Name:_____
Date :_____

Circuit Construction Kit Lab

An exploration lab to discover Ohm's Law, Kirchoff's two laws, resistors, and capacitors!

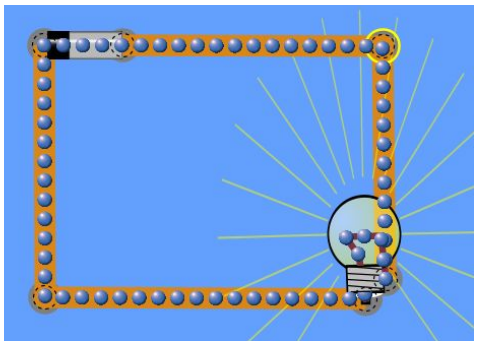
Go to https://phet.colorado.edu/en/simulation/circuit-construction-kit-ac (or type in "Circuit Construction Kit (AC+DC)" on Google). Open the software and try these four experiments.

Part 1: Ohm's Law

Aim: Discover Ohm's Law and find the relationship between voltage, current, and resistance.

Procedure:

1. Create a circuit by connecting one battery and one light bulb using wires. An example is shown below.



2. Click the voltmeter tool on the right side of the screen, and measure the voltage across the battery (put the red tip on the black side of the battery, and the black tip on the silver side of the battery)
3. Using the non-contact ammeter tool, measure the current on any section of the wire.
4. Record the voltage and current.
5. Next, add another battery. Measure and record the voltage and current again.
6. Repeat and continue adding batteries one at a time. Collect data until you have at least 7 batteries.
7. Graph the results below. Your x axis should be the current, and the y axis should be the voltage. Insert a best-fit line.

Questions:

1. What is the relationship between the variables (voltage and current)?

2. What is the slope of the graph?

3. Ohm's Law states that V=IR, or voltage=current x resistance. Voltage is measured in volts (V), current in amperes (A), and resistance in ohms (Ω). Using this knowledge, state what the slope of the graph represents.

4. What is the resistance of the light bulb you used in your circuit?

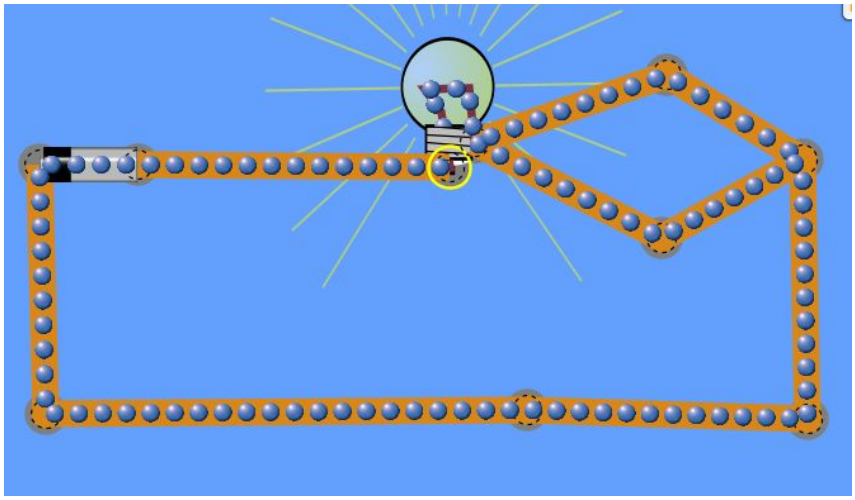
Part 2: Kirchhoff's Two Laws

Aim: To understand Kirchoff's current law and Kirchoff's voltage law.

Kirchoff's Current Law

Procedure:

1. Create a circuit with one battery and one light bulb. However, unlike the previous circuit you created, add two different wire paths from the light bulb to the rest of the circuit. An example is shown below.



2. Using the non-contact ammeter tool, measure the current through all of the wires that connect to the light bulb.
3. Record this in the table below.
4. Keep adding wires to each side of the light bulb, and record the current results in the table below.

Results:

	Current through each wire going into the light bulb (in amps)			Current through each wire going out of the light bulb (in amps)			Total current going in	Total current going out
Trial 1 (1 wire in, 2 wires out)								
Trial 2 (2 wires in, 2 wires out)								
Trial 3 (2 wires in, 3 wires out)								
Trial 4 (3 wires in, 3 wires out								

Questions:

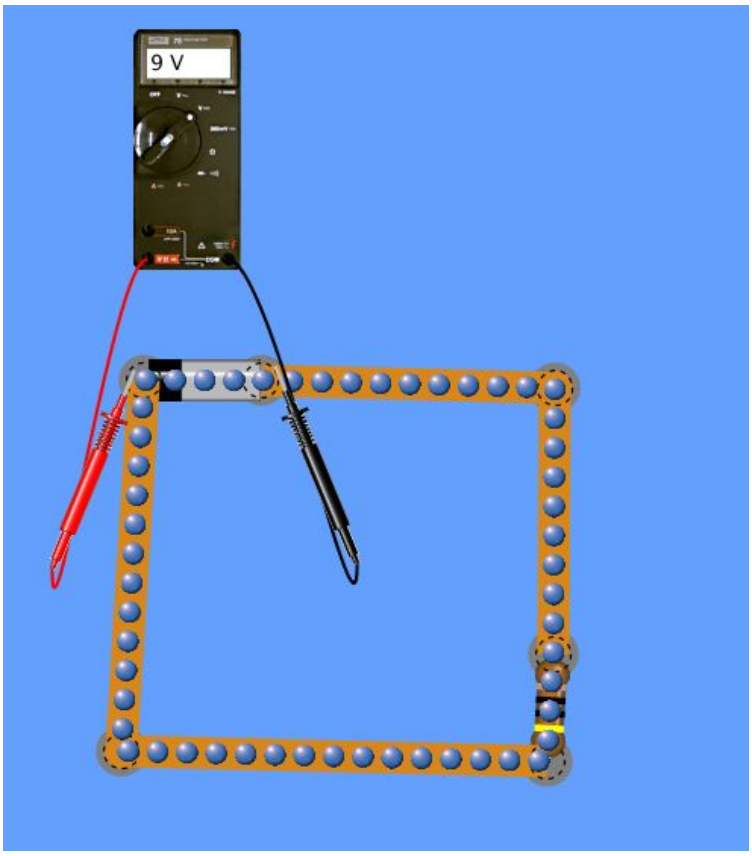
1. What do you notice about the sum of the current going into the light bulb and the sum of the current going out of the light bulb?

