

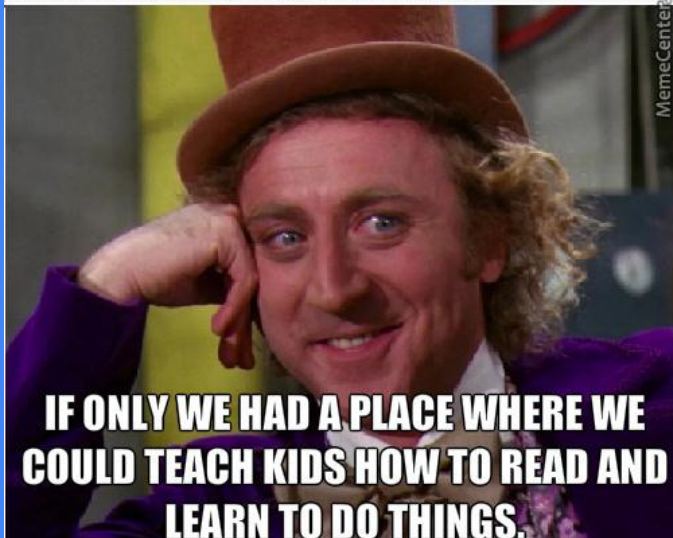
Lab 2: Analog to Digital Circuit Interfaces

EECS 16B Spring 2023

Slides: links.eecs16b.org/lab2-slides



Schools Are Removing Analogue Clocks Because Kids Can't Read Them
As our age becomes more technological, we've become more dependant on the our screens. And this has had a very drama...



Logistics: Makeups/Extensions/Groups

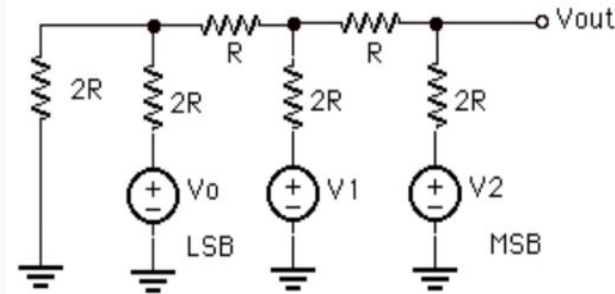
- **Makeup:** you need to attend a different lab section to finish the lab on time
 - Sign up at <https://makeup.eecs16b.org>
 - Only one group member needs to sign up
 - Labs are due by the end of your next section
- **Extension:** you need additional time to complete the lab
 - Same form as HW Extensions: <https://eecs16b.org/extensions>
 - Without an extension, late labs are 50% credit
- **Fill out the Lab Group Form** (necessary to receive an Arduino):
<https://eecs16b.org/lab-groups>

Lab 2 Overview: DAC and ADC

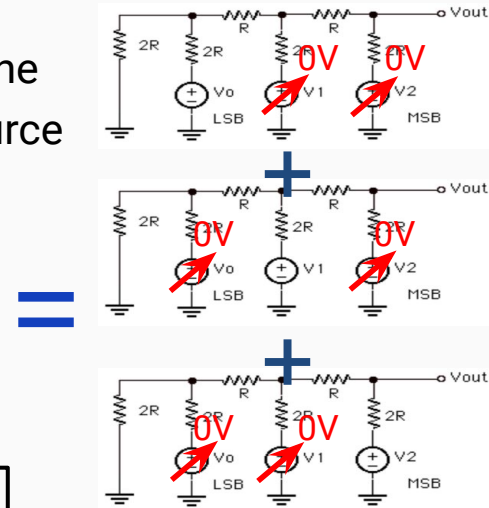
- DAC = Digital to Analog Converter
- ADC = Analog to Digital Converter
- Real world is continuous, but computers need to store data digitally
 - Need to find a way to convert between analog and digital for signals
 - EE 123 discusses consequences of digitally sampling analog signals, EE 140 discusses the design of DACs/ADCs
- DAC/ADC in your life:
 - DAC for MP3 players, analog TVs, video on cell phones
 - ADC for sound/video recording
 - VoIP (voice over IP) uses both!

