

Computer Systems from the Ground Up



Winter 2025

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!**

Learning goals

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

2) Master your tools

Understanding is empowering!

RISC-V 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

Processor control, interrupts

Master your tools

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

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

Programming languages: C, assembly

Compiler: gcc

Assembler: as

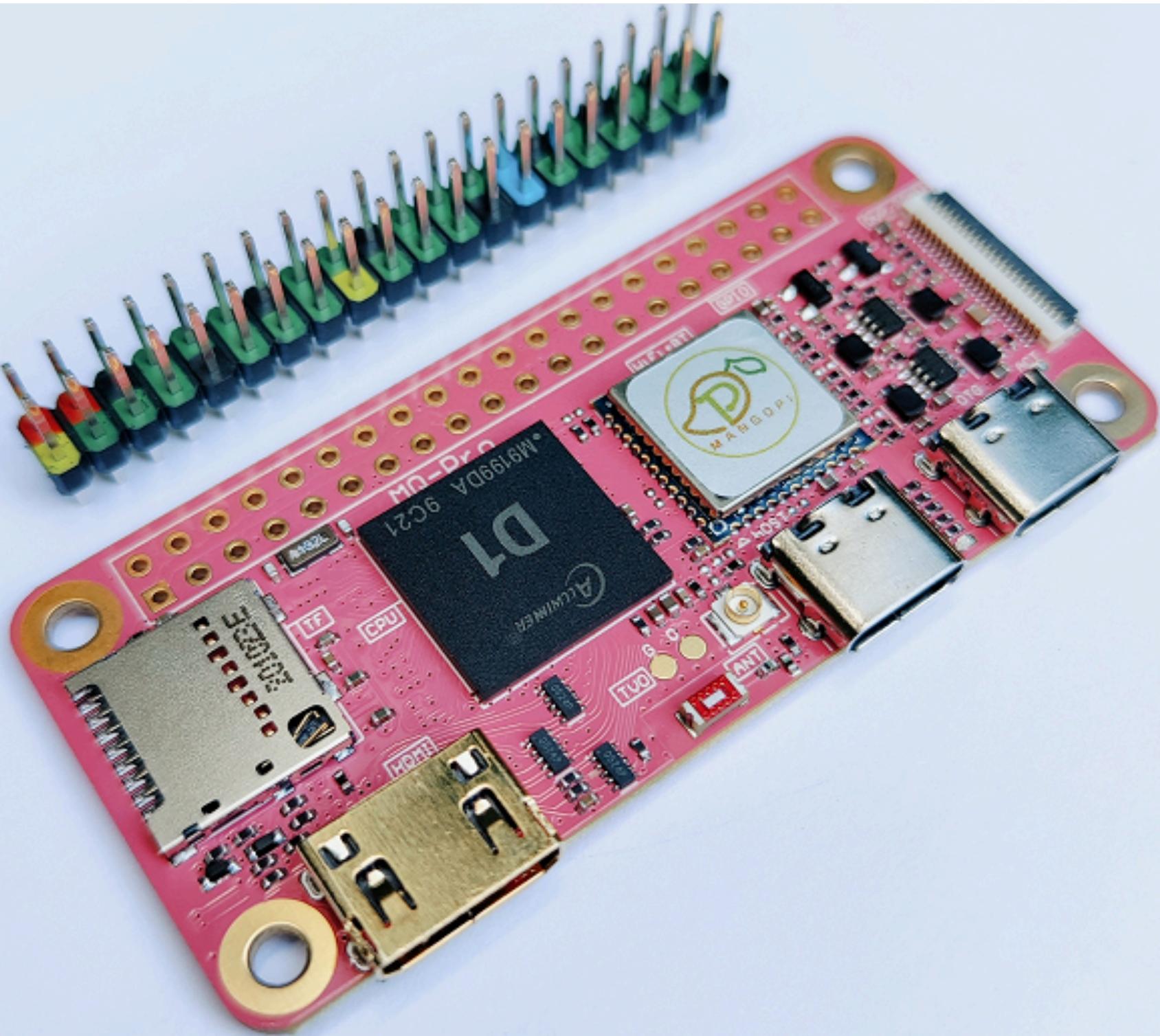
Linker/loader: ld

binutils: nm, objcopy, objdump, ...

