# Basics of Electronics Challenge

# Part 2

## 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:

- Use Ohms Law to design and build some electronic circuits.
- Introduction to the math necessary to build both series and parallel circuits.
- Learn about capacitors and how they change the behavior of a DC circuit.

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:

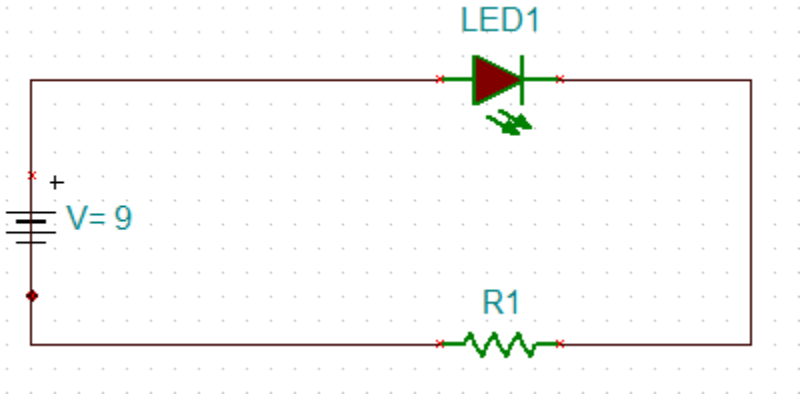
The Electronics Part Two Challenge will be worth up to 250 points

- Students can earn up to 200 points for answering and submitting your responses to the questions on the Challenge Worksheets
- Students can earn up to 50 points for answering and submitting your responses to the five 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

## Calculating the value of a current limiting resistor in a circuit with a single and then multiple LEDs

After completing Basics of Electronics Challenge Part 1, it's time to put that knowledge to work. Let's begin to make some circuits and take some measurements.

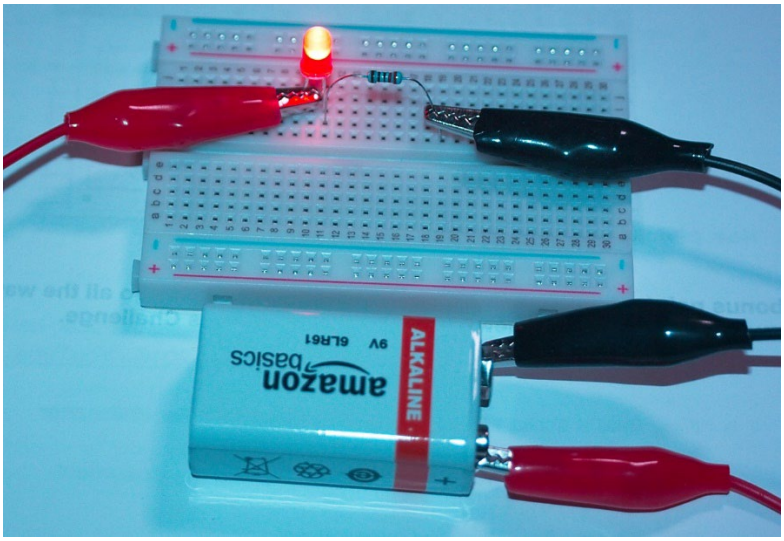
The circuit below shows a battery, a resistor and an LED (light emitting diode). We must use the formula shown below to compute the correct resistor value to use in the circuit.



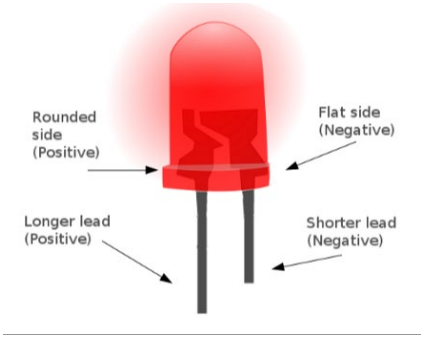

The formula for the value of R1 is: $R = \frac{Vbat - Vled}{Iled}$

Where:
R is the value of the resistor (what you need to find)
Vbat is the battery voltage (9 volts in our circuit)
Vled is the voltage drop of the LED (given in the data sheet, use 1.7 volts)
Iled is the current through the LED (use 20ma for our circuit)

Select the resistor from your kit which is closest in value to the value you got from the formula. Then build the circuit above and answer the questions below. Use the 9V battery and use a red LED. You might want to use two alligator clips to attach the battery to the circuit. Plug the LED and the resistor into the breadboard. Below is a picture of my circuit on the breadboard. Your circuit should look similar.




