Basics of Electronics Challenge
Part One

Due Date:
Tuesday, April 12, 2022

During this challenge you will learn a bit about basic electronic principles. We have the following goals for students taking part of this Challenge:

- Learn to use a digital multimeter and an electronics kit to build and measure circuits.
- Learn how to use an electronics breadboard.
- Learn how to build simple DC circuits and use the multimeter to measure current and voltage.

Students will earn points for the items they submit correctly. The team will earn the points from the student that received the highest points for each Challenge. Each team signed up had a limited number of kits sent to them. Please contact Julie jamiller@mwdh2o.com if there was an issue receiving your kits.

Document It ~ Extra Credit

Use video or photos to document your work. Get creative. Examples include a time-lapse video of you conducting the challenge, a selfie with the finished product, or a self-narrated video about your work. Metropolitan may post selected submissions on our social media accounts to promote Solar Cup and the work students are doing. Be sure to avoid profanity and inappropriate or copyrighted images or music. For a required media release, and upload instructions contact Julie Miller Kalbacher at jamiller@mwdh2o.com. You also may post your videos and photos on your own social media account, or your school's account. Be sure to tag Metropolitan at @mwdh2o and

use the hashtag #SolarCup. Students that turn in a signed media release and upload their finished product to their school folder can earn up to 100 extra points. The more creative your idea, the more points you will earn.

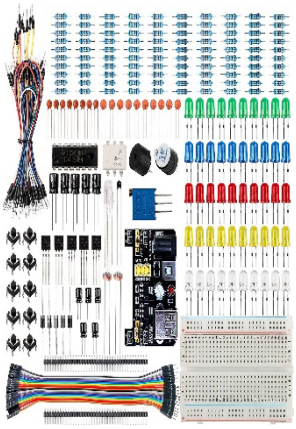
Deliverables and Scoring:

This Challenge will be worth up to 200 points

- Students can earn up to 100 points for answering and submitting your responses to the questions on the Challenge Worksheets
- Students can earn up to 100 points for answering and submitting your responses to the ten questions on the last page of the Challenge
- Students can email their responses to Julie Miller Kalbacher at jamiller@mwdh2o.com
    - Make sure to include your first and last name on the file
    - Your file should also list your school name

Electronics Kit

You will receive an electronics box which contains the breadboard kit you will use to build your circuits for the Challenge. There are three similar kits, you will only have one of the kits that are pictured below:



The Electronics kit contains:

- Breadboard – the 2” x 3” flat white thing in the photo with all the holes in it. There is a picture of it on page 2.
- Red, yellow, and green LEDs
- Small pushbutton switches which are made to plug into the breadboard. These switches are in a plastic box along with many other components (most of which we won’t use)
- Ten pieces each of ten different resistor values. They come in two plastic bags.
- Colored Connecting wires
- Box of capacitors
- Power supply PCB and USB cable

In addition to the Electronics kit, you should also have the following additional items:

- A 9-volt battery
- Five alligator clips
- One multimeter

Please contact us if you are missing items from the kit.

Key terms we will be using in this Challenge:

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

Digital Multimeter (DMM)

A Digital Multimeter (DMM) is a basic device for measuring voltage, resistance, current, and other properties of a circuit. It can measure both DC and AC currents and voltages. It is important to set the dial to the correct position when making measurements. You will only use a few of the functions of the meter during this Challenge, mostly just measuring resistance, current and voltages.

1. The meter comes with the battery already installed.

    a. Move the large dial in the center of the meter from the “OFF” position to any other position to verify that some numbers appear on the LCD screen.

    b. The meter should appear as pictured below.

