Section	
Bench No.	

ECE110 Introduction to Electronics

Experiment1: Introduction to Electronics

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This part is reserved for your instructor

Score	
Instructor Signature	
Date	

Experiment 1: Introduction to 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

- Decipher a typical breadboard used for solderless circuit construction.
- Gain exposure to the voltmeter and the voltage supply.
- Explore simple models for Ohm laws
- Explore simple models for the motor, the Lithium rechargeable battery, and the voltage supply.
- Build a car chassis and experiment with driving via "pulsed" signals to the wheels.

Introduction

Each lab period will begin with a brief instruction. 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 instructors will introduce themselves, discuss the lab syllabus, and showcase past presentations. When this is finished, you will start your work. 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.

Take all of your items to one of the 12 benches (labeled 01 through 12). Since there will be up to 24 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 instructor for a brief introduction to the equipment at your bench. On each bench, you will find the alligator clips, cables are hanging on the edge of the table. You will need to restore the table to its original form at the end of your lab session.

Experimental Setup

Breadboard

First let learn about the breadboard. A breadboard (sometimes called a protoboard) is the white board with lots of holes in it. This board helps with building prototypes– the first version of a design. The holes are connected in a useful way as shown in the diagram below.

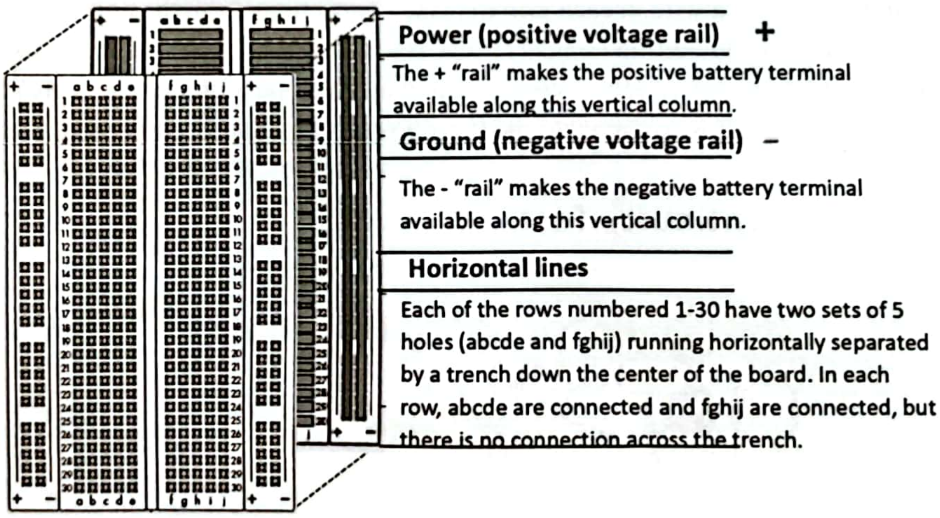


Figure 1: The breadboard "exploded" to show its internal connections.

Multimeter (DDM)

A multimeter is a device used to measure electrical properties such as voltage, current, and resistance. It typically has several functions, including measuring AC and DC voltage, resistance, and continuity. Multimeters can also measure temperature and test diodes and transistors. They are commonly used in electrical engineering, physics, and electronics to diagnose problems, test circuits, and measure electrical properties. The multimeter we used in our lab is show in Figure 2.

