ECE 471 – Embedded Systems
Lecture 1

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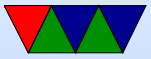
Welcome to ECE471!

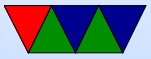
We're going to learn all about embedded systems!

https://web.eece.maine.edu/~vweaver/classes/ece471_2024f/



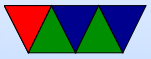
Syllabus – Instructor Info

- I'm Professor Weaver
- Go over syllabus
- QR-Code: Should you trust it?
- Office is 203 Barrows
- Tentative Office hours 11am-noon Tues/Thurs.
  Feel free to stop by if door open
- Lecture notes will be posted to website usually within a day or so



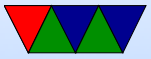
Pre-reqs / Requirements

- ECE271 or equivalent experience
  - Mostly C programming
  - A tiny bit of ARM assembly language
  - Some previous Linux knowledge helps
  - I'll review a lot of this as we go
- No textbook.



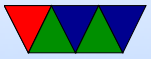
Syllabus – Hardware

- You will need a Raspberry Pi. More on that later.
- You will need a breadboard. I assume you already have one. If not let me know.
- I will provide some jumper wires (that you can keep)
- I will loan out other devices/sensors that you will need to return at the end of the semester (please remember as it counts toward your grade)



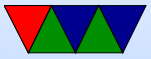
Syllabus – grading

- Homeworks, 50%: 10 or 11 total, lowest dropped.
  - Most will involve the Raspberry Pi.
  - Generally will be due on Friday by beginning of class. Will have a week to do them.
  - Submission by e-mail, grades sent in response to that e-mail, if you don't like that let me know.
  - Will send e-mail when assignment posted on website.
  - Will reply with grades. Brightspace?
- Midterms, two, 15% total



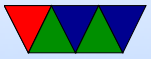
Tentatively 18 October and 18 November (SC)

- Final, 10%, Monday 16 December
- Class participation, 5%
  Part of this is returning borrowed items at end.
- Project, 20%: Involves using what you learned to do a small embedded project, with a final writeup and demo the last week of classes. Can work in group. Doesn't have to be a Pi or written in C. More details as we get closer.



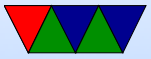
Syllabus – Late Work / Regrade

- Late work penalty. I will consider late work, but best to turn in what you have at time.
- Make regrade requests via e-mail.



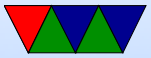
Homework Help

- I'll be glad to help if you get really stuck on homeworks
- Often the easiest way to do this is send me your code, as I can run it through the compiler and test it. Describing your issue or sending me a screenshot might not be enough and I'll probably ask you to send your code



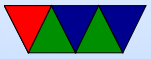
Covid/Mask Policy

- Follow UMaine Guidance
- I feel this year is more dangerous than previous years
- If you test positive for Covid/Mpox/Bird-Flu/etc please don't come to class. Let me know and we can make sure you get the work done
- If you are sick for any reason but still coming to class I encourage you to wear a mask



Syllabus – Academic Honesty

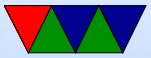
- This has been a problem in the past!
- Do not copy code from other students, either current or from previous years.
- Asking help from the professor/TA is fine
- Asking for general help, or discussing with classmates is fine
- Even having someone look over your code to help find a problem is fine
- Try to avoid giving someone code to use as a reference



as in my experience it's too tempting and the person will "accidentally" submit it as their own

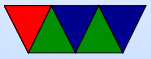
- Just don't copy someone else's code and submit it as your own

  This includes cut-and-paste or retyping
- Also don't copy code off the internet (again, looking for advice online is fine, but copying code directly is not)
- Don't use AI tools that do the homework for you! (Like Microsoft/Github Co-pilot/ChatGPT)



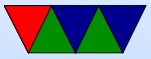
Why not AI?