make

git and github.com

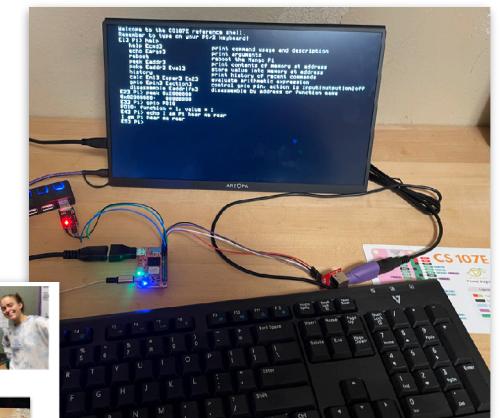
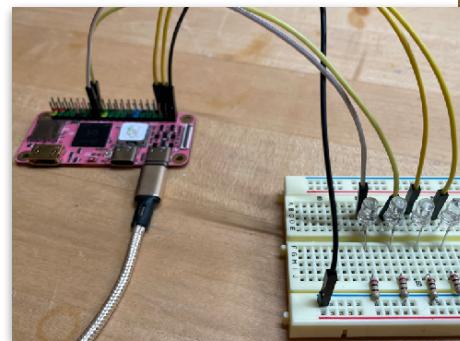
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Course Syllabus

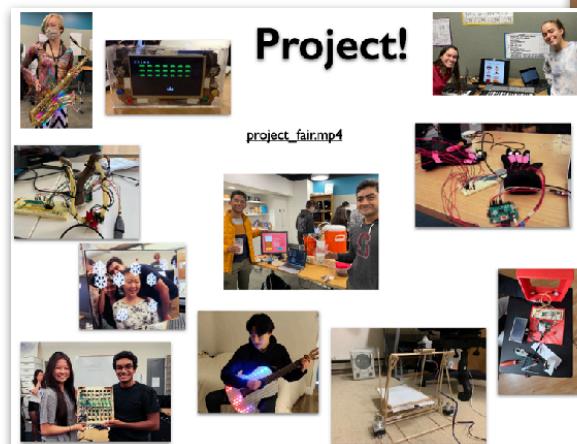
§1 Bare Metal Programming

- RISC-V 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

Schedule

First ~8 weeks follow **weekly cadence**, each week has focus topic

- Pair of coordinated lectures on **Fri** and **Mon 10:30am-12pm**
- Lab session Tues/Wed evening **6:30-8:30pm**
- Assignment out after Wed lab, due before next Tue lab

Last 2 weeks are **project-focus**

- Lecture on special topics
- Labs used as project work sessions
- Projects due at end of finals week
- Demo day is **Fri March 21st 9-11am**

Lectures

Attendance is **necessary**

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

In-person attendance allows you to participate, ask questions,
keep on schedule, stay connected