2. Kirchoff's current law states that "the sum of the currents in a node is 0". (positive current means that it is going into the node, and negative current means that it is going out of the node.) What is the "node" in the circuit you made?

Kirchhoff's Voltage Law

Procedure:

1. Create a circuit with one battery and one resistor. An example is shown below.



2. Using the voltmeter tool, measure the voltage across the battery. Record this number in the table below.
3. Measure the voltage across the resistor. Make sure that the black pointer is placed in front of the red pointer in relation to the electron flow. Record the voltage in the table.
4. Find the sum of the voltages.
5. Repeat this process, adding one resistor each time up to 5 resistors (you can do more if you have time)

Results:

	Voltage (V) across….						Sum of Voltages
	battery	resistor 1	resistor 2	resistor 3	resistor 4	resistor 5	
example: (1 resistor)	9	-9	-	-	-	-	0
Trial 2 (2 resistors)							
Trial 3 (3 resistors)							
Trial 4 (4 resistors)							
Trial 5 (5 resistors)							

Questions:

1. What do you notice about the sum of the voltages in each trial?

2. Kirchoff's Law states that $\Delta V=0$ (the sum of all voltages in a loop must equal 0). How does this relate to your results?

3. Would the sum of the voltages be the same in a parallel circuit? Test it out! Remember: the sum of all voltages in a *loop* must equal zero.

Part 3: Resistors in Parallel and Series

Aim: To understand how the magnitude of the total resistance is calculated in a parallel and series circuit.

Resistors in Series

Procedure:

1. Create a circuit with one battery and 2 resistors in series.
2. Using the voltmeter tool, measure the voltage across each resistor, and then the whole circuit. Record results in table below.
3. Using the non-contact ammeter tool, measure the current through the wire near each resistor and the battery. Record the results.
4. Calculate the resistance for each resistor and the whole circuit using the equation R=V/I (Ohm's Law).
5. Repeat these steps, but add another resistor each time. Go up to 4 resistors.

Results:

2 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Whole circuit (measure across the battery)			

3 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Resistor 3			

Whole circuit (measure across the battery)			

4 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Resistor 3			
Resistor 4			
Whole circuit (measure across the battery)			

Questions:

1. What do you notice about the calculated resistance for the whole circuit?

2. Total resistance in a series circuit is calculated by adding up the resistance of each resistor. $R_T = R_1 + R_2 + R_3 + ...$ Does this concept match with your results?

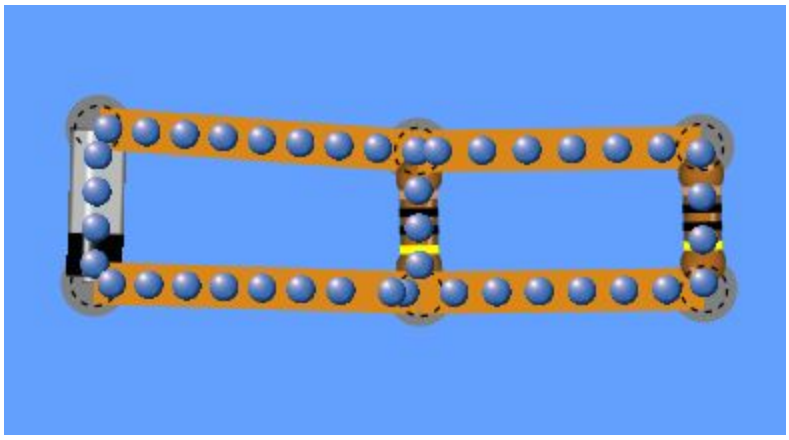
3. Show an example calculation for R_T.

4. What other observations can you make about the current or voltage?

Resistors in Parallel

Procedure:

1. Create a circuit with one battery and 2 resistors in parallel. Here is an example.



2. Using the voltmeter tool, measure the voltage across each resistor, and then the whole circuit. Record results in table below.
3. Using the non-contact ammeter tool, measure the current through the wire near each resistor and the battery. Record the results.
4. Calculate the resistance for each resistor and the whole circuit using the equation R=V/I (Ohm's Law).
5. Repeat these steps, but add another resistor each time. Go up to 4 resistors.

Results:

2 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Whole circuit (measure across the battery)			

3 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Resistor 3			
Whole circuit (measure across the battery)			

4 Resistors

	Voltage across resistor (do not include negatives)	Current through resistor	Calculated Resistance (R=V/I)
Resistor 1			
Resistor 2			
Resistor 3			
Resistor 4			
Whole circuit (measure across the battery)			

Questions:

1. What do you notice about the calculated resistance for the whole circuit?

2. Total resistance in a parallel circuit is calculated by adding up the reciprocals of the resistance of each resistor, and then taking the reciprocal of the total sum.
   $1 / R_T = 1 / R_1 + 1 / R_2 + 1 / R_3 + ...$
   Does this concept match with your results?

3. Show an example calculation for R_T.

4. What other observations can you make about the current or voltage?