

Name:

NetID:

Today's bench partner:

Section AB/BB (circle one):

0 1 2 3 4 5 6 7

8 9 A B C D E F

Bench (circle one):

A B C D E F G H

I J K L M N O P

# 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 exposure to the voltmeter and the voltage supply.
- Explore simple models for the motor, the NiMH rechargeable battery, and the voltage supply.

## 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. 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

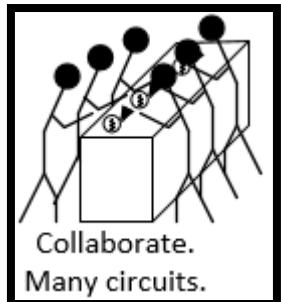
*Please use this Notes margin for both notes to yourself about the experiment as well as for feedback to your TA on the quality or clarity of the lab procedure. Thanks!*

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.

## In the Lab...Move into 1001 ECEB

When we transition from 1005 to 1001 ECEB, we will first meet (in two 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 and work together until every team's car chassis is 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.

The internal construction of the breadboard is shown in the diagram of Figure 1 below. Briefly discuss it with the other students in your breakout session and be ready to head to head to your benches for measurements.

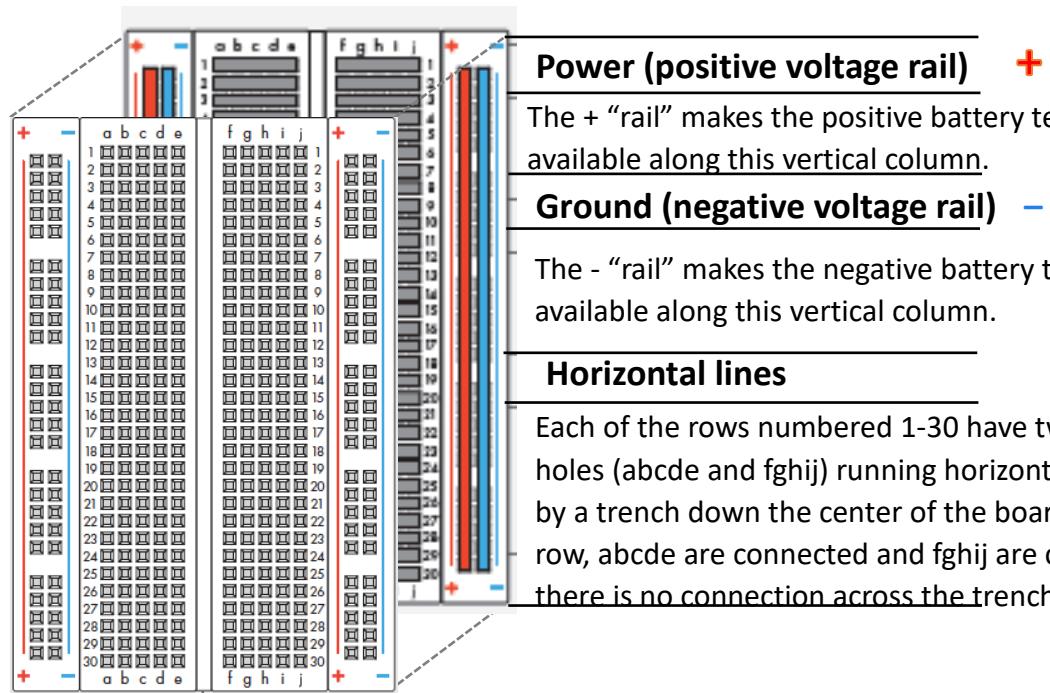
Notes:

Find this:



**NOTE:** There is a ***strict limit of two students per bench***. If you are nervous about being the only student at your bench, an undergraduate course aide will be assigned to provide you special assistance.

Notes:



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

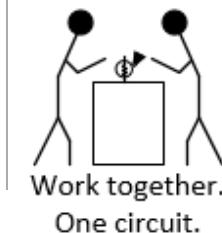
Take all of your items to one of the 16 benches (labeled A through P). Since there will be up to 32 students per section, two students will need to share equipment and often take measurements as a team.