Note that the LED is polarized, that is, it has a plus and minus lead as shown in the picture below. The plus side of the LED must be connected to the plus (+) side of the battery. If you think your circuit is correct but the LED won't light up, try reversing the LED in the breadboard.



What value did you choose for R? R=

1) What is the current in your circuit? I =

   Refer to the “Measuring Current” section above if you are unsure how to make this measurement)

2) Measure the voltage drop across the LED. What is the voltage drop across the LED? V =

   Refer to the “Measuring Voltage” section.

3) What is the voltage drop across the resistor? V=

4) Are these values what you expected?

5) Why or why not?

## LEDs in a Series Circuit

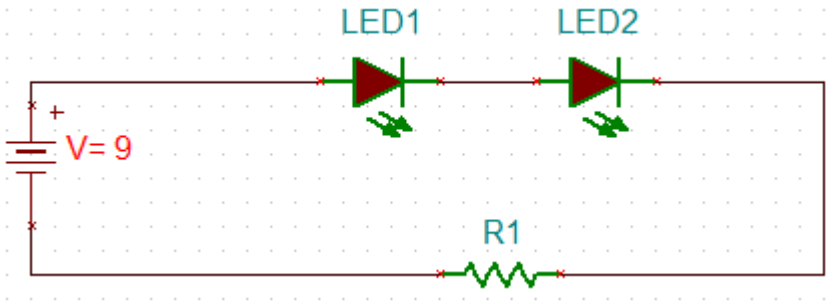
The equation below gets only slightly more complicated when you connect multiple LEDs in series. The voltage drop across the LEDs increases, reducing the voltage drop across the resistor. The current through the resistor (and the LEDs) remains the same.

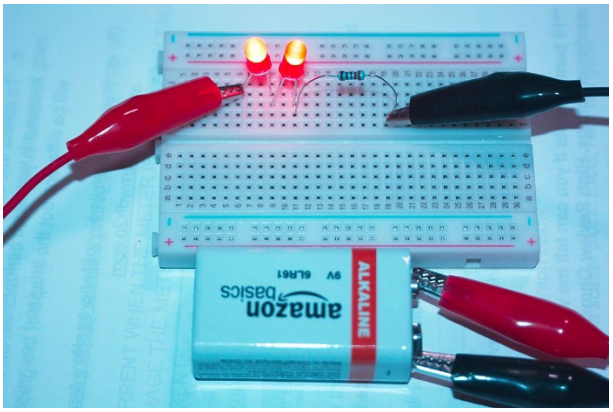
$$R = \frac{Vbat - nVled}{Iled}$$

Where:

R is the value of the resistor (what you need to find)
*n* is the number of LEDs in the series circuit.
Vbat is the battery voltage
Vled is the voltage drop of the LED
Iled is the current through the LED

The figure below shows an example with two LEDs connected in series. The voltage drop across the LEDs is two times the voltage drop across a single LED.




