

# **CS107e**

## **Computer Systems from the Ground Up**

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**Winter 2021**

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

# **Learning Goal 1**

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

# Saturn V Kennedy Space Center







# Falcon 9





**Understanding is Empowering**

# **Understand ...**

**ARM processor and memory architecture**

**Peripherals: GPIO, timers, UART, ...**

**Assembly language and machine code**

**Low-level representation of information / bits**

**From assembly language to C**

**Function calls and stack frames**

**Serial communication and strings**

**Modules and libraries: Building and linking**

**Memory management: Memory map & heap**



# **Learning Goal 2**

**Master your tools**

# Software Tools

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

**Text editor: vim, emacs, sublime, ...**

**Programming languages: C, ...**

**Compiler: gcc**

**Assembler: as**

**Linker/loader: ld**

**binutils: nm, objcopy, objdump, ...**

**make**

**git and github.com**

**documentation: markdown**

# Software Tools

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

**Text editor: vim, emacs, sublime, ...**

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**make**

**git and [github.com](https://github.com)**

**documentation: markdown**



# Different Tools for Different Jobs



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



# Organized Development Environment



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

A close-up photograph of a person's hands using a hand plane to smooth a piece of wood. The person is wearing a dark apron. The hand plane is held in the right hand, and the left hand is guiding the wood. The wood is being planed on a wooden workbench. In the background, there is a metal stand with a blue label that says "Verban Vre-acc" and a clear plastic water bottle.

**Practice, Practice, Practice**



# Debugging and Troubleshooting



# **Engineering Best Practices**

**Test, test, test, and test some more**

**Start from a known working state, take small steps**

**Make things visible (printf, logic analyzer, gdb)**

**Methodical, systematic. Form hypotheses and perform experiments to confirm.**

**Fast prototyping, embrace automation, one-click build, source control, clean compile**

**Don't let bugs get you down, natural part of the work, relish the challenge -- you will learn something new!**

**Wellness important! ergonomics, healthy sleep/fuel, maintain perspective**





**CS ED WEEK 20**  
 DECEMBER 7-13  
 #CSFORSOCIALJUSTICE





# *Have you ever wondered ...*

- how a computer represents data?
- what operations a computer understands?
- how a program executes?
- what happens when a user types on keyboard?
- how text and drawing appears on a display?
- how things *really* work inside this wondrous box?