2. Two probes are used for making contact on different points of your circuit
    a. Typically, the red lead is connected to the positive input (labeled V/W/mA in the picture above)

b. The black lead is typically connected to the negative input (labeled Com) in the picture above

3. After you unbox your meter insert the probes into the meter. Make sure they are pushed in all the way.

4. We will take a few practice readings in the next sections to help you understand how the meter is used.

Multimeter Abbreviations and Symbols

A	Ampere (unit of current
mA	Milliampere (unit of current)
µA	Microampere (unit of current)
V	Volt
Ω	Ohm (unit of resistance)
	DC (direct current)
~	AC (alternating current)
Hz	Hertz (unit of frequency)
	Continuity Test (buzzer)
	Diode
	Capacitance
NCV	Non-Contact Voltage
HOLD	Freezes the Display Value

1. Looking at your multimeter and the chart above, which side of the multimeter will you use to measure resistance?
    a. Upper right side of the dial
    b. Lower right side of the dial
    c. Upper left side of the dial
    d. Lower left side of the dial

2. Looking at your multimeter and the chart above, which side of the multimeter will you use to measure AC voltage?
    a. Upper right side of the dial
    b. Lower right side of the dial
    c. Upper left side of the dial
    d. Lower left side of the dial

Measuring DC voltage

We will use our multimeter to measure the voltage across the 9-volt battery we sent you. The large circular knob in the center of the meter is used to choose between the various meter functions.

Voltage is the pressure from an electrical circuit's power source that pushes through a conducting loop, enabling them to do work such as illuminating a light. A very good description of voltage can be found here: [What Is Voltage? | Fluke]

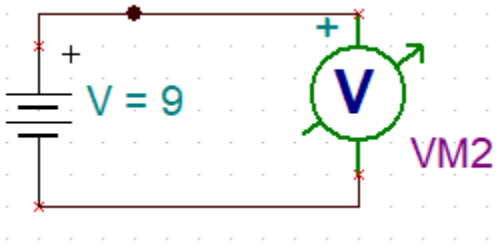
1. To measure a DC voltage, turn the dial from the red “OFF” position three clicks **counterclockwise**. The icon for DC Volts looks like this:

2. The ranges for DC voltage are 200m, 2000m, 20, 200, 500. These numbers indicate the maximum voltage which can be measured using that range.

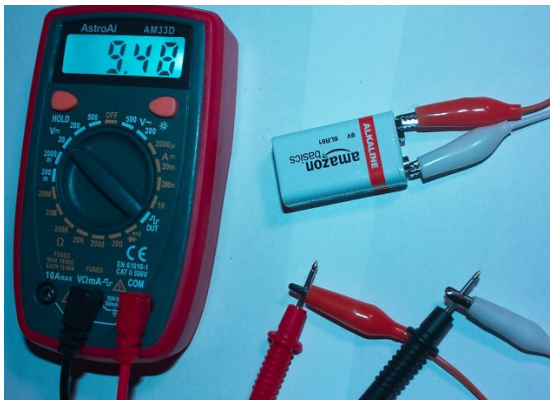
    a. In our case we are going to measure a 9-volt battery so we will use the range which is the closest to 9 volts.

    b. If we were going to measure a voltage of 21 volts, we would have to switch the meter to the 200 range, as the voltage is over 20 volts. The “m” is for milli meaning millivolt in this case.

3. Here is a schematic of the multimeter measuring the battery voltage:



4. Duplicate the schematic by placing the meter probes across your 9-volt battery as shown in the picture below. The picture shows how to use the alligator clips to connect the meter to the battery to measure its voltage.

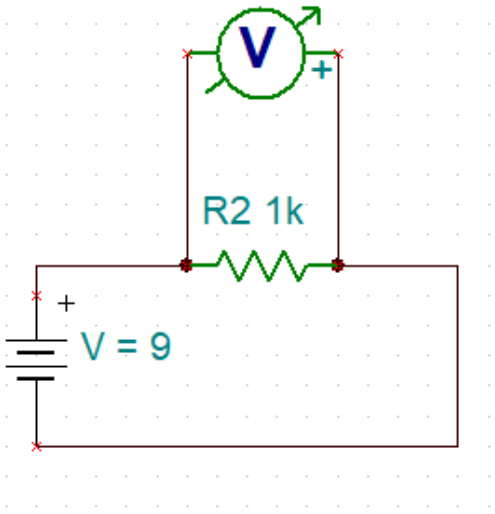


a. The normal voltage of a 9-volt battery should be slightly higher than 9 volts.