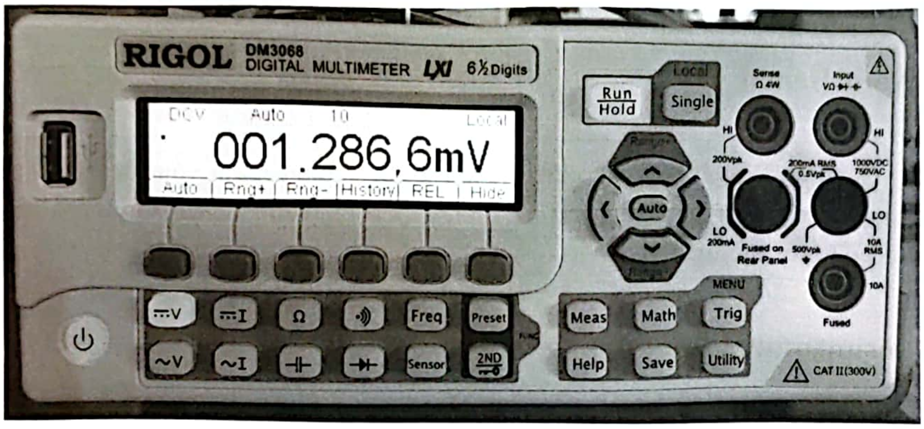
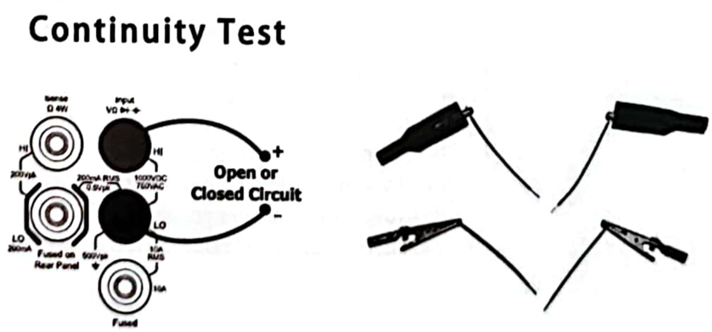


Figure 2: RIGOL Multimeter

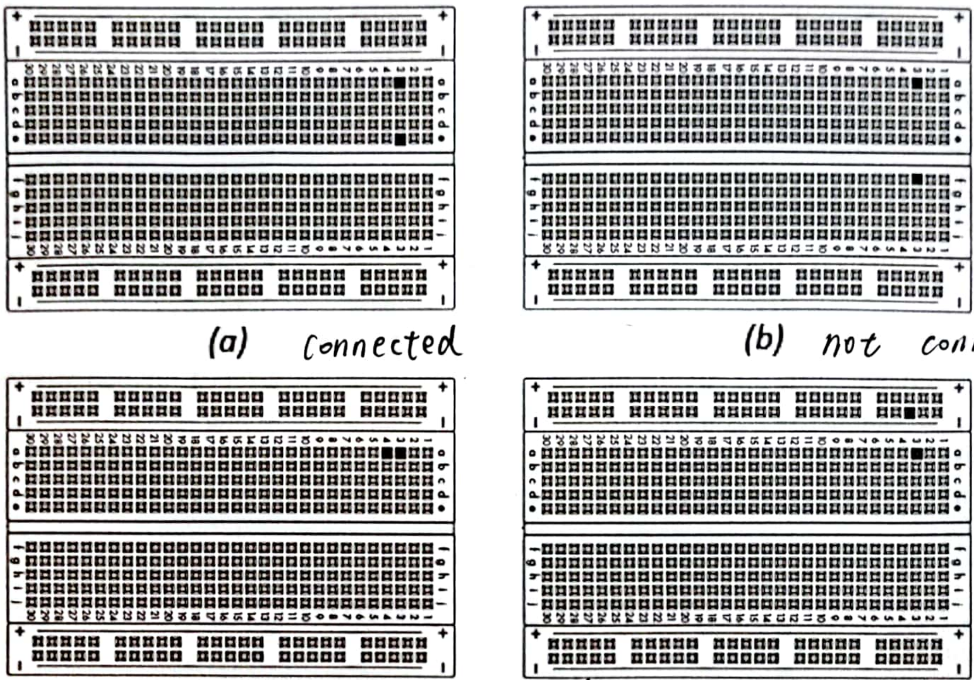
Use the continuity setting ( ) of the digital multi-meter to validate the construction of your breadboard (You can see how to connect the multimeter in Figure 3). Use alligator clips with a wire in each grip to make connections from the equipment to the breadboard. You should find no inadvertent “shorts” 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.



(a)The connection on multimeter *(b) Alligator clips*

Figure 3: How to connect multimeter when do continuity test.

Question 1: What does the continuity tester indicate when measuring as shown in Figure 4, a, b, c, and d? For each subfigure, answer "connected" or "not connected".



(a) connected

(b) not connected

(c) not connected

(d) not connected

Figure 4: Example continuity tests on the breadboard.

DC Power Supply & Battery

In our lab you can use DC Power supply or battery to make the circuit work. The DC power supply can provide a regulated and stable source of power, which is important to ensure that electronic devices are not damaged from fluctuations in voltage or current. The DC power supply we use is show in Figure 5, it has three channels, two of them can provide 0-30V, 0-3A power, the third one provides a 0-5V voltage.

