Ohm's Law II – Resistors in Series and Parallel Prelab

by

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Electrical circuits contain a battery or voltage source that allows charges to move in a loop or circuit. A battery in a circuit pumps electrons around the circuit by converting chemical energy into electric potential energy. Circuits may contain elements such as resistors, capacitors, and inductors. In this lab, the circuits contain resistors. Recall from the last lab that resistance is the impedance to current flow. In this lab, you will learn how resistors in series and parallel add and how these configurations affect the current flowing in the circuit. In the last lab, you may have noticed that your experiment (not the simulation in the prelab) did not exactly predict Ohm's Law $V=IR$. When heat is dumped into a metal (like a tungsten filament in a light bulb), the temperature may affect the resistance of the metal. The higher the voltage and current, the higher the amount of heat was dumped into the tungsten. This temperature rise in the tungsten caused the tungsten to get hot enough to emit light, and this rise in temperature affected the resistance. In the *Ohm's Law I* experiment the resistance was not exactly constant throughout the experiment. In the *Ohm's Law II* experiment the resistance will be constant throughout the experiment and Ohm's Law will be obeyed.

Recall the analogy of the traffic jam. If you have two traffic jams in series (one after another), the flow of traffic will decrease more than if there is just one traffic jam. When there are two or more resistors in series, the overall resistance or equivalent resistance R_{eq} is just the sum of the resistors.

$$R_{eq} = R_1 + R_2 + R_3 + \cdots$$

The voltage drop across each resistor is $I_{tot}R_1$, $I_{tot}R_2$, $I_{tot}R_3$,…. The total voltage drop across the resistors is $I_{tot}R_{eq}$. Three resistors in series is shown in Fig. 1.

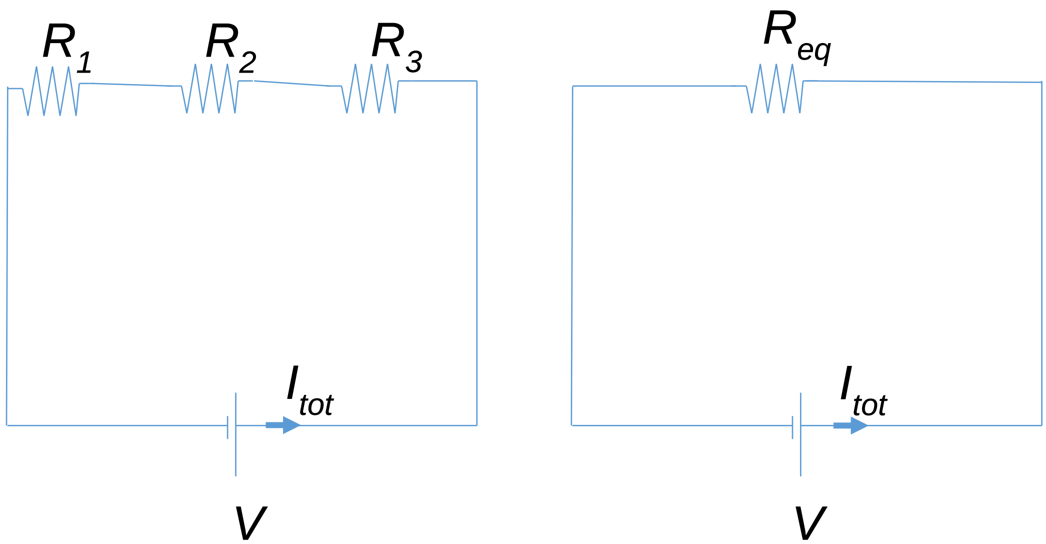


Figure 1. Three resistors in series with a power supply *V*. The circuit to the right shows the equivalent resistance circuit.

For resistors in parallel, recall the traffic jam where there are multiple paths from *A* to *B*. If there are multiple paths from *A* to *B*, then the traffic flow can increase because cars can take different routes just like you may use an app on your phone to find another way home if you see that there is an accident on the path you are currently traveling. This is analogous to electrons coming to a junction like in a parallel circuit where some will go one direction and others will go another.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

The voltage drop across each resistor is I_1R_1, I_2R_2, I_3R_3,…. The voltage drop is the same across each branch of the parallel configuration (V_1=V_2=V_3) as shown in Fig. 2 with three resistors in parallel. The voltage drop across the resistors is $I_{tot}R_{eq}$ which is equivalent to V_1, V_2, and V_3.

