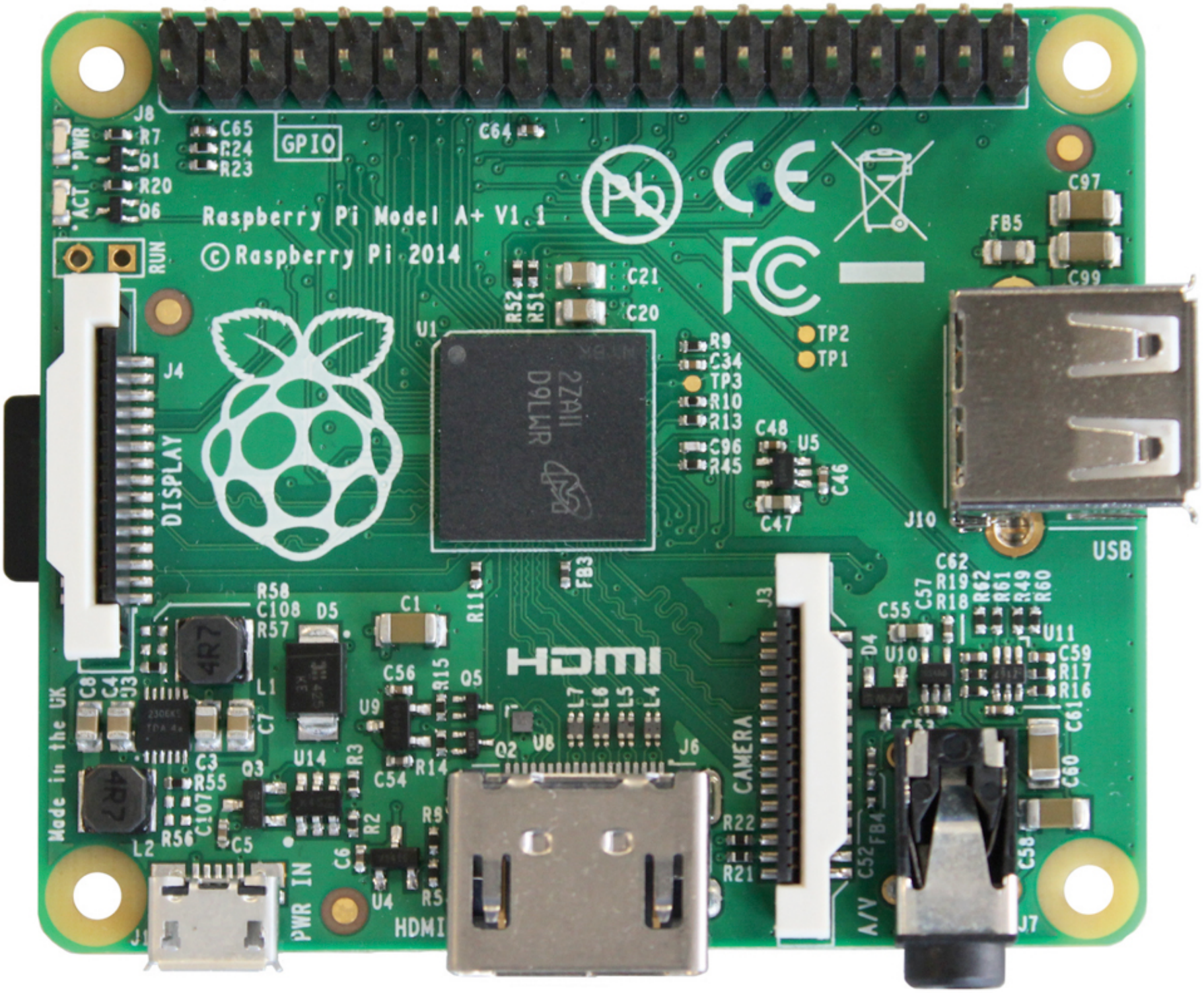
That's why we're here!