**1)** What value did you choose for R1? R=

**2)** What is the current in the circuit? I =

**3)** Measure the voltage drop across the LEDs. What is the voltage drop across LED1? V =

**4)** What is the voltage drop across LED2? V =

**5)** What is the voltage drop across the resistor? V=

**6)** Is this what you expected?

**7)** Why or why not?

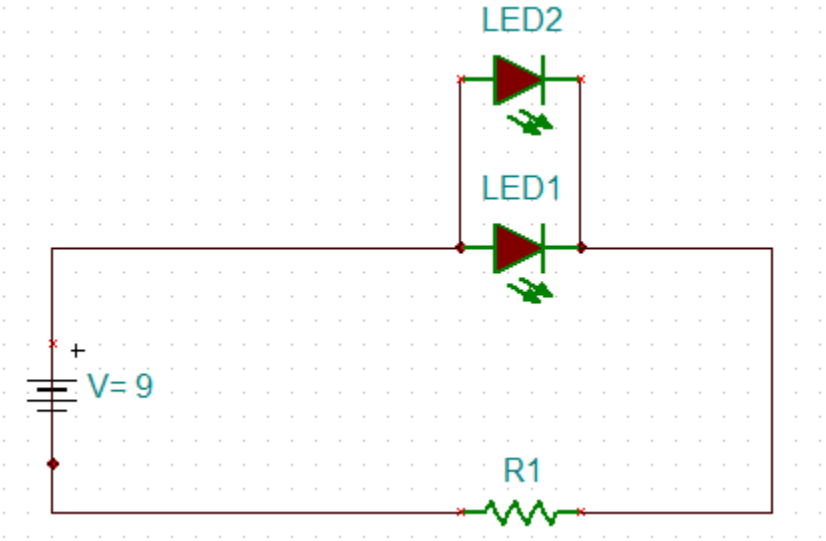
## LEDs in Parallel

If you connect multiple LEDs in parallel, the current through the resistor increases (though the current through each LED remains the same). The voltage drop across the LEDs is unaffected, as is the voltage drop across the resistor:

$$R = \frac{Vbat - Vled}{nIled}$$

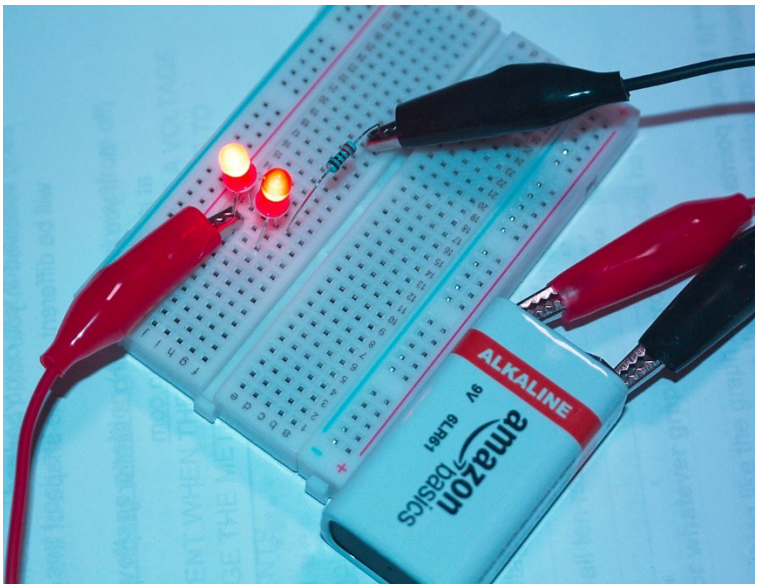
where *n* is the number of LEDs in parallel. The figure below shows an example of two LEDs connected in parallel. The current through the circuit is two times the current of a single LED.

When building the circuit, make sure that the parallel LED's are wired correctly. Because of the increased current in the circuit, there will be a problem if one of them is wired incorrectly or if one of the LEDs burns out. The increased current will shorten the lifetime of the remaining LED and may even cause it to burn out.



Use the formula above to find the value of R, and then build the circuit shown above. Be sure to use the same color LED's, don't mix colors. Because of the increased current in the circuit the resistor R1 may overheat if you leave it connected too long, or if the value of R1 is not correct. If the resistor overheats (it may smell funny too) disconnect the battery and let it cool down.

Here is a picture of my circuit, yours should look about the same. Note that the + leads of the LED's share a common column of the breadboard, as do the – leads:




**1)** What value did you choose for R1? R=

**3)** Measure the voltage drop across the LEDs. What is the voltage drop across LED1? V =

**4)** What is the voltage drop across LED2? V =

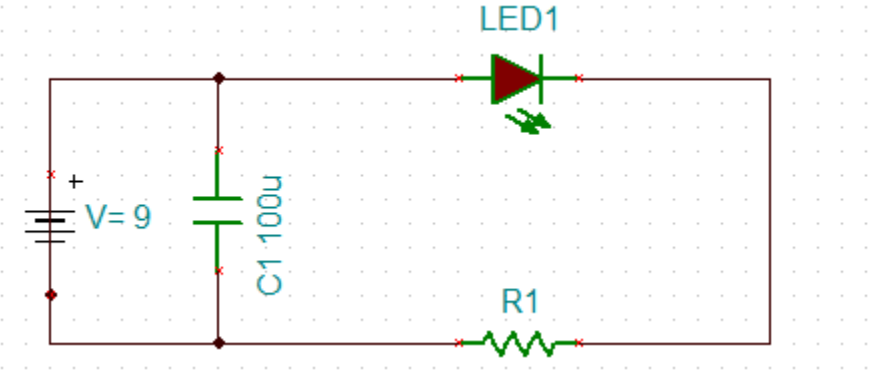
**5)** Is this what you expected?