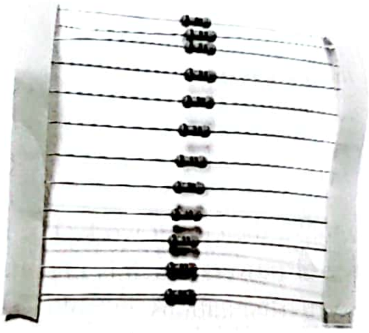
Figure 5: RIGOL DC Power Supply

If you doing some lab from home later, you can use the battery we provide in the kit, the batteries are rechargeable lithium battery. But be careful after you finish the lab, **make sure the wires of two end of the battery (positive end and negative end) will not connect, or it will cause a short circuit.**

Build a circuit and have a try

In this part, we will try to build a simple LED illuminate circuit with a current-limiting resistor. And try to measure the voltage on LED, use formula to calculate the voltage and current on resistor.

First, let's have a quick look at resistor and diode. Fixed resistors are the most widely used components in the circuit, and there are many kinds of resistors. Common resistors include carbon film resistors, metal film resistors, wire wound resistors, cement resistors, patch resistors, etc. In our experiment, 1/4W metal film resistors are used, and their appearance is shown in Figure 6(a). In the experiment we use 5-color ring resistor, and you can refer to below link to see how to read the color ring : http://en.wikipedia.org/wiki/Electronic_color_code. The schematic symbol is as show in Figure 6(b).



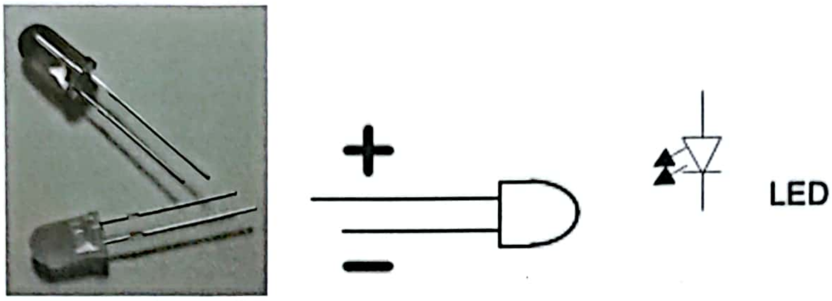
(a) Physical diagram of resistor

(b) The schematic symbol of resistor

Figure 6: 1/4W 5-color ring resistor

Diodes are electronic components that allow current to flow in only one direction. They are most commonly used to convert AC power to DC power, and can also be used to protect electronic circuits from reverse current or to regulate voltage. Diodes are typically made of semiconductor materials such as silicon or germanium, and they work by creating a "p-n junction" between two different types of semiconductor material. When a voltage is applied across the junction in the forward direction, current can flow through the diode, but when the voltage is applied in the reverse direction, the diode blocks the current.

And in today's lab, we will use LED, LEDs (Light Emitting Diodes) are a specialized type of diode that emit light when current flows through them. They are commonly used in electronic devices such as indicators, displays, and lamps. All diodes have an anode and a cathode. **If the LED is inserted in reverse, it will not illuminate** as the voltage is increased. The physical diagram of LED is show in Figure 7(a), the common conduct voltage of different color LEDs are show in Table 1



(a) Physical diagram of LED (b) Anode and cathode of the LED (c) The schematic symbol of LED

Figure 7: Physical diagram and schematic symbol of LED

Emit color	Red	Yellow	Green	White
Typical conduct voltage	1.8-2.0V	1.9-2.1V	2.0-2.2V	3.0-3.3V

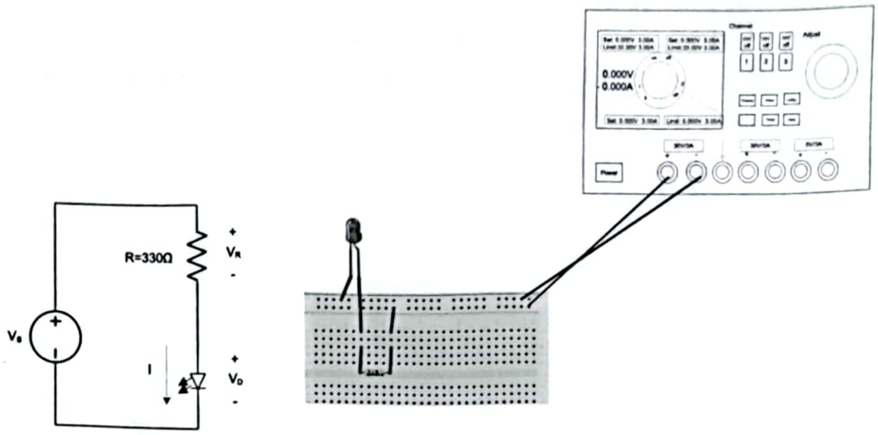
- *Table 1: The conduct voltage of common color LEDs*

