ECEN 4013
Design of Engineering Systems

Agenda

Electrical Safety
Project 1 Introduction
Project 1 Team Assignments

Electrical Safety Review

This electrical safety review is prepared for engineering students in ECEN 4013, ECEN 4024, and Interdisciplinary projects.

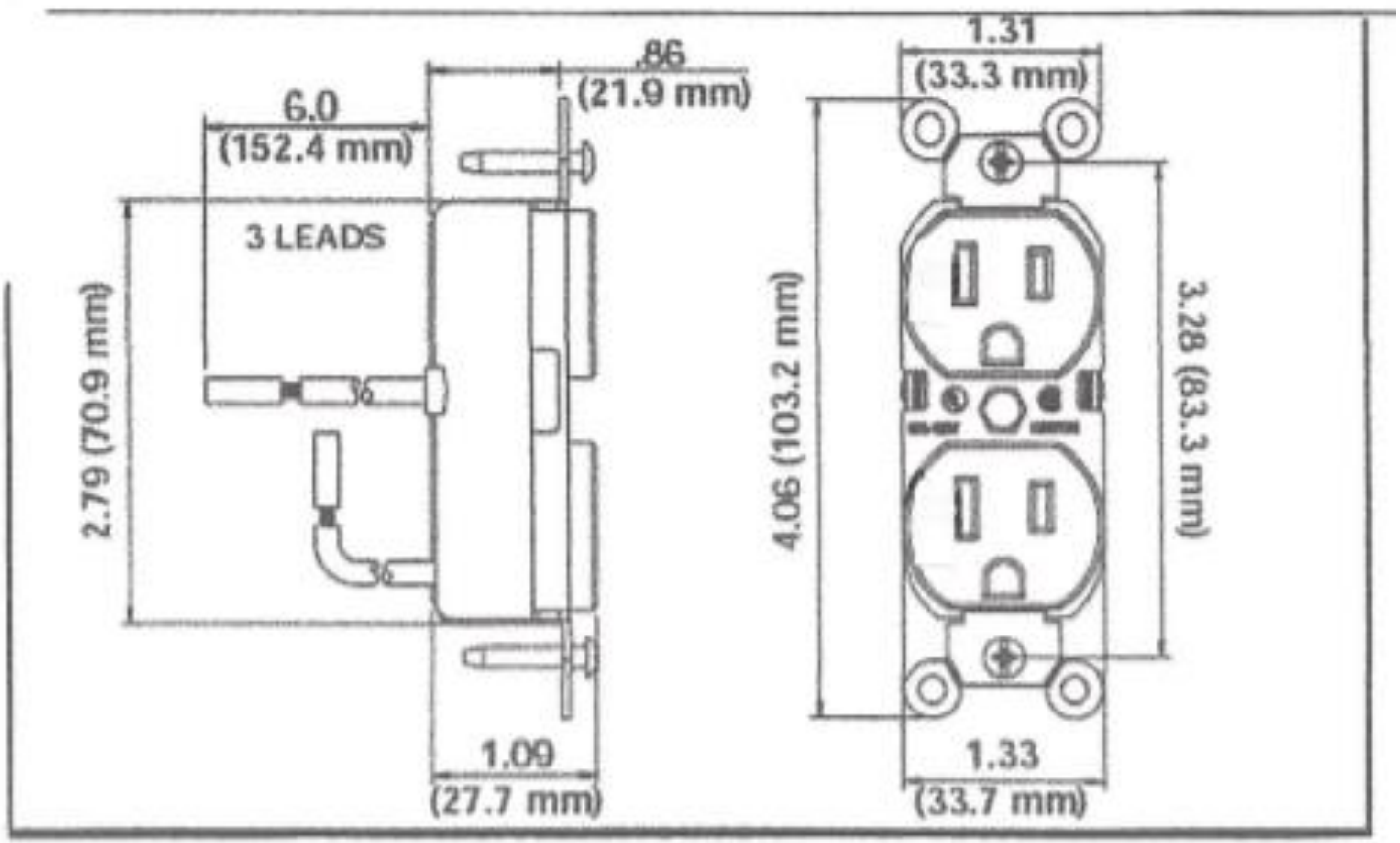
A quiz on this material is on Canvas. ECE students <u>must</u> pass with a score of 100% in a maximum of three attempts.

