Experiment 1: Getting Started with Electronics

Name:

NetID:

Today's bench partner:

Section AB/BB:

0 1 2 3 4 5 6 7

8 9 A B C D E F

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!

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 10 minutes after the designated start-time of the lab, you will be deducted two 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 deducted 5 points from the daily lab grade. If a TA brings food or drink into the lab, they will need to serve 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 #1

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. At the center table, work together until everyone’s car chassis is properly assembled.

Assign one student to lead the construction. Follow the instructions provided by the TA (if the video is available) or SparkFun at https://learn.sparkfun.com/tutorials/assembly-guide-for-redbot-with-shadow-chassis. Because the chassis is the dedicated platform of their RedBot, these instructions include some parts that you will not need right now. Navigate to the next page, **2. Wheels and Motors**. Attach the wheels and motors to the bottom of the body. *Skip* the instructions for loading the line-following sensors and mechanical bumpers. Just move on to the section **5. Chassis**.

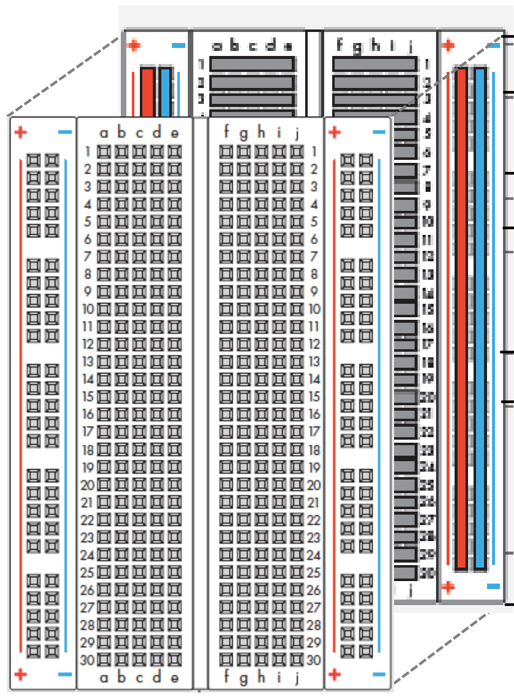
Once the cars are assembled, open your ECE110 Electronics Kit and find one (of two) breadboards, the white-handled screwdriver, and the barrel adaptor. Be careful not to lose any of the other parts of your kit as you place them back into the box for later. Identify the + and the - sides of the barrel adapter and use the screwdriver to secure a solid-core red and a solid-core black wire into each, respectively.

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 these:

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.



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.*

When everyone at the table has assembled their barrel adaptors, 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.

Circle the bench you are working at today: A B C D E F G H I J K L M N O P

While you are welcome to change benches and bench partners next week, this is the bench you will use for the rest of today. Furthermore, 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 also be provided a wire kit. The wires are yours to keep, but the box itself must be returned at the semester's end.

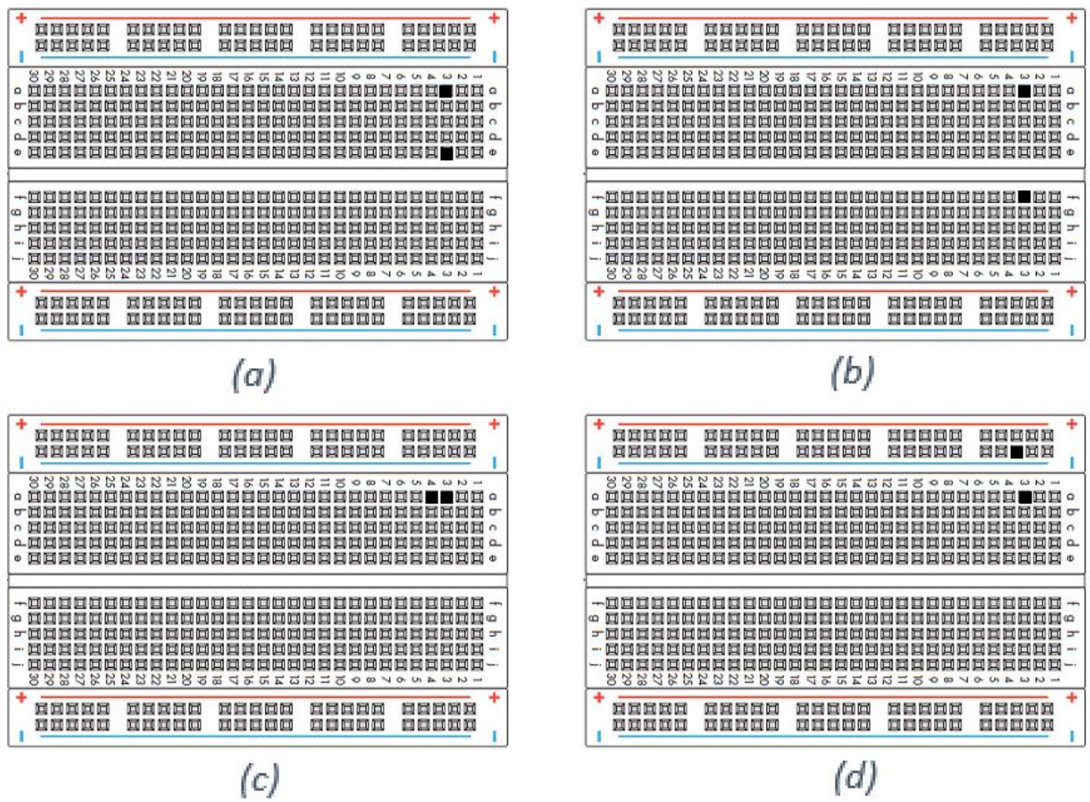
Notes:

At your Bench

Join your TA for a brief introduction to the equipment at your bench. Check out a toolbox from your TA containing alligator clips among other items. You will need to return all items to the kit and to your TA at the end of the 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 wire deep into the breadboard 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”.



Notes:

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

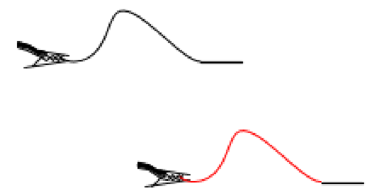


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Figure 2: Example continuity tests on the breadboard.

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

Question 2: What is the voltage across the battery when it is open-circuited (not powering any device, Figure 3)?

$$V_{battery,oc} = \_\_\_\_\_\_\_\_\_\_$$

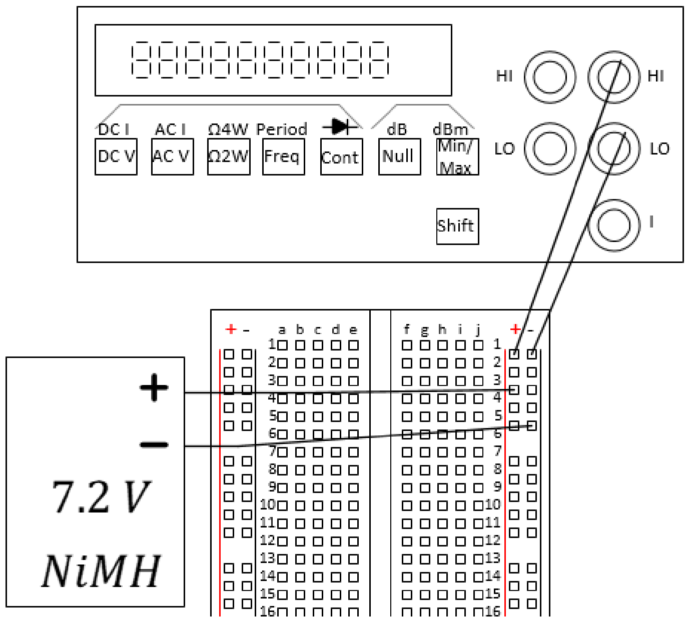

Figure 3: Measuring the open-circuit battery voltage. The breadboard is used to facilitate the connections.

Question 3: What is the voltage across the battery when it is powering a single car motor?

$$V_{battery,1motor} = \_\_\_\_\_\_\_\_\_\_$$

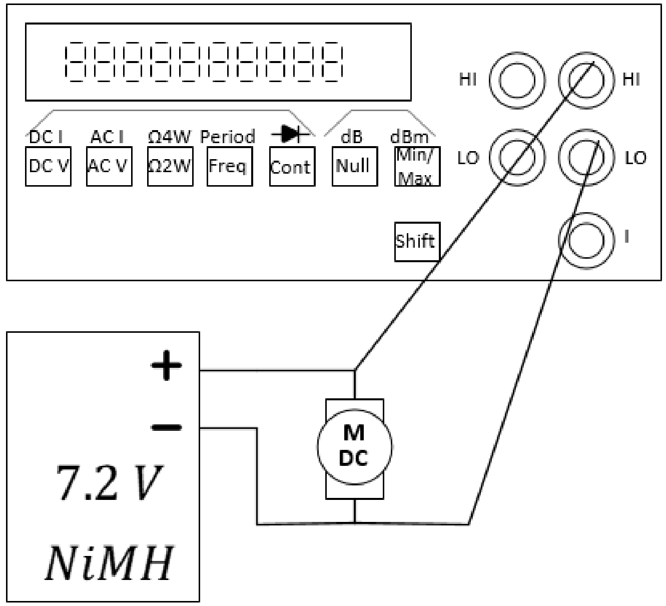

Figure 4: Measuring the battery voltage under load of a single motor. As before, use a breadboard to make the connections.

