

CS107e

Computer Systems from

the Ground Up

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

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



Christos



Maria



Matt



Liana



Anna

Learning Goal I

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

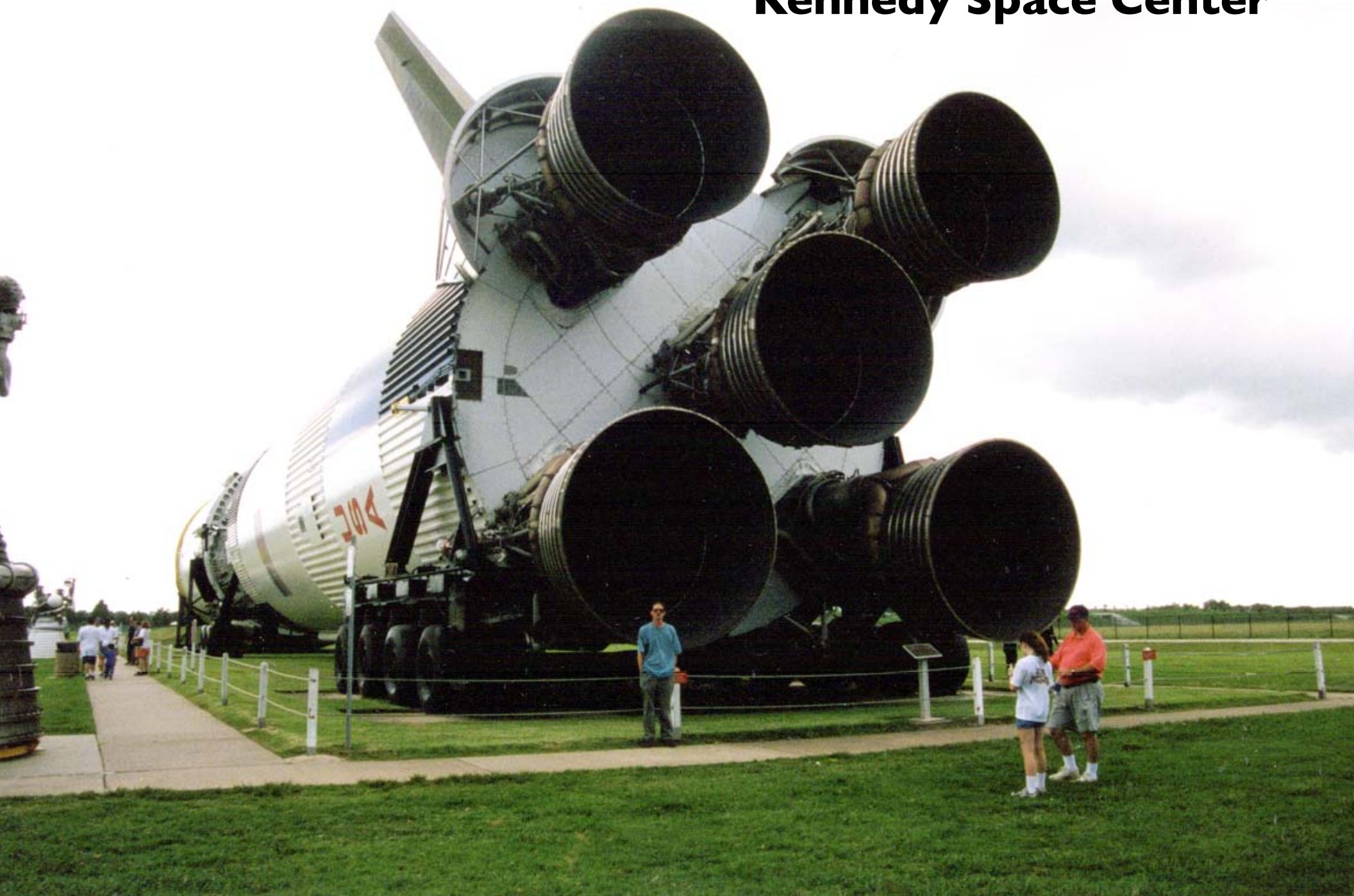
Why?

```
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



Falcon 9





Engineer for Excellence!

Perseverance!

