Name:____________________ UIN: | | | | | | | | | Section AB/BB:

Experiment 1: Getting Started with Electronics

Laboratory Outline

In each lab experiment, you will generally be asked to read a little background material (often in a pre-laboratory exercise) and work your way through a well-defined set of lab procedures. Within the lab procedure, you will generally

- Setup the hardware needed in the experiment.
- Record measurements.
- Visualize the data through the use of graphs.
- Analyze the data to extract information about the behavior of the "circuit under test".
- Document the experimental setup using circuit schematics, equations, and tables.
- Record what was observed during the experiment.
- Draw conclusions as to why these results will aid in completing the semester's tasks in ECE110.

Not explicitly mentioned in the list above are two key elements: build community with the other students in the lab and, most importantly, ***have fun***. If you do the prior, you will surely do the latter.

Learning Objectives

- Build a car chassis and experiment with driving via "pulsed" signals to the wheels.
- Decipher a typical breadboard used for solderless circuit construction.
- Gain the skill of mapping a circuit schematic to a breadboard.
- Learn the basics of the ohmmeter, its use, and its idealized circuit model.
- Learn the basics of the voltmeter, its use, and its idealized circuit model.
- Gain exposure to the voltmeter and the voltage supply.
- Explore simple models for the motor, the NiMH rechargeable battery, and the voltage supply.

Please use this Notes margin for both notes to yourself about the experiment as well as for feedback to your TA on the quality or clarity of the lab procedure. Thanks!

Notes:

Introduction…Meet in 1005 ECEB

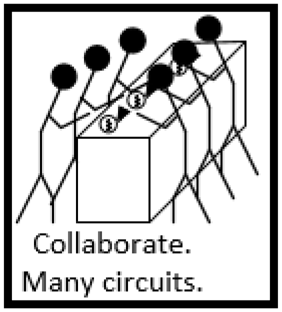
Each lab period will begin with a brief instruction in 1005 ECEB. If you arrive after the prelab assignment has been checked or more than 5 minutes after the designated start-time of the lab, you will be deducted points from the daily lab grade. Today, your TA will introduce themselves, discuss the lab syllabus, and showcase past presentations, and assign you to teams. When this is finished, you will proceed to 1001 ECEB (the lab). No food or drink is allowed into the lab. If a student brings food or drink into the lab, they will be deducted points from his or her grade. By the way, if a TA brings food or drink into the lab, he or she will be assigned extra duties like an extra session of Saturday open lab or Final-Exam proctoring.

Find this:

In the Lab…Move into 1001 ECEB

When we transition from 1005 to 1001 ECEB, we will first meet (in four groups) at the center tables. Generally, this first "breakout" session is where students will discuss and perfect their prelab assignments which often involve a circuit built at home or other group discussion.

Breakout Session



Since this is the first meeting of the year, there is no prelab to discuss. Instead, the TAs will provide you with a car chassis, one per pair. At the center tables, form groups of 8 students (two teams) and work together until every pair of students have a car chassis properly assembled.

Assign one student to lead the construction. Follow the instructions provided by the TA. A video is available. While it is easier not to put on the wheels yet, don't worry if you do. Just use the small wooden block to keep your wheels off the table while you take measurements of the motors today. When finished assembling the chassis, continue with this procedure.

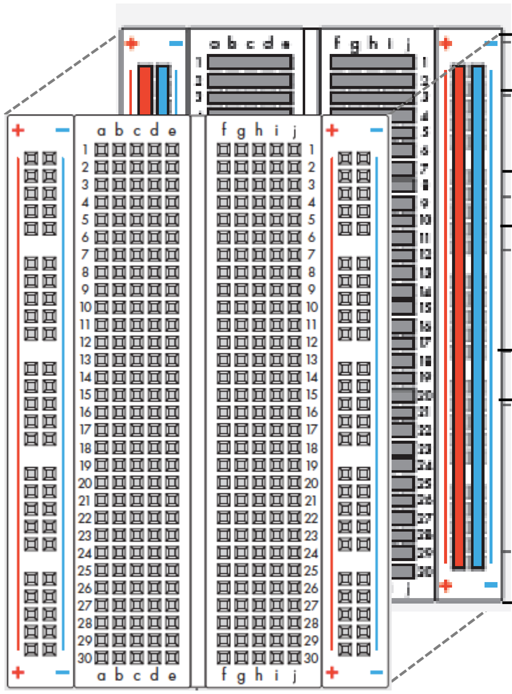
NOTE: There is a ***strict limit of two students per bench***. When a student is missing a partner, an undergraduate course aide will be assigned to provide you special assistance.