Labs

Set of guided exercises, follow up on lecture content

Work in groups

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

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

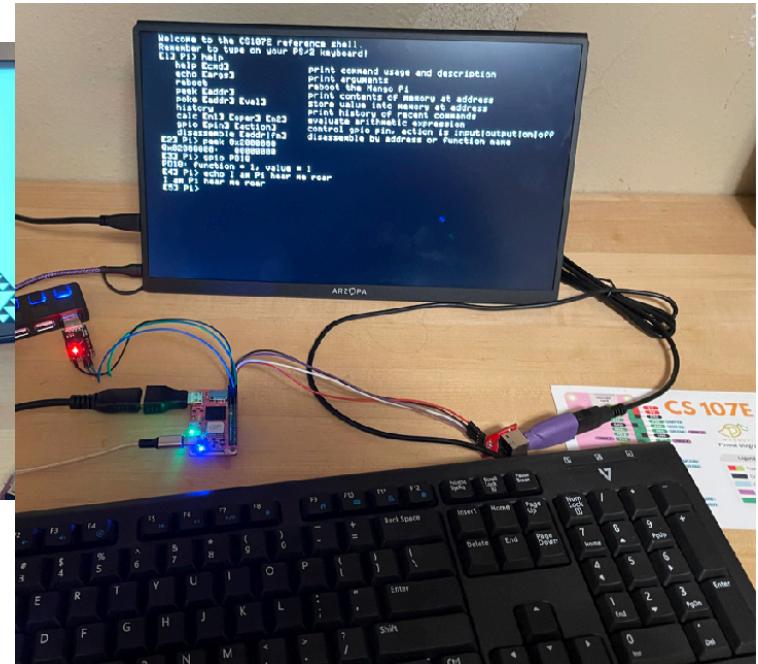
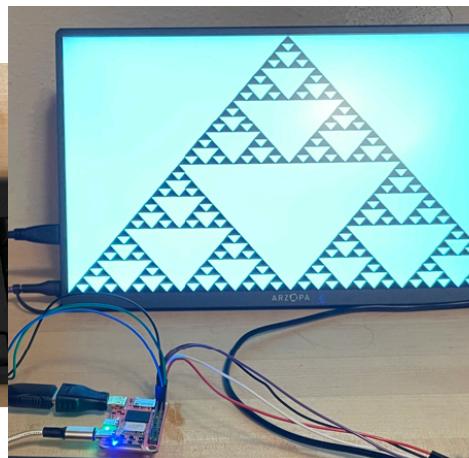
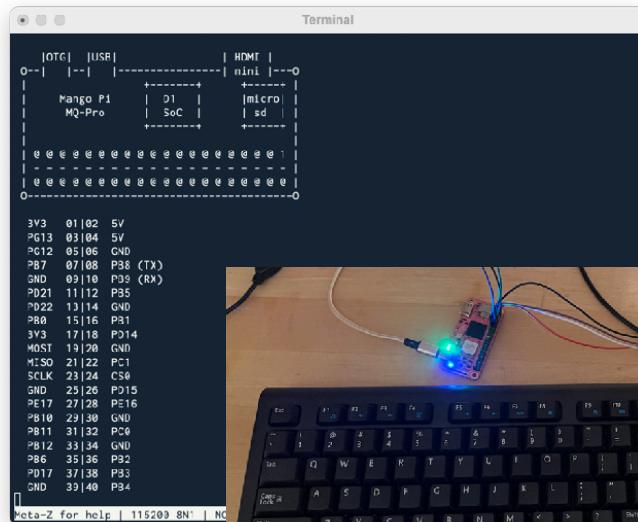
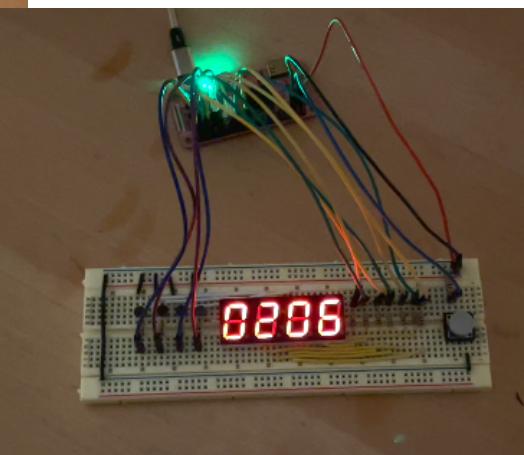
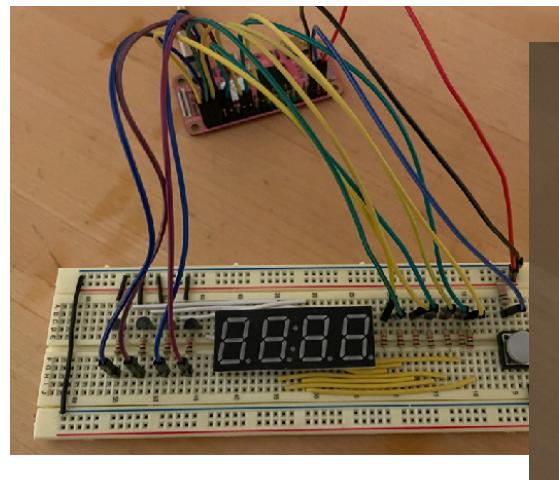
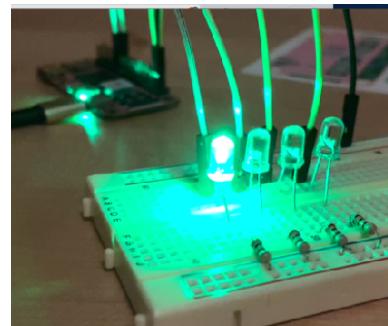
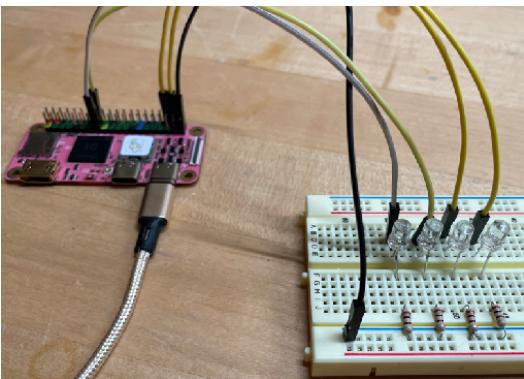
Each assignment has