DAC Review: Superposition

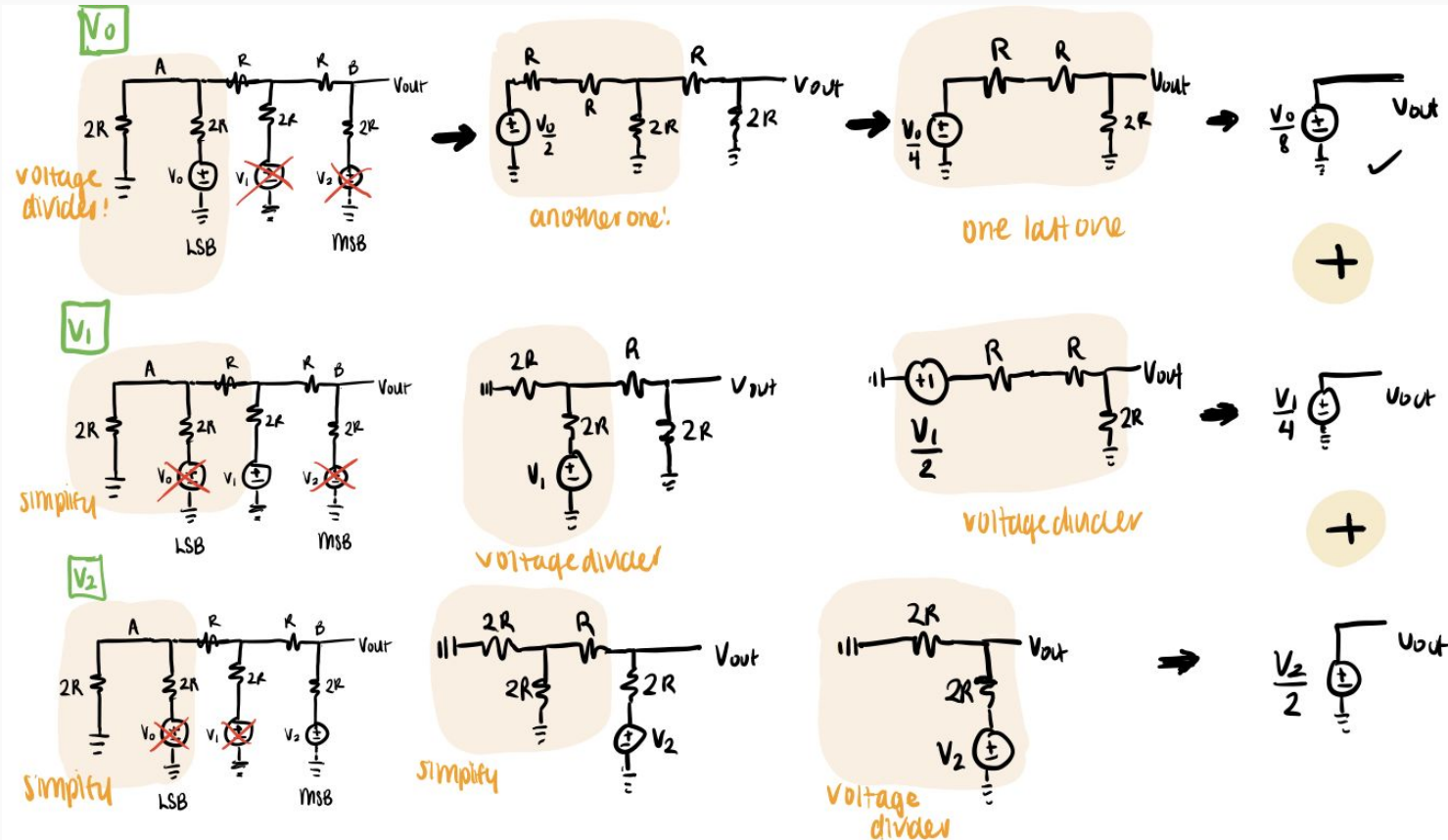
- Since resistive circuits are linear, we can apply the principle of superposition:
 - Treat each source independently – zero out all but one
 - The total effect is the sum of the effects of each source
- Example:



$$V_{out} = V_{out_1} + V_{out_2} + V_{out_3}$$

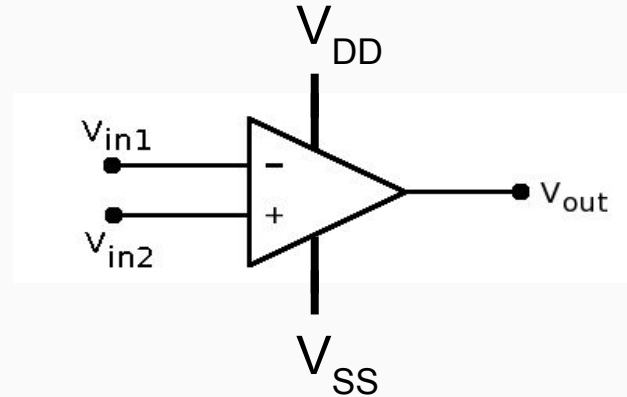


DAC Review: Superposition Example



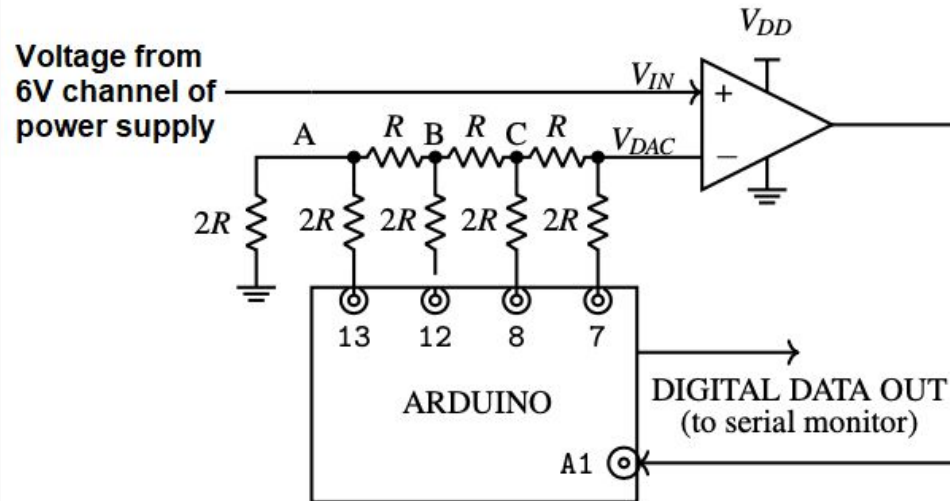
ADC Review: Comparators

- A device that compares two voltages (or currents) and outputs a digital signal to indicate which is larger
- Op-amp Implementation:
 - If $V_{in2} > V_{in1}$, V_{out} goes to V_{DD}
 - If $V_{in1} > V_{in2}$, V_{out} goes to V_{SS}
 - (think: if V_{out} is connected to V^- , its value will bring V^- closer to V^+)
- NOTE: Arduinos use 5V pin logic
 - $V_{DD} = 5\text{ V}$
 - $V_{SS} = 0\text{ V}$