Take all of your items to one of the 16 benches (labeled A through P). Since there will be up to 32 students per section, two students will share equipment and take measurements as a partnership. Partners will rotate weekly.

You are individually responsible for returning any laboratory equipment used, including the rechargeable batteries, cables, alligator clips, etc. The car chassis are yours to keep and use throughout the semester. You will store the chassis in your locker.

Each bench also has a wire kit. You can use these wires while in the lab or even add to your own electronics kit as needed throughout the semester. Please leave the box on the bench for other sections to use. The shop will refill them as needed.

The internal construction of the breadboard is shown in the diagram of Figure 1 below.



Power (positive voltage rail) +

The + “rail” makes the positive battery terminal available along this vertical column.

Ground (negative voltage rail) –

The - “rail” makes the negative battery terminal available along this vertical column.

Horizontal lines

Each of the rows numbered 1-30 have two sets of 5 holes (abcde and fghij) running horizontally separated by a trench down the center of the board. In each row, abcde are connected and fghij are connected, but there is no connection across the trench.

***Figure 1**: An expanded view of the breadboard showing the configuration of the underlying metal clips.*

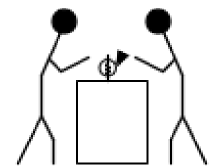
At your Bench

Join your TA for a brief introduction to the equipment at your bench. On each bench, you will find a box containing alligator clips, cables, and batteries. You will need to return all items to the cable-and-battery box at the end of your lab session.

Use the continuity setting of the digital multi-meter to validate the construction of your breadboard. You should find no inadvertent “shorts” in your brand-new boards, but beware that a faulty circuit that gets very hot may melt and compromise a breadboard. Inserting a very thin wire deep into the breadboard (more than 1 cm) could cause a short as well.

Notes:

Symbols like the one below will keep you aware of what is expected. In this part of the procedure, you will work with a teammate to take a series of measurements together on a single breadboard.



Work together.
One circuit.

Question 1: What does the continuity tester indicate when measuring as shown in Figure 2, a, b, c, and d? For each subfigure, answer "connected" or "not connected".