These questions and more to be answered by  
**studying computer systems!**

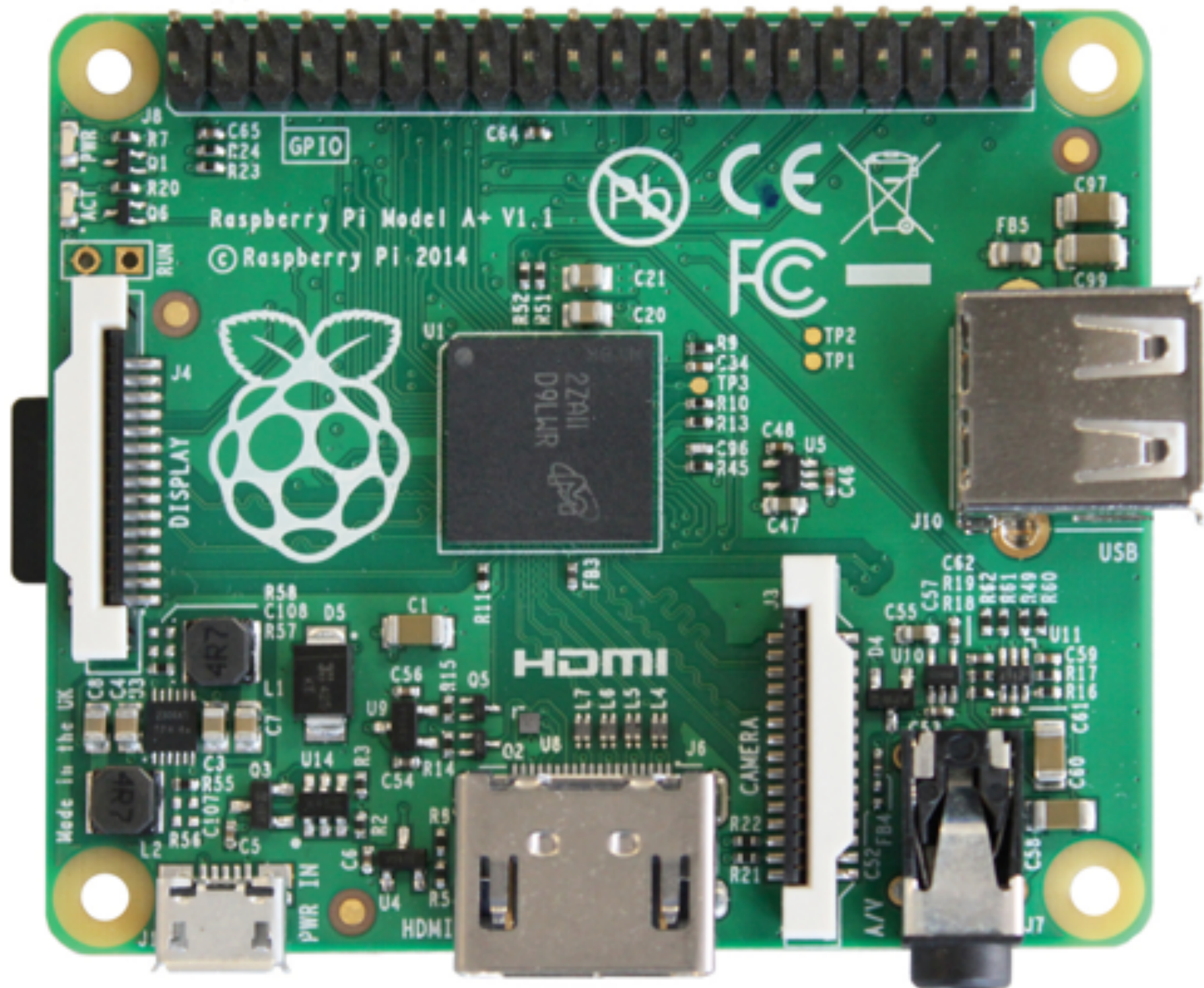
# Computer Systems From the Ground Up

What system to study and where to start?

## *Bare Metal on the Raspberry Pi*

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

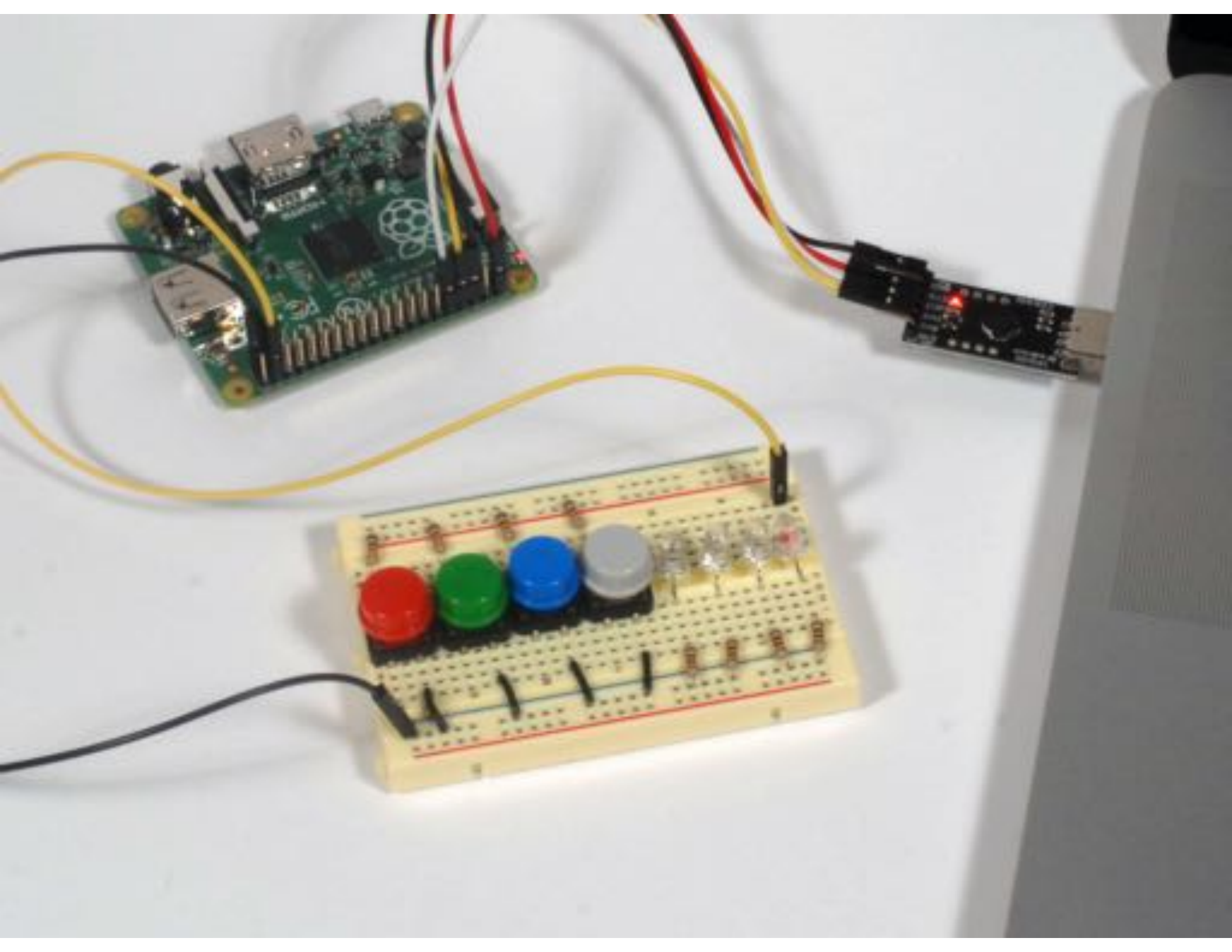
Bare metal programs boot and startup on their own, and directly control peripherals