**6)** Why or why not?

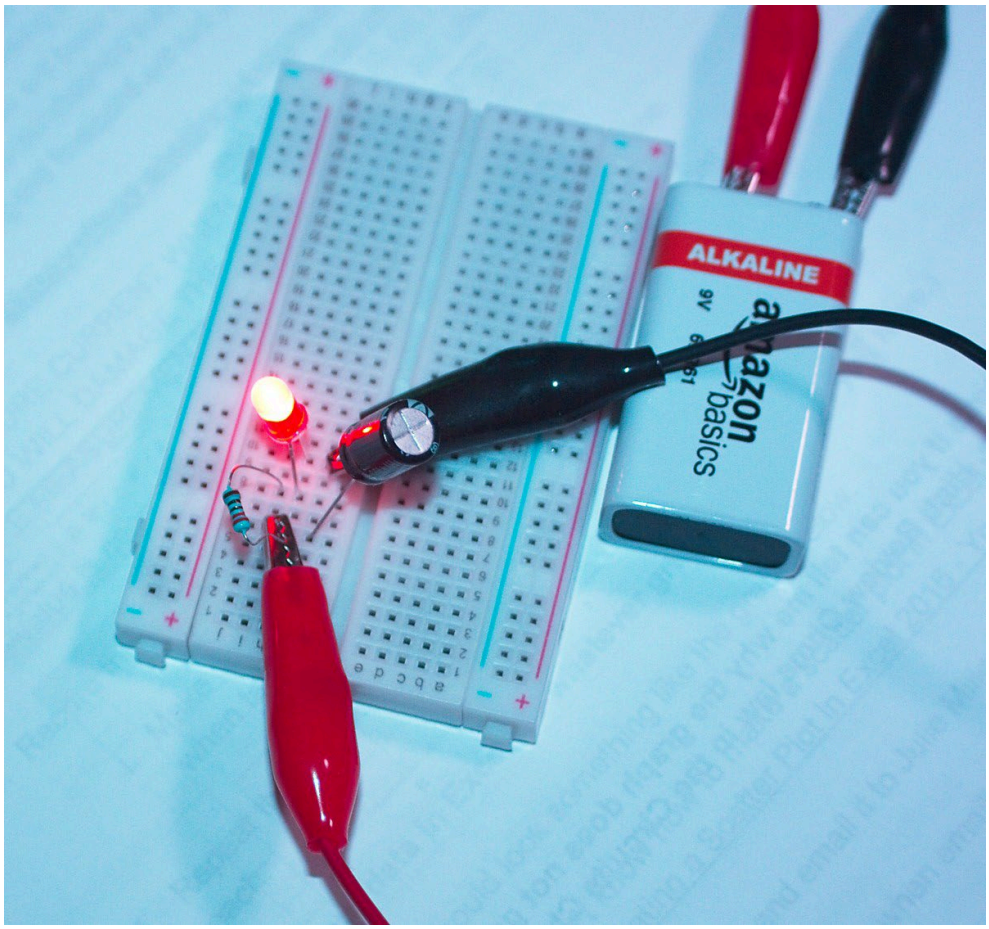
## Adding a Capacitor to the Circuit

A capacitor is a component that stores charges, just like a battery. Capacitors cannot hold the same number of charges as a battery; however, it can deliver its charges much quicker than a battery. You will find capacitors in almost all electronic circuits. The picture below shows a capacitor like the ones supplied in your kit. Select the 100 uF (micro Farad) from the kit to use in your circuit.

Note that the capacitor is polarized, that is it has a positive and a negative lead. Make sure that you connect the positive meter lead (red) to the positive lead of the capacitor. The negative (shorter) lead of the capacitor is usually indicated by a minus sign in a stripe going down the side of the capacitor.


Here is a picture of my circuit, yours should look somewhat the same:




**Electronics Challenge Part Two Quiz:**

1. What happens in the circuit when the battery is disconnected?

2. Why does this happen?

3. What happens if you put two capacitors in parallel? Three? Four?

4. Change the value of the resistor to 100k ohms. What is the difference in the brightness of the LED? Why?

5. Disconnect the battery and see what happens. What does changing the resistor value do to the LED?

Congratulations, you've finished Electronics Challenge part 2 for Solar Cup 2022. Be sure to submit your finished answers as requested in the introduction.