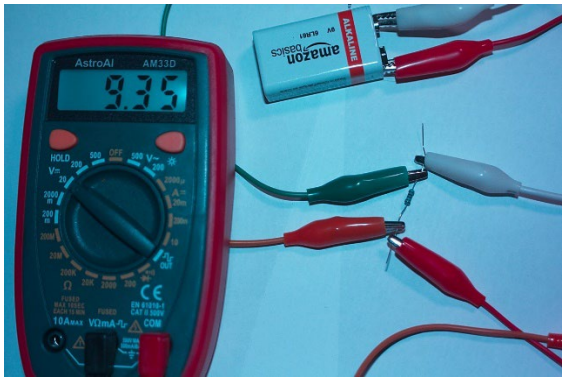
b. What measurement did you get for your battery? _____

c. What happens if you reverse the multimeter leads? _____

5. In a circuit with more than one component, you must put the meter in parallel (across) the component to measure the voltage drop across that component. This is the schematic of how to measure the voltage drop across a resistor.



6. The meter in the picture below is measuring the voltage drop across the resistor. You can see that the green and red alligator clips are hooked up to the meter leads are across the resistor.



a. Try to duplicate the circuit below from the parts in your kit. Pick one of the higher value resistors.

b. What is the value of voltage drop across the resistor in your circuit?

_____

c. Is this the same as the battery voltage? Why or Why Not?

_____

_____

Measuring Current

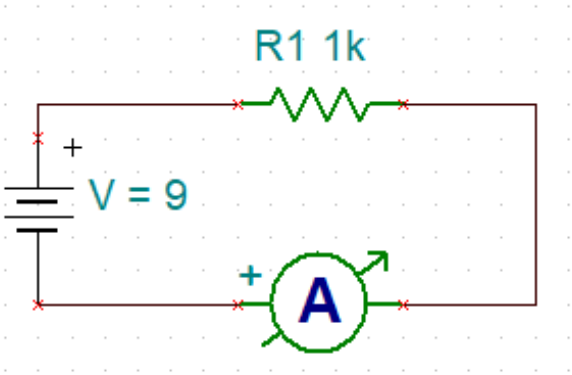
Just as with voltage, you must select the correct meter range when measuring current. The large circular knob in the center of the meter is used to choose between the various meter functions. This will be either 4, 5, 6, or 7 clicks clockwise.

Current is a measurement of the flow of electrons in a circuit. A very good explanation of current can be found here: What Is Current? | Fluke

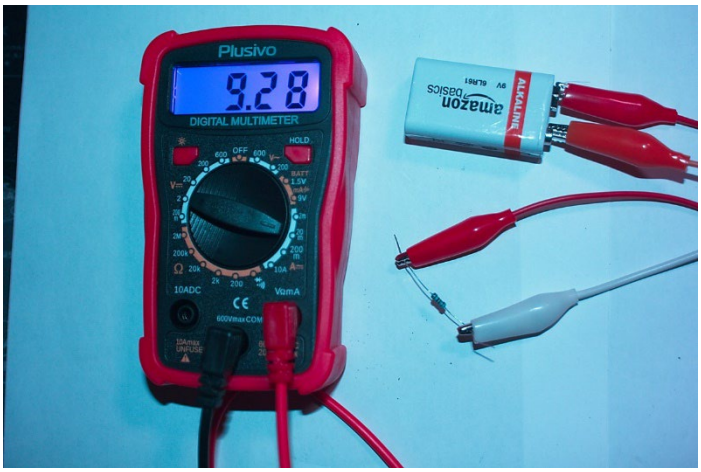
1. To measure current, turn the dial from the red “OFF” position four clicks **clockwise**.
    a. The symbol will be 20m (for 20 milliamps)
    b. For most of the experiments, four clicks **clockwise** will put you in the correct range to measure current

c. The ranges for current are tinted yellow, and are labeled 2000u, 20, 200,10. Like the voltage ranges above, the numbers indicate the maximum current which can be measured using that range. The “u” is for micro, microamps in this case.

2. To measure current, you must put the meter in series with the components, as is shown in the schematic below. You can see that the battery current goes to the resistor, then around into the meter, and then back to the battery in a single loop.