First steps are often the hardest

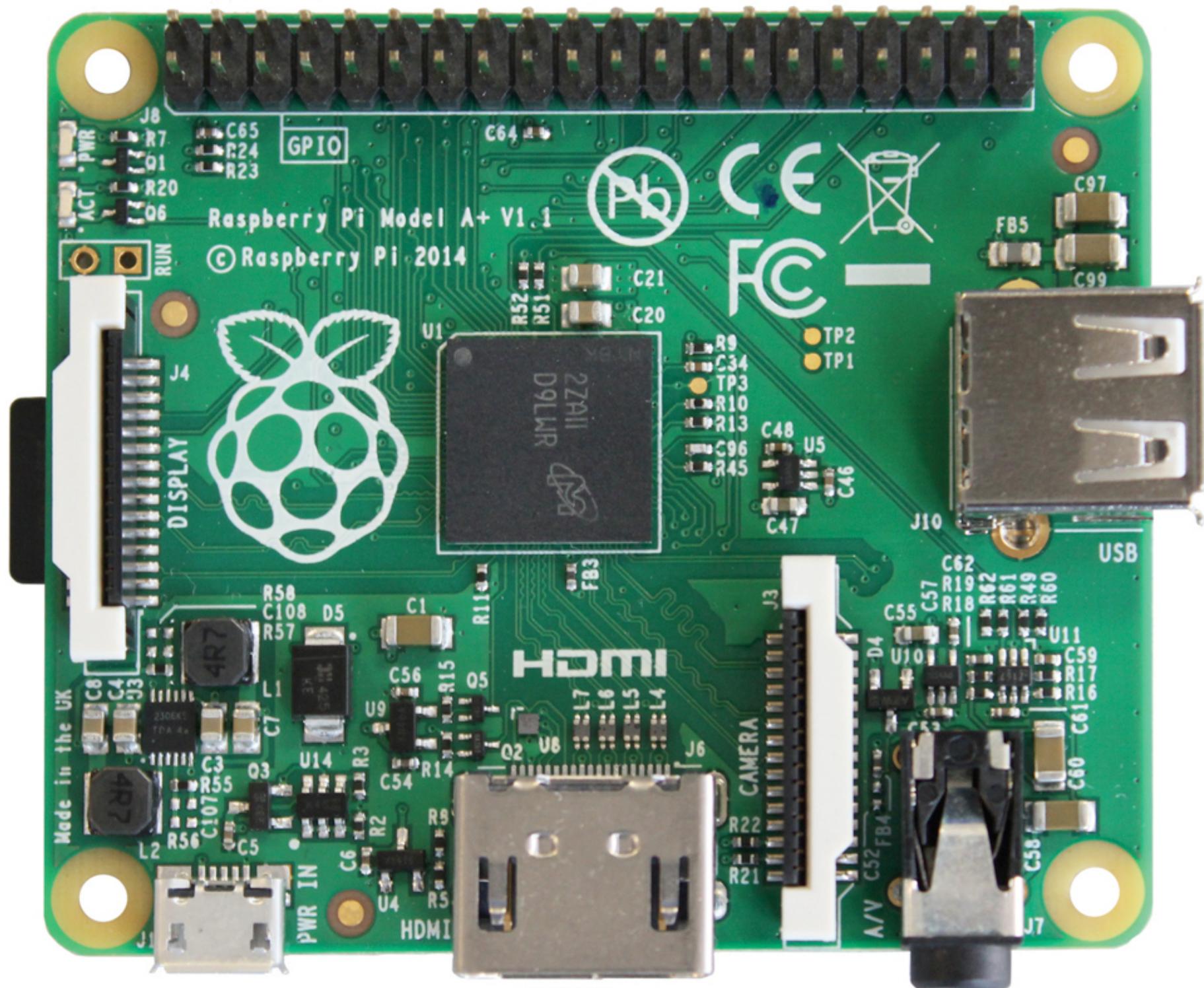
That's why we're here!

Bare Metal on the Raspberry Pi

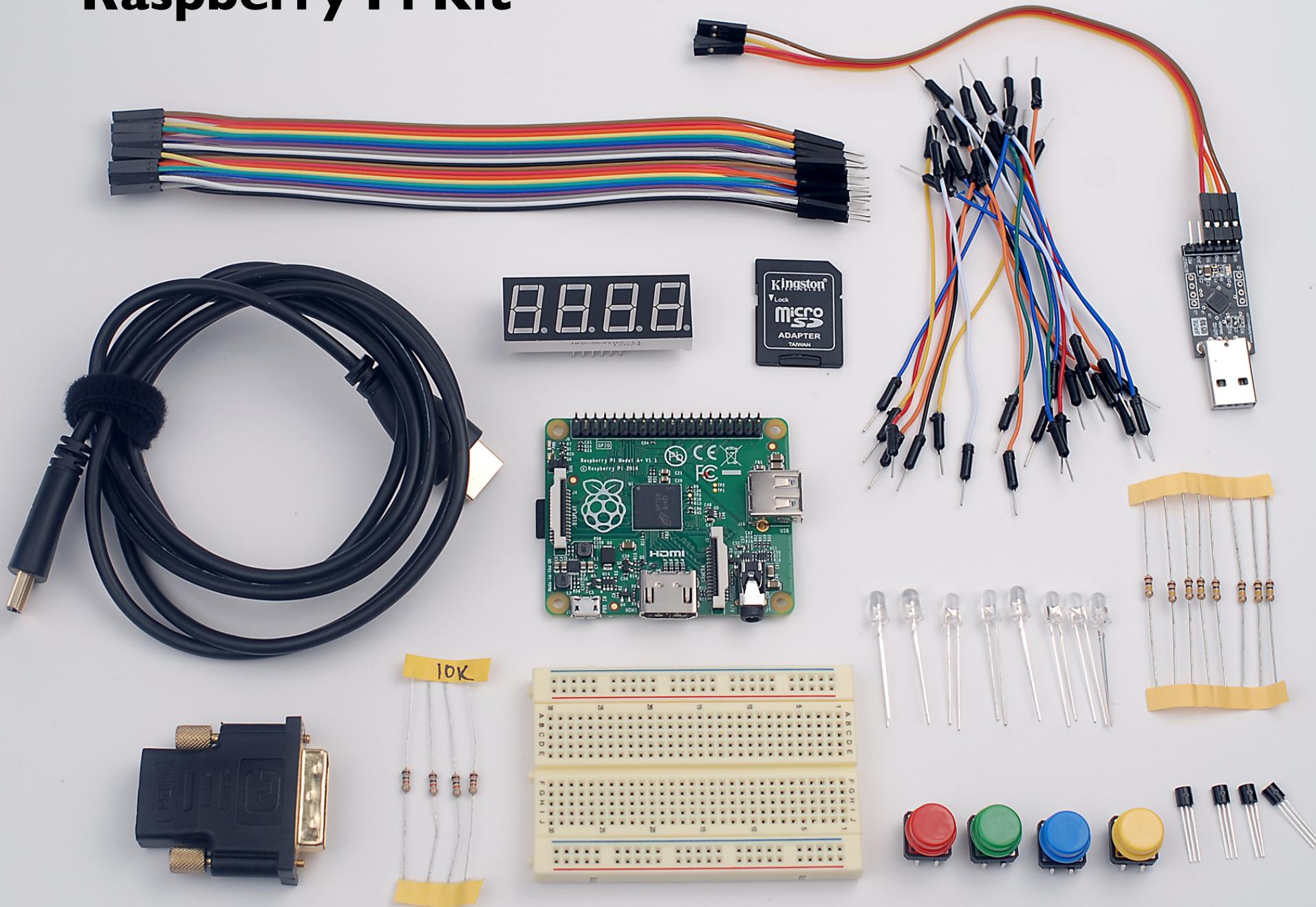
Definition: Bare metal programming involves no operating system (programmer constructs libraries)

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

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

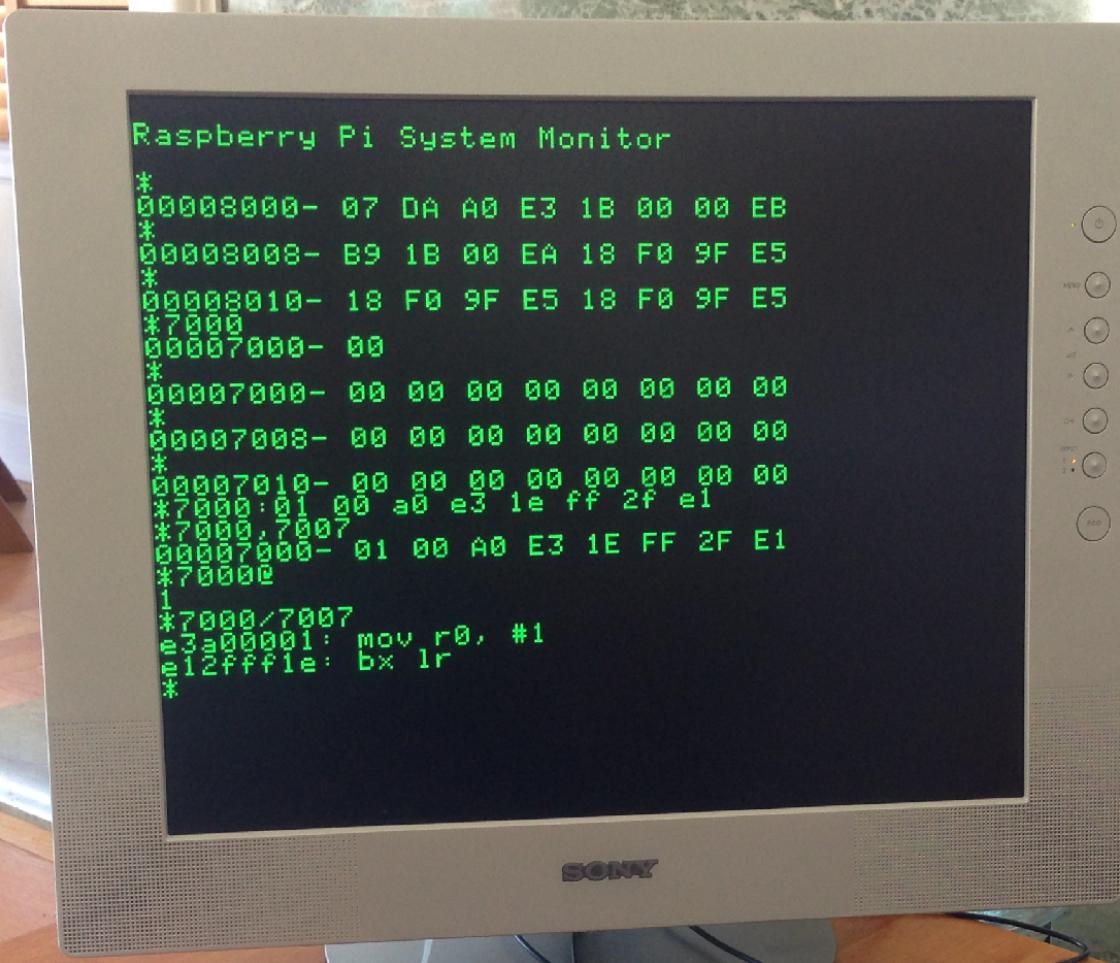