# Parts Kit











# Course Schedule

## §1 Bare Metal Programming

- ARM architecture and assembly language
- C functions and pointers
- Serial communication
- Linking and loading
- Memory allocation

## §2 Build a Personal Computer

- Keyboard
- Graphics
- Interrupts

## §3 Create Your Own Project

- Sensors
- Performance

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

# Weekly Cadence

Each week has a focus topic

Pair of coordinated lectures on Fri and Mon

Lab session on Wed

Assignment released Wed after lab, due following Tue at midnight

# Labs

Set of guided exercises that follow up on lecture

~2 hours (lab open 4 hours for flexibility)

Work with partner(s)

Complete exercises and check in with staff

Leave lab ready to start assignment

Lab participation is **mandatory**

Philosophy: lab is hands-on, collaborative, supported, fun!

# Assignments

7 weekly assignments that build on each other  
This is where the learning really happens!

Each assignment has

- **Basic** requirement (tight spec, guided steps)
- Optional **extension** (opportunity for exploration/creativity)

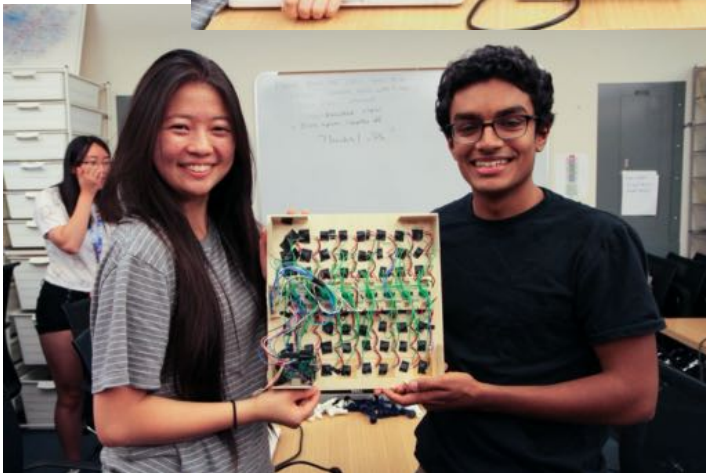
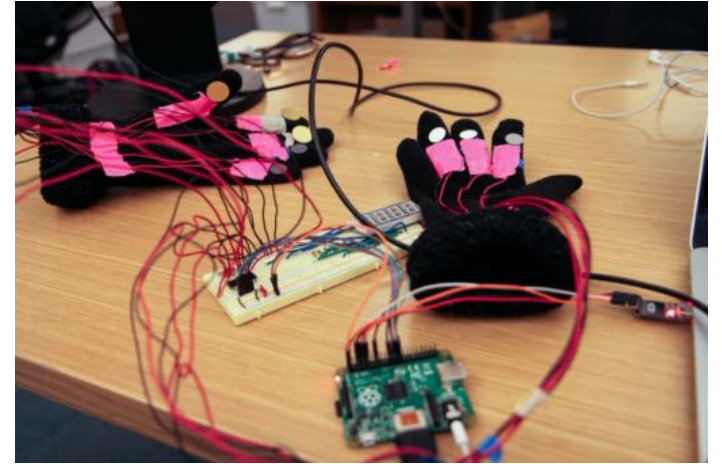
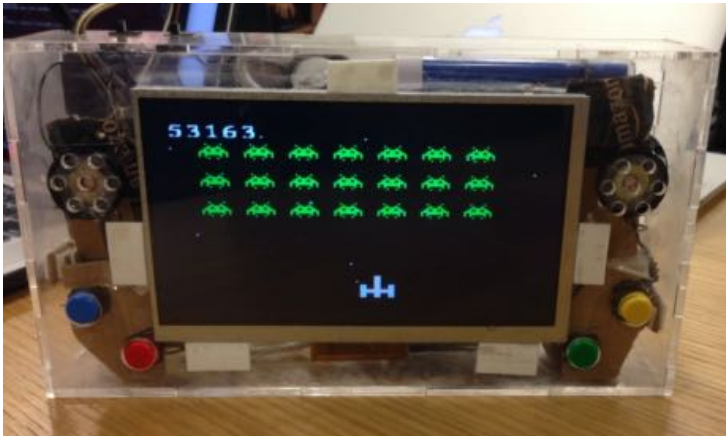
Encouraged to resubmit and correct issues in basic

End goal is complete working system of your own



# Project!

project\_fair.mp4



# Markers for success

- Solid prerequisites: CS106B, C++, debugging
- Curiosity
- Perseverance
- Motivation

How to thrive in this course

- Consistency, follow through
  - Leverage our resources, support, feedback
- Ask questions, reach out when you need help

# Interested?

FAQ [cs107e.stanford.edu](http://cs107e.stanford.edu)

Follow up discussion on Ed forum

Submit student questionnaire by Dec 15th

Our decisions by Dec 18th, your commitment by Dec 20th

Kits shipped and we hit the ground running Jan 11th