Electrical Safety Review

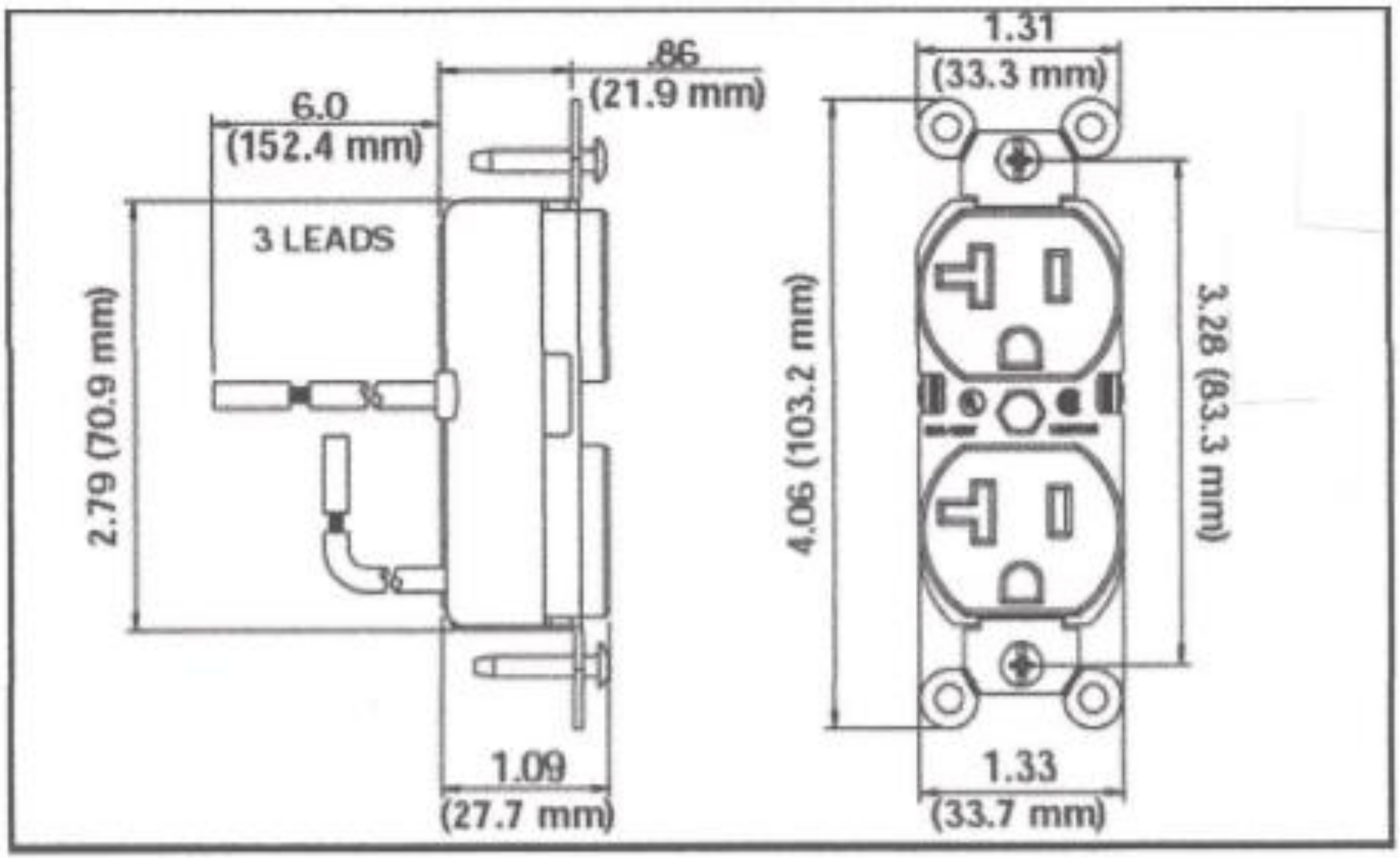
This review will cover only $120V_{rms}$ domestic wall power. Any other project power sources may require specialized safety training.

$120V_{rms}$ wall outlets in ENDEAVOR and other campus buildings are fundamentally the same as a domestic power arrangement.

