Description (not part of the original document):
This document was a proposal written by me and my co-head lab TA Shrey Aeron for EECS 16B, in which we propose switching the 16B lab curriculum from using a TI Launchpad microcontroller to Arduino Leonardos. We ended up successfully making the transition for the Fall 2022 semester.

EECS 16B Fa22 Arduino Transition

Introduction

Over the past few semesters, 16B has been making efforts to migrate labs from utilizing Launchpads to using Arduinos. As of Summer 22, 16B has completed migrating all of our labs to work on Arduino Leonardos; as a result, we would like to have our Fall 22 offering to have labs in Arduino rather than with Launchpads. The purpose of this document is to outline the justification, plans, and timeline for this transition.

Why Arduino, and Why Now?

EECS 16B Lab saw almost 300 fried launchpads in just Spring alone, a rate that is simply not sustainable. At around 12 dollars per launchpad, this amounts to almost $4000 of monetary loss simply from frying. The main sources of frying of Launchpads are: accidentally plugging in DC power and the micro usb connection at the same time; and the Launchpad pins receiving a voltage higher than their rated voltage (3.3V).

With the Arduino, we are able to avoid both of these issues: Arduino's have a MOSFET switch which automatically switches between DC power and Micro-USB power, making it safe to have both power sources plugged in at the same time. Moreover, they can directly be powered with 9V, avoiding the 5V regulator and its risk of frying. Arduino pins are rated for up to 5V rather than the Launchpad's 3.3V; since no components of our circuit will be using voltages higher than 3.3V, this vastly reduces the chances of pins frying.

More importantly, Arduinos have more real world applicability than Launchpads do: on top of being easier to work with for students and more resilient, Arduinos have a very large open source community and can be found in many EE projects.

While rolling out Arduino development this Fall may seem a little hasty, we believe that rolling out this Fall would be a superior option to rolling out next Spring. We will be dealing with a much smaller class size this coming Fall, due to a combination of Fall offerings being smaller in general as well as the recent L&S decision to drop 16B as a requirement. This smaller class size gives us a great opportunity to work on large changes to the course while mitigating the risks associated with transitioning a 1000+ student course.

Our Options

Our options are as follows

1. Fall Labs will be only offered in Arduino, All lab groups get their own Arduino (we would need ~130)
2. Fall Labs will be only offered in Arduino, Arduinos will be loaned out each section (we would need ~35)
3. All labs will be ran with both Arduino and Launchpad, with students having the decision to choose which one they want to use
4. Some lab sections will be ran using Arduino and others will be with Launchpad
5. No Arduino and still use Launchpad, which makes us sad

Notes: 1 and 2 are our preferred options. Under 1, we would likely have to look into increasing the course material fee by around ~10 dollars since individual Arduinos are a bit more expensive than launchpads. However, because we expect close to no Arduinos to be frying compared to the ~$4000 dollars worth of Launchpads frying in just one semester. Even with an incredibly extreme estimate that 10% of our Arduinos will fry, this will amount to thousands of dollars of savings each year). Having staffing and staff training for both Arduino and Launchpad labs (3 and 4) will, in our opinion, be more logistically complicated than it is worth (especially since most staff will teach multiple sections).
Professor Sahai has expressed that he thinks we should avoid doing a loaner system, as he wants students to keep their car as sort of a prize/memory/memento. Since EECS 16B lab is more involved, many students end up working on labs in the comfort of their homes; no access to the microcontroller would hinder their progress.
Currently, we are facing a crisis in the semiconductor industry with a dearth of people stepping up to the jobs, and though seemingly non-trivial, allowing students to keep their microcontroller after completing the class would encourage them to satiate their curiosities and engage in side projects that motivate them toward EE. (We have several anecdotes on this front.)

Risks and Risk Mitigation

As with any transition, we will face a number of risks, which we have primarily categorized as:

- More bugs, making labs more time-consuming for both students and staff
- Staff may not be equipped to deal with Arduino specific issues
- In a worst case scenario, we may face some unsolvable bug in Arduino that prevents further lab progress
- *[add anything else here]*

We will mitigate the risk of potential Arduino lab bugs through thorough testing, which is discussed in detail in the following section. Moreover, we have designed all of our labs to remain on using 3.3V logic for the circuitry. Thus, in the absolute *worst* case scenario that we face some

unsolvable bug in Arduino that prevents further lab progress, it is little to no effort to swap back to Launchpads (of which we currently have in stock).

Our Tasks & Timeline

We defined the following list of tasks and milestones that must be completed in order to enable a successful transition:

1. Get labs working on Arduino
2. Update pre-labs, lab notes, and lab notebooks to reflect any changes to lab content or procedures
3. Test additional lab runthroughts to find potential bugs and ensure reproducibility for both individuals and hardware
4. *[add anything else here]*

1. Get Labs Working on Arduino

Completed 07/09

2. Update pre-labs, lab notes, and lab notebooks to reflect any changes to lab content or procedures

This is a task that is typically completed throughout the semester, and as a result is not a huge priority. However, we (Shrey and Mingyang) have done a preliminary pass and updated all the necessary components of the lab (updated instructions that changed and Launchpad specific references/match, cut non-relevant parts etc) as of 07/14. The more minor changes (ie content ordering within labs and stylistic changes) will be left to be done with the standard lab content schedule. We have additionally developed a checklist to ensure that all lab content is updated, which is located in the appendix.

3. Test additional lab runthroughts to find potential bugs and ensure reproducibility for both individuals and hardware

We are doing extensive tests over the summer to make sure that our labs are consistent and reproducible.

Currently, two of our summer ASEs (Joy and Sai) are doing a thorough test of the Arduino labs to fix bugs and document potential student issues. The current plan is to have them

1. Run through all the labs using their old circuits/car
2. Utilize the ~15 leftover cars inside Cory 125 and multiple Arduinos to ensure that labs still work when dealing with hardware differences across arduinos/circuit components.
3. If time permits, redo the lab with brand new circuits/car.

They will additionally be explicitly testing different potential mistakes that students may make, and keep an internal document of any bugs and their corresponding fixes they run into.

Semester Starts: 08/24

Action Items We Need from the Department

1. Updating Lab Kits
   Aside from replacing Launchpads with Arduinos (specifically, Arduino Leonardos), the lack of male headers on the Arduino would mean that we would also need male-to-male jumper wires rather than only male-to-female jumper wires.
   Otherwise, nothing else in lab kits will change.
2. Sourcing Arduinos
   How will we be sourcing Arduinos? Will we or the department be handling that? How much will the final cost be after getting potential discounts? As briefly mentioned previously, will we have to deal with increasing the course material fee? Should we try to negotiate a sponsorship with Arduino, similar to the likes of TI (especially given the fact that Arduino is an active supporter of education)?
3. Installing Software
   We'd need to install the Arduino IDE and the necessary board manager software on all lab computers.

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Fa22 16B Lab Admin
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Appendix

Checklist for Updating Labs

- Replace ino file
- Update lab notes
    - Basically same process as lab notebook
- Update pre-lab
    - Don't think there's any actual changes to make aside from replacing launchpads with Arduinos but will check
- Update lab notebooks
    - Replace launchpads with Arduinos
    - Update pins to match the new ino files
    - Update diagrams to arduino pins/use tinkercad diagrams which already have the arduino pinout setup
    - Update instructions on how to use Arduino (ie power circuitry with 9V input vs USB input works)
    - Update lab specific calculations/explanations, ie:
        - Update encoder setup notes
        - Update calculation for adc/dac lab (or fix code to use 3.3v logic but this makes the code less understandable for students)
        - Micboard powered off 3.3v