Procedure:

1. Build the circuit show in Figure 8(a), and (b) is a physical connection, pay attention to the connect of the cables of DC power supply. The red one connect with "+" terminals, the black one connect with "-"terminal. Also pay attention to the direction of the anode end of the LED.

2. Carefully pull out the resistor, measure the value of it. Use multimeter to measure the value of resistor, press  to change the function to resistor measured. The connection is the same as continuity test. 330.48
Question2: The measured value is R=~~46.67~~ Ω. The Led color is: red.
Why is there an error between the measured value and the rated value, is the error within the allowable range? explain it.

Yes, ~~the measured value is~~
because the error is instrumental error.



(a) Schematic *(b)Physical connection*

Figure 8: Illuminating an LED safely using a current-limiting resistor.

3. Use DC power supply to set different voltage(V_s)：

- In Channel area, press 1/2 () to choose channel 1 or channel 2.
- After you choose the channel, the corresponding channel parameter will be highlight () . Default is to set voltage first. Then use the number key () to set the voltage and current, do not forget to choose the right unit. For example, you press number 9 and "V" , that means you set the voltage as 9V, and if you press number 1, and "A", means you set the current as 1A. **Hint**: Suggest you to set the current to 0.5A, for it can avoid too large current to damage the LED.
- After set all the parameters, press "On/Off" () to turn on the DC power.
- When the power turn on, if you set the circuit current, there will be value show in the screen of the DC power.

4. Connect the multimeter to measure voltage on diode.

- Set the multimeter function to DCV .

➢ Connect the multimeter to your LED circuit, the connect way of multimeter is the same as continuity test. And for the circuit end, the black cable should connect to the negative end of DC power, the red cable should connect to the positive end of LED(as show in Figure 9).

Question3: Use DC power supply to generate different voltage, and use multimeter to measure the voltage V_D , complete the column for V_D in Table 2.

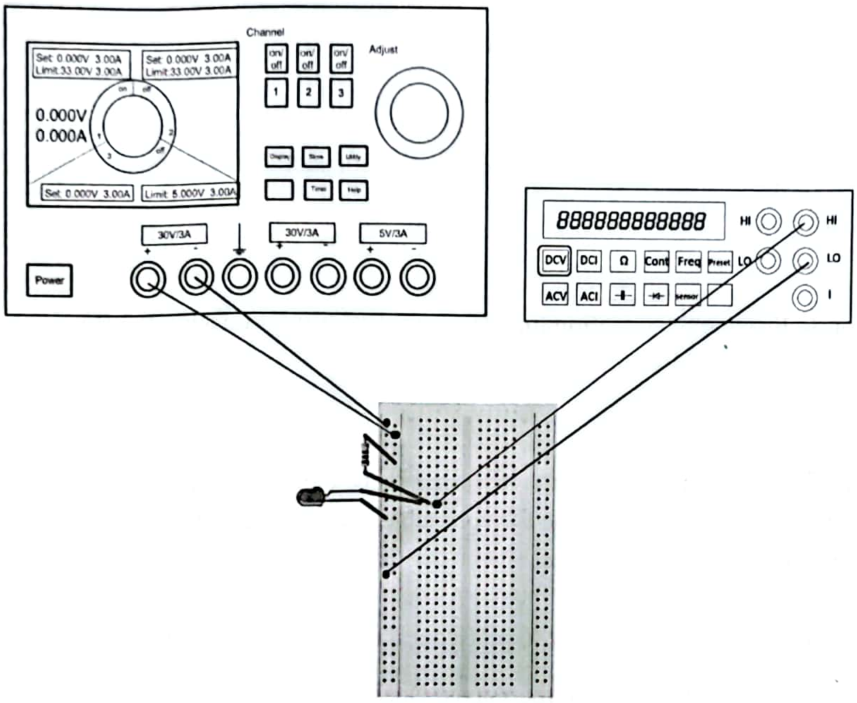


Figure 9: How to measure V_{D}

V_s (V)	V_D (V)	V_R	I	Comment
0.0	0	~~0.500~~ 0	0.0	
0.5	0.500	0	0.0	
1.0	0.999	0.001	0.0	
1.5	1.499	0.001	0.0	
2.0	1.803	0.197	0.60mA	
2.5	1.877	0.623	1.89mA	
3.0	1.9265	1.075	3.26mA	