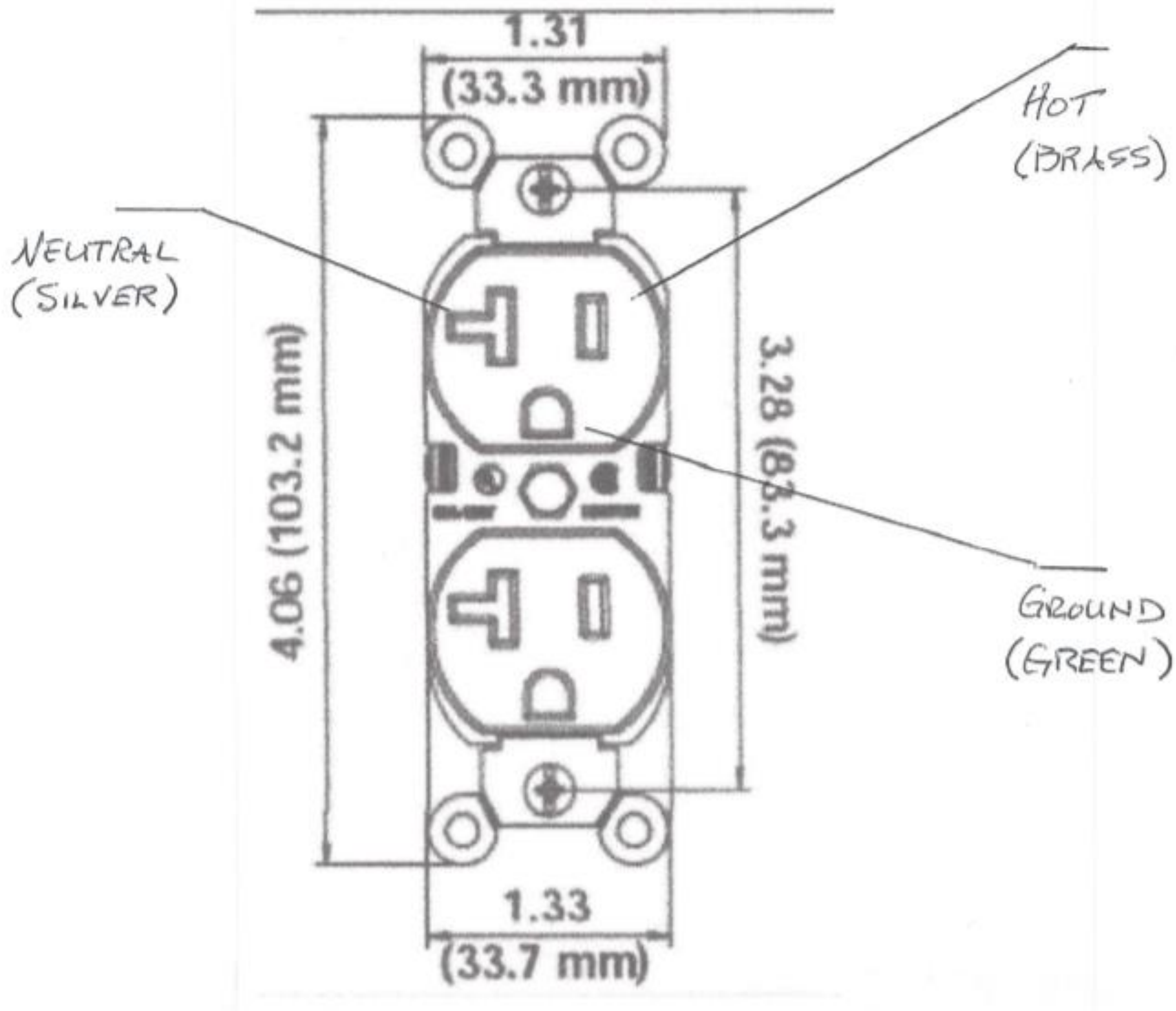
15 Amp Duplex Receptacle



20 Amp Duplex Receptacle



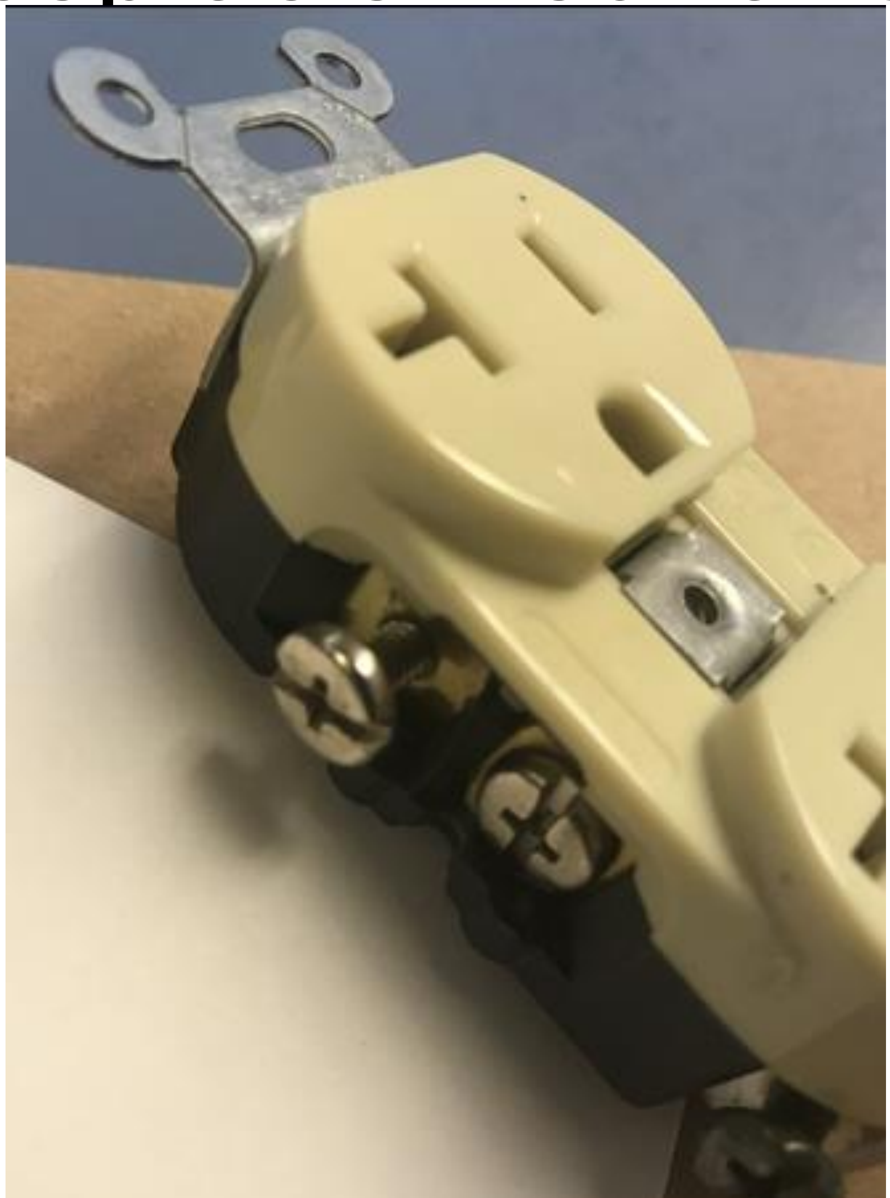
Receptacle Wiring Nomenclature



Receptacle Face

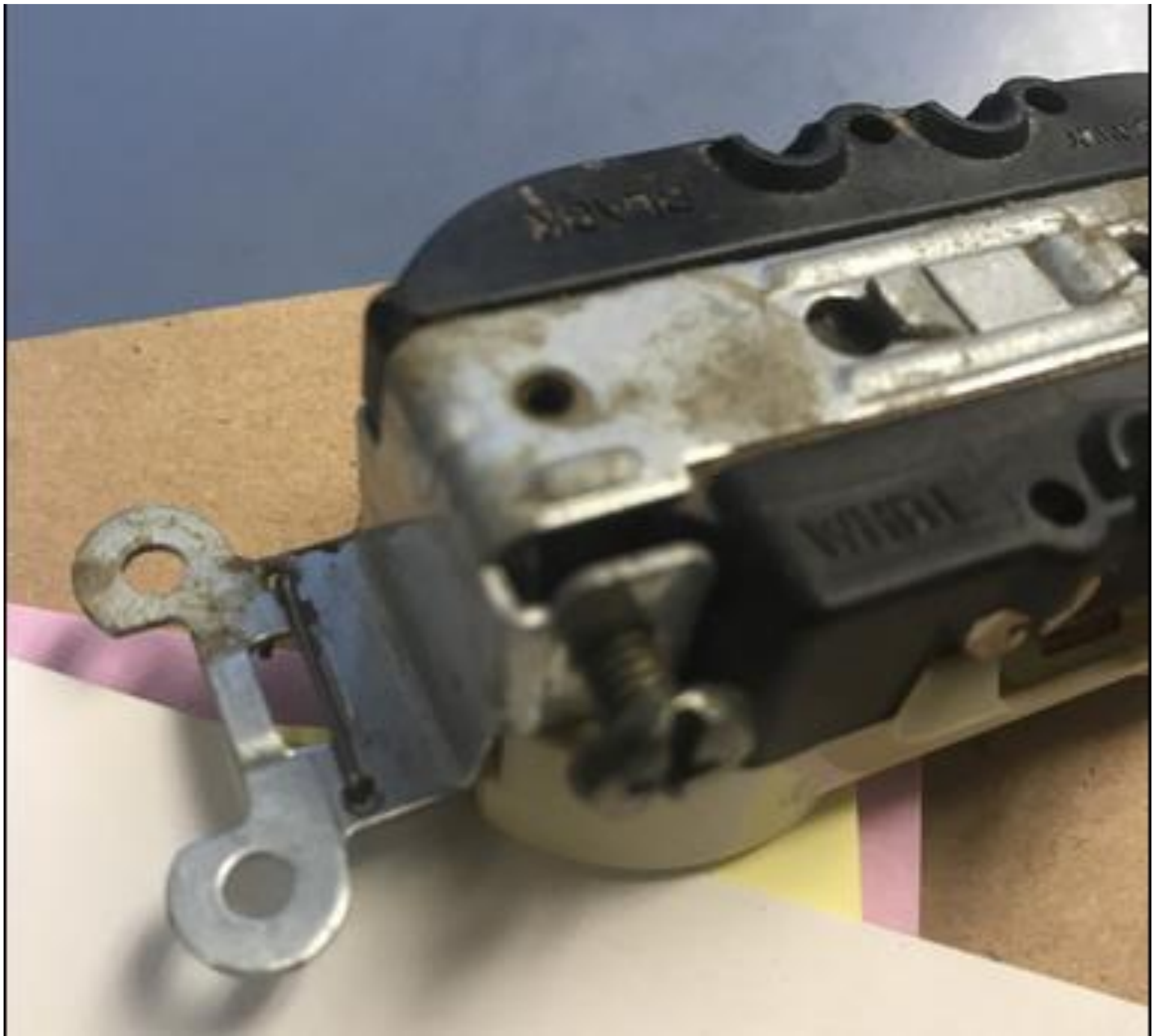
Receptacle Back

Receptacle Neutral Side



Receptacle Hot Side

Receptacle Ground



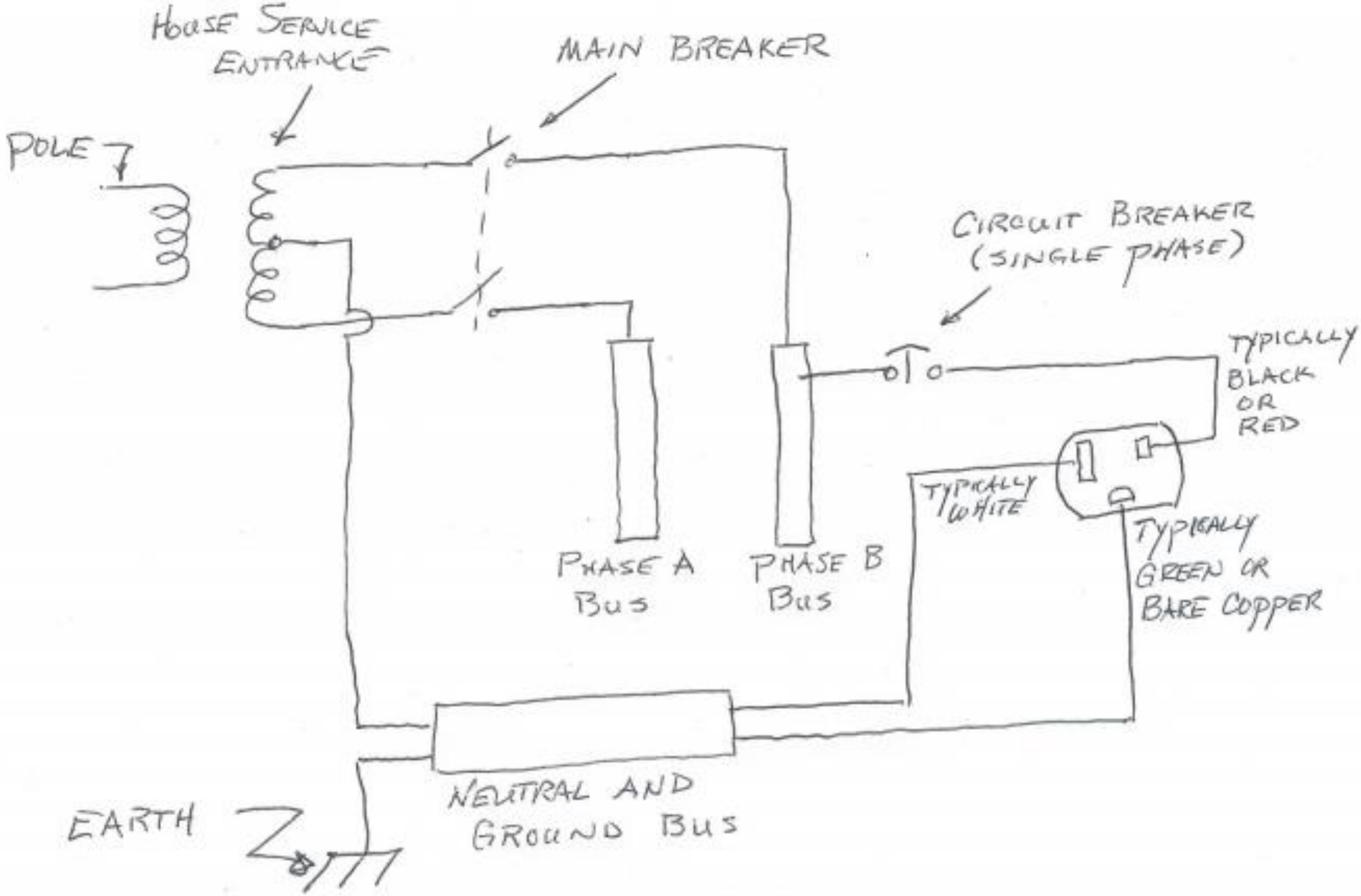
Typical Domestic Power Panel

Typical US domestic color conventions (receptacle and plug wiring):