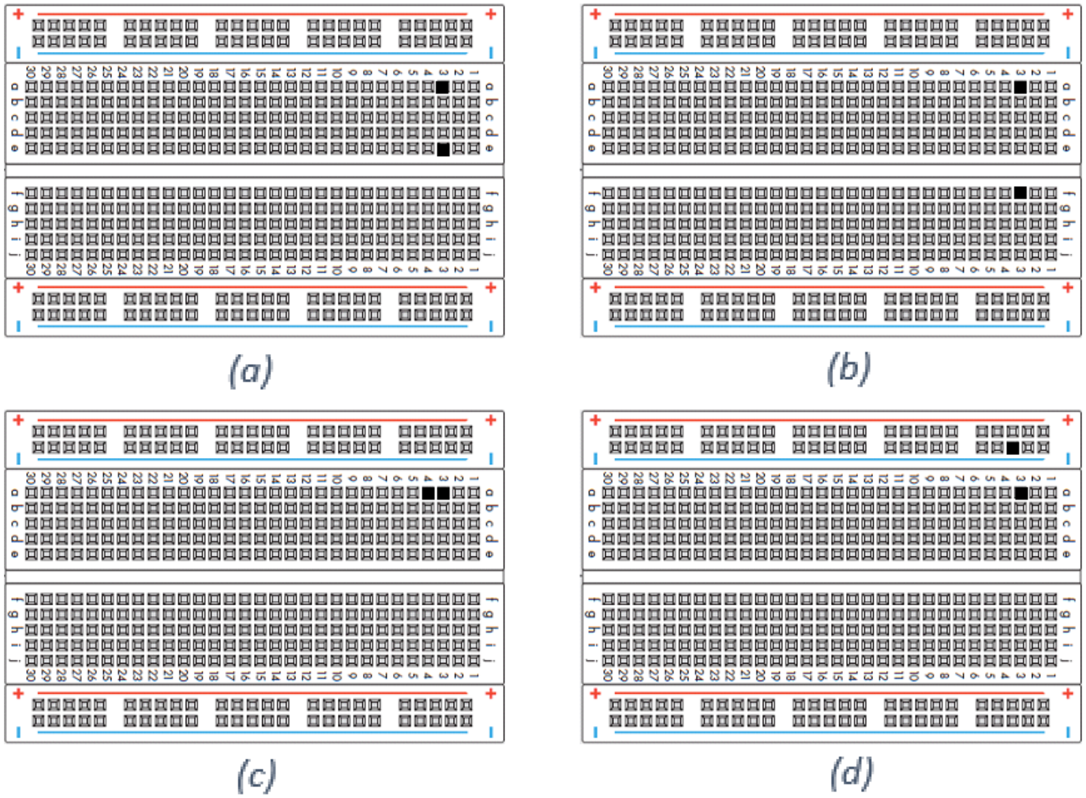


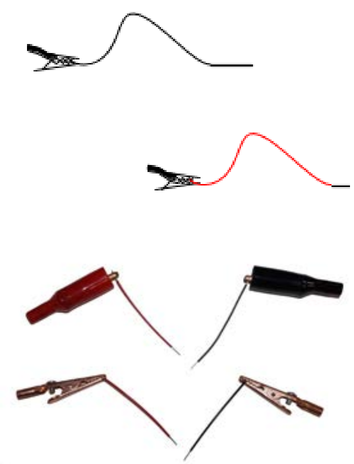
Figure 2: *Example continuity tests on the breadboard.*

Configure your DMM for measuring DC voltage (voltmeter). Use the voltmeter to measure the voltage across your NiMH battery in three different situations. The voltage "written" on the battery (in this case 7.2 volts) is often called the *nominal* voltage…it is likely to differ from the *actual* voltage as measured by the voltmeter!

Question 2: What is the voltage across the battery when it is open-circuited (not powering any device, Figure 3)? Please answer in the first row of Table 1.

Notes:

NOTE: Use alligator clips with a wire in each grip to make connections from the equipment to the breadboard.



Open Circuit means "with nothing attached". In this case, we want the voltage across a battery's terminals the way it is as it sits on a store's shelf.

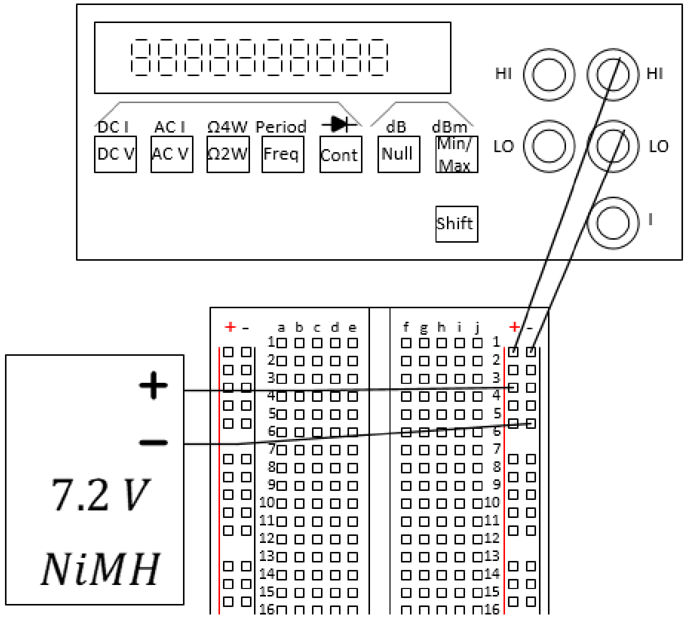


Figure 3: *Measuring the open-circuit battery voltage. The breadboard is used to facilitate the connections.*

$V_{battery}$ [volts]	**Conditions**	**Comments:**
	Open circuit	
	1 motor in parallel	
	2 motors in parallel	