3. My circuit is shown below. With a 1k resistor, my current is 9.28 milliamps.



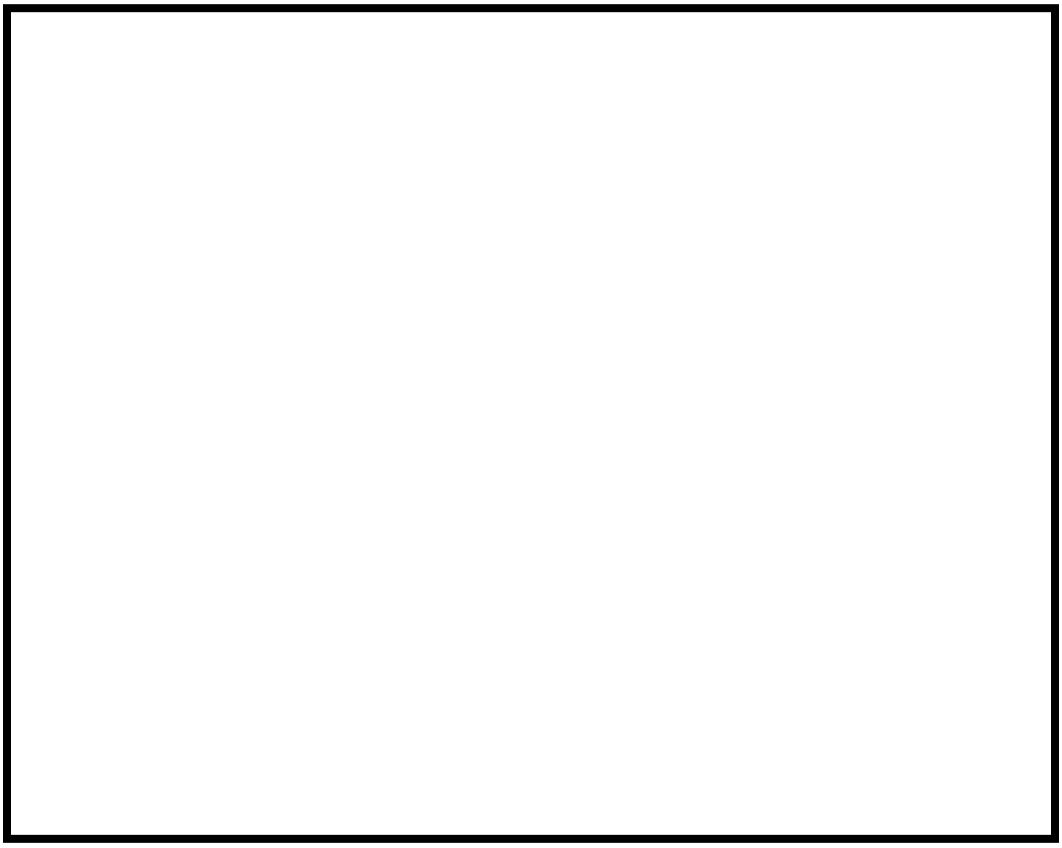
4. The multimeter you will be using in the Circuits Challenge does not require you to switch the red lead when making low current readings.

5. Try building the circuit as shown in the photo in question 3 on the previous page. Choose the 9v battery and any resistor from your kit other than 1k ohm.

a. What is the current in your circuit?

_____

b. For practice, in the space below draw a schematic of your circuit.



Measuring Resistance

Resistance is a measure of the opposition to current flow in an electrical circuit. A very good description of resistance can be found here: What Is Resistance? | Fluke

Make sure you remove the battery connections from the previous exercise before switching your multimeter.

To measure resistance, turn the dial from the red “OFF” position nine clicks counterclockwise.