Hot	Black or Red
Neutral	White
Ground	Green or bare copper; possibly green with yellow stripe

European and some purchased cord set color conventions are different.

Typical Domestic Power Panel



Using AC power in the lab

Do not work on energized equipment – disconnect from the outlet.

Open and lock out the breaker when possible.

After working on equipment, confirm all voltages using a voltmeter.

Using AC power in the lab

Confirm correct power switch operation using a voltmeter.

Remove rings and other jewelry in the laboratory – they are conductors!

Keep one hand in a pocket when making AC voltage measurements.

Using AC power in the lab

Breakers, switches, and equipment can be wired incorrectly – take nothing for granted. Check it yourself.

Ask for help – take no risks.

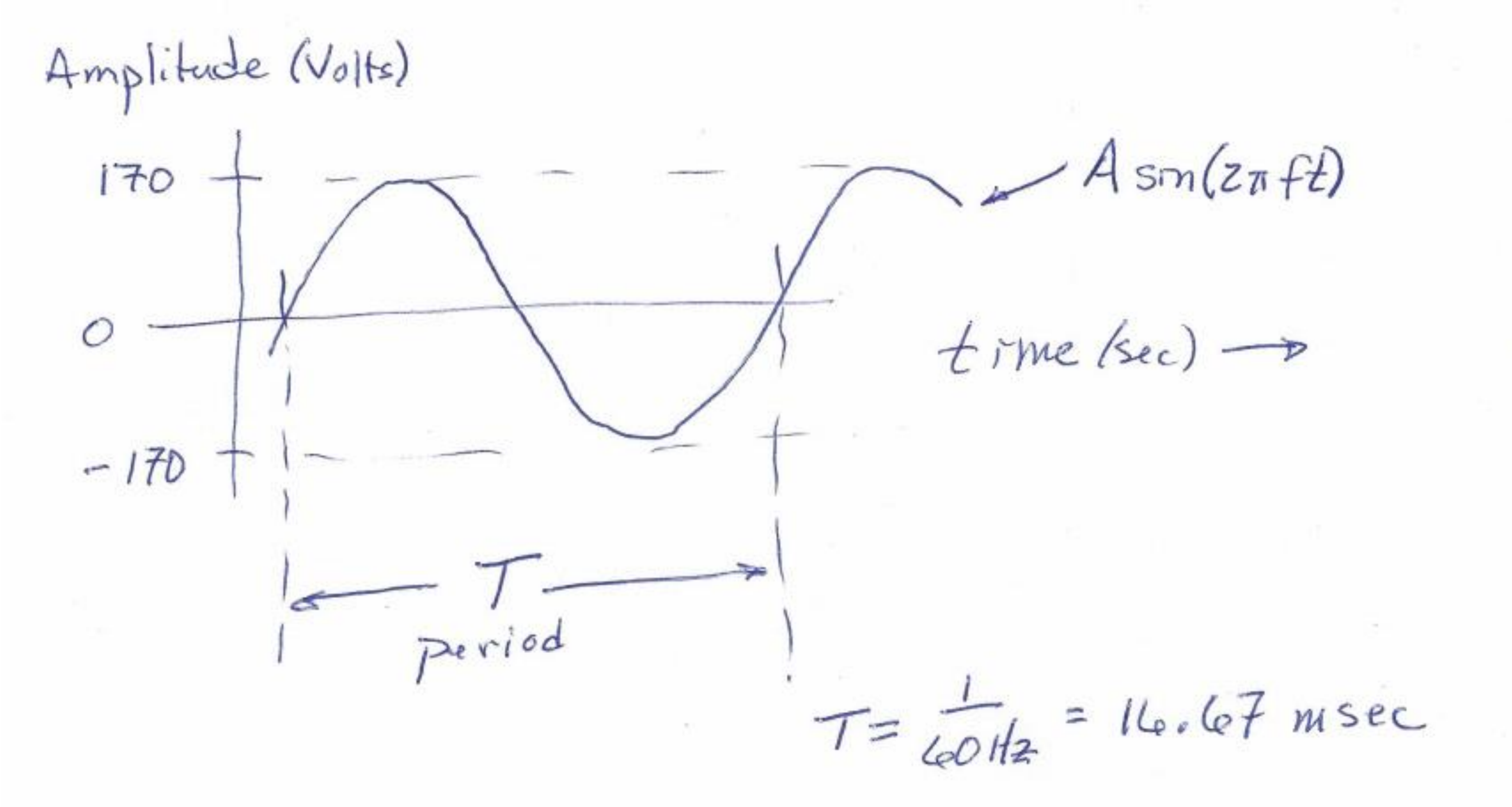
No horseplay or practical jokes – lab work is serious business.