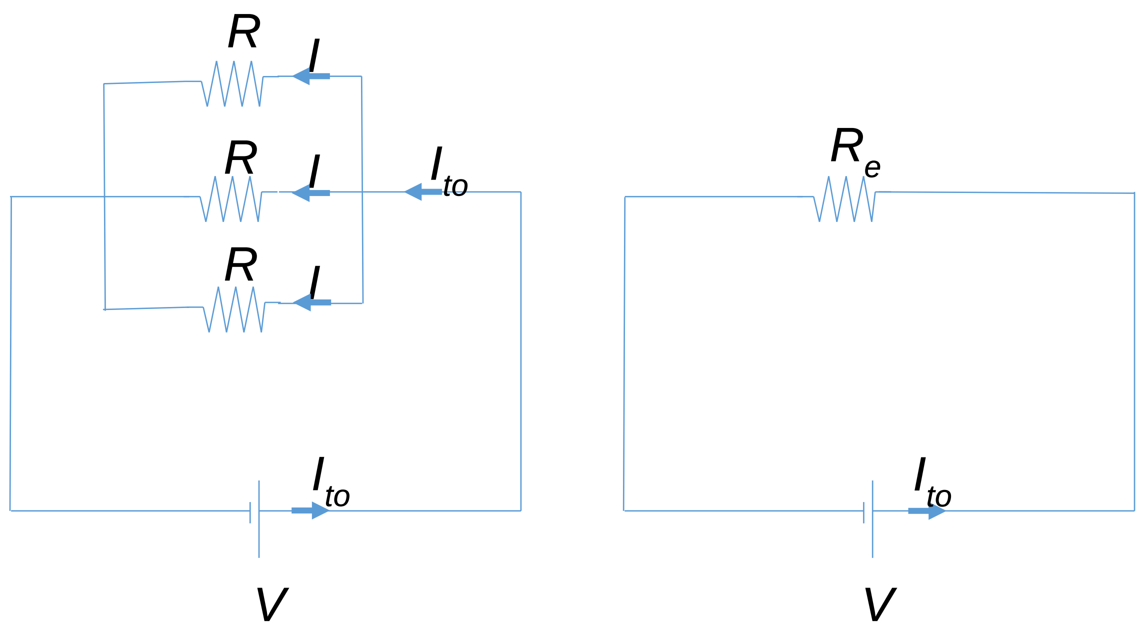
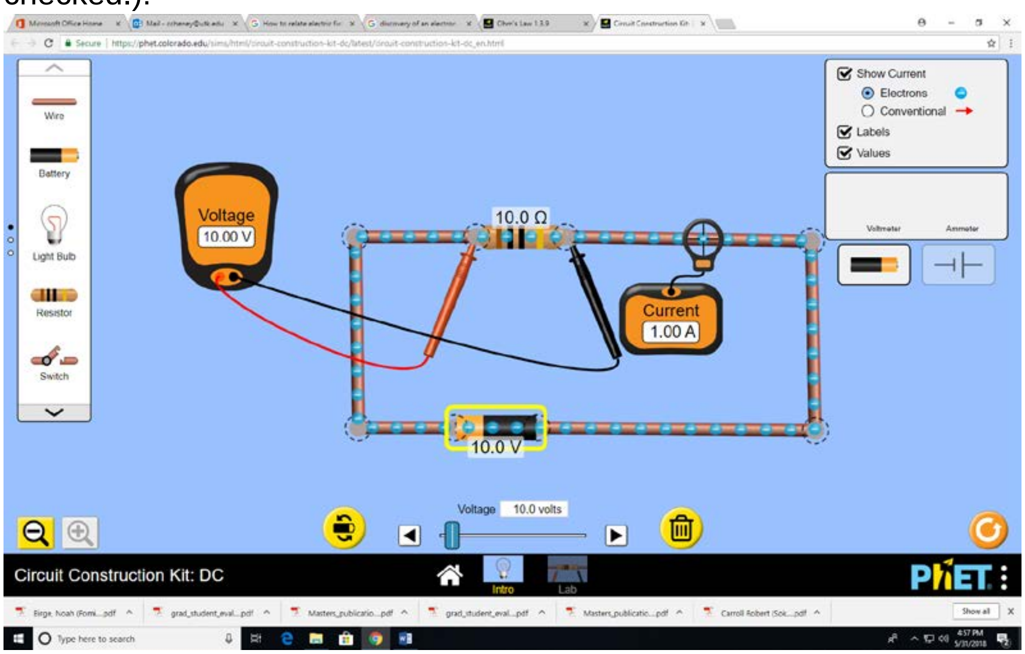


Figure 2. Three resistors in parallel with a power supply *V*. The voltage drop across each resistor is the same. The circuit to the right shows the equivalent resistance circuit.