Bare Metal on the Raspberry Pi

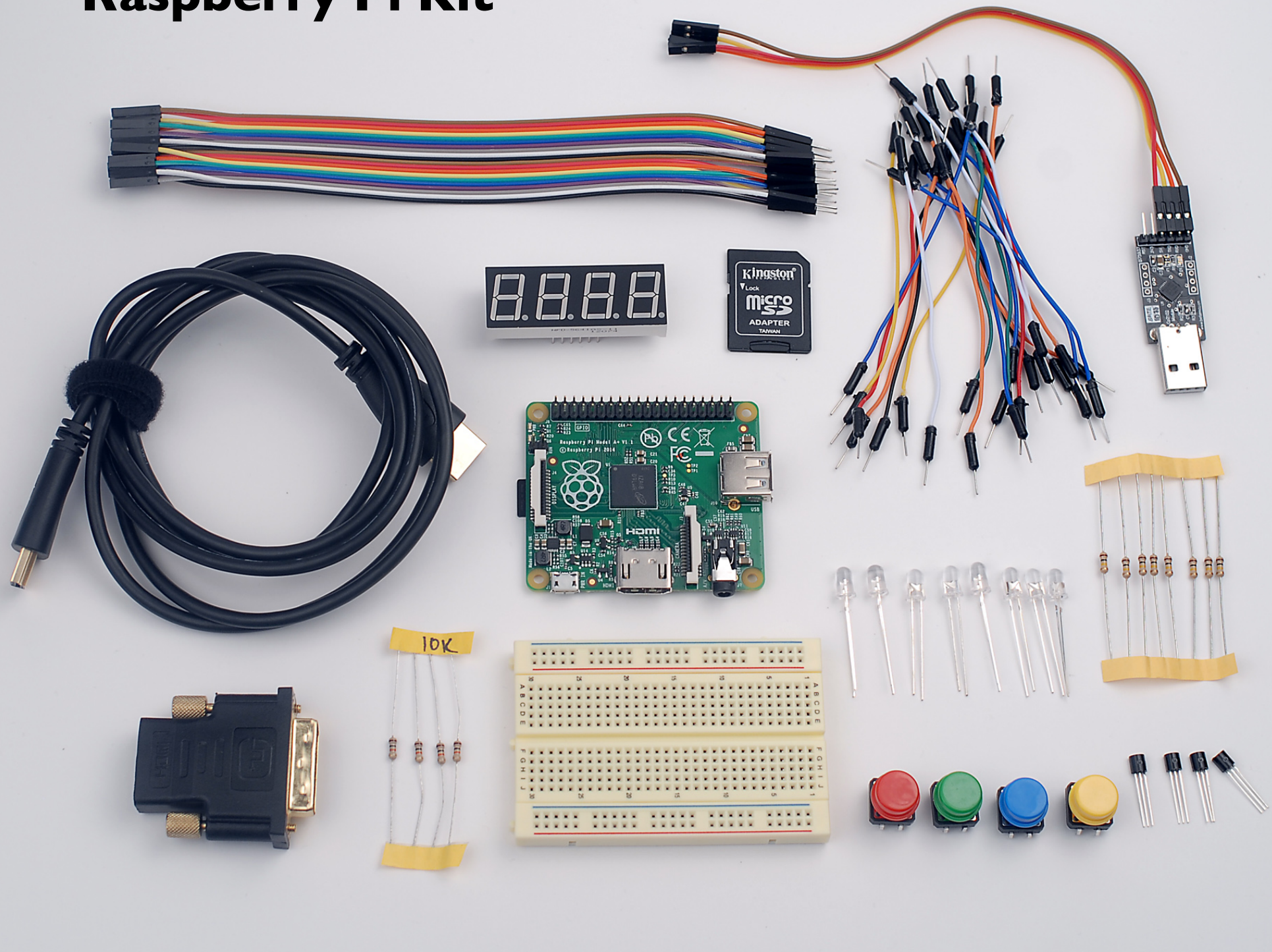
Definition: Bare metal programming involves no operating system (programmer constructs libraries)

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

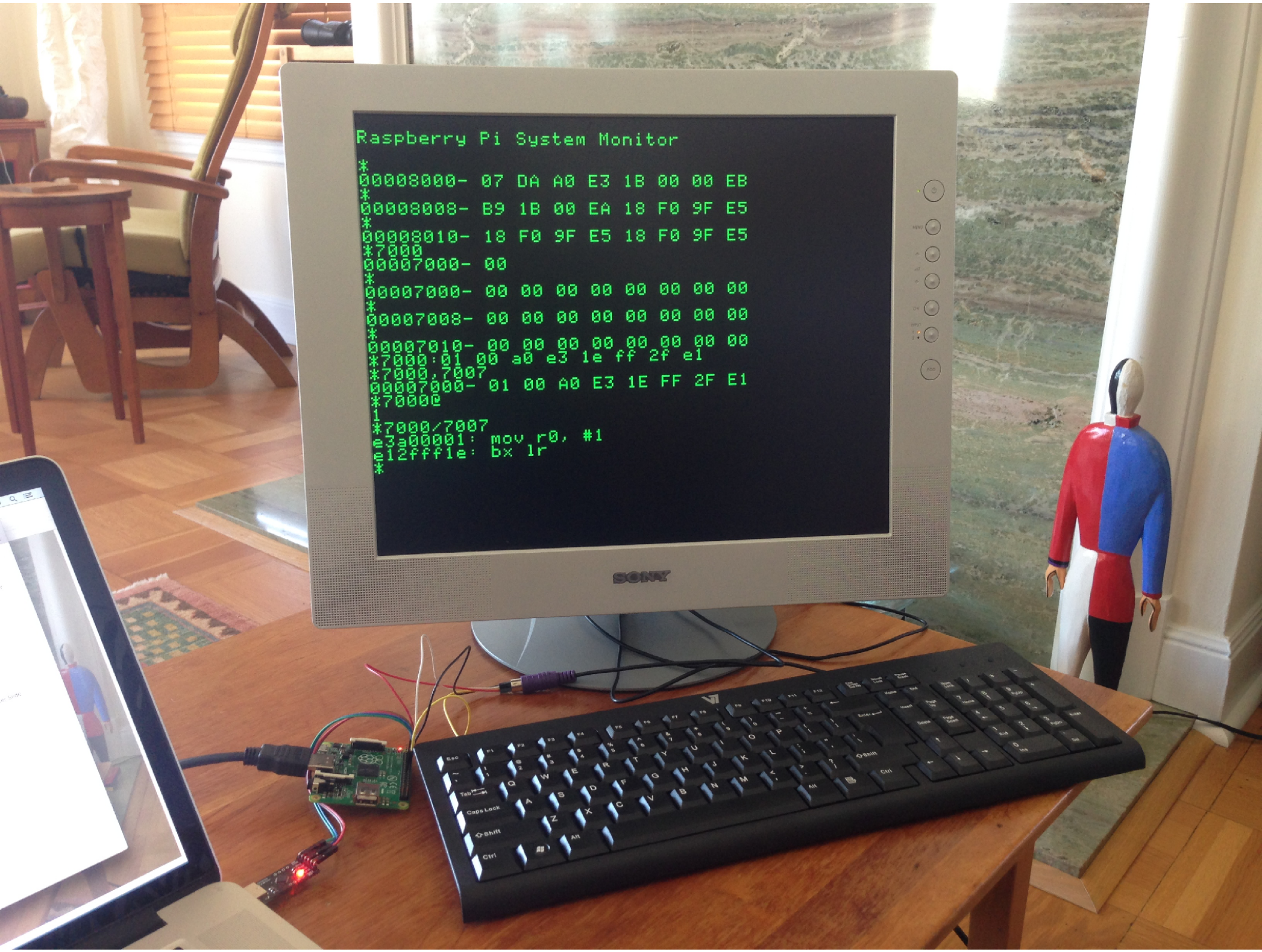
You'll understand every line of code in the system.


