THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Technical Workshop: Electrical
December 3, 2016

ELECTRICAL: CIRCUITS

Key terms we will be using today:

Voltage (V): The difference in electrical potential at one point in a circuit in relation to another. The units of voltage is Volts (V).

Current (I): The amount of flow of electric charge in a circuit. It is specified as the charge per unit time crossing a given area. The units of current is Amperes (A).

Resistance (R): The resistance that a material offers to the flow of electric current. The unit of resistance is Ohms (Ω)

Parallel Circuit: A way of connecting circuit elements so that there are multiple paths for the charge to travel through the circuit.

Series Circuit: A way of connecting circuit elements so that there is only a single path for the charge to travel through the circuit.

Ammeter: A device used for measuring current. The meter must be connected in series with the circuit elements to properly measure the current.

Voltmeter: A device used for measuring voltage. The meter must be connected in parallel, across two points in the circuit to properly measure voltage.

BATTERIES:

What does a battery do?

- Batteries convert and store chemical energy into electrical energy.

Battery Terminology

Cranking Amps/Cold-Cranking Amps (CA/CCA): total current a lead-acid battery can deliver for 30 seconds at maximum voltage, CA given at 20° C and CCA given at 0°

Reserve Capacity: how long the battery will last:

- Reserve capacity is defined as the number of minutes a fully charged 12-volt battery at 80 degrees Fahrenheit can provide 25 amperes at a voltage of 10.5 volts or above.

- The higher the ampere-hour (Ah) rating, the longer the battery will last

Deep Cycle: A battery meant for continuous usage, it can be drained low but recover rapidly when recharged. These batteries have thicker plates that deliver less peak current, but withstand frequent discharging.

Open-Circuit Voltage: For a battery that is neither charging nor discharging, the open circuit voltage equals the EMF of the battery. This is the given voltage on a battery data sheet.

Exercise 1.0:

Given a capacity of 100 Ah running at I=5A how long will the battery last?

Using I=50A, how long will the battery last?

Please note that the computations above are an oversimplification. In your technical reports, please search the Internet for “Peukert’s Law” to get a more accurate way of measuring battery run times. Try this:

http://www.batterystuff.com/kb/tools/peukert-s-law-a-nerds-attempt-to-explain-battery-capacity.html

I. Using a Multimeter

1) With your partner, find a lab space. Each space should have a multimeter, some light bulbs, alligator clips, and a 9V battery. In the first part of the lab we will learn how to use the multimeter to measure both voltage and current. We will then use these skills to build both a series and parallel circuit, and to measure voltages and current in both.

Here are some electrical symbols we will be using today.

Component	Circuit Diagram Symbol
Wire	
Resistor	
Light bulb	
Cell	
Battery	

I. Measuring Voltage – We will begin by using the Multimeter to make sure we have a good 9 volt battery for our experiments. We will do this by measuring its open circuit voltage.

1) Turn on your multimeter and set the large dial to the 20 volt range. If you are not sure how to set the meter, ask one of the instructors to explain the settings.

2) Make sure the red probe is plugged into the socket market V/Ohms (the far right socket). Plug the black probe into the COM (common or negative) socket.

3) Connect the red multimeter lead to the positive battery terminal. For a more reliable connection, you might try using the alligator clips to make the connections.

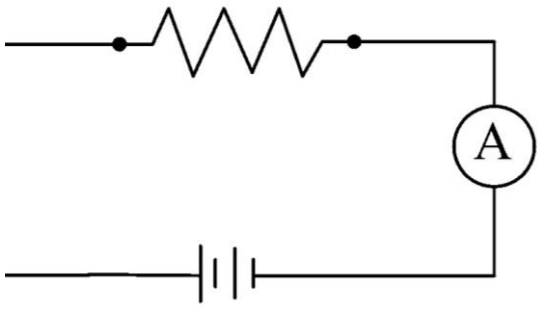
4) Attach the black multimeter lead to the negative battery terminal.

5) Read the voltage value on the LCD screen of your multimeter. If you are on the correct scale you should get a value of something slightly higher than 9 volts. If the voltage is much less than that, get a new battery from one of the instructors. If the reading is -9 volts, you have the leads reversed.

6) Record the value of the voltage of your battery. V =

II. Measuring Current

1) You will receive a resistor from one of the instructors. A resistor has resistance which limits the amount of current in a circuit. Hook it up as shown in the diagram below. Use the clip leads to connect all of the components. Make sure you switch your meter to the current measuring mode. PLEASE DO NOT CONNECT THE AMMETER DIRECTLY ACROSS THE BATTERY OR YOU WILL DESTROY THE METER.



2) Check the polarity on your ammeter's connections. If the value on the screen is negative, simple reverse the position of the leads (you have it backward)

3) Continue to adjust the selector switch for the ammeter. Start with the highest range and go downward until you get the maximum response from the meter that does not go out of range. Check this range setting and the meter reading to get the correct amperage. For example, if you are using the 0.1 to 1 range on the ammeter and the reading is 6, then the current is 0.6 amperes.