Table 1: *Voltage measurements using the NiMH battery pack.*

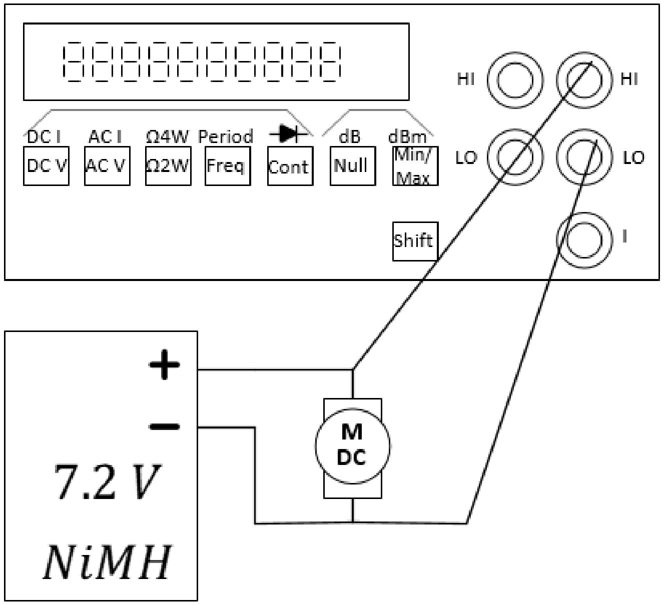
Notes:

7.2-volt Ni-MH battery

Barrel-to-wire adaptor

Make sure battery is turned on to use.

Notes:



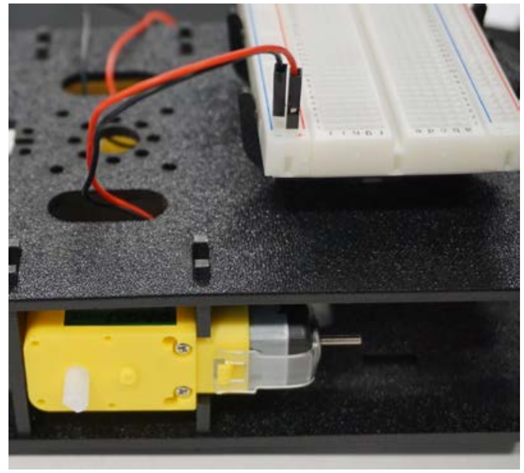
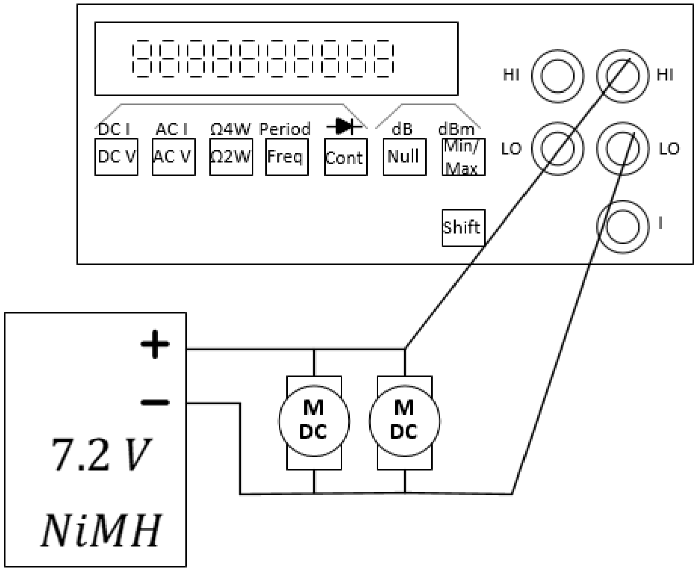


Figure 4: *Measuring the battery voltage under load of a single motor. As before, use a breadboard to make the connections.*

Question 3: What is the voltage across the battery when it is powering a single car motor? Please place your answer in Table 1.



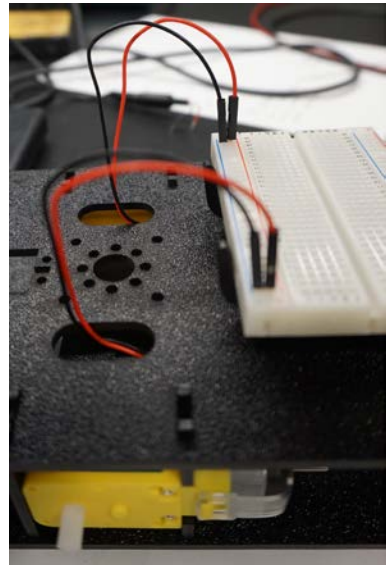


Figure 5: *Measuring the battery voltage under load of two motors in parallel.*

Question 4: What is the voltage across the battery when it is powering both car motors? Please answer in Table 1.