GPIO
Raspberry Pi Model A+ V1.1
© Raspberry Pi 2014
DISPLAY
HDMI
CAMERA
USB
A/V
PWR IN
HDMI
Made in the UK

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
*7000@
1
*7000/7007
e3a00001: mov r0, #1
e12fff1e: bx lr
*
SONY

Almost every instruction will be code you've written!

Learning Goal 2

Master your tools
Learn their value

Software Tools

UNIX command line: `bash, cd, ls, …`

Programming languages: C, …

`gcc`

`as`

`ld`

binutils: `nm, objcopy, objdump, …`

`make`

`git` and github.com

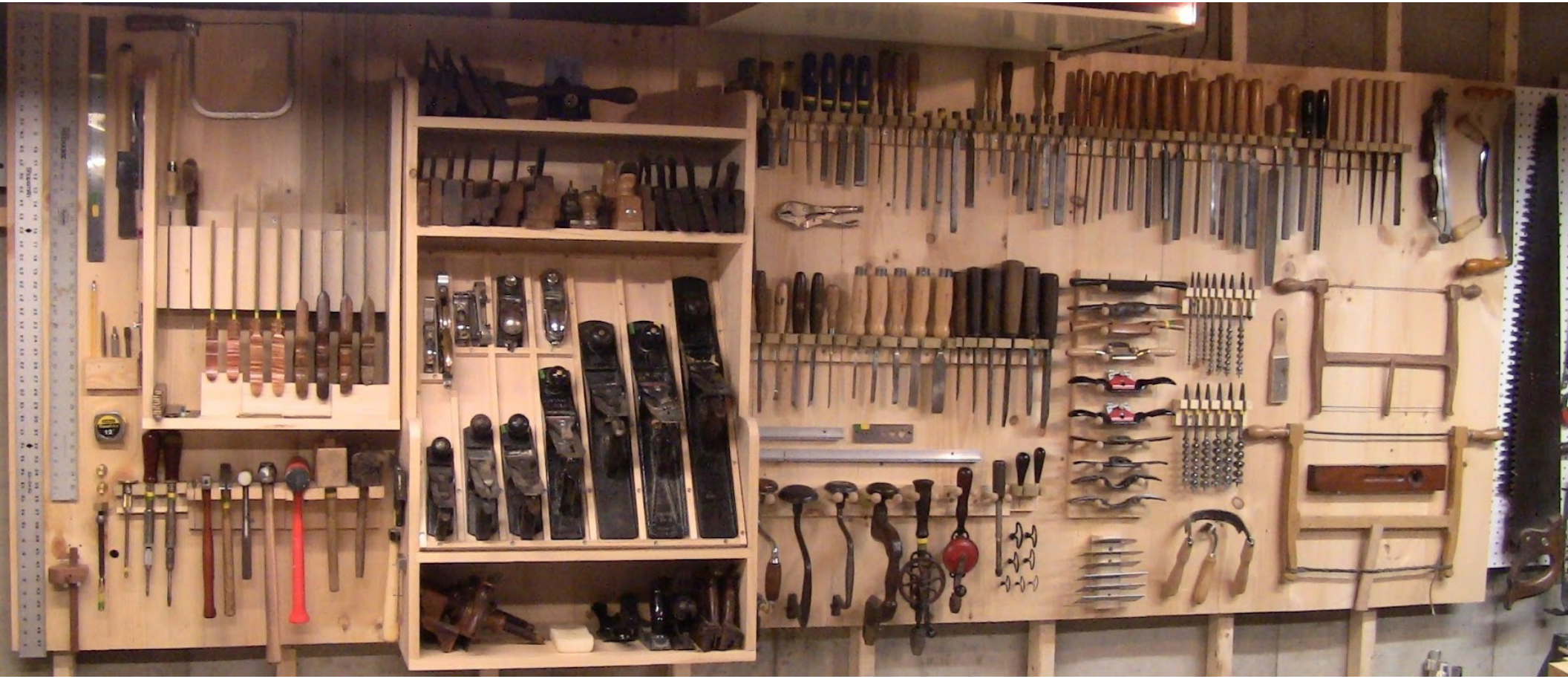
documentation: markdown


Non-Contact Voltage Detector
EXTECH
INSTRUMENTS
NCV
REL
MODE
HOLD
RANGE
OFF
VAC
VDC
μA
mA
10A
°F
°C
EX330
AutoRanging
MultiMeter
CAT III - 600V
CAT II -1000V
COM
V/mA/μA/CAP
Ω/Hz/Temp
10A
600V MAX
600V
400mA
MAX
FUSED