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 generally store them in your locker. You will also be provided a wire kit. The wires are yours to keep (both team members should put some in their kits), but the box itself must be returned at the semester's end.

## At your Bench

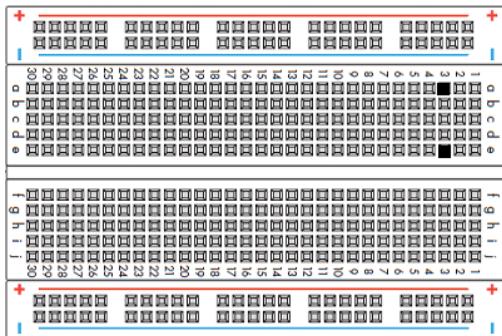
Join your TA for a brief introduction to the equipment at your bench. On each bench, you will find a box containing alligator clips, cables, and batteries. You will need to return all items to the cable-and-battery box at the end of your lab session.

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.



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.

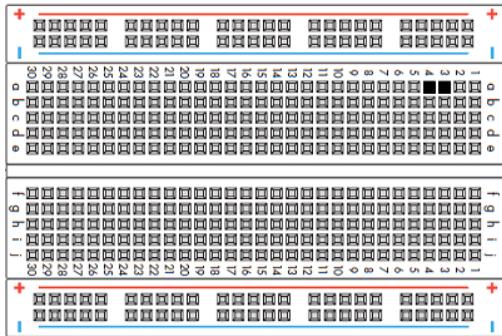
**Question 1:** What does the continuity tester indicate when measuring as shown in Figure 2, a, b, c, and d? For each subfigure, answer “connected” or “not connected”.



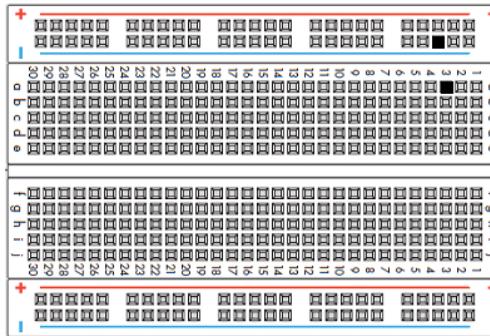
(a)



(b)



(c)



(d)

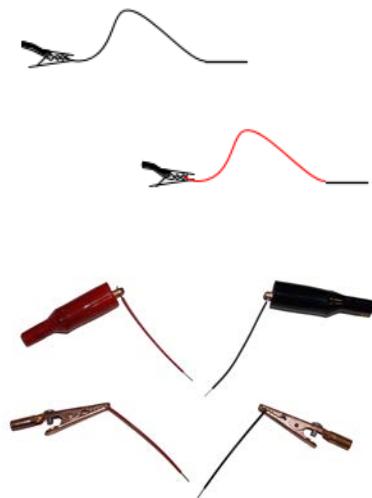
**Figure 2:** Example continuity tests on the breadboard.

Configure your DMM for measuring DC voltage (voltmeter). Use the voltmeter to measure the voltage across your NiMH battery in three different situations.

Notes:

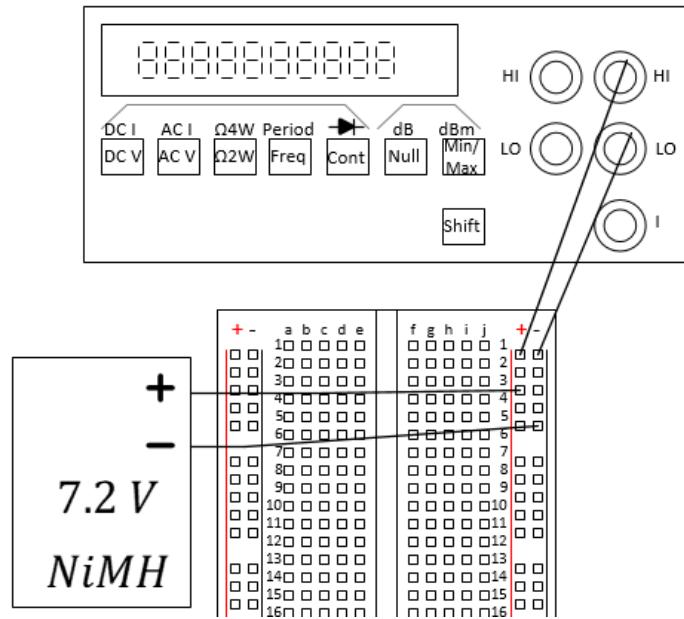


**NOTE:** Use alligator clips with a wire in each grip to make connections from the equipment to the breadboard.



**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.



*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:

**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.



7.2-volt Ni-MH battery



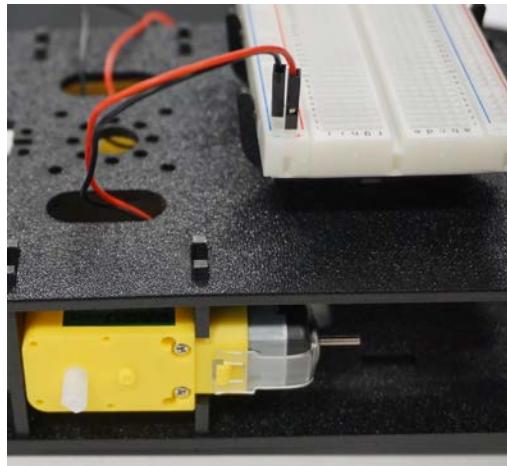
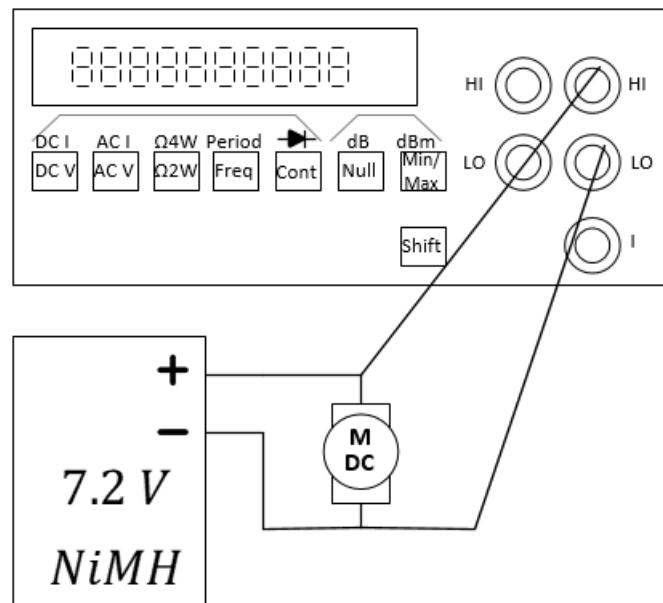
Barrel-to-wire adaptor



Make sure battery is turned on to use.

Notes:

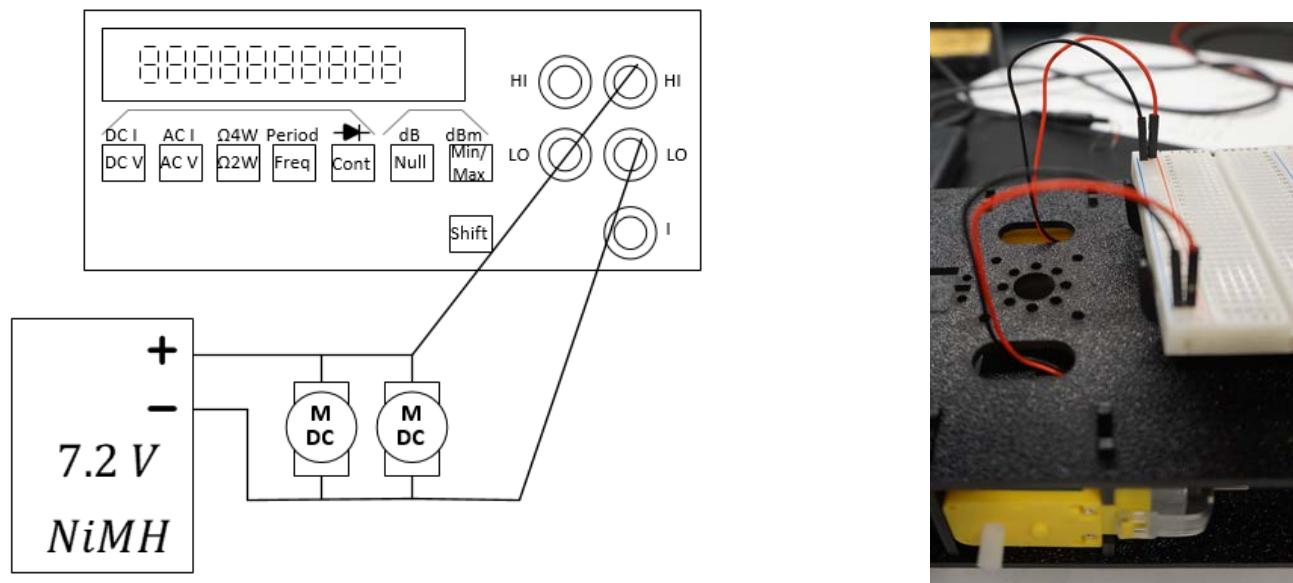
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**Figure 4:** Measuring the battery voltage under load of a single motor. As before, use a breadboard to make the connections.

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

Notes:



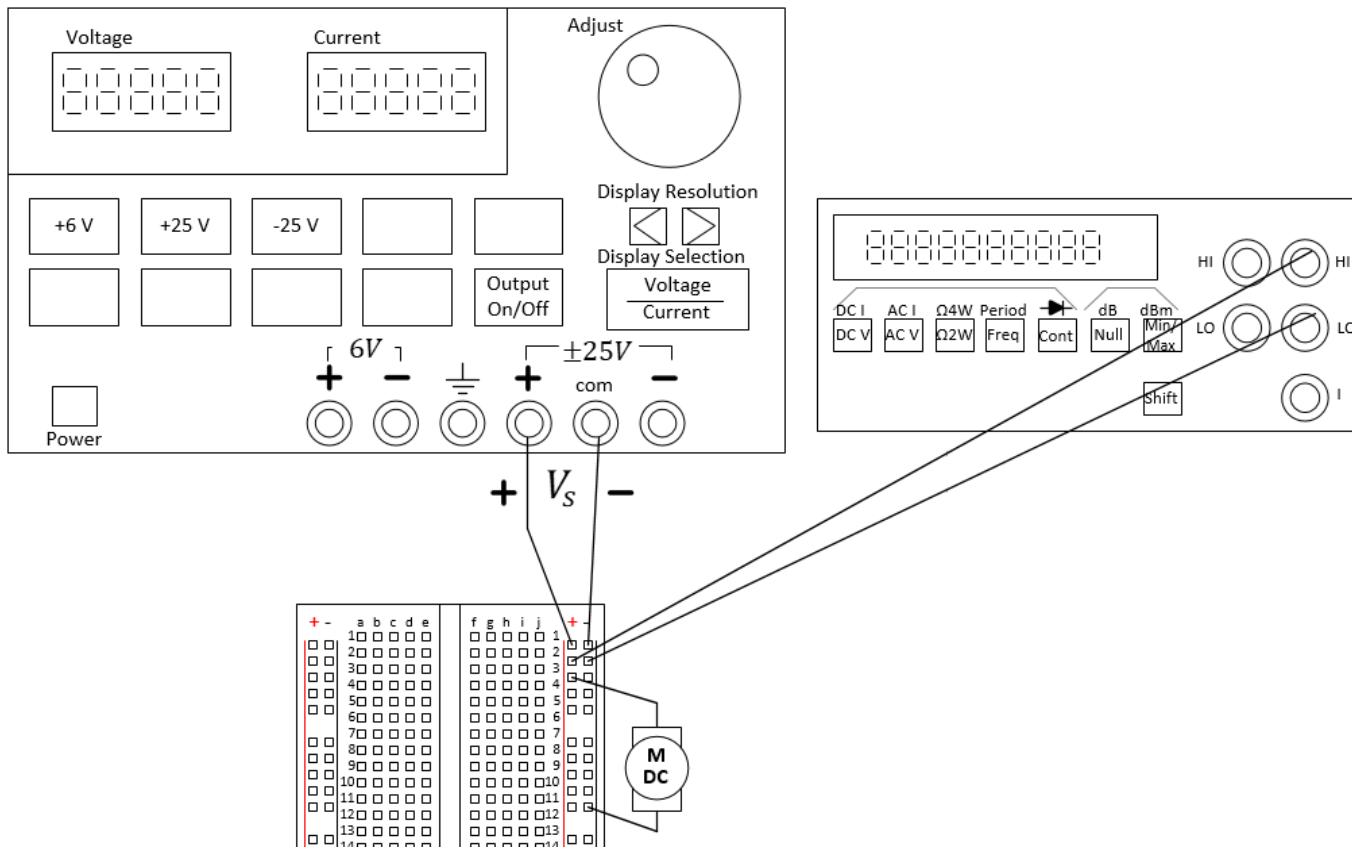
*Figure 5: Measuring the battery voltage under load of two motors in parallel.*