Table 2: Measurement data and calculate data for circuit in Figure 8

Question 4: In the circuit schematic of Figure 8(a), V_S is the voltage provided by the voltage source (power supply) in the lab. The power supply controls the voltage across the resistor/diode combination, forcing it to take on the value of V_S. Looking at the other side of the schematic, we see that the voltage drops across the resistor, V_R, and the voltage drop across the diode, V_D, must sum to the value of V_S. Write the relationship between V_S, V_R, and V_D as a simple mathematical formula in the space below. Your table should support this formula.

***Hint:** Later, we will formalize this observation as Kirchhoff's Voltage Law (KVL).*

$V_S =$ $V_D + V_R$

Question 5: Provide the equation that describes the voltage across the resistor, V_R, in terms of V_S and V_D.

$$V_R = V_S - V_D$$

For an "Ohmic" device (like a resistor), the ratio of the voltage across the device to the current through the device should be roughly constant. We call this constant the resistance, R: $R = \frac{V}{I}$.

Question 6: Provide the equation that describes the current through the (Ohmic) resistor I, in terms of V_R and R.

$$I = \frac{V_R}{R}$$

Question 7: Complete the table above, filling in the calculated values of V_R and I. Be sure to provide a descriptive name for your table and add the units for these two variables to the top of the columns.

Question 8: Use the figure below to plot your data points from Table 2 by hand, placing I on the y-axis and V_D on the x-axis. Does the LED appear Ohmic? Explain.

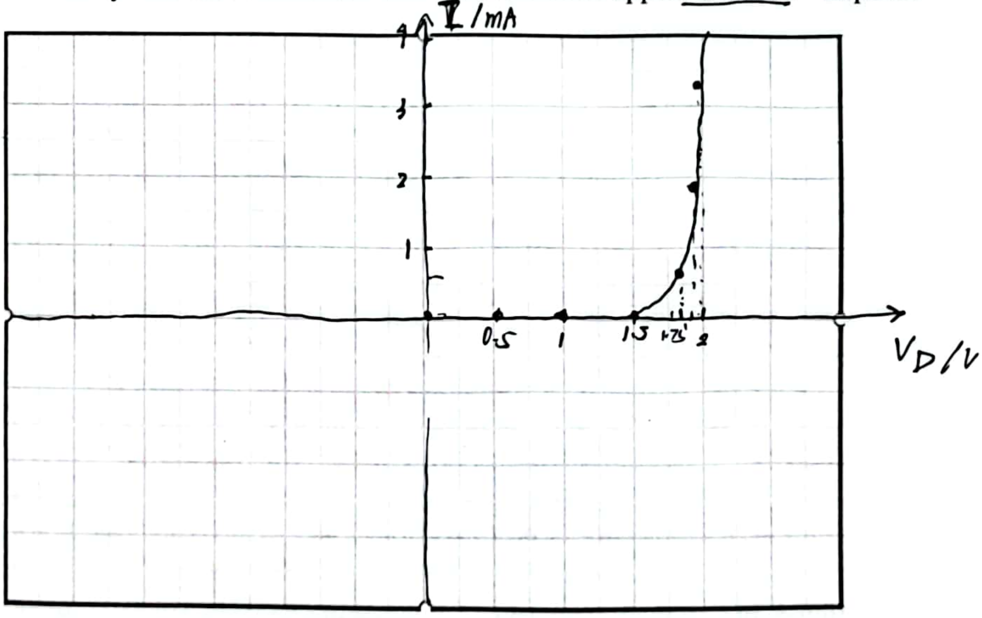
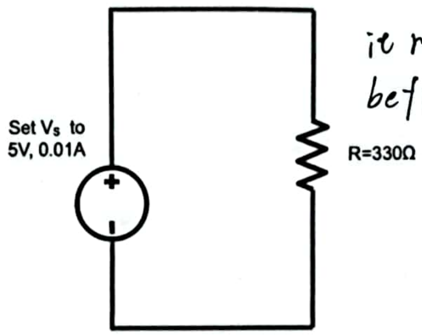


Figure 10: Current through a LED as a function of the voltage across it

No, the ratio of the voltage across the device to the current through the device isn't constant.