Consolidated
ELECTRONIC WIRE & CABLE
100
FT
RoHs
36920
36822
36792
36856


SOLID
IDEAL INDUSTRIES
SYCAMORE IL U.S.A.

Different Tools for Different Jobs



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

Organized Development Environment

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

Don't Avoid Activation Energy

$$CO_{(g)} + NO_{2(g)} \longrightarrow CO_{2(g)} + NO_{(g)}$$

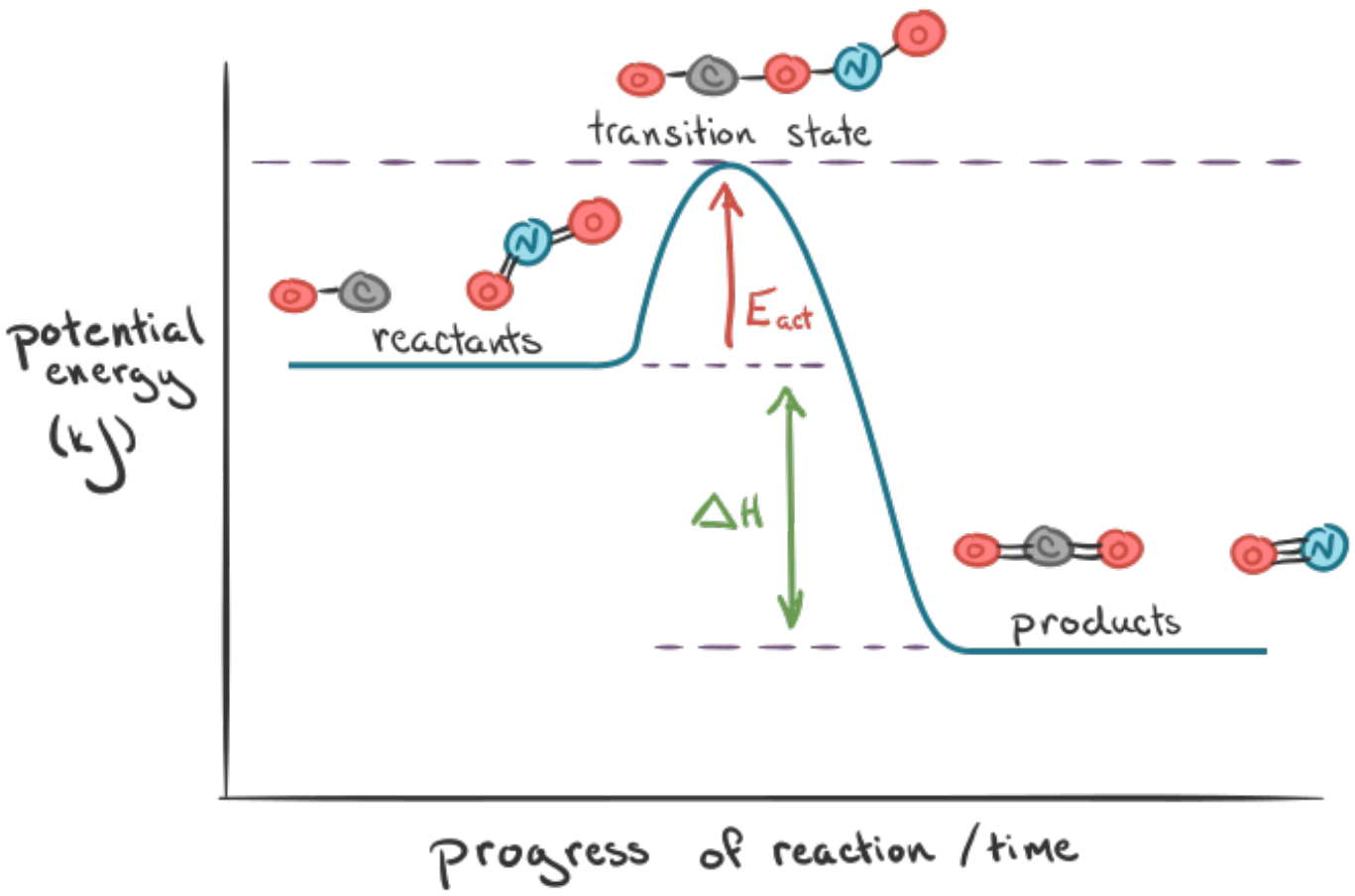


Figure from Khan Academy

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

Don't Avoid Activation Energy

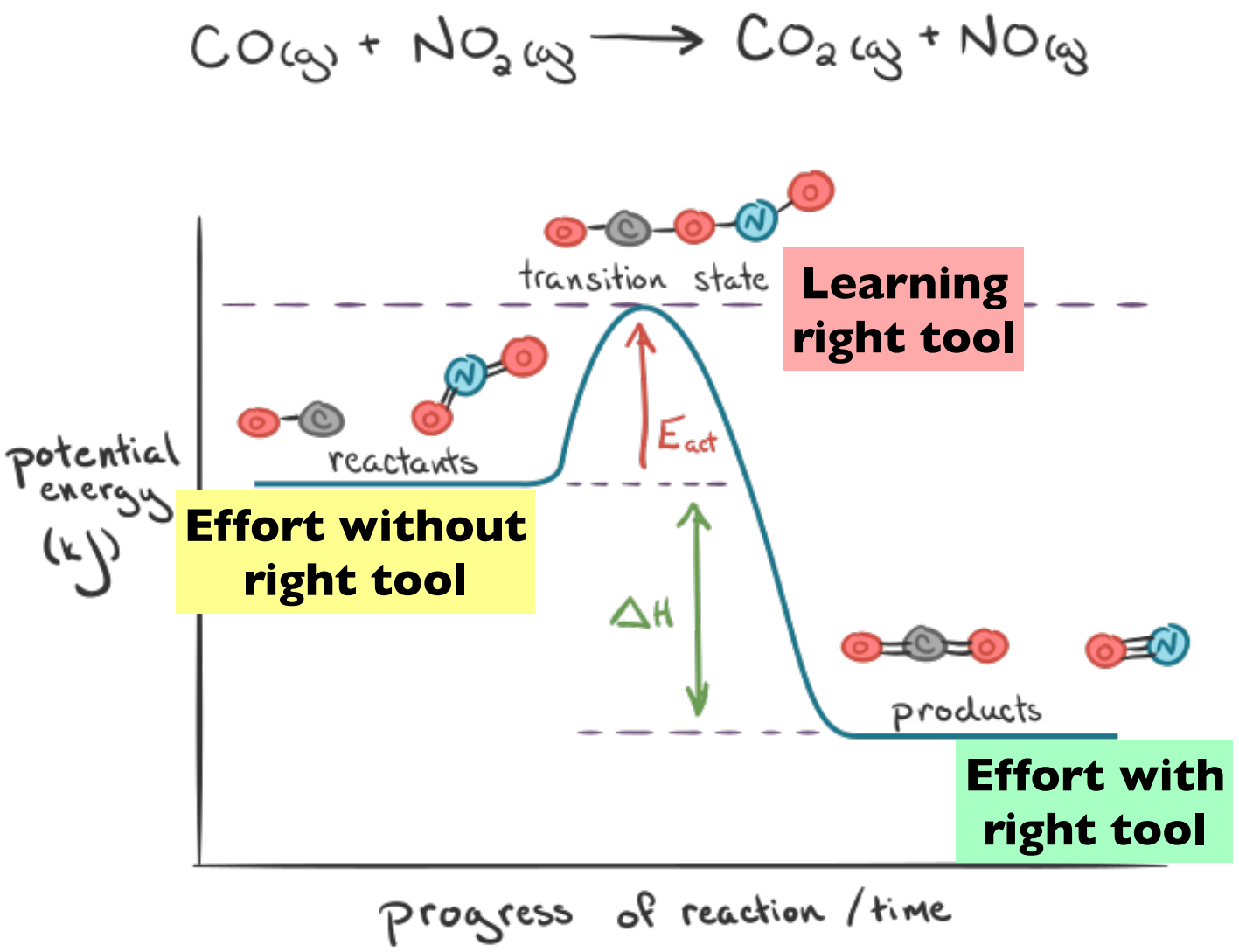


Figure from Khan Academy

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

Hyperbolic Discounting

