§ 1 Introduction

In this lab we will check to see if Kirchhhoff's Laws are accurate for a real circuit.

§ 2 Background

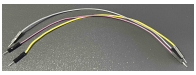
Kirchhoff's Law Loop Rule states that the sum of voltage changes around a closed loop is zero.

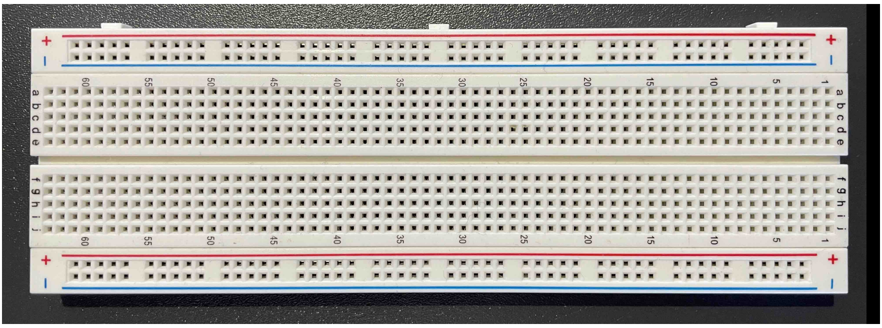
$$\sum_{n} V_n = 0$$

Kirchhoff's Junction Rule states that the sum of the currents going into a junction equals the sum of currents going out of the junction.

$$\sum_{n \text{ in}} I_n = \sum_{n \text{ out}} I_n$$

§ 3 Breadboard and Jumpers

Find the jumpers  and breadboard.



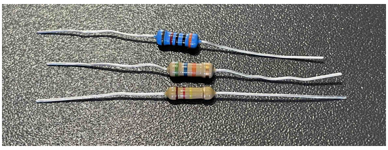
Connect the orange jumper to the red test lead of the DMM and the green jumper to the black test lead.  

Now set the DMM to the resistance measuring setting  and then press the $\frac{\text{FUNC}}{\text{HOLD}}$ button once. Notice that if you now touch the ends of the green and orange jumpers together that the DMM beeps, annoyingly. The annoying sound is intentional. It allows you to use the DMM as a "continuity tester" without looking at the DMM. If the resistance between the two leads is nearly zero it beeps. Use this figure to test to see which holes in the breadboard are electrically connected to each other. Draw lines over the image of the breadboard to indicate which holes are electrically connected together. Here is the image if you want to print it.

The breadboard is used to make electrical connections between components of a circuit. We will be using to do that today.

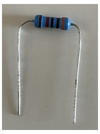
§ 4 **Wiring a circuit**

1) Measure the resistance of the three resistors pictured.

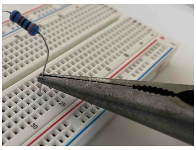


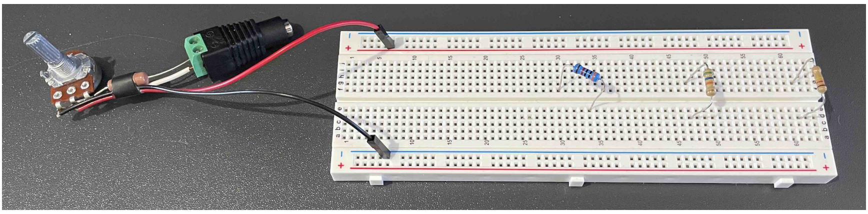
Write down the three resistances R_1, R_2 and R_3 with R_1 the smallest resistance and R_2 the biggest resistance. The two brown ones are similar but you can tell them apart by the color coded lines painted on them. Note and write down some distinguishing feature of each resistor so that you will know which is which without having to measure the resistance again.

2) Bend the leads of the resistors so that they look like this.