Question 9: Think about the below scenario. Set the current of the power supply to 0.01A, the voltage to 5V, and connect it with a 330Ω resistor (as show in Figure 11), when turn on the power, what will happen, what will be the voltage on the resistor? Hint: When DC power reach the setting current, it will trun in CC(constant current) mode, the current will not increase.

3.295V

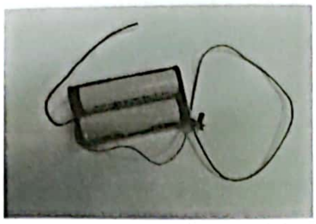


it reaches setting current before reaching setting wltage

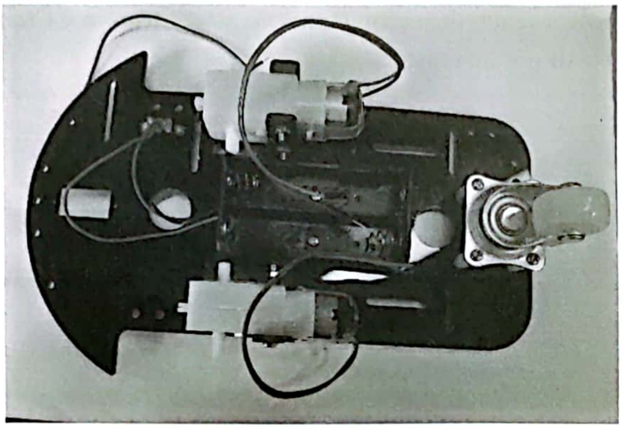
Figure 11: schematic of a current-limiting circuit.

Build the Car Chassis and Play

Our semester-long project will revolve around the construction and design of an autonomous robotic car. Our first step is to build the chassis – the plastic platform that holds the motors and the circuitry. Following the instructions provided in our lab computer and build the car chassis. Because the chassis is the dedicated platform of their complete intelligent car, the instructions include some parts that you will not need right now. You can look through the whole set of instructions, but you will leave out some portions.



(a) Battery box *(b) battery positive end*



(c) Assembled car

Figure 12: The car chassis

- Make sure you have all the chassis' parts – the black/transparent plastic body, the motors with two wires, the wheels and the battery box.

- Attach the motors to the bottom of the body (do not need to install the wheels now),.

- Skipping the instructions for loading the line-following sensors, H-bridge and Arduino (you may need these instructions later).

After assembling the car, following the next step to compare the DC power supply and Battery, and answer the question. In our lab, we offer you the lithium battery, the voltage of each battery is 3.7V, and we will use 2 lithium batteries to drive the car. Before the final project, you can also use the DC power to drive the circuit. In the next session, we will do some measurement to see what the difference between the DC power and the battery is.

Procedure:

1. Change the DDM to DCV mode, and connect it with the battery by the breadboard (see Figure 13), then measure the voltage across the battery when it is open-circuited (not powering any device)? Fill in Table 3

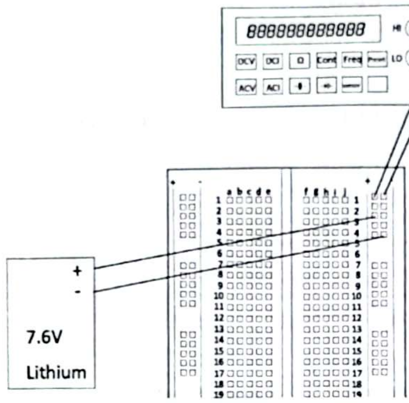


Figure 13: Measuring the open-circuit battery voltage.