Question 4: What is the voltage across the battery when it is powering both car motors?

$$V_{battery,2motors} = \_\_\_\_\_\_\_\_\_\_$$

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

Notes:

Did you **remember your units** (volts)? If not, expect to lose lab points!

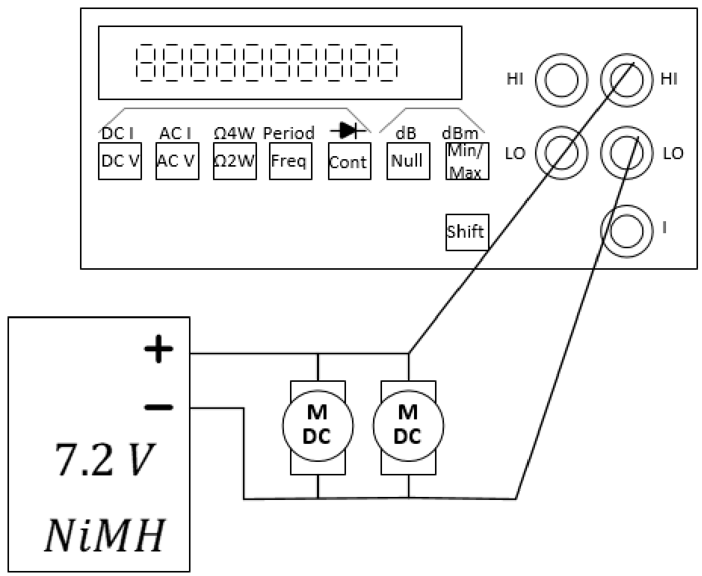

Figure 5: *Measuring the battery voltage under load of two motors.*

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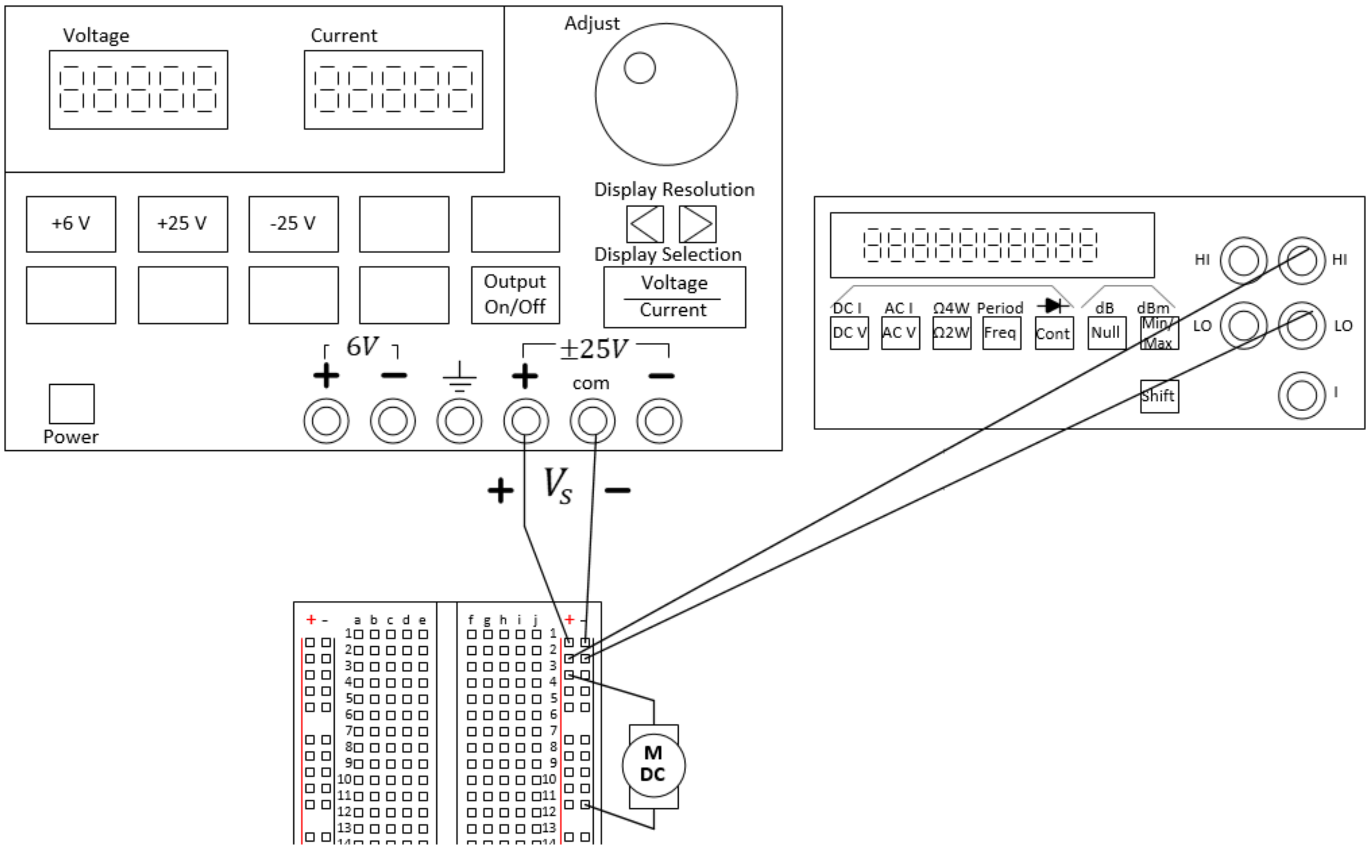