**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

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

Notes:



**Figure 6:** Driving a motor with the voltage “power” supply. All three devices are connected in “parallel”.

Set the voltage source to provide the same open-circuit voltage as the NiMH battery ( $V_{battery,oc}$ ), then repeat the voltage measurements above with zero, one and two motors. See 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.

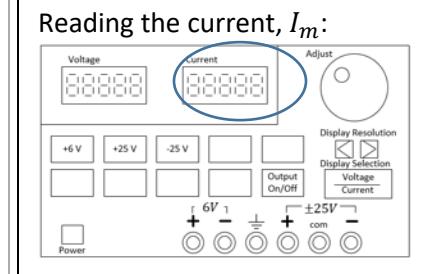
**Question 7:** Is this benchtop power supply a reliable **constant-voltage source**? Explain.

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!).

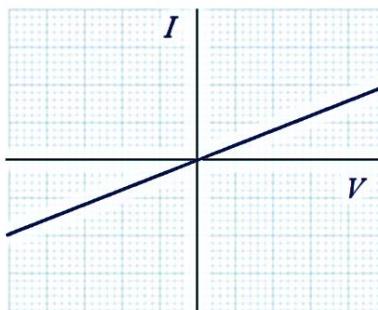
**Question 8:** Write the voltage and the resulting current below.

When  $V = \underline{\hspace{2cm}}$ ,  $I = \underline{\hspace{2cm}}$

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: \_\_\_\_\_



**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.

$$R_m = \underline{\hspace{2cm}}$$

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.

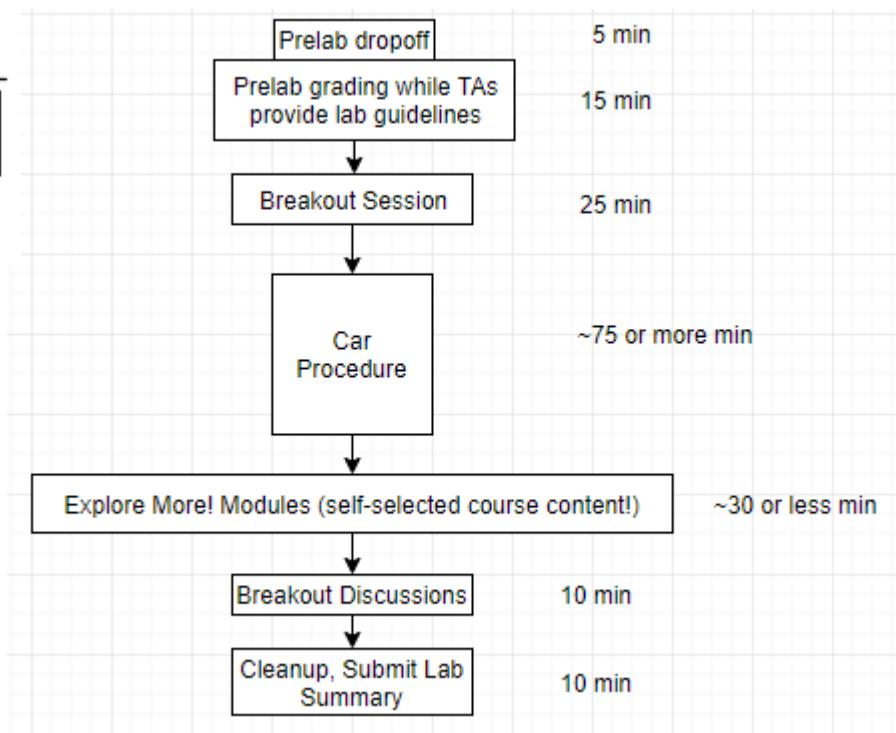
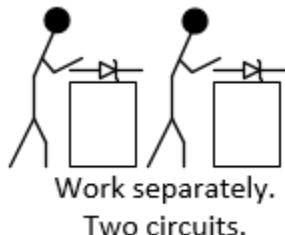
**Question 10:** Take measurements to complete the table below for a single motor powered by the voltage supply.