2. Connect a single motor with the battery pack, and then use the DDM to measure the voltage, then fill in Table 3.

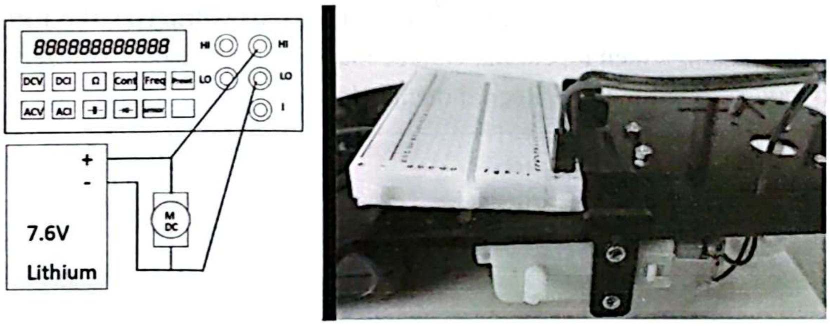


Figure 14: Measuring the battery voltage under load of a single motor. As before, use a breadboard to make the connections

3. Connect both motors with the battery pack, and then use the DDM to measure the voltage, then fill in Table 3.

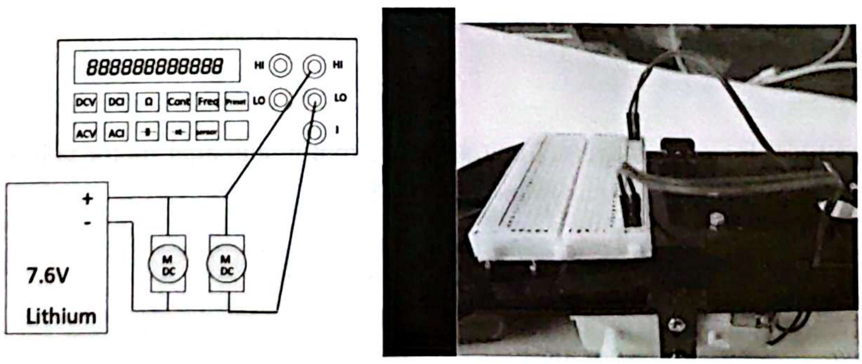


Figure 15: Measuring the battery voltage under load of two motors in parallel.

Question 10: What is the voltage across the battery when open circuit, powering a single car motor and both car motors.

$V_{battery}$(volts)	Conditions	Comments
7.487	Open circuit	
7.425	1 motor in parallel	
7.356	2 motors in parallel	

Table 3: Voltage measurements using the lithium battery pack.

Question 11: Is the battery a reliable **constant-voltage source**? Explain

~~Yes, Because Vbattery is roughly constant no matter what conditions.~~

NO, because when conditions changes, the V battery is not constant, the battery has internal resistance

4. Set the voltage source to provide **the same open-circuit voltage as the Lithium battery** ($V_{battery,oc}$), then repeat the voltage measurements above with zero, one and two motors. See Figure 6. Record them below.

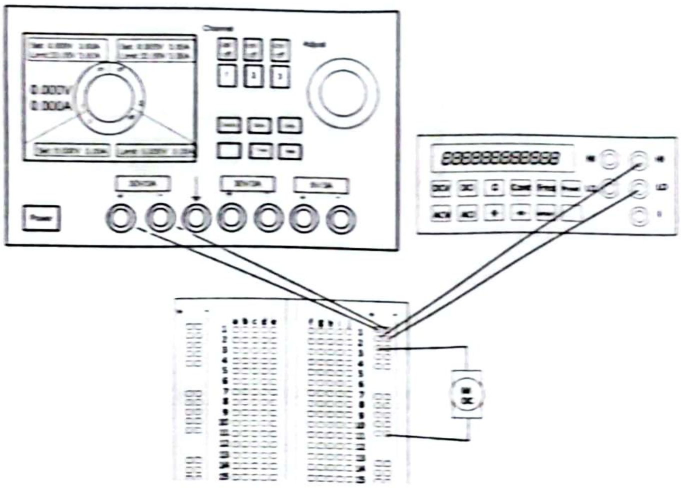


Figure 16: Driving a motor with the voltage "power" supply. All three devices are connected in "parallel".

Question 12: What are the open-circuited, single-motor, and dual-motor voltages of the power supply? Place your answers in Table 4.

$V_{DC\,power}$(volts)	Conditions	Comments
7.604	Open circuit	
7.573	1 motor in parallel	
7.542	2 motors in parallel	

Table 4: Voltage measurements using the benchtop power supply.

Question 13: Is this benchtop power supply a reliable **constant-voltage source**? Explain.

Yes

because when condition changes, the Vbattery is roughly constant.

Explore More! Modules

This week, complete one or more of the following Explore More! Modules (does not need to submitted today):

Explore More! Understanding Resistors	**Explore More! Engineering Ethics**	**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 6 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.