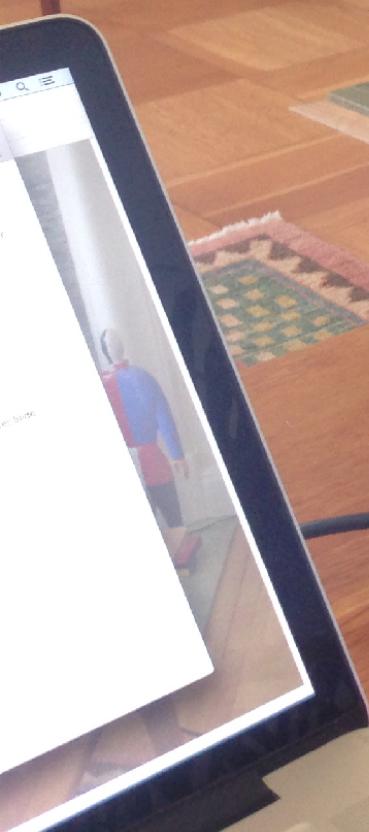


Raspberry Pi Kit



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
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



Different Tools for Different Jobs



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

Organized Development Environment



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

Don't Avoid Activation Energy

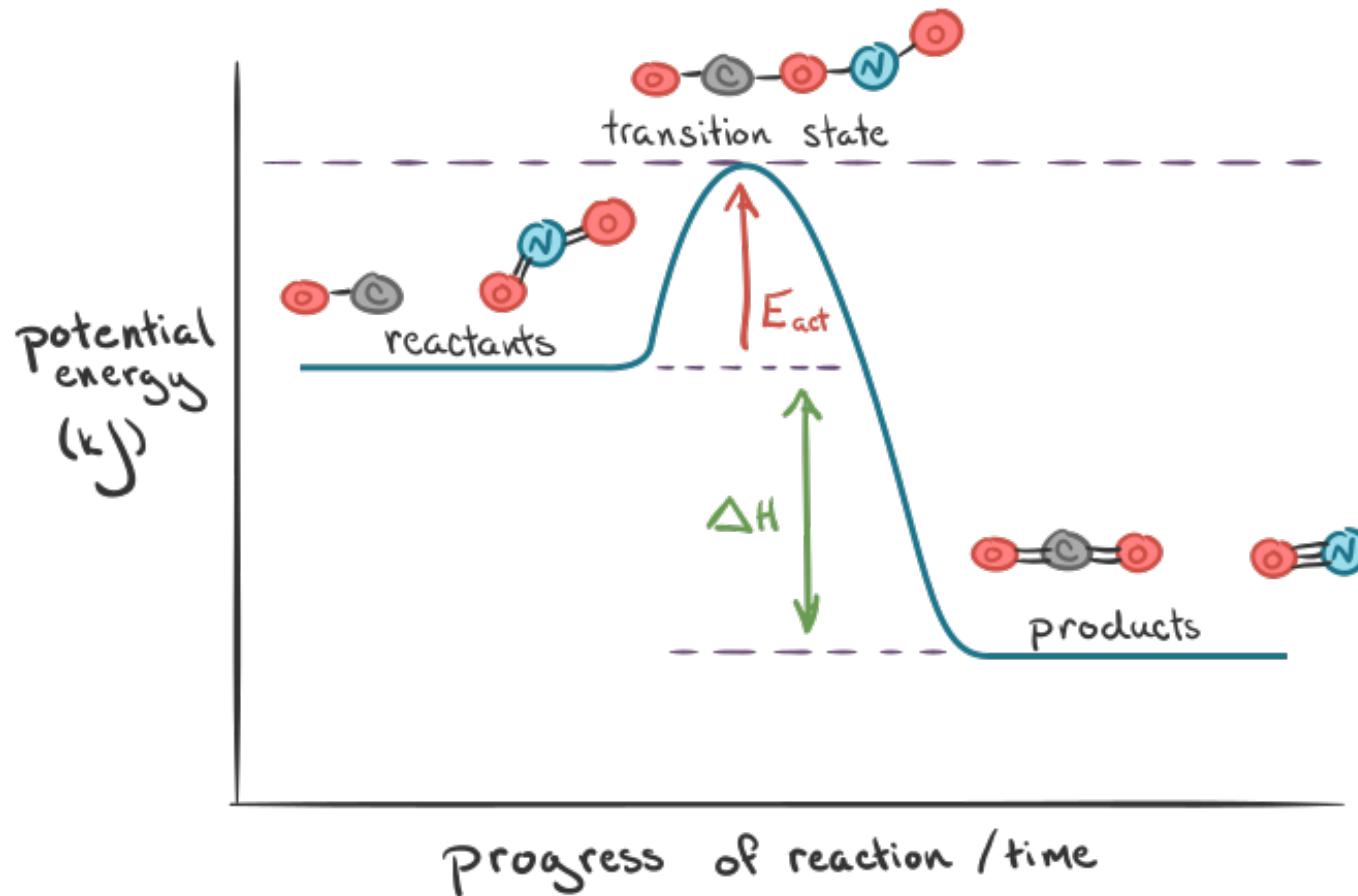


Figure from Khan Academy

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

Don't Avoid Activation Energy

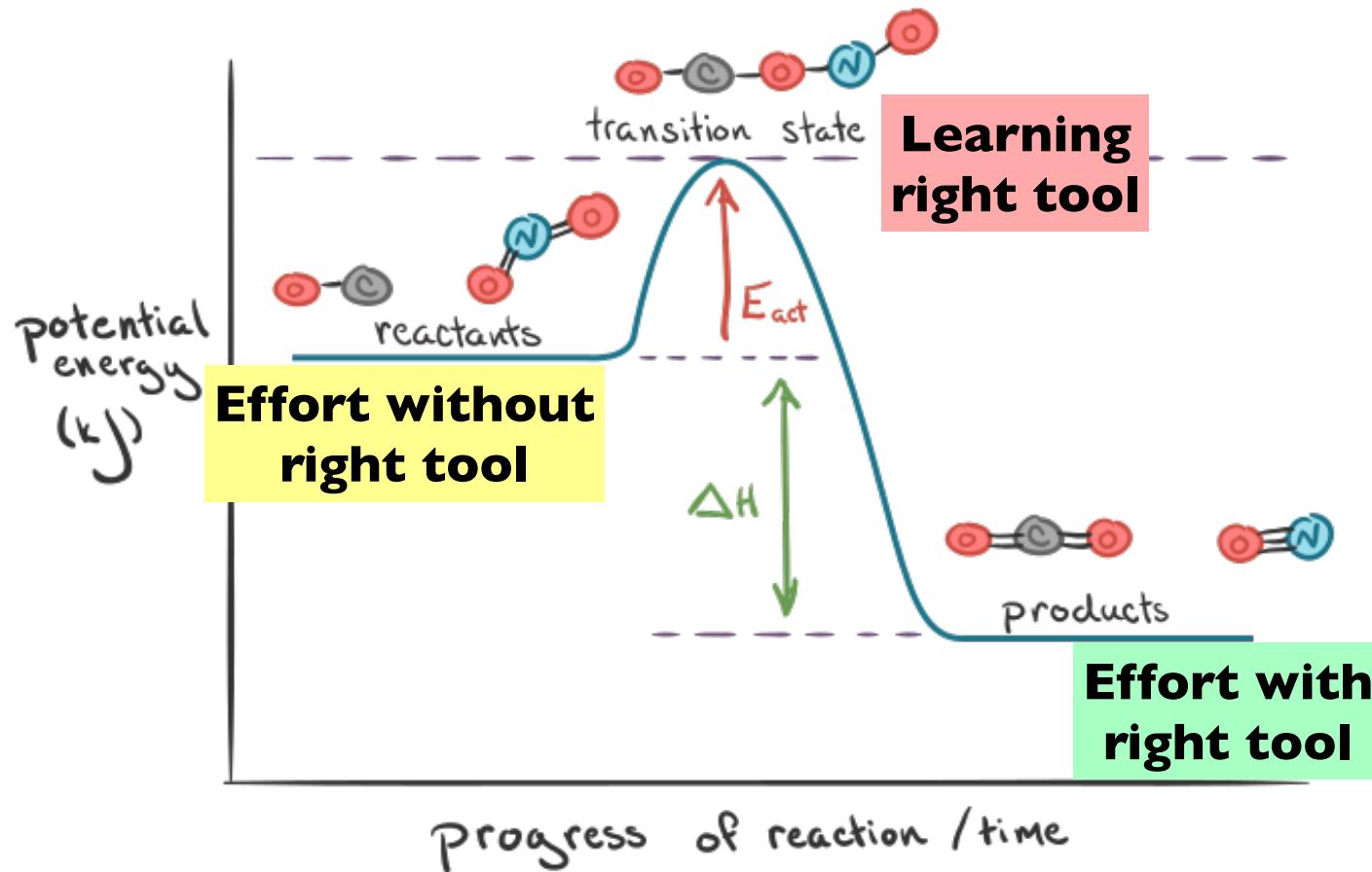


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Hyperbolic Discounting



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

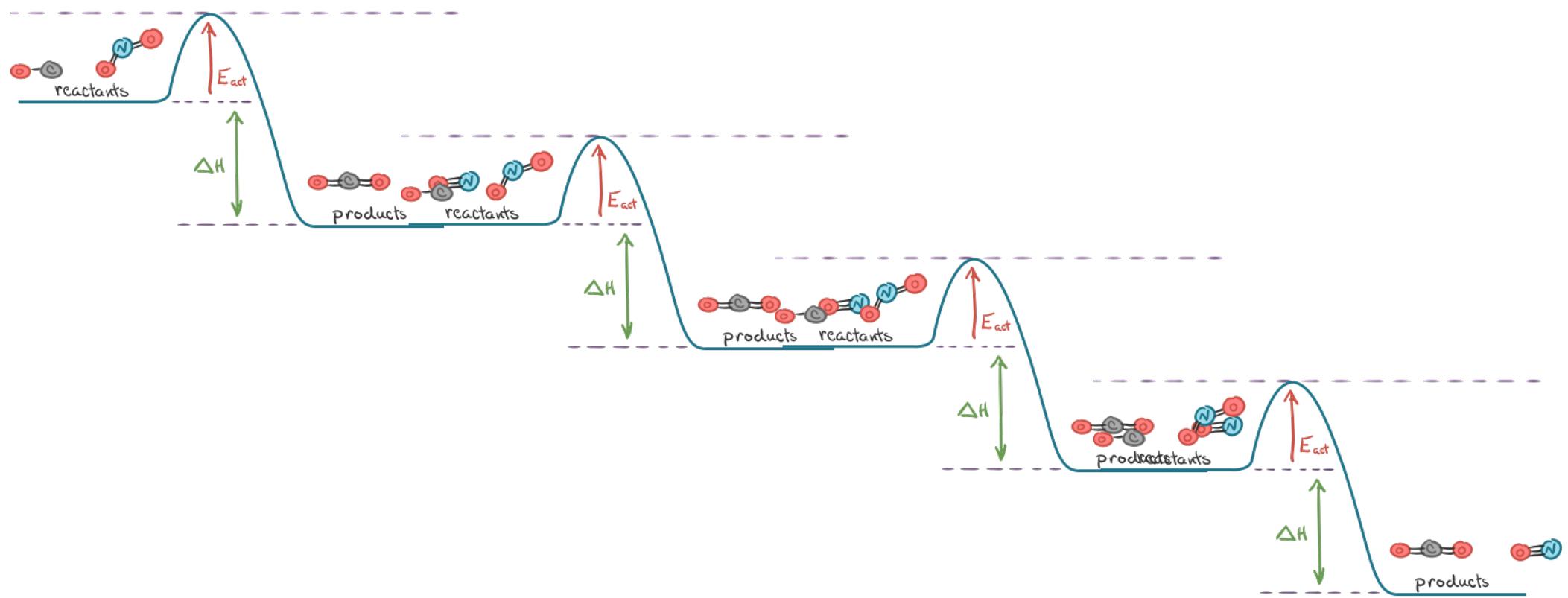
Hyperbolic Discounting