4) Record the voltage you measured above and current values in your circuit:

V = I = 9 V / 10k ohm =

II. Ohm's Law

V = I*R

V = voltage, I = current, and R = resistance

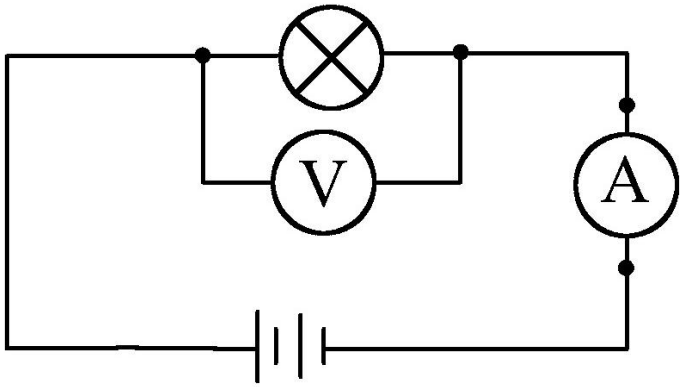
1) Use ohms law to figure out the value of the resistor in your circuit.

2) Check your number by using the color stripes on the resistor to determine its value. R = _____

3) Replace the resistor in the circuit with a light bulb, as shown in the picture below. Use Ohm's law to determine the resistance of the bulb.

4) Current I = R =

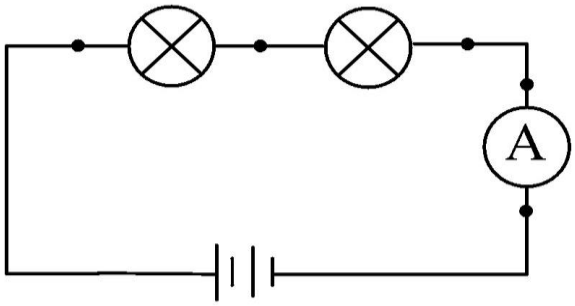
5) Measure the resistance with the multimeter to confirm your number.



PARALLEL AND SERIES CIRCUIT ACTIVITIES:

Series Circuits.

A series circuit is shown in the diagram below. You will notice that there is only one possible path for the current in this circuit. It goes from the battery through the first bulb, through the second bulb and then back to the other side of the battery. Take a few minutes to build this circuit, we'll wait. Make sure your multimeter is set to measure current. Please ask one of the instructors if you have any questions, they are here to help! Before you start, re-check the voltage of the battery, you may have worn it down a bit.



Let's take a closer look at the current and the voltages in this circuit.

1. What is the reading on the ammeter? I =
2. Move the ammeter so that it is between the two bulbs. Is the reading the same?
3. Move the ammeter to the other side of the bulbs. Is the reading the same?
4. Based on your numbers, what can you say about the current in a series circuit?
5. Remove the ammeter from the circuit and change the meter setting to measure voltage. (Ask for help if you need it) Measure the voltage drop across each of the bulbs.

   Voltage across bulb 1 =
   Voltage across bulb 2 =

   Are the readings the same? Why or why not? Explain what is happening.

6. Based on your number, what can you say about the voltage in a series circuit?

7. Use Ohm's Law to figure out the resistance of each of the bulbs. Please show all your work.

   Resistance Bulb 1 =

   Resistance Bulb 2 =

8. Have one of the instructors check you work to make sure you understand how to apply Ohm's Law in a series circuit.

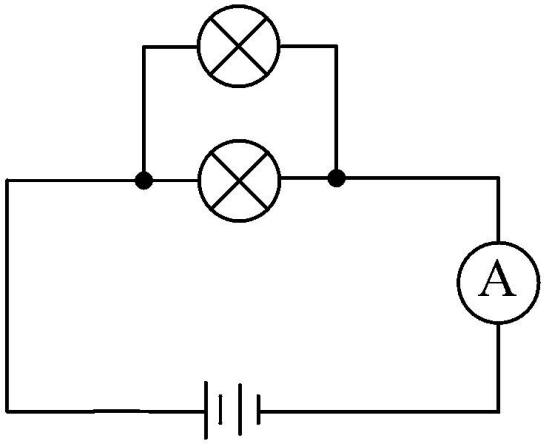
9. Can you remove any part of the circuit and still have light bulbs lit? Explain this phenomena based on what you know about electricity.

10. If you remove any part of a series circuit the entire circuit will not function.

11. How does measuring the voltage drop across a bulb or resistor help you in the Solar Cup?

Parallel Circuits.

A parallel circuit is shown in the diagram below. You will notice that unlike the series circuit above, there are two possible paths for the current in this circuit. It can go from the battery through the lower OR the upper bulb and then back to the battery. Before you start, re-check the voltage of the battery, you may have worn it down a bit.



Let's take a closer look at the current and the voltages in this circuit.

1. What is the reading on the ammeter? I =
2. Is this number different than the current in the series circuit above? Explain:
3. Move the ammeter so that it only measures the current going through the bottom bulb. Ask for help if you have to. I_{bottom} =
4. Move the ammeter so that it only measures the current going through the top bulb. I_{top} =
5. Are the readings the same? Why of why not?
6. Based on your numbers, what can you say about the current in a parallel circuit?

7. Remove the ammeter from the circuit and change the meter setting to measure voltage. (Ask for help if you need it) Measure the voltage drop across each of the bulbs.

    a. Voltage across bulb 1 =
    b. Voltage across bulb 2 =

8. Are the readings the same? Why or why not? Explain what is happening.

9. Based on your numbers, what can you say about the voltage in a parallel circuit?

10. Can you remove any part of the circuit and still have light bulbs lit? Explain this phenomenon based on what you know about electricity.

11. Is there a difference between the measurements you found in the series and parallel circuits? What can you conclude about the relationship between circuits in series and parallel (Write out in sentences)?

12. What is the best way to connect two light bulbs? Why?

13. Can you design a circuit that is both series and parallel? Give it a try, ask for more wires if you need them. Make a table which shows the voltage and current for every leg of the circuit. Show your work to one of the instructors.