$V_s$ [V]	$I_s$ [mA]	Comments:
0		
3		
4		
5		
6		
7.2		

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

Notes:

## Explore More! Modules



**Figure 9:** Explore More! 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 **Explore More! Modules** (does not need to be submitted today):

<b>Explore More! Understanding Resistors</b>	<b>Explore More! Engineering Ethics</b>	<b>Explore More! Intro to Arduino</b> (RedBoard/Arduino available for purchase from the ECE Supply Center)
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At the end of the semester, you will earn points towards your total semester lab score by having completed a minimum of 10 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:

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## Breakout Discussion

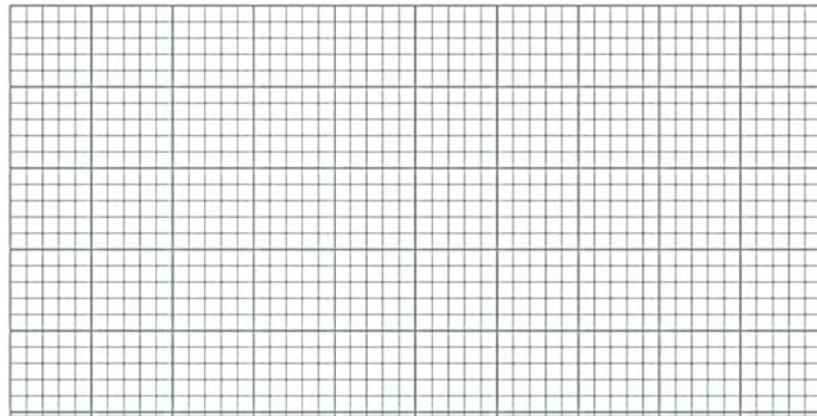
Return to the breakout session when instructed by the TA. At this time, we would like for you to complete the Lab Summary together. Discuss the goals of this lab and determine if everyone has come to the same conclusions.

## Lab 1 Summary (To be submitted at the end of the laboratory session)

**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.



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

Notes:

Name:

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Section AB/BB:

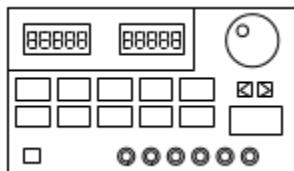
0 1 2 3 4 5 6 7

8 9 A B C D E F

(circle one)

Return your borrowed equipment, clean up your benchtop, and submit your lab summary before leaving for the day. Thank you!

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



Notes: \_\_\_\_\_

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

**For TA use only:**

- Prelab Check: full/half/zero credit
- Student was engaged and active throughout the lab, sharing duties with partner, not distracted by phone, homework, etc.

TA initials: \_\_\_\_ N/A \_\_\_\_\_

TA initials: \_\_\_\_\_

Lab grade (reasons for deductions and/or total points awarded):

\_\_\_\_\_ /8