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

A close-up photograph showing a person's hands working on a piece of wood. The person is using a chisel to create a rectangular cutout in a dark, rectangular block of wood. The wood is held in place by several metal clamps. The person's hands are steady, focused on the task. In the background, there's a bottle of water and some workshop equipment.

Learn & Practice, Practice, Practice



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

§ 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

- I. 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 B21

Assignments

7 weekly assignments

Build on each other, complete full system

Assignment specifications

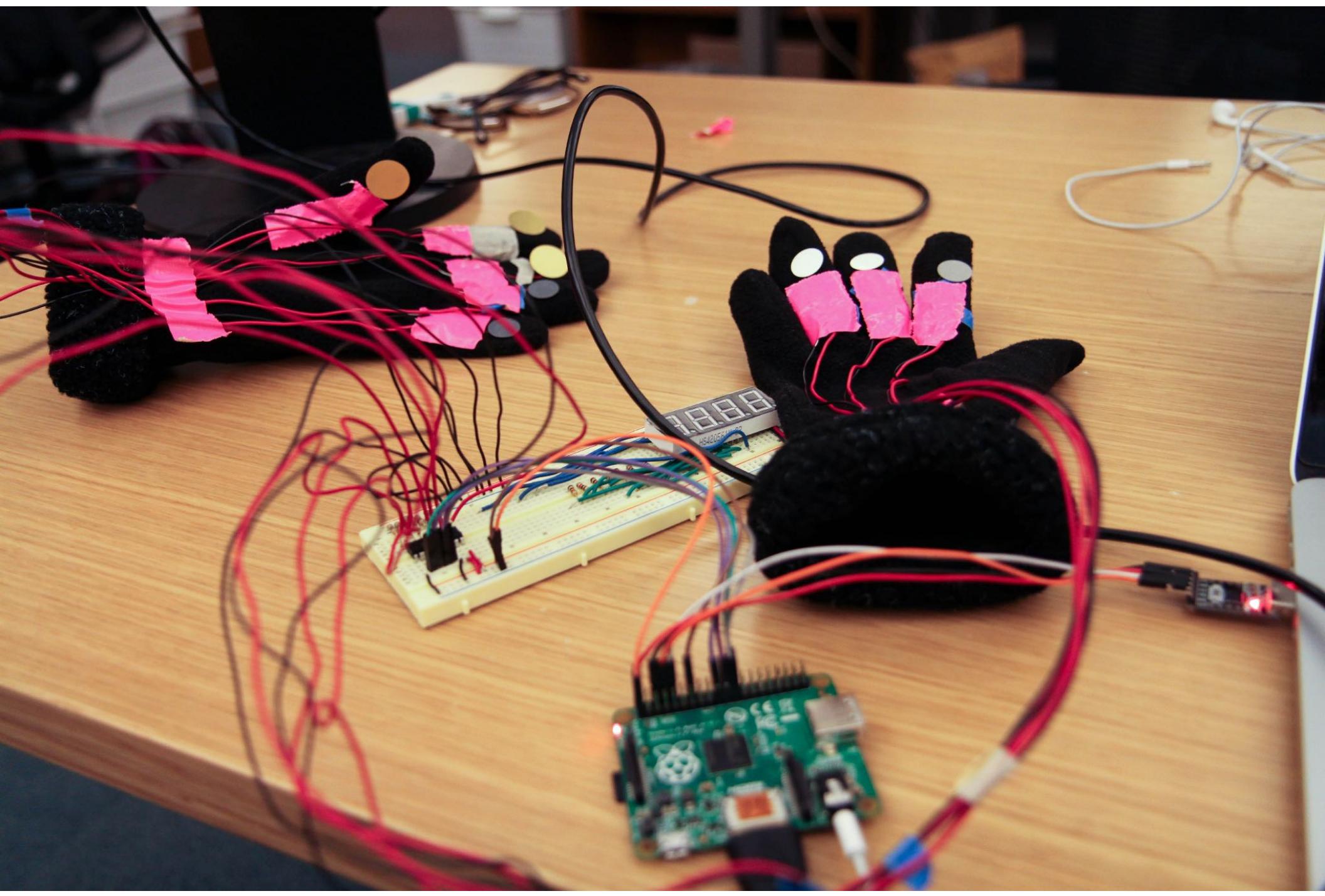
Core (required, tight spec, guided steps)

Extension (optional, opportunity for your exploration/