Figure 6: Driving a motor with the voltage "power" supply. All three devices are connected in "parallel".

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?

$V_{oc} =$ ____________, $V_{1motor} =$ ____________, $V_{2motors} =$ ____________

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 again, 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.

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

When $V_m =$ ________________, $I_m =$________________

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.

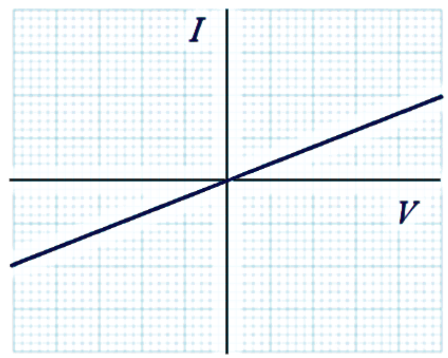


Figure 7: Current and voltage relationship for an "Ohmic" device.

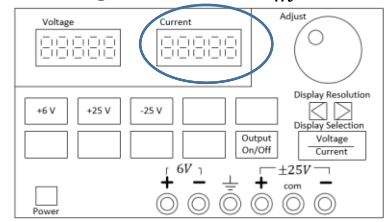
Question 9: Model the motor as an Ohmic device based on the voltage supplied across the motor and the current that flows through it in the previous question. Imagine placing your data point on the curve above. Ask for help if you don't understand.

$R_m =$________________

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 such that the current that flows through the motor is given by $I_m = \frac{1}{R_m} V_m$ for any voltage V_m applied across the motor. Since $I_m = \frac{1}{R_m} V_m$ is

Notes:

Reading the current, I_m:



Notes:

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

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

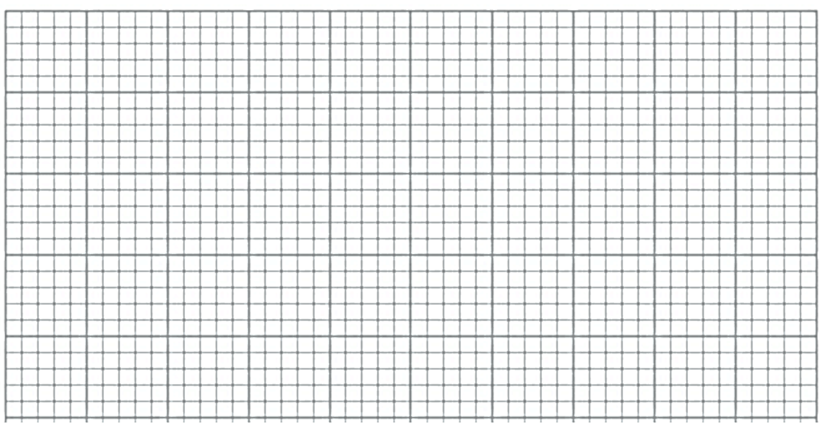


Figure 8: *Current through a motor as a function of the voltage across it.*

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

Notes:

Explore More! Modules

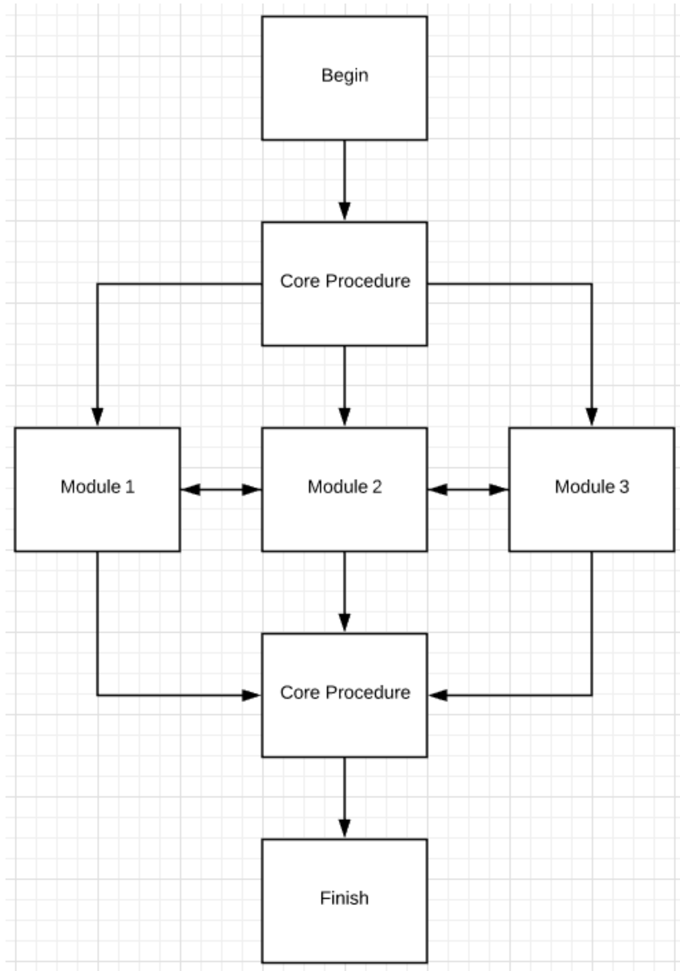


Figure 9: *Explore More! Modules provide students with options to investigate new concepts! As time allows, do one or more of the modules before returning to the laboratory's core procedure.*

Notes:

This week, we highly recommend the following ***Explore More! Modules:***

***Explore More*! Understanding Resistors**	~~***Explore More*! Understanding Capacitors?**~~ Sorry, you'll be ready for this later…	***Explore More*! Intro to Arduino**

At the end of the semester, you will earn points towards your total semester lab score by having completed a minimum of 8 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.

Breakout Session #2

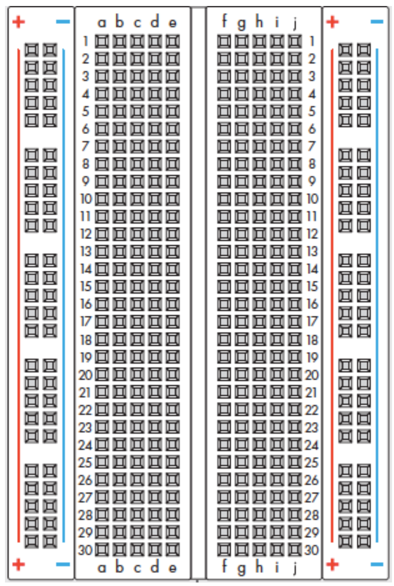
Return to the breakout session when instructed by the TA. At this time, we would like for you to complete the Lab Summary together. Discuss the goals of this lab and determine if everyone has come to the same conclusions.

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

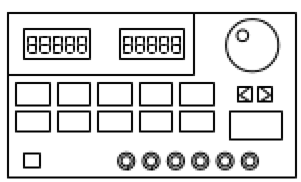
For TA use only:

Student was prompt, participated in Breakout Session #1. Points earned: **0**, **1**, **2** (TA circle one) TA initials: ________________

Question 12: Draw lines to connect the test points of the breadboard above to show the internal connections.



Question 13: Label 5 or more important features of the voltage supply.



Notes:

Name:

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0 1 2 3 4 5 6 7

8 9 A B C D E F

Notes:

Question 14: Several different voltages were measured across the battery under different loading conditions. Why?

Question 15: Do your measurements support modeling the motor as an Ohmic device? Why or why not?

For TA use only:

Student was engaged throughout the lab, without distractions like cell phone, homework non-course-related videos, etc.

Points earned: **0**, **1**, **2** (TA circle one)

TA initials: ________________

Modules submitted today:________________