The icon for resistance looks like this: Ω 20k

1. The ranges for resistance are labeled 200,2000, 20k, 200k, 20M, and 200M. Like the voltage and current ranges described above, these numbers indicate the maximum resistance which can be measured using that range. K = 1000 and M= 1,000,000

2. Select one of the resistors in the breadboard kit. The resistors look like this:

3. The value of the resistor is given by the colored bands.

4. What colors are on the resistor you selected?

   _____

5. Measure the resistor value with your meter. Below is a picture of my meter measuring the value of a 1k resistor. (Note: it might not be exactly 1000 ohms)

   a. It's best to put the resistor down on your tabletop and press the meter probes against the resistor leads.

      i. What measurement does your meter show?
      _____

      ii. If the meter reading is 1 followed by blank spaces, the meter is set to a range which is too low.

iii. You will need to change the meter settings to read the higher value, i.e., if the meter is set to the 2k range, it will only read a value up to 2,000 ohms.

b. Try holding just the metal section of the multimeter probes with your fingers as you measure the resistor value

   i. What measurement does your multimeter show?

      _____

   ii. If you use your fingers to hold the probes to the resistor leads the meter will also read the resistance of your body in parallel with the resistance of the resistor.

c. Try holding the metal section of the multimeter probes and wet your fingers, explain how the value changes:

   _____

   _____

d. If you can't get a steady reading, use two of the alligator clips to make the connections.

e. Measure three different values of the resistors:

   i. For your first resistor, list the colors that are on the resistor

      _____

   ii. What measurement did your multimeter show? _____

   iii. For your second resistor, list the colors that are on the resistor

      _____

   iv. What measurement did your multimeter show? _____

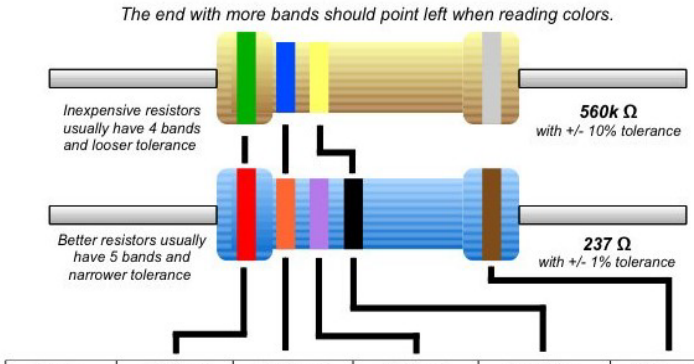
   v. For your third resistor, list the colors that are on the resistor

      _____

   vi. What measurement did your multimeter show? _____

Resistor Color Codes

Resistor Color Codes can be used to check your multimeter readings. We will use the yellow or blue resistor in the picture below to learn how to find the resistor values by the color coding.



Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	x 1 Ω	
Brown	1	1	1	x 10 Ω	+/- 1%
Red	2	2	2	x 100 Ω	+/- 2%
Orange	3	3	3	x 1K Ω	
Yellow	4	4	4	x 10K Ω	
Green	5	5	5	x 100K Ω	+/- .5%
Blue	6	6	6	x 1M Ω	+/- .25%
Violet	7	7	7	x 10M Ω	+/- .1%
Grey	8	8	8		+/- .05%
White	9	9	9		
Gold				x .1 Ω	+/- 5%
Silver				x .01 Ω	+/- 10%

Use the chart above to answer the questions:

a. The number assigned to the green band is_____

b. The number assigned to the blue band is _____

c. The multiplier assigned to the yellow band is _____

d. Put the numbers from questions **a** and question **b** here_____ (for example a 2 and a 3 becomes 23)

e. Multiply the number in you got for question **d** by the number in question **c** _____

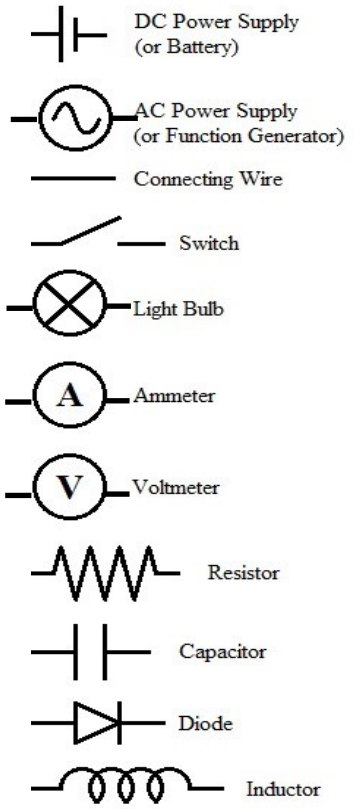
f. Now go back to the previous section where you measured three different resistors using your multimeter. Use the color code method to check one of your resistor measurements. What were your findings?