creativity)

Revise and **resubmit** to address issues in core functionality

Project

Design and build **your own system**

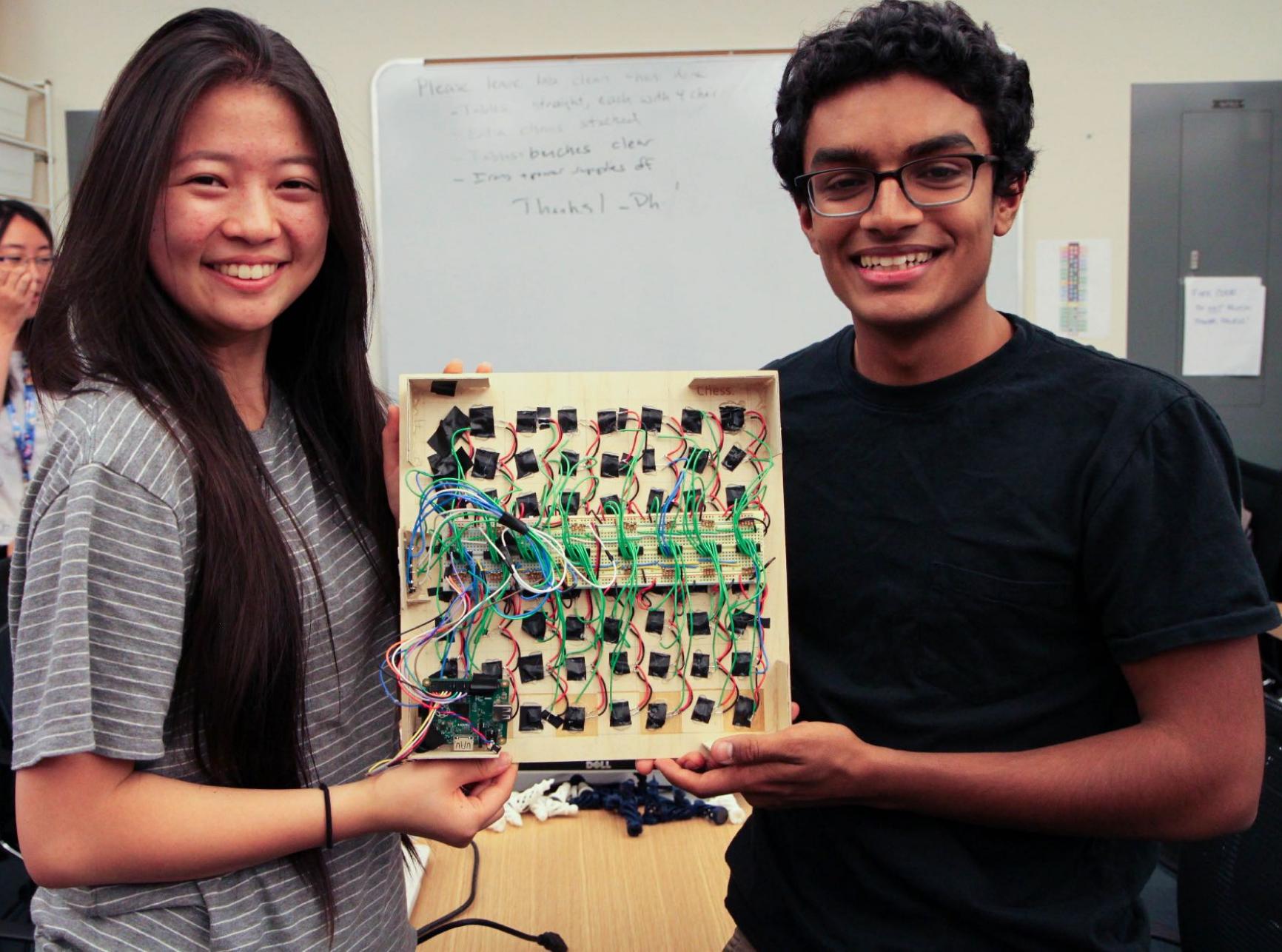


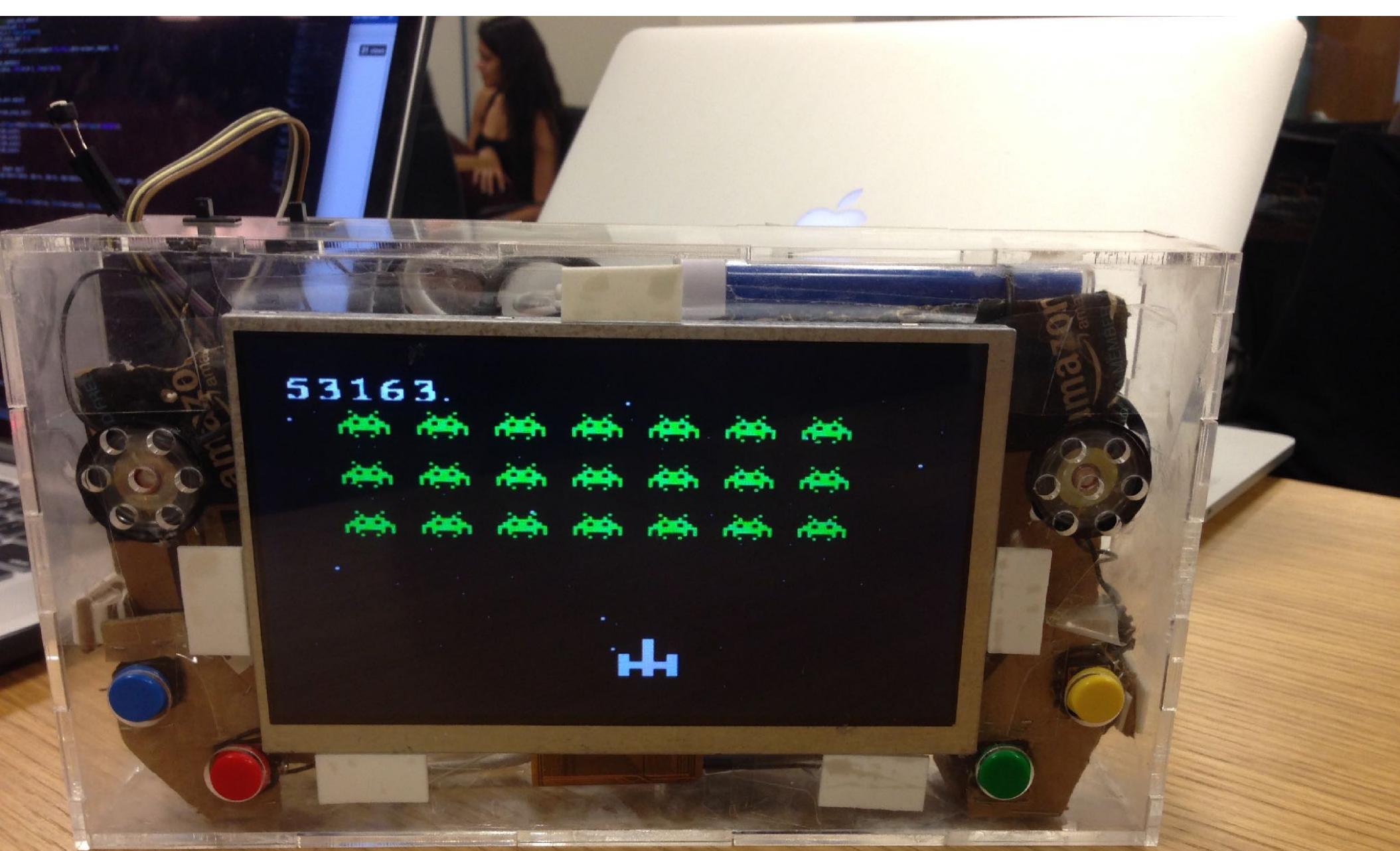




Please leave box clean - no dust
- Tables straight, each with 4 chairs
- Extra chairs stacked
- Tissue boxes clear
- Irons & paper supplies off

Thanks! - Dh





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

The Washington Post
Democracy Dies in Darkness

Philip Levis

Health

Parenting a child under 12 in the age of delta: 'It's like a fire alarm every day'

Routine outings become tricky decisions for the youngest Americans, who are still ineligible for coronavirus vaccines

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/](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!