Question 5: Is the battery a reliable **constant-voltage source**? Explain

Notes:

Parallel means next to each other with both ends touching. The double-l "ll" in the word parallel can help you remember that meaning.

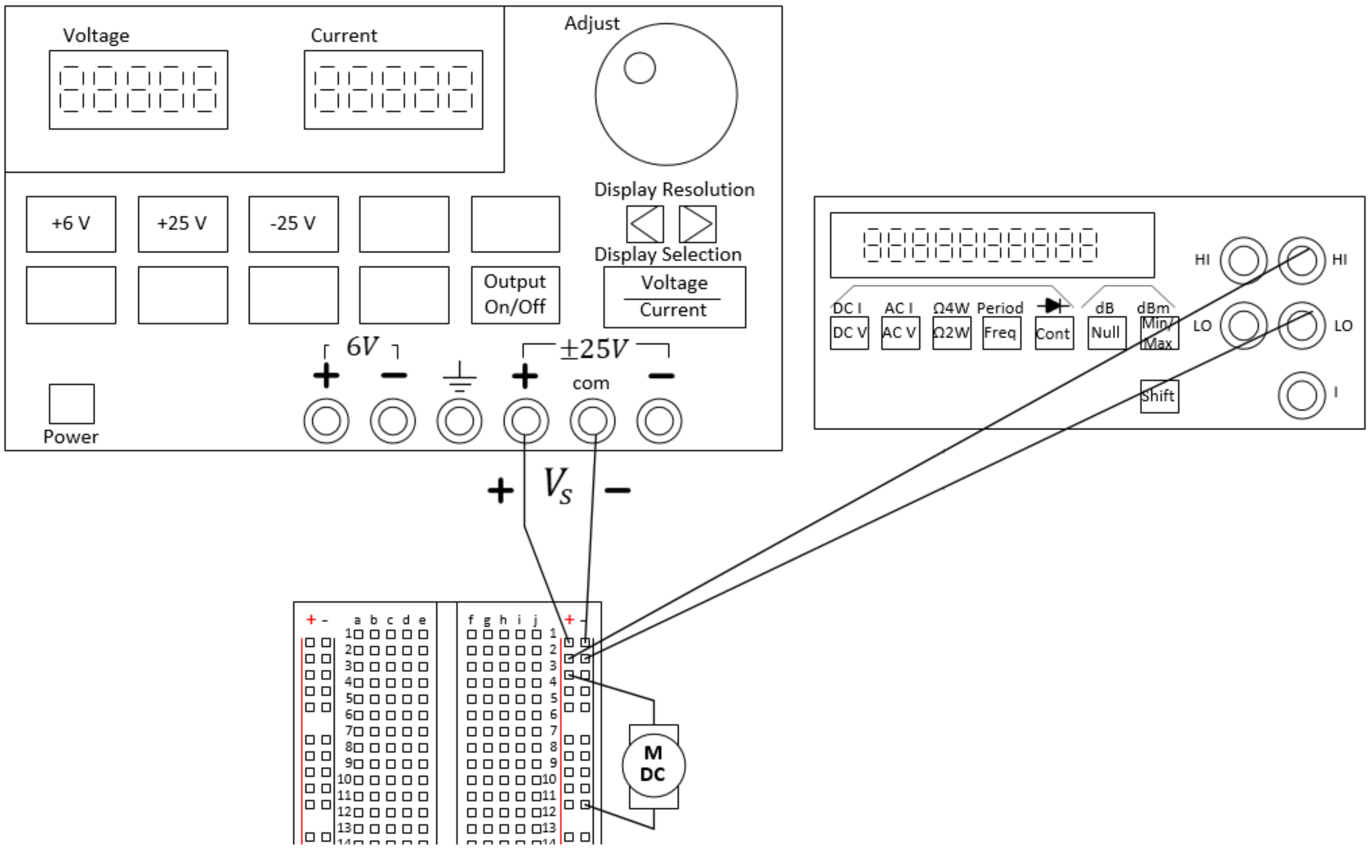


Figure 6: Driving a motor with the voltage "power" supply. All three devices are connected in "parallel". You will need to use banana-plug wires and "alligator" clips with wires to make the breadboard connections.