How is single-phase power specified?

There are three different ways:

- Amplitude of a sine wave (V)
- Peak-to-peak voltage ($V_{p\text{-}p}$)
- Rms voltage (V_{rms})

US domestic single-phase power



Root-mean-square (*rms*) calculation

$$V_{rms} = \sqrt{\frac{1}{T}\int_{T}\left[A\sin(2\pi f t)\right]^{2}\,dt}$$

square

mean

root

rms = root mean square

Single-phase AC voltage amplitude

Domestic distribution line voltage is nominally 120 V_{ac}. 120 V_{ac} is really 120 V_{rms}: the root mean square voltage of an assumed undistorted sinusoid.

Nominal means "in name only." In reality, the common AC power line can be anywhere between 105 V_{ac} to 125 V_{ac}.

Single phase AC voltage amplitude

A single-phase sinusoid is commonly specified in three different ways.

$$120\ V_{rms} = 170 \sin(2\pi f t)\ \text{Volts}$$

$$= 340\ V_{p\text{-}p}$$

You must understand these relationships when selecting component voltage ratings.

Ground Fault Circuit Interrupter

- In normal operation, the hot and neutral conductors to a load must carry the same current.

- If hot and neutral currents aren’t the same, the difference current has to be going somewhere. This is called a ground fault. The missing current is assumed to be going to ground - somewhere.

Ground Fault Circuit Interrupter

- The National Electric Code mandates use of GFCIs in specific locations, particularly within six feet of water – typically, kitchens and bathrooms.

- What current difference is required to trip?
  Class A: 5 mA (common use)
  Class B: 20 mA (pools)