_____

_____

Circuit Symbols

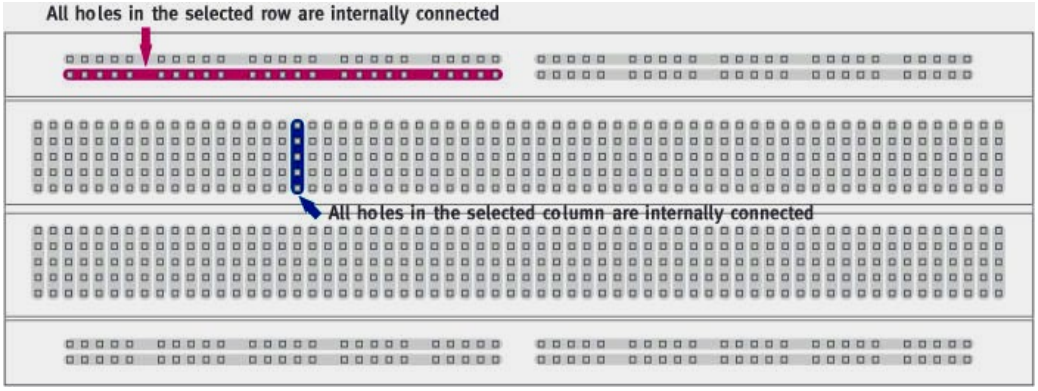
When drawing schematics or diagrams of electrical circuits, we will use the following conventional circuit element symbols.



Breadboard Connections and Continuity Check

Breadboards are used to build circuits. Wires and electrical elements are simply pushed into the holes to form a completed circuit to which power can be supplied. One of the main advantages of using a breadboard is that the circuit elements are not soldered in place. If they are positioned incorrectly, they can be easily moved to a new position on the board.

Find out how the breadboard holes are connected to each other.

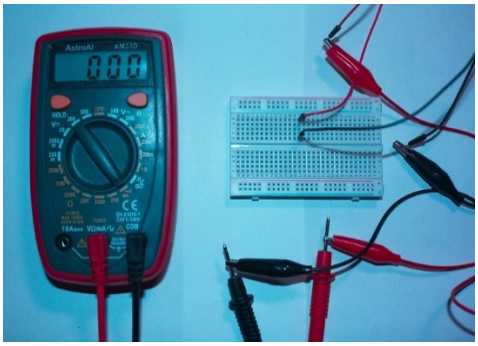


MAKE SURE YOU UNDERSTAND HOW THE BREADBOARD MAKES CONNECTIONS BEFORE PROCEEDING WITH THE CHALLENGE.

1. The simplest way to check connections is to use a multimeter set to the Audible Continuity (buzzer) mode.

   b. Touch the two probes from the multimeter together, you should hear a beep.
   c. Apply the probes between two holes in the same row. Then apply the probes between two holes in the same column.

      i. You can use short pieces of wire that are in the kit to assist with this measurement, as the holes in the breadboard are too small for the probes to fit.
      ii. The picture below shows how you can use the wires to check the continuity across the breadboard column



d. The value displayed is the resistance in ohms, which should be 0.

e. If no connection in present, the value reads “OL.”

2. The buzzer sounds at low resistances (indicating a connection), so you can quickly probe for continuity without looking at the meter each time.

Questions to Answer – 10 points each

(You may have to search a bit on the Internet for some of these)

1. A resistor has color bands of red-brown-purple. What is the resistance: _____
2. A resistor has color bands of brown-green-green. What is the resistance: _____
3. What is the voltage of your 9V battery? _____
4. If it is exactly 9.0 volts why? _____
5. If it is not exactly 9.0 volts, why not? _____
6. Why is the breadboard called a breadboard? _____
   _____
7. What is Voltage? _____
8. What is the unit of measure of voltage? _____
9. What is Current? _____
10. What is the unit of measure of current? _____

Congratulations, you’ve finished Electronics Challenge part 1 for Solar Cup 2022. Be sure to submit your finished answers as requested in the introduction.