https://medium.com/behavior-design/hyperbolic-discounting-aefb7acec46e

Hyperbolic Discounting

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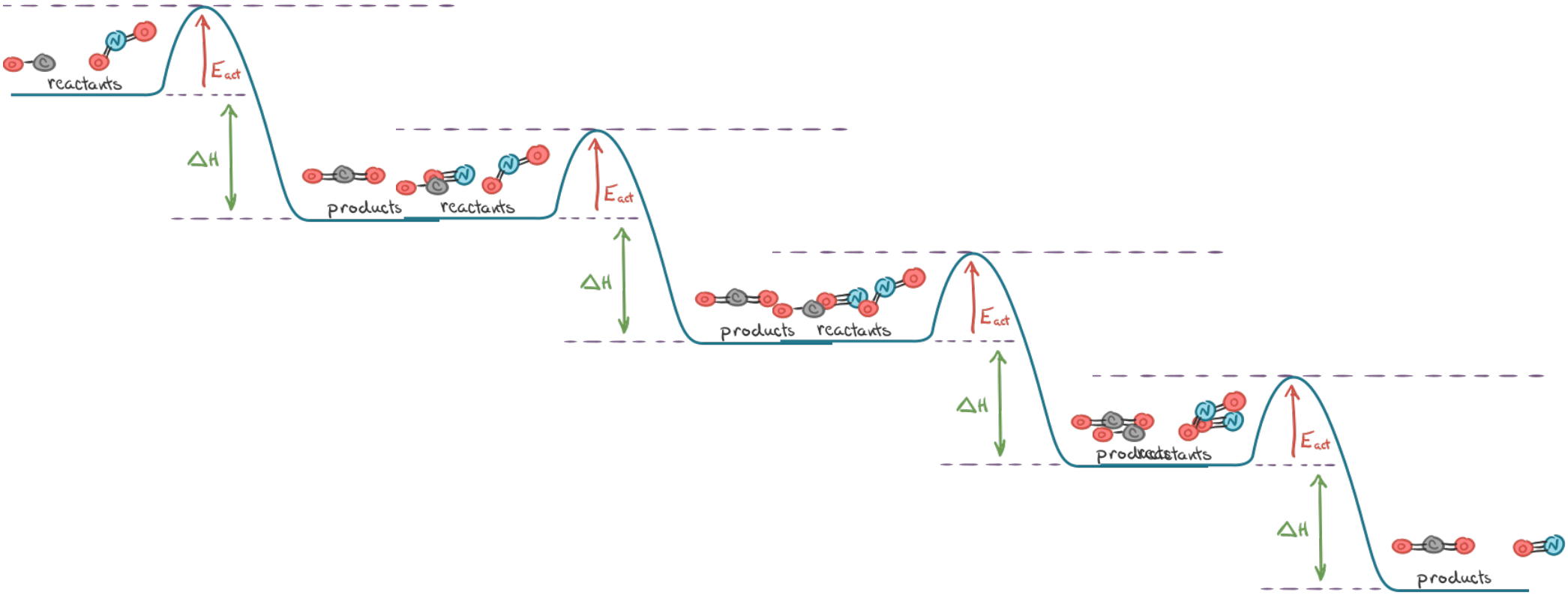
Learn & Practice, Practice, Practice
https://paulsellers.com/tag/gouge/



It never ends... 1000x improvements possible!

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

§1 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

1. Keyboard
2. Graphics
3. Interrupts

Goal: Build Raspberry Pi shell

§3 Additional Topics

1. Sensors
2. Performance

And a couple of special/guest lectures

Administration

Weekly Cadence

Each week has a focus **topic**

Pair of coordinated **lectures** on Wed and Mon

Lab on Tue/Wed

Assignment handed out Wed after lab, YEAH session Thu, due following Tuesday 5pm