Ground Fault Circuit Interrupter

Ground Fault Circuit Interrupter

Ground Fault Circuit Interrupter

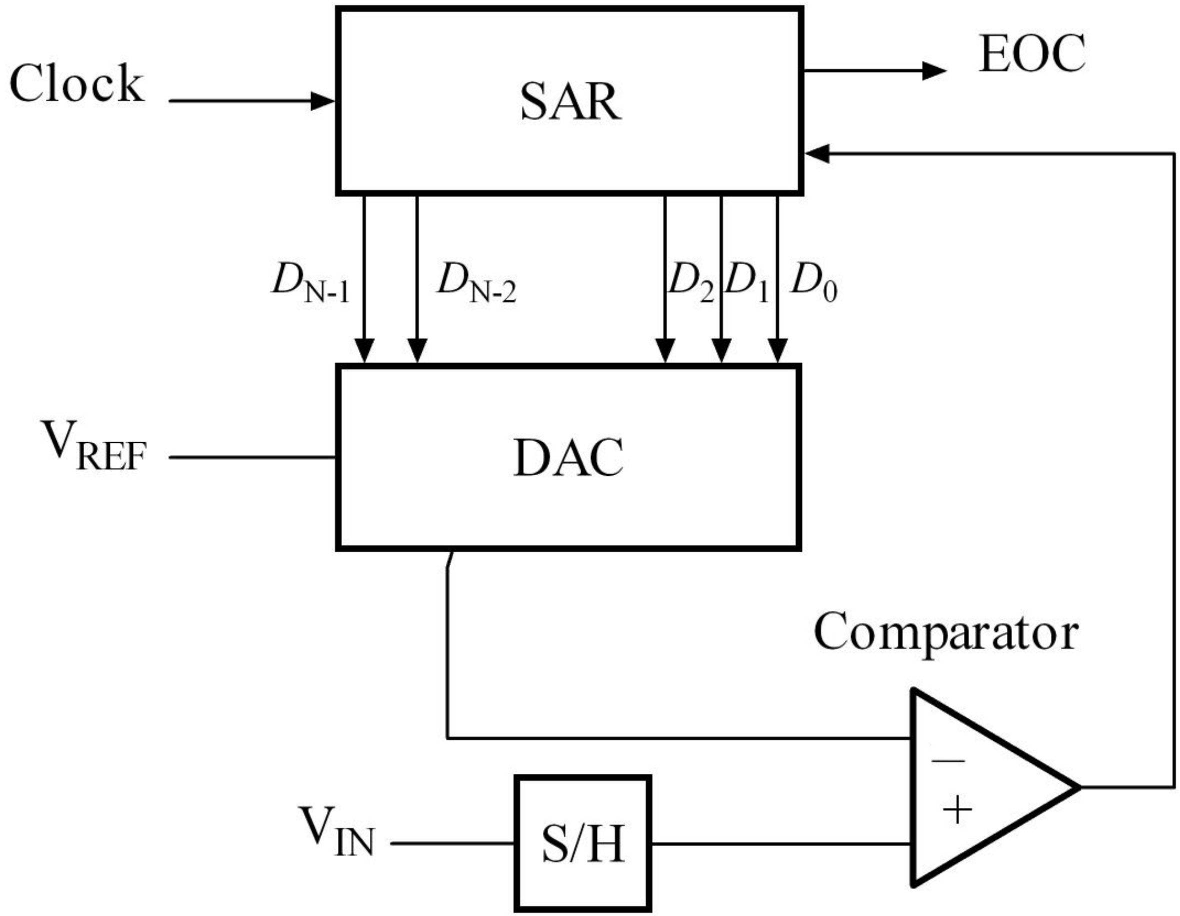
Project 1

4-bit Successive Approximation A to D Converter

Major elements:

- Sample/hold amplifier (S/H)
- D/A converter
- Comparator (Schmitt trigger recommended)
- Storage register
- Clock
- Control and sequencing logic

Project 1



Initial Specifications: Project #1

Create a 4-bit unipolar input SAR A/D converter which will

(1) Initiate a conversion sequence on command

(2) Present a digital parallel 4-bit conversion result (nibble) when data ready.

Initial Specifications: Project #1

3. Have an input range of 0-5 VDC.

4. Have a data conversion of at least 100 samples/second (sps). Conversion rate in excess of 1 ksps is desired.

5. No missing codes.

Initial Specifications: Project #1

(6) Have a unipolar power source or bipolar supply connections from bench power supply.
(7) Have an adequate associated test plan in which all tests pass.

Your design must not use any modern processors with the following exceptions:

- Act as control for your AD converter.
- to transfer data and display the result.

Anything that is part of the 4000-series CMOS family or equivalent is fair game. You have a budget of $100 for parts that cannot be found in the part store.

A few notes on A/D converters

- Convert an analog voltage into a digital representation
  - e.g., 2.45v → 0110
  - This conversion is dependent on the range of voltages to be converted and the number of bits used to represent the voltage

Notes on A/D Converters

Resolution: the smallest possible change that can be identified (resolved). Also called Least Significant Bit (LSB).

The term “LSB” or “counts” is used in several different ways. For example, a signal may have “five counts of noise.” This means the observed noise is equivalent to five times the value of the LSB.

Notes on A/D Converters

Bits of resolution	Number distinct values	Theoretical resolution
4	16	6.25%
8	256	0.39% = 3906 ppm
10	1024	977 ppm
12	4096	244 ppm
14	16384	61 ppm
16	65536	15 ppm
20	1048576	1 ppm

Notes on A/D Converters

Resolution and reference voltage are related, because sampled signal values are interpreted as a binary fraction of the reference voltage.