Remove the battery. Set the voltage source to provide the same open-circuit voltage as the NiMH battery ($V_{battery,oc}$) and connect it instead of the battery. Now, repeat the voltage measurements above with zero, one and two motors as shown in Figure 6. Record them below.

Question 6: What are the open-circuited, single-motor, and dual-motor voltages of the power supply? Place your answers in Table 2.

Notes:

$V_{battery}$ [volts]	Conditions	Comments:
	Open circuit	
	1 motor in parallel	
	2 motors in parallel	

Table 2: *Voltage measurements using the benchtop power supply.*

Question 7: Is this benchtop power supply a reliable **constant-voltage source**? Explain.

With the **voltage supply** set to the 1-motor voltage of the NiMH battery ($V_{battery,1motor}$), connect a single motor. Run the motor for about 1 minute to "warm it up". Now, we will record how much current flows through the motor. This current can be read directly from the voltage supply (which is why we are using it instead of the battery right now!).

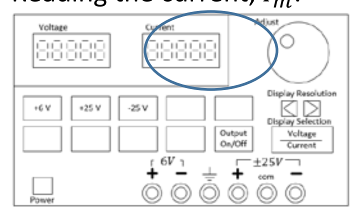
Question 8: Write the voltage and the resulting current below.

When $V =$ ________________, $I =$________________

Ohm's law states that the current that flows through and the voltage across an Ohmic device are related by the resistance of that Ohmic device, that is, $R = \frac{V}{I}$. A motor is not really an Ohmic device, but we could attempt to model it as an Ohmic device.

Notes:

Reading the current, I_m:



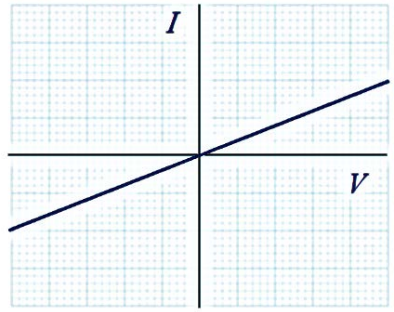


Figure 7: *Current and voltage relationship for an "Ohmic" device.*

Question 9: Model the motor as an Ohmic device based on the voltage supplied across the motor and the current that flows through it. Imagine placing your data point on the curve above. Ask for help if you don't understand.

$$R_m = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

How do we know a motor is not an Ohmic device? If a motor were an Ohmic device, we could find a value R_m to represent the motor such that the current that flows through the motor is given by $I = \frac{1}{R_m}V$ for any voltage V applied across the motor. Since $I = \frac{1}{R_m}V$ is just the equation of a line with slope $1/R_m$, let's take some measurements of the current through the motor as we change the voltage across the motor and see if they lie on a line.

Question 10: Take measurements to complete the table below for a single motor powered by the voltage supply.

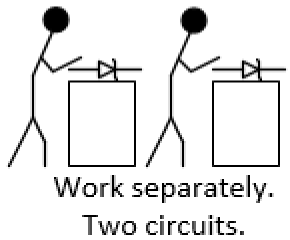
V_S $[V]$	I_S $[mA]$	Comments:
0		
3		
4		
5		
6		
7.2		

Table 3: *Current through a motor for various voltages across it.*

Notes:

Notes:

Mini-Project Modules



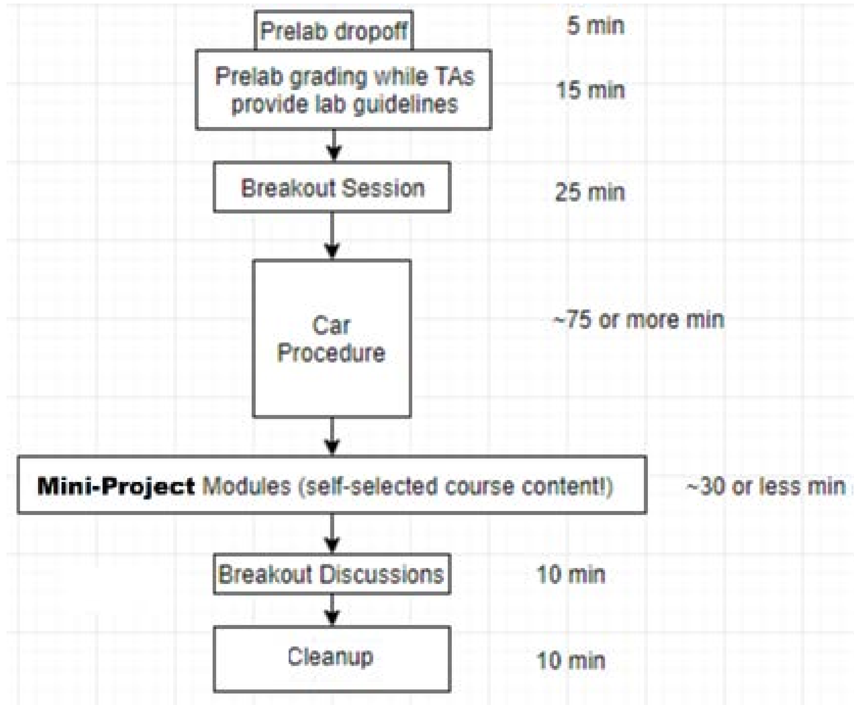


Figure 9: *Mini-Project modules provide students with options to investigate new concepts! As time allows, do one or more of the modules before returning to the laboratory's core procedure.*

This week, complete one or more of the following ***Mini-Project Modules*** (does not need to be submitted today):

***Mini-Project* Understanding Resistors**	***Mini-Project* Engineering Ethics**	***Mini-Project* Intro to Arduino (RedBoard/Arduino available for purchase from the ECE Supply Center)**

At the end of the semester, you will earn points towards your total semester lab score by having completed a minimum of 10 Mini-Project modules. If you wish to be eligible for a Course Aide position in the future, please consider doing more and impressing us with your command of the material and your ability to aid your classmates.

Notes:

Breakout Discussion

Return to the breakout session when instructed by the TA. At this time, we would like for you to complete the Lab Summary together. Discuss the goals of this lab and determine if everyone has come to the same conclusions.

Lab 1 Summary

Question 11: Use the figure below to plot your data points from Table 3 by hand, placing I_S on the y-axis and V_S on the x-axis. Does your motor appear Ohmic? Explain.

V_S $[V]$	I_S $[mA]$
0	
3	
4	
5	
6	
7.2	

Table 3 data.

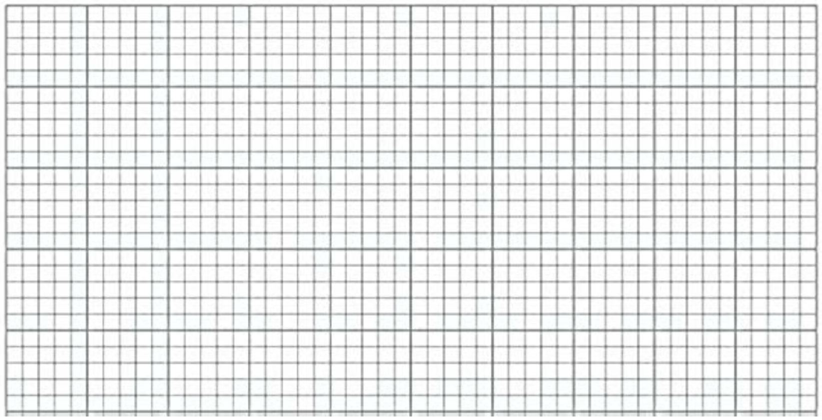
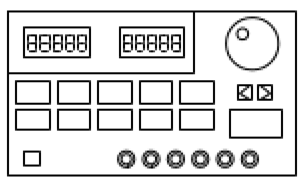


Figure 8: *Current through a motor as a function of the voltage across it.*

Question 12: Label 5 or more important features of the voltage supply.



Notes:

Looking Ahead: In Prelab 2, you will use software to plot this data and perform a “linear curve fit” to the data.

Question 13: Why do you think the battery voltage changes under different loading conditions (open, one motor, two motors)?

Notes:

Return your borrowed equipment and clean up your benchtop before leaving for the day.

Thank you!