Staying on pace leads to best outcomes!

Lectures

Attendance is **necessary**

Content is unique to our course, no textbook
The readings/slides are not a standalone resource

Attendance allows you to participate, ask questions, stay on schedule

Pose questions verbally or type in chat, but **do ask**!!

Labs

Attendance is **mandatory**

Guided exercises, work with peers, **check in** with staff

Finish lab **ready** for assignment, esp. experience with tricky parts (hardware/software interface)

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

Lab room: Gates B02

Assignments

7 weekly assignments

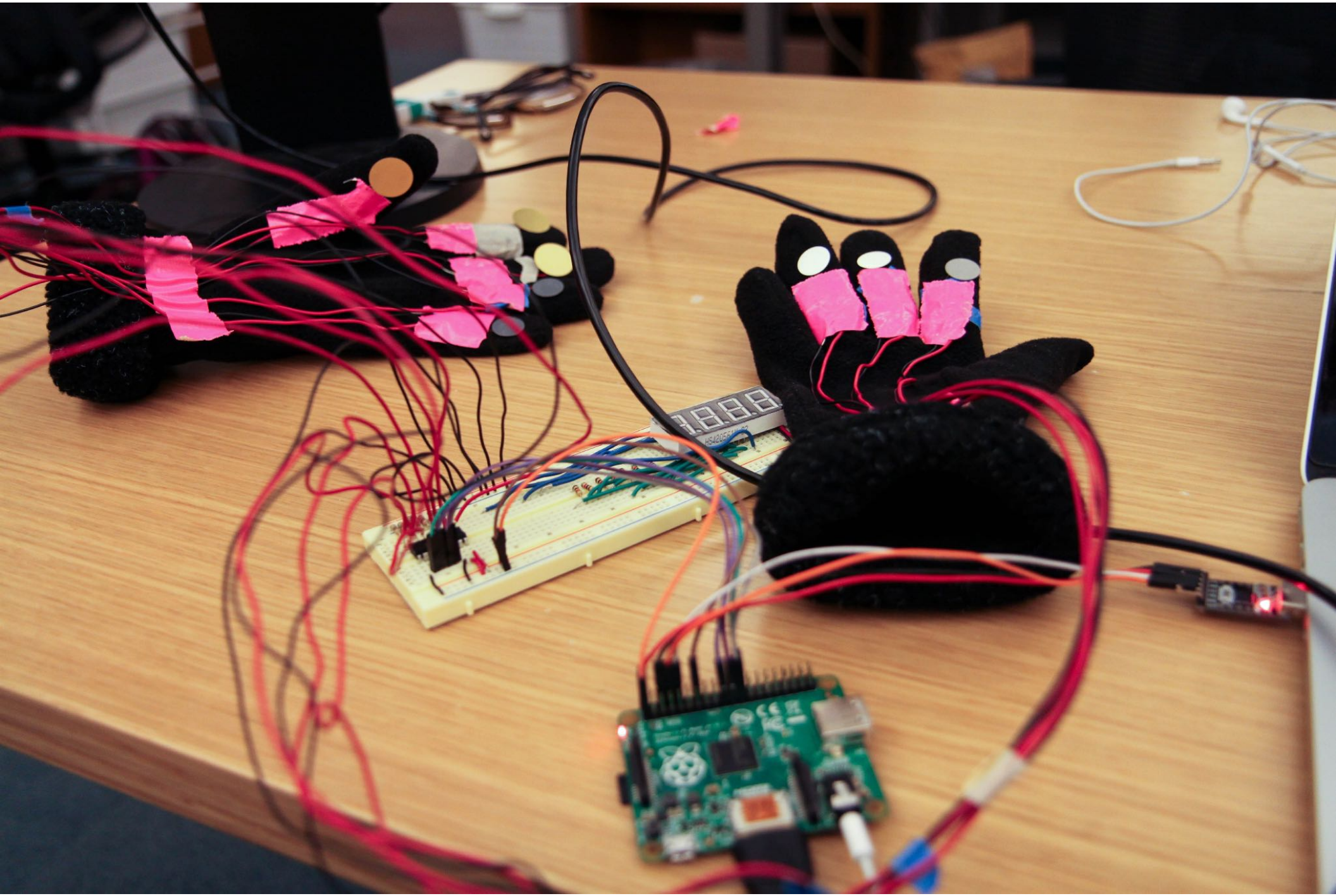
- **Build** on each other, complete full system