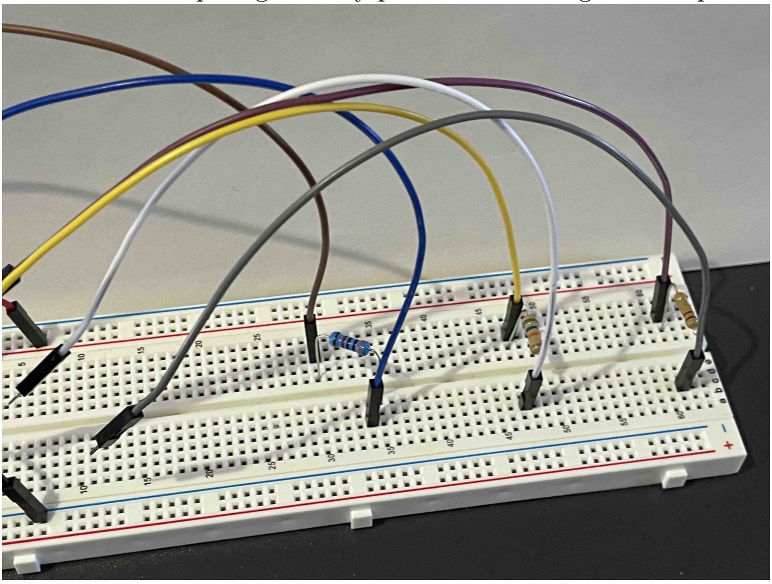


3) Now plug the resistors and power supply into the "breadboard" as shown. The leads of the resistors are thin and bendy, the pliers are very helpful for getting the leads into the holes of the breadboard.

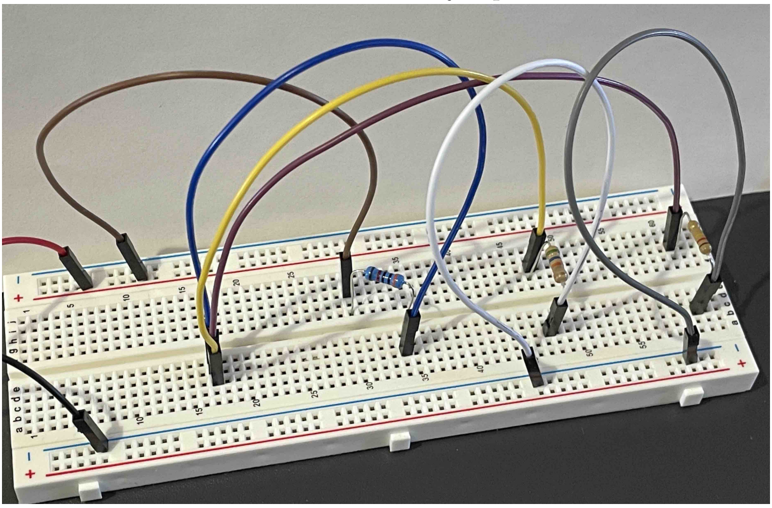




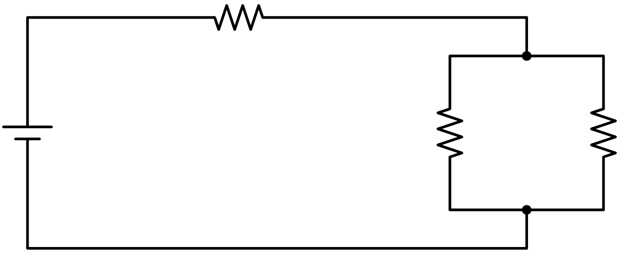
4) Next connect six jumpers to the ends of the resistor as shown. Use the same color jumpers as in the photo so that it will be easier for the instructor to help diagnose any problems that might develop.



5) Next connect the loose end of the six jumpers as shown.



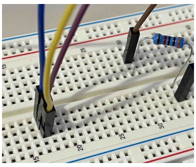
Congratulations you have just built the circuit shown in the circuit diagram below. Notice that the circuit diagram does not look anything like the circuit itself, even though I tried to make them similar. The actual circuit looks much more complicated than the circuit diagram, but to the electrons that populate the actual circuit it is as simple as the circuit diagram, and so is the physics.



Label the resistor in the circuit diagram with R_1, R_2 or R_3. You will need to follow the jumpers of the actual circuit to see which resistor is which in the diagram since the actual circuit looks nothing like the circuit diagram. I suggest that you start at the power supply, since that is a unique element of the circuit. If it helps label the wires in the circuit diagram with the color of the jumper you used for that connection.

▷ QUESTION 1

Identify in the circuit diagram the three wire junction shown to the right. Draw a small circle around that junction in the diagram.



