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Ideas for advanced labs for remote learning compiled from the advanced labs listserv :

1. "**SPAD Circuit Construction**" <https://advlabs.aapt.org/bfyiii/Detail.cfm?id=7554> Students borrow/use Analog Discovery 2 USB Oscilloscope and some parts to recreate
2. "**Using an LED as a Low-Efficiency Single Photon Avalanche Diode**" workshop from BFYII<https://advlabs.aapt.org/bfyii/Detail.cfm?id=6072>

model a physical phenomen in python (ball bouncing), and then compare it to some data (collected analytically with cell phone)

1. **Cosmic ray detection with phone:** One of the most sophisticated tools students have at home is, of course, their cell phones. So for the Nuclear and Elementary Particle Physics category of our experimental physics decathlon, I have suggested looking into using phones for cosmic ray detection.

Major professionally-developed projects have produced apps for this endeavor:

CrayFis

<http://www.i2u2.org/elab/cosmic/library/resources.jsp?options=project>

<https://arxiv.org/abs/1410.2895>

CREDO

[https://credo.science<https://credo.science/>](https://credo.science/)

<https://credo.science/credo-detector-mobile-app/>

Important things you can do: (1) expand upon the idea of detecting cosmic rays using mobile phone cameras by estimating the probability that any given image would record such an event, (2) learn how CCD / CMOS sensors work as an instrument and try to understand why they could register the passage of a cosmic ray, and (3) think about and document approaches to data analysis that help you search several (perhaps many) images for possible events. (It might be possible to use a python adaptation of OpenCV to automate this process.)

1. **General cell phone sensors as a starting point** : Physics Toolbox Apps [https://www.vieyrasoftware.net](https://www.vieyrasoftware.net/)
2. **Analog/Digital interfacing** : I am purchasing several openscope modules which function as an oscilloscope, a waveform generator and a voltage supply. The module connects to the internet, and you can interact with it through your computer very easily. You can learn more about it here: <https://store.digilentinc.com/openscope-mz-open-source-all-in-one-instrumentation/>. $100 for each one; they retail for $150, so this is a pretty good deal. I intend to loan these to student along with some components from the lab, and a solderless breadboard so that we can continue to build projects.
3. **Inland Basic Starter v2.0 Kit for Arduino.**<https://www.microcenter.com/product/617046/inland-basic-starter-v2-kit-for-arduino-uno>I will be constructing exercises on sensors, data acquisiont and maybe some exercises on motor control. A key feature of the work is the use of pyfirmata as a means to use python to do data exchange with the Arduino from with Jupyter notebooks.
4. **More Arduino use:** We got an oscilloscope to everyone, along with an Arduino Due, ICs, protoboard, and basic components. We're planning to use the Arduino to supply single-sided DC, we're going to use two 9V batteries as a bipolar supply, and we've tested ways of using the Arduino Due to serve as a potentiometer- controlled function generator.
5. **Theoretical part of experimental physics**: Students will write a term paper instead of the last big experimental investigation. They are asked to do a “scholarly” investigation of a physics phenomenon, covering its early discovery/prediction, theoretical and experimental developments related to it, and its modern status. We tell them it is like writing an opening chapter of a PhD dissertation on an experimental topic.
6. **More arduino:** "Most Complete Arduino Starter Kit" which brings an Arduino and bunch of sensors and various output devices (motors, lights, LCD screen), also brings a series of tutorials. You can get the pdfs here: <https://www.elegoo.com/tutorial/Elegoo%20The%20Most%20Complete%20Starter%20Kit%20for%20UNO%20V1.0.2019.10.21.zip>
7. Phone sensor links:
   1. [Phyphox](https://phyphox.org/) (Physical Phone Experiments), which is both Android and iOS. In addition to providing access to phone sensor data, it provides some practical features like sound-driven timers (measure time interval between two loud noises, e.g. ball bouncing). Lots of documentation and [example usage videos](https://phyphox.org/experiments/), as well.
   2. Google Science Journal <https://sciencejournal.withgoogle.com/> , and the associated apps in a remote lab? It allows students to use all the sensors on modern cell phones (light, sound, temperature, barometric pressure, accelerometer) similarly to the IOlab, however without the special tool.
8. **'Investigate photoresistor's behavior along with Malus' Law**. PRs have a power-law dependence on intensity, so it should be possible to determine that exponent if we can assume that Malus' Law is correct - without ever knowing the true intensity of the light shining on the PR. I did a version of this experiment with high school teachers many years ago. I'll probably be sending a 3.2V 650nm diode laser module (from aixiz) as the light source (along with LEDS, resistors, polarizers, thermistor, etc.) and a DMM to make measurements. Lots of other data acquisition devices could work , of course. Photoresistors are light and temperature dependent, and even dependent on the history of their exposure to light. (Lowell McCain)
9. **Remote materials characterization**: I have been running a materials science module, using AFM, remotely for our advanced lab since January. I walk through the AFM image analysis via Zoom, sharing my screen, and interact via the live-web conferencing during lab time with students.

**Sophomore lab ideas :**

Logger Pro has a nice experiment to measure speed of sound with a Vernier microphone and a mailing tube. In the Modern Physics lab, some of the relevant experiments that we do include speed of light, Michelson interferometer, and electron diffraction.

You might look into the OSU Paradigms in Physics <https://physics.oregonstate.edu/paradigms> .

The old book by Crawford on Waves has a large number of home experiments