Assignment specifications

- **Core** (required, tight spec, guided steps)
- **Extension** (optional, opportunity for your exploration/ creativity)
- Revise and **resubmit** to address issues in core functionality

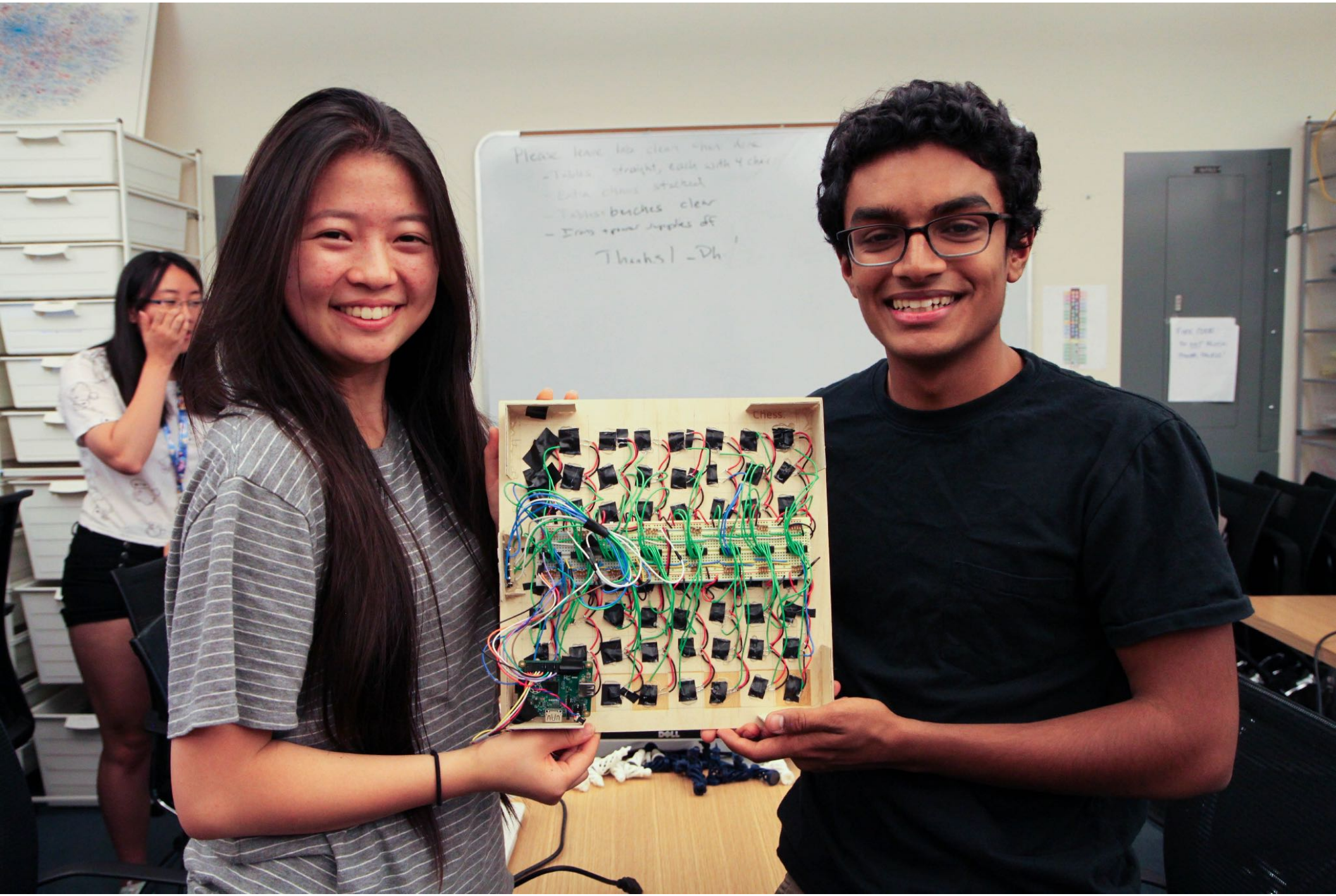
Project

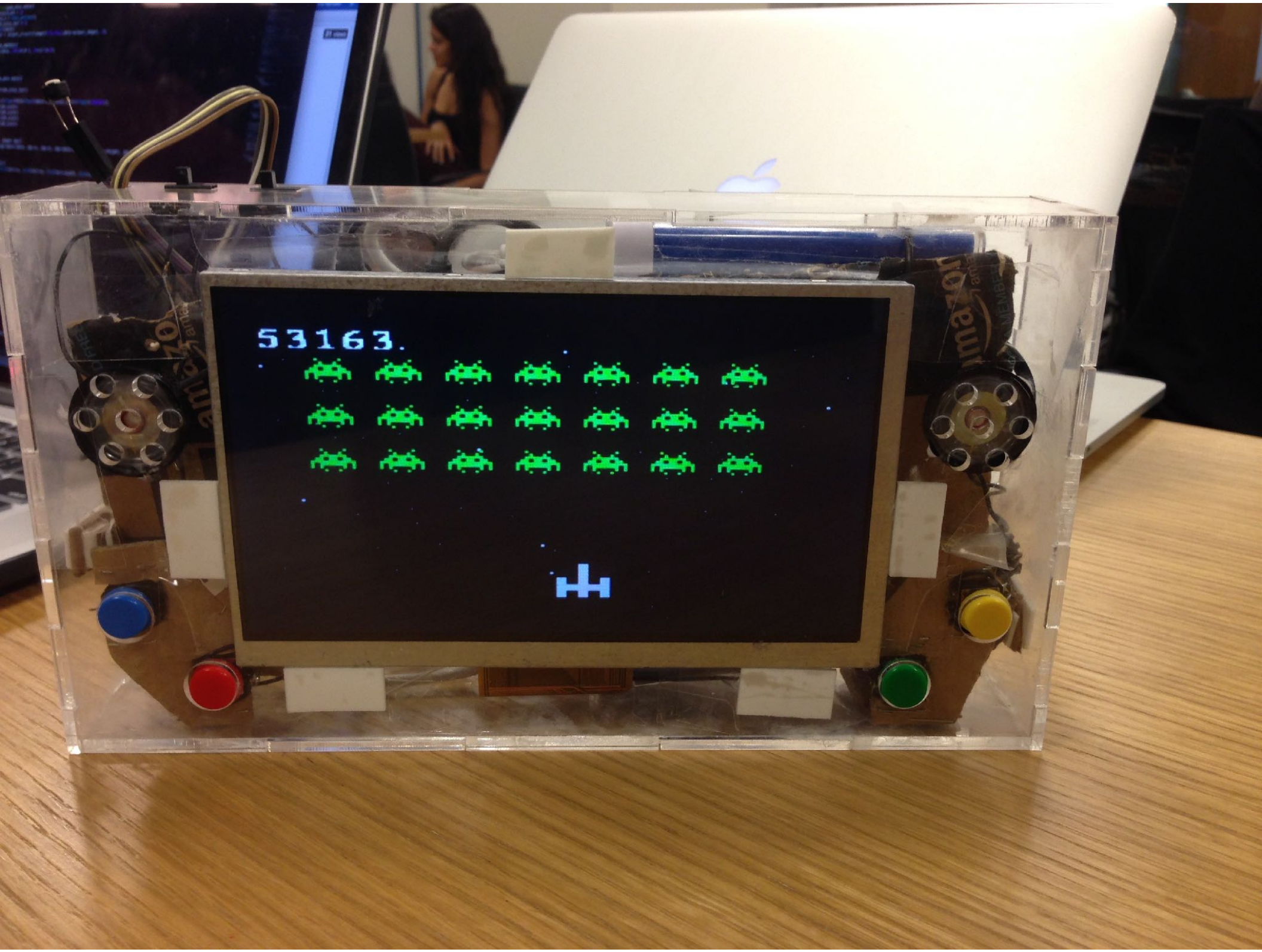
- Design and build **your own system**




a new CS
twitch
STANFORD


game mode
DELL


Please leave lab clean when done
- Tables straight, each with 4 chairs
- Extra chairs stacked
- Tables benches clear
- Iron + power supplies off
Thanks! -Dh
Chess


53163.

Learning community

Stay **connected**

- **Participate** in lecture
- **Collaborate** in lab
- **Discuss** on Ed forum
- **Come** to office hours
- **Meet up** in lab room

Be **curious**. Learn by **doing**. Ask for and offer **help**.

Dealing with COVID

Screenshot

I have small kids (not vaccinated yet)

Delighted to be teaching in person but need to be careful

Stanford requires masks are worn in lectures

- Please wear them well and carefully! Even if you are alone in lab.

First Week

Today

Fill out course application if you haven't already

Make sure you are registered on Axess

Assignment 0

Join forum https://edstem.org/us/courses/21299/discussion/

Read and understand our guides on basic topics: electricity, numbers, and UNIX

Create github account and send us your GitHub id

Install/setup your development environment

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!