▷ QUESTION 2

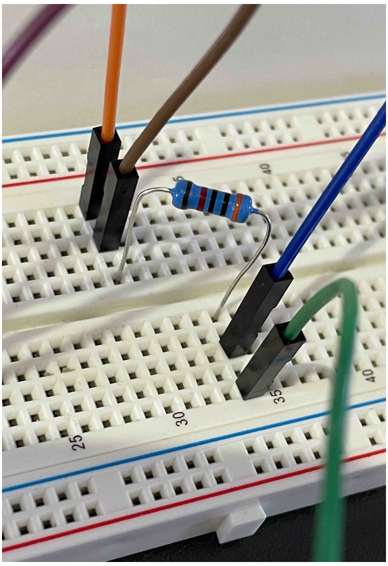
There is another three wire junction in the circuit diagram. Can you find it in the actual circuit?

▷ QUESTION 3

There are three regions of constant potential. Can you identify them in the circuit diagram? Remember that wires are effectively perfect conductors in this context so that a wire is an equipotential. Also two wires that touch become like one wire.

§ 5 Kirchhoff's Loop Rule

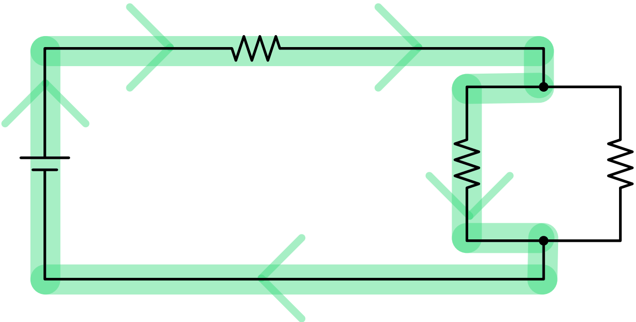
Plug the power supply into the wall and turn it up to maximum. Measure the voltage across the three resistors and the power supply. As an example I will explain here how to measure the voltage across the blue resistor. Set the DMM to measure voltage. Connect your meter to the circuit as shown in the photo to the right. Recall that the orange and green wires are the red and black test leads of the DMM. The voltage across the resistor will be on the display now. If the displayed value is negative then it means that the green(black) lead is at a higher potential than the orange(red) lead. If there is no negative then the orange lead is at a higher potential.



Find the symbol in the circuit diagram representing the blue resistor. On the diagram put a + on the end of the resistor symbol that is at the higher potential and a − on the end which is at a lower potential. Them write the value of the potential difference next to the resistor symbol.

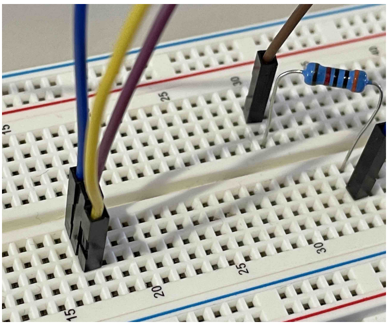
Repeat this for the other two resistors and the power supply, labeling each with it's voltage and putting + and − to indicate which is higher potential and which is lower potential.

Now go around the loop indicated below. Each time you cross a circuit element add the voltage change as you cross the element. If you go from high to low the change is negative, if you go from low to high the change is positive.

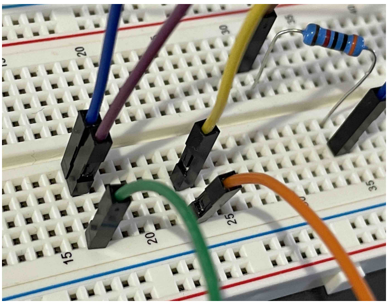


▷ QUESTION 4
Is Kirchhoff's loop rule followed?

§ 6 Kirchhoff's Junction Rule



Find the junction shown to the right. You will now measure the three currents going into this junction. As an example I will explain how to measure the current in the yellow wire. First move the red test lead from the voltage measuring connection (V) to the current measuring connection (mA) of the DMM. Then set the dial to the μA position.



Once this is done, take the yellow wire from the junction and place it as shown to the right. Next connect the green and orange leads of the DMM as shown. This will reconnect the yellow wire to the junction through the meter so that the meter now reads the current going into the junction from the yellow wire. If the meter displays a negative number then the yellow wire is a current going **out** of the junction. Do the same for the other two wires.

▷ QUESTION 5
Is Kirchhoff's junction rule followed?