Advanced Lab Spring 2021

This is a tentative syllabus. The final syllabus will be on Canvas. Questions? Please email jbrody@emory.edu

Course Competencies: After completing this course, you will be able to:

- Design, analyze, and run quantum circuits remotely via the IBM Quantum Experience
- Program and wire an Arduino circuit board as a computer interface
- Derive and experimentally test the ideal diode law
- Use Fourier series to explain measured temperatures at the top of a nail dipped in ice water
- Determine the rotational speed of THE WHOLE ENTIRE GALAXY by using Emory's radio telescope to record Doppler shift in radio waves from interstellar hydrogen clouds
- Use Princeton's remote plasma lab to measure the breakdown voltage as a function of electrode distance and gas pressure
- Write lab reports in the style of scientific journal papers

Course Schedule: Synchronous experiments with lab partners are the first ten Thursdays 2:40-5:35. There are no synchronous meetings on Tuesdays, but there are asynchronous labs that you're welcome to do on Tuesdays (or any other day).

Experiments:

- Quantum Computing and the Nature of Reality. There are ten afternoons allotted to this experiment, which you may do with a lab partner.
- There are three asynchronous labs that will each take approximately five afternoons. They may be done in any order, except that Arduino Lab 1 comes before Arduino Lab 2.
    - Galactic rotation: You probably want to do this one first if you're in the Atlanta time zone. There's a 3-hour window every day when the telescope's range encompasses what we want to measure. In February, the window is approximately 8-11 a.m., and it gets two hours earlier every month.
    - Arduino Lab 1: Ideal Diode Law
    - Arduino Lab 2: Transient Heat Conduction in a Heat Fin
- There is one asynchronous lab that takes approximately three afternoons: Princeton Plasma Lab.
- Suggested dates for experiments:
    - Synchronous Lab (quantum computing): 1/28, 2/4, 2/11, 2/18, 2/25, 3/4, 3/11, 3/18, 3/25, 4/1
    - Asynchronous Lab A: 1/26, 2/2, 2/9, 2/16, 2/23
    - Asynchronous Lab B: 3/2, 3/9, 3/16, 3/23, 3/30
    - Asynchronous Lab C and Princeton Plasma Lab: 4/6, 4/8, 4/13, 4/15, 4/20, 4/22, 4/27, 4/29

Lab Reports:

- You write your own lab reports, even if you have a lab partner.
- You should submit at least two drafts of each lab report. You may submit as many drafts as you want.
- I expect to grade all drafts within one week.
- There are no late penalties, but everything must be submitted by May 7.

Grading:

- 30% Synchronous Lab (Quantum Computing and the Nature of Reality)
- 20% each asynchronous lab except Princeton Plasma Lab
- 10% Princeton Plasma Lab

Equipment List (for the Arduino labs):

- The shopping cart is here: https://www.digikey.com/short/z139mr. You will also need a cable that connects the Arduino Nano Every to your computer. This Arduino uses a micro USB connector, which many devices (some phones, Kindle, etc.) use, so you may already have the necessary cable. (I've found that micro A and micro B cables both fit in the Arduino Nano Every.) If your computer has a USB A port (the "normal" one), the Digikey part number for a cable you could use is 380-1431-ND. If your computer has a USB C port (newer Macs, I think), I think the part number is 1528-2704-ND, but please confirm; I don't have a Mac.

- You may consider ordering an extra temperature sensor (TMP36GT9Z, $1.48) because it will break if you abuse it. The diode ($0.10) is very easy to destroy by wiring it incorrectly, so you may consider ordering a couple extras.
- If you're overseas, it's probably cheaper to find a local supplier instead of ordering from Digikey. If you already have an Arduino and breadboard, you don't need to order new ones. I'm recommending the Arduino Nano Every just because it's the cheapest. There are Arduino imitations that are cheaper, but an instructor at another institution reported problems with those.
- Other equipment you'll need and may already have: a ruler, a drop of glue (superglue may be best), a nail or other small metal rod, and a cup of ice water.