Go to:

https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

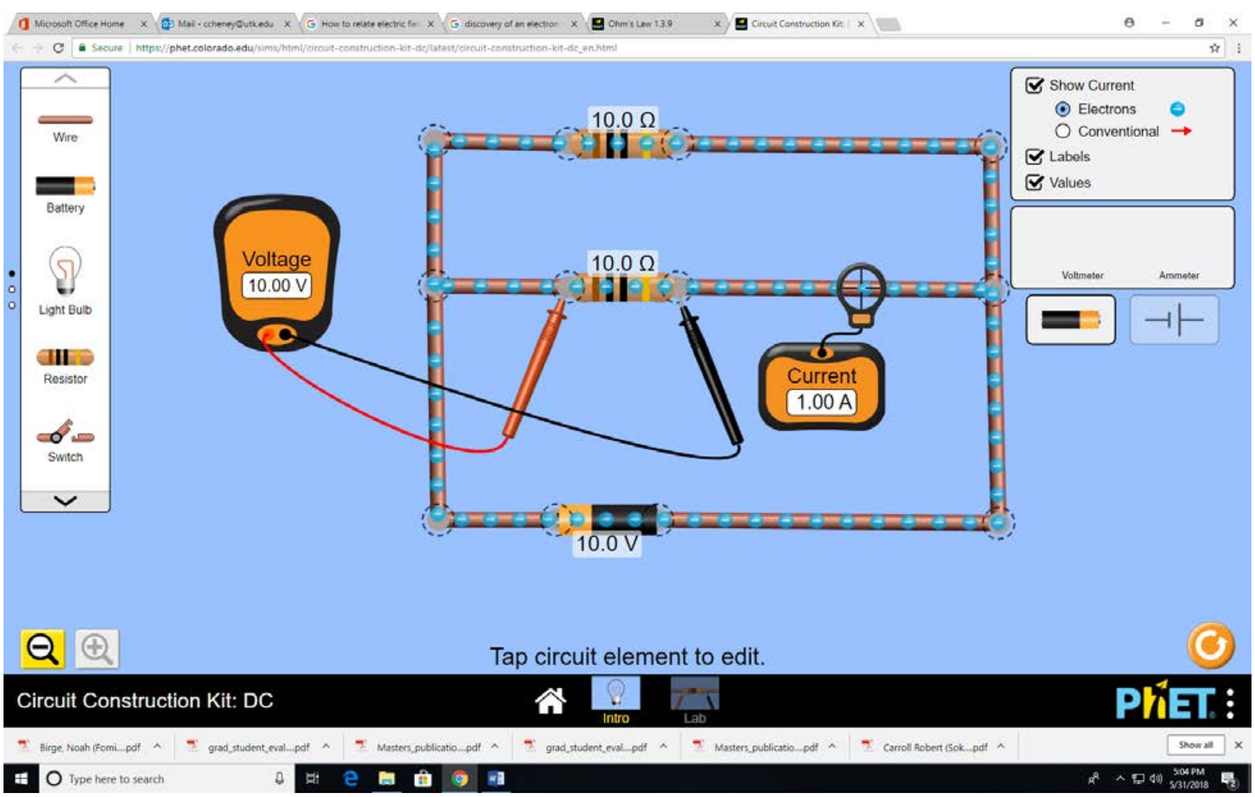
1. Click on the link to the lab section of the Phet simulation.
2. Build a Simple Circuit using a resistor, wires, battery, voltmeter, and ammeter like the one pictured below (Make sure that *Labels* and *Values* boxes are checked.):



3. The resistor should read 10.0 Ω. Tap on the battery so that the voltage adjustment window pops up. Adjust the voltage to 10.0 V. What is the current in the circuit? What is the voltage across the resistor?

4. Now build the circuit with two resistors in series with 10.0 Ω each (Series Circuit). What is the current through the circuit with a battery voltage of 10.0 V? How does this compare to the current with just one resistor of 10.0 Ω in the circuit? What is the voltage drop across one resistor? What is the voltage drop across the other resistor? How do the total voltage drops compare to the battery voltage?

5. Create a circuit with two resistors in parallel as shown below. What is the current through the resistor in the bottom branch of the circuit? What is the voltage across the resistor in the bottom branch of the circuit? Move the ammeter to the top branch and the voltmeter to the resistor in the top branch. What is the current through that branch? What is the voltage across the resistor in the top branch? How does that voltage compare to the battery voltage? Move the ammeter to right before (or after) the battery. What is the current through that part of the circuit? How does it compare to the current in the bottom and top branches of the circuit?



6. Notice that the voltmeter is place in parallel with whatever it is measuring. It has close to infinite resistance so that the current does not want to pass through it. Thus, the placement of the voltmeter in parallel to the circuit element will not affect the circuit very much. Notice that the ammeter is placed in series with the element that the current is going through. The ammeter has very low resistance and will have a negligible voltage drop across it and thus will not affect the circuit.
7. In the actual experiment, the resistors will not have the exact quantity that they are marked. There is usually ~5% tolerance when they make resistors, and the value can be ±5% of the value marked. You can measure the resistance with the multimeter to get the correct value.