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

Opportunity to revise/resubmit to correct missed basic requirements

End goal is complete working system of your own

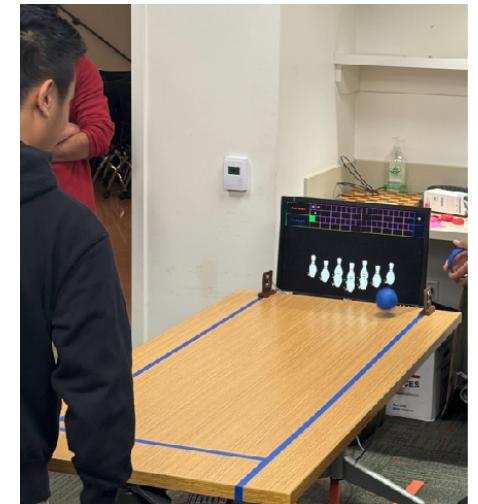
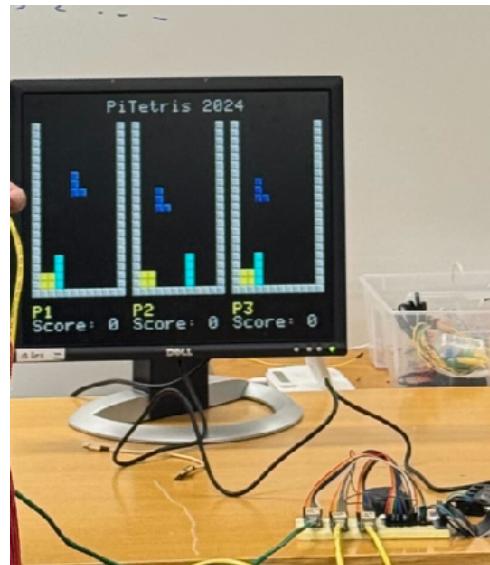
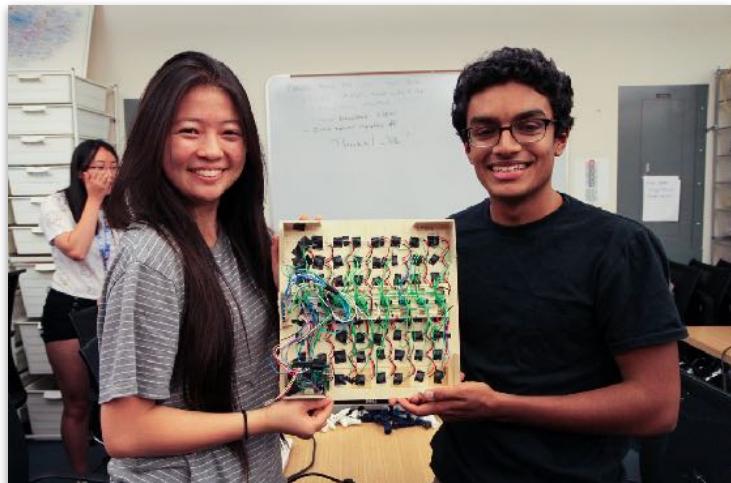
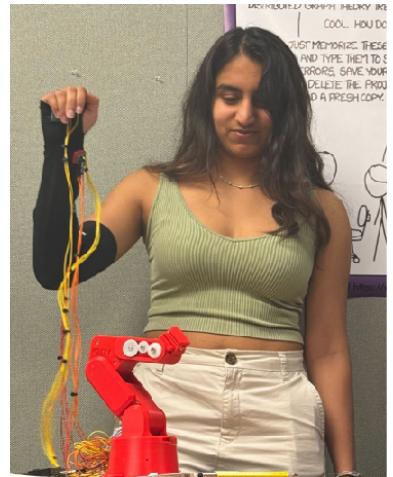
Your complete system



Nearly every instruction is code you wrote yourself!

Project!

project_fair.mp4



Input → output

Before, you bring:

Required: CS106B, C++, debugging

During, apply your
Curiosity
Perseverance
Hard work



Value and appreciate small learning community!

After, you will have:

Knowledge of how computer works

Built a complete system from ground up + creative project!

Leveled up your programming skills

Enrollment process

We can enroll up to 40 students

Lightweight questionnaire for you to share your interest
and fit (linked at <https://cs107e.stanford.edu>)

Questionnaire open Dec 6 through Dec 20
Must submit questionnaire to be considered, don't forget!

Decision email over winter break, ask for your response
Please only accept if your commitment is firm