- You'll note that I'm not a huge fan of AI
- Makes me unusual as it's the current fad
- You're here to become an expert on embedded systems
- AI can be subtly wrong, and you can only catch it if you actually know what's going on
- I do my best to give feedback on your code, waste of time if I'm grading some AI



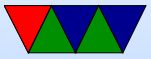
Syllabus – Boilerplate

- Go over boilerplate



Raspberry Pi

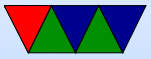
- We will be using Raspberry Pi devices for the homeworks
- Luckily the parts shortage seems to have finally eased `https://rpilocator.com/`
- See note on course website about what you need
- If you can't get a Pi before HW#2, let me know and I have some really old ones I can loan out



Raspberry Pi – Models

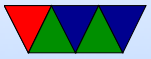
- Pi Foundation constantly changing up the Pi lineup
  Thanks to Linux we can use most of the various models with some cautions
- See the website for a longer writeup on this:

  `https://web.eece.maine.edu/~vweaver/classes/ece471_2024f/rasp-pi.html`



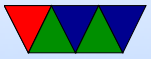
Raspberry Pi – Good for this Class

- Model 3B/3B+ (probably best)
- Model 4B (faster, but often cost more and have more annoying accessories)
- Model 5 (fastest, but expensive and also annoying accessories)
- Model 2B/1B (older and harder to find, also no wifi)
- Model 2A/3A/4A – these work for the class but lack wired Ethernet
- Model 400 – a Model 4 build into a keyboard



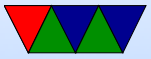
Raspberry Pi – OK for this Class

- Pi Zero/Zero-2/Zero-W/Zero-2W
  These have limited or no networking, the header isn't soldered on, and have other limitations. They will work though.



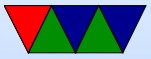
Raspberry Pi – Please Avoid

- Compute Modules CM1/CM2/CM3/CM4
  Technically they would but you'd need hundreds of dollars of additional backplanes
- Pi Pico – has a very different chip and won't run Linux



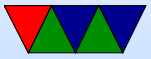
Additional Parts – SD Card

- You will also need an SD card (8GB or bigger)
- Older Pis take the wide ones, newer the narrow ones. Usually not a problem as they tend to come with those adapters.
- You will want to install Linux (I tend to use Raspbian AKA Raspberry Pi Linux), getting a card pre-installed with Raspbian can save an hour or so of writing the SD card. (We will discuss this more in HW#2)



Additional Parts – Power Adapter

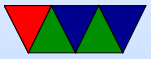
- You will need an adapter and/or cable
- Pi3 and older you need a USB-micro charger, generally 1A for older and 2A for newer. You can often get away with just a USB-micro cable plugged into a USB port of desktop/laptop
- Pi4/Pi5 you need a USB-C adapter and there can be issues using ones that aren't the official one



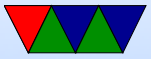
Pi Optional Accessories

It can be fun to accessorize, but the stuff on the previous page is all you need. Below are some *optional* extras.

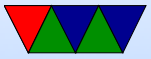
- A case can be useful, if only to avoid accidentally shorting out things. Many people get by just fine without one.
- HDMI adapter to connect to a screen
  (note pre-3 regular HDMI is fine, pi-zero I think use mini and pi-4/pi-5 use micro)
- USB keyboard/mouse if using it like a desktop
- USB serial if you're hardcore



- Ethernet cable if connecting to a wired network
- A dedicated GPIO connector to breadboard adapter



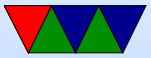
Embedded Systems



What are some embedded systems?

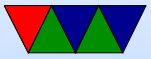
Seemingly everything has a computer in it these days. IoT.

- Cellphone (though lines blurring, general purpose)
- Vehicles (Cars/Airplanes)
- Appliances (TVs, Washers, Microwaves)
- Medical Equipment
- Industrial/Factory
- Space Probes
- Video Games?



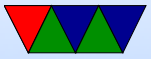
Characteristics of an Embedded System

- Embedded.
  Inside of something.
- Fixed-purpose.
  Why? You can optimize.
  For cost, power, size, reliability, performance.
- Resource constrained.
  Small CPU, Memory, Disk, I/O, Bandwidth
- Lots of I/O
  For reading sensors (input) or controlling hardware



(output)

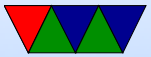
- Often real-time constraints.
  Want I/O to happen in guaranteed timeframe.



What Size CPU/Memory?

- Anything from 8-bit/tiny RAM to 32-bit 1GHz 1GB
- Performance has greatly improved over the years. ARM Cortex A9 in an iPad2 scores same on Linpack as an early Cray supercomputer

Type			Speed	RAM	Disk	GPU
Intel	Xeon	64-bit	4GHz	16GB	1TB	Nvidia
ARM	A53	64-bit(?)	1GHz	1GB	8GB	VC4
ARM	M0	32-bit	32MHz	16kB	128kB	none
MOS	6502	8-bit	1MHz	64kB	140kB	none



Discussion

- What concerns might you have when designing an embedded system?
  Security is a big one these days
- What language might you write your code in?
  C is still popular despite security issues.