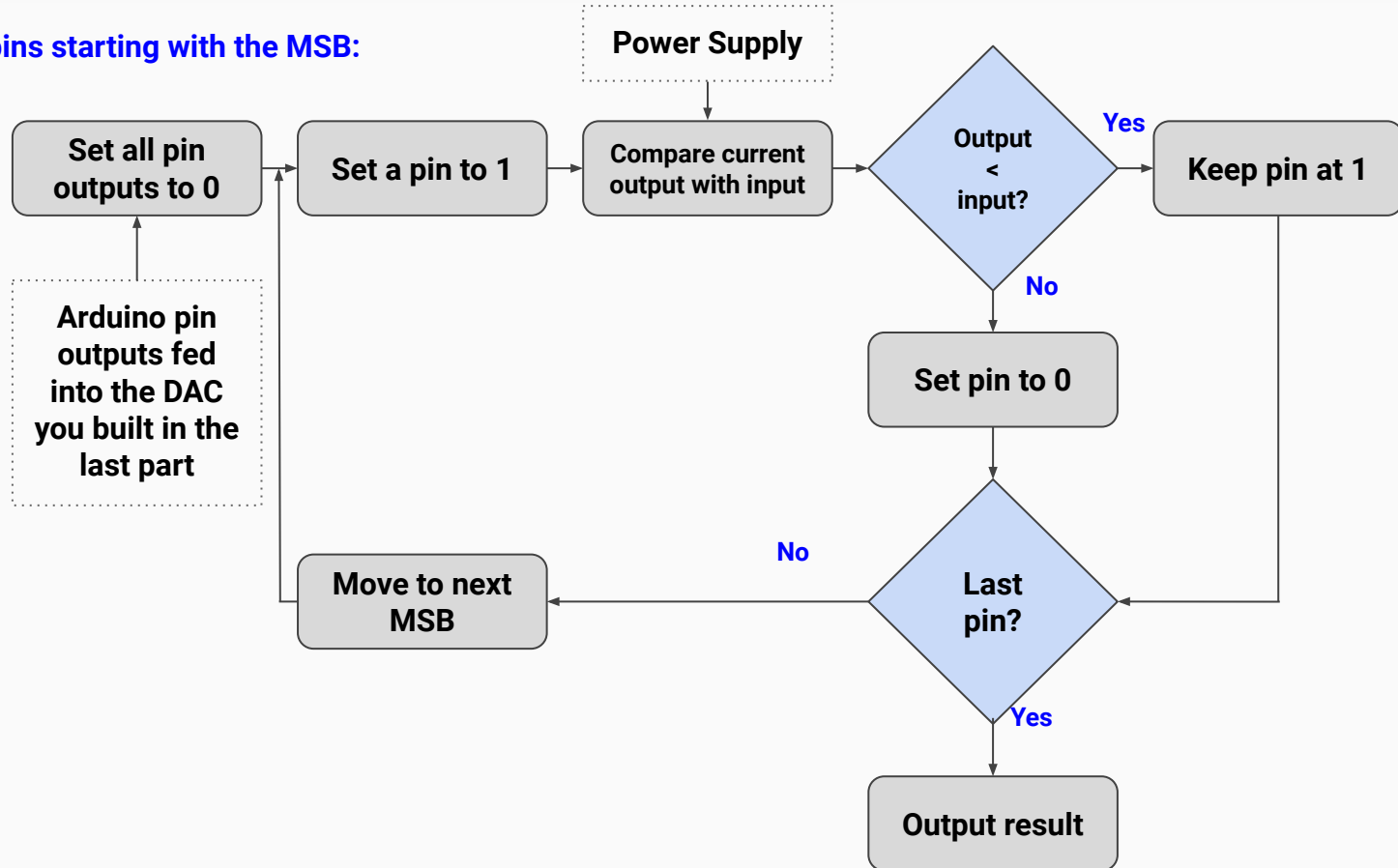
Review: ADC

- ADC - The Arduino uses binary search when turning on MSB (most significant bit) to LSB (least significant bit) and comparing the resulting V_{DAC} with V_{in}

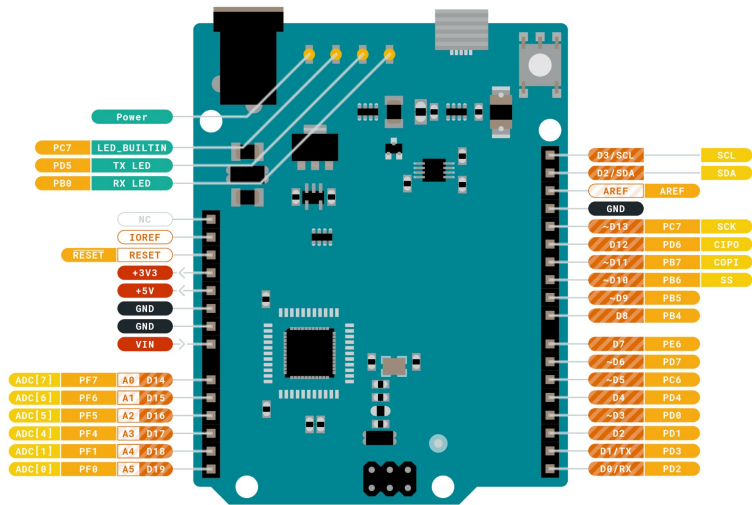


Successive Approx. Register ADC

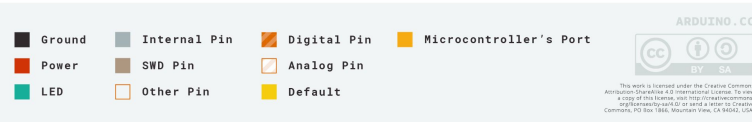
Loop over all pins starting with the MSB:



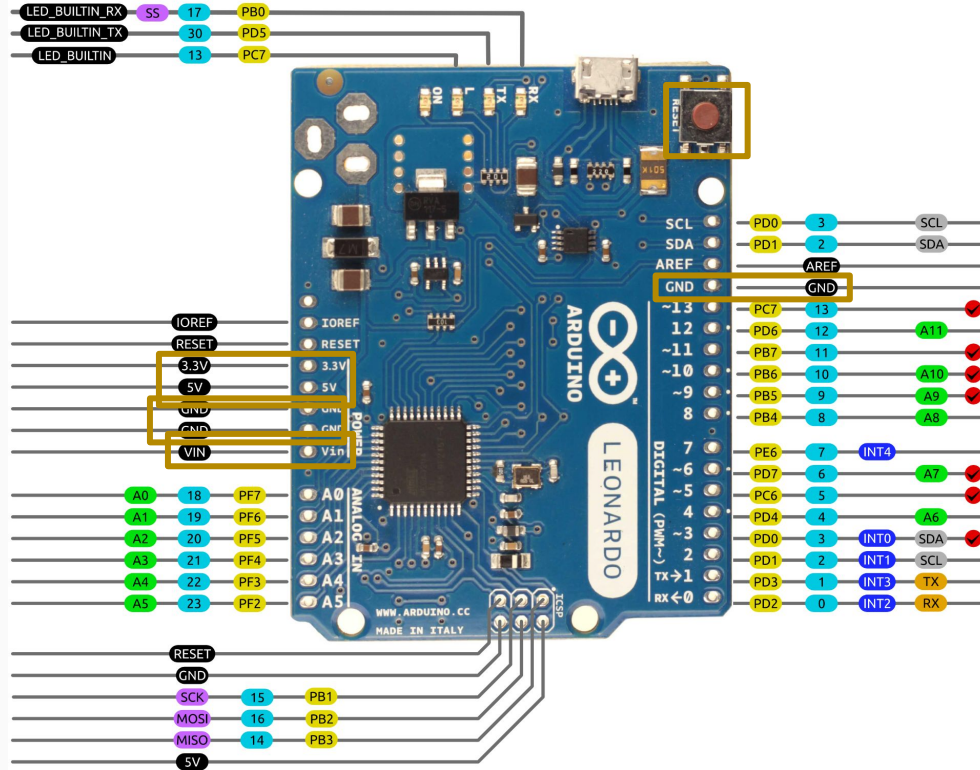
Introduction to Arduinos



- There are 4 main “Pin Modes”
- Digital: High (5V) or Low (0V) [1s and 0s]
 1. Digital Output
 2. Digital Input
- Analog: range from 0-5V [numerical values]
 1. Analog Output: mapped from 0 - 255
 2. Analog Input: mapped to 0 - 1023



Arduino Leonardo Pinout

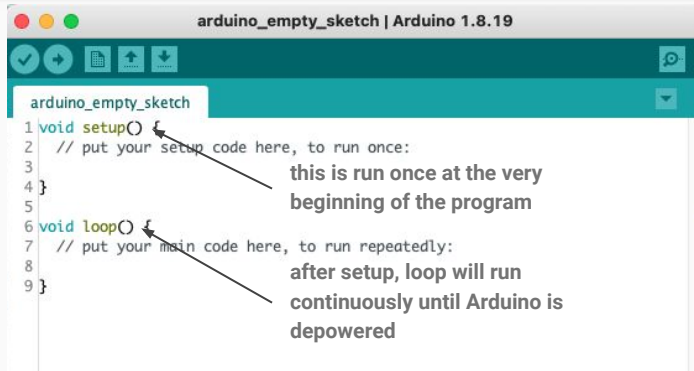


AVR DIGITAL ANALOG POWER SERIAL SPI I2C PWM INTERRUPT



2014 by Bouni, 2016 bperrybap
Photo by Arduino.cc

Introduction to Arduinos



Note: Arduino is programmed in **C** via the [Arduino IDE](#) (pre-installed on lab computers)

