

# Renewable Energy

Group Lab – Batteries and Circuits

Name \_\_\_\_\_

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## **Introduction/Purpose:**

The objective of this lab is to familiarize you with voltage, current and resistance, validate Ohm's law and construct a battery out of a lemon.

## **Apparatus:**

Voltmeter, Ammeter, Batteries, Decade resistance box, Lemon, Galvanized nail, Copper wire, Steel paper clip, Banana plug test leads, Sandpaper, Alligator clips, Light bulb, LED light

## **Theory:**

Georg Ohm discovered that the current through a conductor between two points is directly proportional to the potential difference, or voltage, across those two points. This relationship is known as Ohm's Law and is given by:

$$V = I \times R \quad (1)$$

Where:

V is the voltage, measured in Volts

I is the current, measured in Amps

R is the resistance, measured in Ohms

Today, we will validate Ohm's Law by using circuits in both series and parallel. In a series circuit, the current has only one path to take. The total current is the same throughout the circuit and the total voltage is the sum of the voltages in the circuit. In a parallel circuit, the current has two paths it can take, and there isn't a simple equation to calculate the total voltage for the circuit you are using today.

The electromotive force (emf) is the maximum potential difference between two electrodes and is measured in volts. The emf refers to tendency for an element to gain or lose an electron. In today's lab, the emf refers to the voltage generated by a battery, particularly a battery constructed by a lemon. Batteries consist of two different metals in an acidic solution. Copper and zinc will be used for the metals, also known as the electrodes, and a lemon will be used for the acidic solution, also known as the electrolyte.

## **Procedure**

### *DC Voltage Measurements*

1. Insert the red banana plug test lead into the red socket and the black lead into the black socket of the voltmeter. Do the same thing to connect the leads to the ammeter. Set the measurement scale to auto. Turn on the meter.
2. Measure the voltage of each battery by connecting the meter leads between the red and black terminals. The batteries may be mounted in the holders for convenience, but you

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must physically touch the meter leads to the end contacts of each battery. Record your readings. Note how the meter responds when you reverse the leads at the battery terminals; which color is negative? Which is positive?

4. Arrange the batteries in the holders or connect separate mounted batteries in series (Figure 1a) and measure their total voltage.

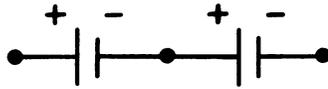


Figure 1a. Series Connection

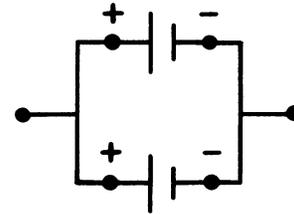


Figure 1b. Parallel Connection

The total voltage for batteries in series is predicted to be the sum of the individual voltages. Compare the measured and predicted series battery voltages.

5. Connect the batteries in parallel and measure their common voltage. **Be sure that you connect them as shown (plus to plus, minus to minus) in Figure 1b, or you will effectively have created a series circuit with very little resistance, and you will generate high currents, heating, and ruining the batteries.** Batteries in parallel will have a common voltage between the individual battery voltages. Is your measured value reasonable? Disconnect all wires from the batteries.

### *DC Current Measurements and Ohm's Law*

1. Hook up the circuit shown in Figure 2. Use one battery and the decade resistance box set to 250 ohms. **IMPORTANT:** Dial the correct resistance before connecting the battery. Ask your instructor to certify that your circuit is correct.

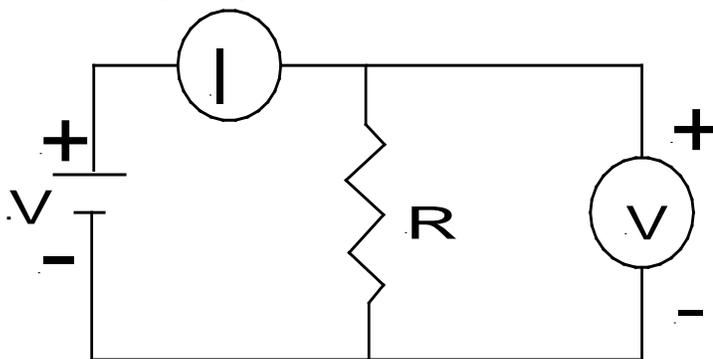


Figure 2. Ohm's Law Test Circuit

2. Measure the voltage and current values for your circuit. You may change to a more sensitive current range to achieve the best precision.
3. Use Ohm's Law to calculate the resistance from your measurements (remember that currents must be converted to amperes in this formula). Compare your predicted R to the dial value on the decade box.

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4. Repeat your measurements for decade box settings of 137, 330 and 405 ohms and compare to the dial values.

### *Construct a Lemon Battery:*

1. Polish a galvanized nail and copper wire with sandpaper
2. Squeeze the lemon without breaking the skin. This will help release juices inside the lemon, which is acting as the electrolyte in this system.
3. Make two small cuts near the two ends of the lemon.
4. Insert the galvanized nail in one cut, and the copper wire in the other cut. Make sure the wire and nail DO NOT touch.
5. Hook one meter lead with an alligator clip attached to the nail, and another to the copper wire.
6. Connect the meter leads to a voltmeter.
7. Determine the potential difference (voltage) of the battery.
8. Replace the copper wire with a paper clip constructed of steel. Is the EMF different?
9. Can you use the lemon battery to light a light bulb? LED? Explain.