If V_{ref} = 5.00 V_{DC} and we are doing an 8-bit conversion,

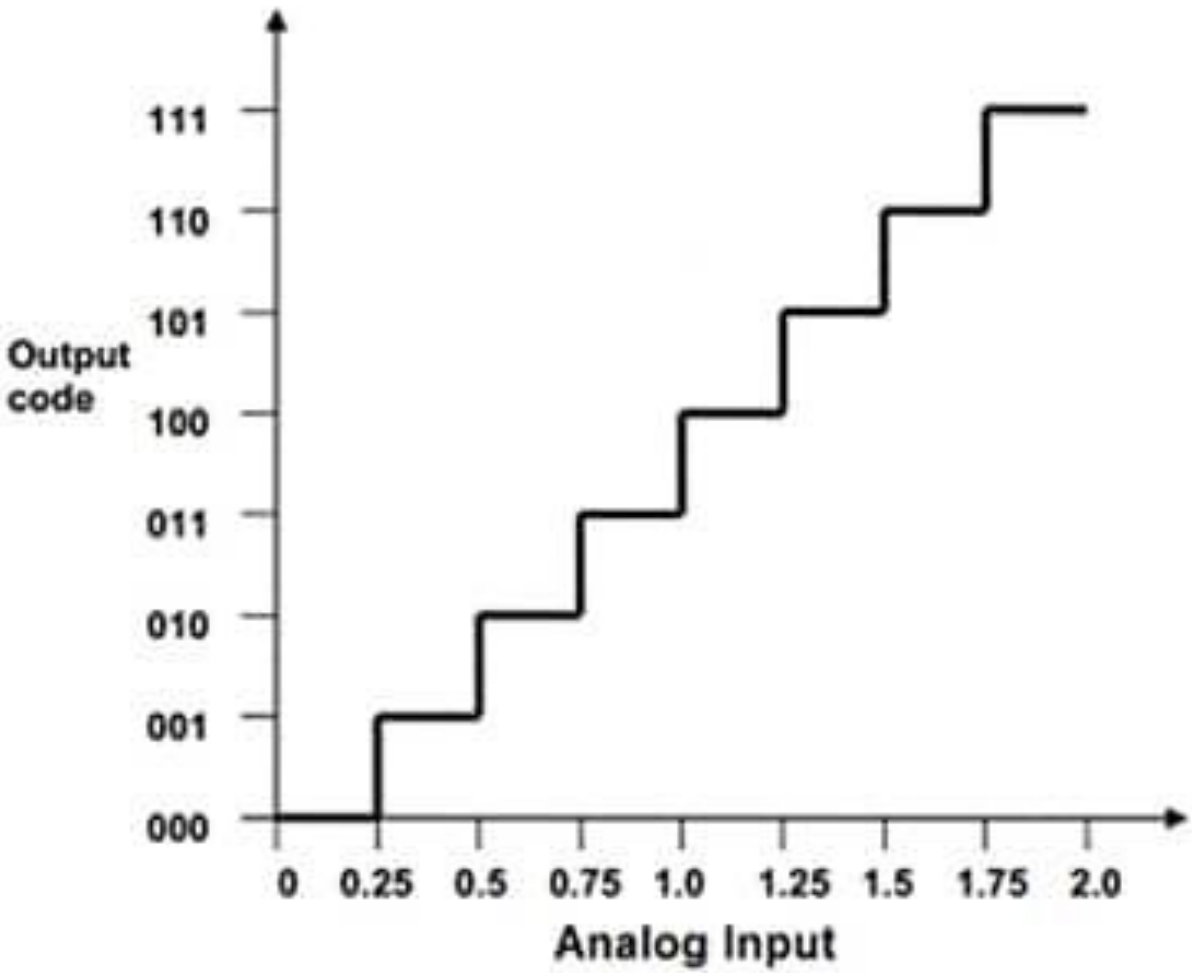
Resolution = 5V/(256 values) = 19.5 mV/value

Notes on A/D Converters

If V_{ref} = 4.096 V_{DC} and we are doing a 12-bit conversion,
Resolution = 4.096V/(4096 values) = 1mV/value

The digitized signal value is equal to the number of counts (binary value) multiplied by the resolution. Any error from the original signal is called digitization noise.

Notes on A/D Converters



PROJECT #1
Team Assignments

Group1 — 4 students

Brent Bertaux	Jacob Erwin	Katilynn Mar
Johnny Williamson		

Group2 — 4 students

Connor Collins *(He/Him)*	Koby Goree	Sam Myers
Reid Wilson		

Group3 — 4 students

Kyle Bowser	Gavin McKee	Cody Myers
Emerson Pummill		

Group4 — 4 students

Brendan Bovenschen	Brandon Collings	Luke McIntyre
John Terzian		

Group5 — 4 students

Kaci Anderson	Nathan Johnson	Jarett Woodard
Karson Younger		

PROJECT #1
Team Assignments

Group6 — 4 students

Ashley Holland *(She/Her)*	John Muths	Amelia Neumeyer *(She/Her)*
Angel Trujillo		

Group7 — 4 students

Curtis Fodor	Benjamin Page	Fidel Ramirez Ramirez
Gus Smith		

Group8 — 4 students

Mohammad Alsalem	Nathan Fant	Joey Goller
Miguel Vergara		

Group9 — 4 students

Fawaz Alroumi	Tyler Bushyhead	Gaurav Das
Kali Henry		

Group10 — 4 students

Blake Burton	Phillip Farris	Dylan Saltos
Trenton Strawderman		

PROJECT #1
Team Assignments

Group11

4 students

- Brooke Desai
- Richard Powers
- Brenna Stewart
- Titus Teague

Group12

4 students

- Landon Fox
- Carsten Logan
- Zachary Oyer
- Juliette Reeder

Group13

4 students

- Karsen Madole
- Jacob Riley
- Gabe Saliba
- Cory Thrutchley

Group14

4 students

- Evan Burk
- Brayan Leija Flores
- Colin Rockholt
- Greg Shildt

Group15

4 students

- Jordan Andrews
- Pedro Carbajal Orellana
- Bryan Struble
- Evelyn Wilson *(She/Her)*

PROJECT #1
Team Assignments

Group16
4 students

Sivan Auerbach	Hagen Patterson	Ben Pons
Forrest Tuschhoff		

Group17
4 students

Collin Bovenschen	Aidan Hamm	Yosep Lazar
Jake Witcher		

Group18
3 students

Mike Arledge	Soren Petersen	Philip Strachan

Your Homework Assignments due before next class

Take the electrical safety quiz (on Canvas).

Upload survey with your picture so that I can get to know you.

Download MultiSim and KiCad and run the tutorials. Instructions are found on Canvas (use new instructions I sent for MultiSim found in Canvas Announcements) .

Create a user for icescrum on http://daleksec.es-private.okstate.edu:8080/icescrum/ (do not use icescrum.com, we have our own private server so that we can have teams larger than 2)

Get with your groups and assign roles

- POC - You will be in charge of contacting your TAs when you have questions and need to order parts
- Scrum Master – We will go over creating a project in iceScrum on Monday