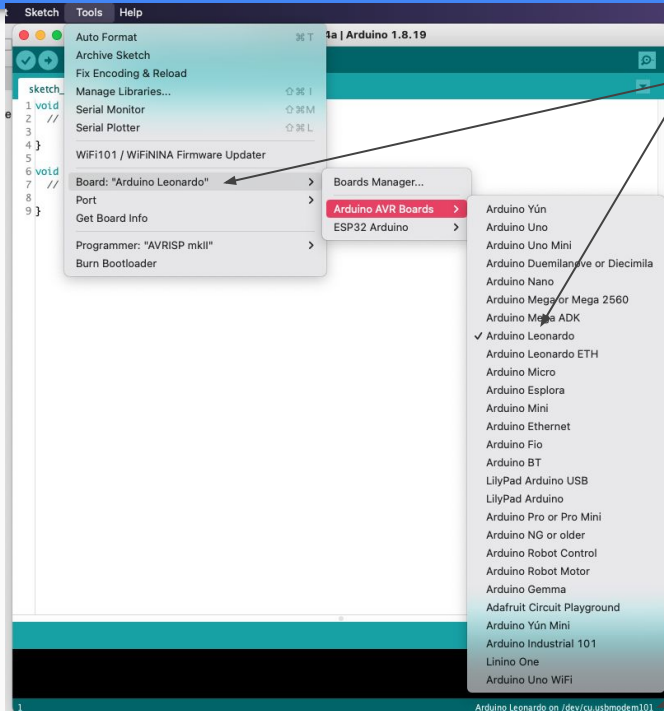
- Code uploaded from computer to Arduino via micro-USB port
- If powered, code is ALWAYS running
 - RST -> restart
 - Unpowering and powering Arduino -> begins re-running whatever was last uploaded
- If you find this to be an issue, the easiest solution is to upload a blank program

Quick Rundown: Arduino vs Launchpads

- Launchpads operate on 3.3V logic while Arduinos operate on 5V logic
 - However, for most labs other than this one, we will be keeping our circuits operating at 3.3V for stability reasons.
- External Power: the Launchpad can take 5V as an input to its 5V pin, while Arduino requires 7-12V as an input to its V_{in} pin.
 - safe to power the Arduino via both the micro=USB and V_{in} at the same time
 - Launchpads... however... go bakoom
- You actually see the word Arduino outside of 16B, when did you ever see the word “Launchpad” other than complaints about 16B

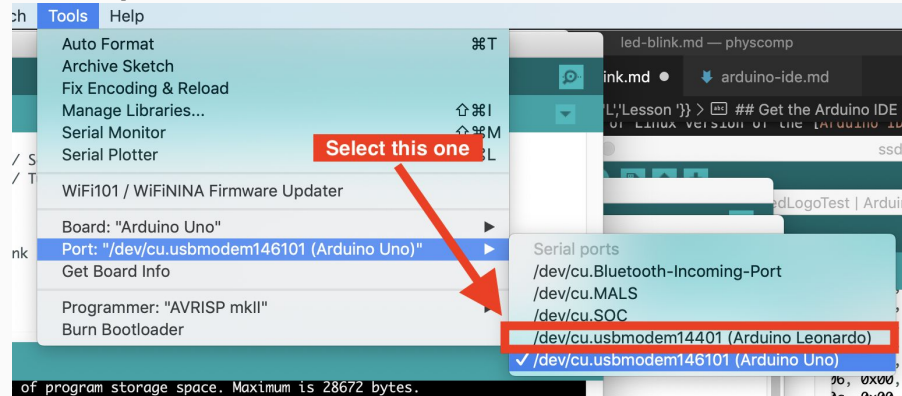


Uploading Code to Arduino



Ensure this says *Arduino Leonardo*, otherwise select it

- PORT selection
- Upload button



Arduino *should* auto-detect your port

(works 100% of the time 25% of the time)

Arduino Logistics (pt2)

- Arduinos will be passed out during lab today
- **Arduinos are property of 16B and have to be returned to us by the end of the semester**
- Fill out <https://eecs16b.org/lab-groups> to receive your Arduino

General Reminders/Habits

- Connect all grounds together, including the Arduino GND pin (any works)
- In general, avoid having voltage/currents going into your Arduino if your Arduino isn't already powered
- Check that your probes are working by probing a known voltage value
 - i.e. 5V/3.3V/GND from power supply
- PLEASE CLEAN UP AFTER YOURSELF!! Put probes back, pack up kits, throw away stripped wires etc.
- Don't unplug computers
- Work on the lab report :), the deadline will creep up on you

Important Forms/Links

- Help request form: <https://eecs16b.org/lab-help>
- Checkoff request form: <https://eecs16b.org/lab-checkoff>
- Extension Requests: <https://eecs16b.org/extensions>
- Slides: <https://eecs16b.org/lab2-slides>
- Lab Groups: <https://eecs16b.org/lab-groups>
- Anon Feedback: <https://eecs16b.org/lab-anon-feedback>
- <https://eecs16c.org>