Electric Circuits II – Virtual

GOALS

- To closely study what current does when it reaches a junction
- To observe Kirchhoff's Loop Rule in practice for some circuits

Activity 2: Kirchhoff's Loop Rule

The following activities will be performed using the simulation here:
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html

NOTE: The properties of circuit elements can be adjusted by clicking on the element.

Two resistors-series

1. Build the following circuit using two bulbs that have *different* resistance, one twice the resistance of the other (10 and 20 ohms are good choices). Click on the bulb to adjust.
2. Set the **battery voltage to 6 volts**. Click on the battery to adjust.
3. Measure the potential difference across the power supply using the voltmeter (right side) by placing the red lead at point A and the black lead at point E. Record your value in the table below.
4. Next, "slide" the leads around the circuit. Place the black lead at point A and the red lead at point B. Record the potential difference. Record your value in the table below.
5. Place the black lead at point B and the red lead at point C. Record your value in the table below.
6. Place the black lead at C and the red lead at D. Record your value in the table below.
7. Place the black lead at D and the red lead at E. Record your value in the table below.

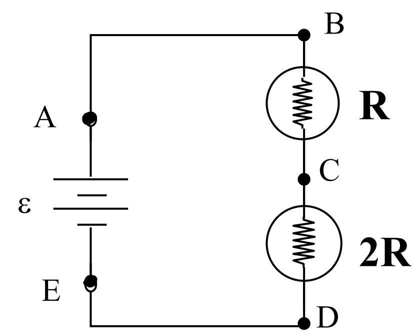


Table I.

Circuit locations compared	Measured ΔV
$\Delta V_{AE} = V_A - V_E$	
$\Delta V_{BA} = V_B - V_A$	
$\Delta V_{CB} = V_C - V_B$	
$\Delta V_{DC} = V_D - V_C$	
$\Delta V_{ED} = V_E - V_D$	
$\Delta V_{AE} + \Delta V_{BA} + \Delta V_{CB} + \Delta V_{DC} + \Delta V_{ED} =$	

- Q2.1: What is the sum of the potential differences around the loop ABCDEA? Is it about 0 V as expected? Explain why 0 V is expected and whether your measurement disagrees significantly.

- Q2.2: Why was it important to preserve the relative orientation of the black and red leads in this measurement? or Why was it important for the red lead to advance first around the circuit?

- Q2.3: Why is the potential difference between points A and B so small? Use Ohm's law in your explanation.

- Q2.4: What does your answer to the last question imply about the resistance of the wires?

- Q2.5: Is it necessary to measure the potential between A & B and D & E?

- Q2.6: How do the voltages across each resistor compare to each other? Explain why this is so.

8. Let us specify that the potential at point E is zero, $V_E = 0$ V, now label the potential at points A, B, C, and D on the diagram above.

9. Use the ammeter (on the right) to measure the current in the circuit: __________. NOTE: You will need to remove a wire, insert the ammeter, and reconnect the wires so the ammeter is in series with the battery and the bulbs.

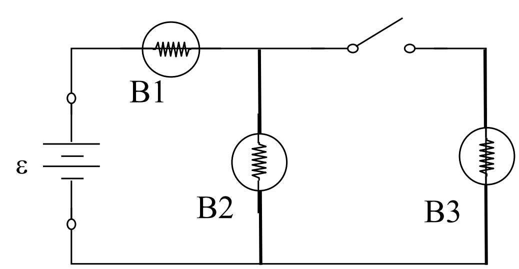
10. Calculate the expected potential difference across each resistor using Ohm's Law and complete the table below.

Table II.

Resistance (as you adjusted it)	Current (measured)	Calculated ΔV_{calc} ($\Delta V_{calc}=IR$)	Measured ΔV_{meas} (from table)	% difference

Activity 3: Circuit modifications

Imagine that we hook up circuit shown at right, with the switch open and all bulbs identical.



- P3.1: *Predict* the order of brightnesses (brightest to least) of the bulbs when the switch is open?

- P3.2: *Predict* the order of brightnesses (brightest to least) of the bulbs when the switch is closed?

- P3.3: *Predict*, when the switch is closed, whether the brightness of bulb B1 will *increase*, *decrease*, or *stay the same*?

- P3.4: *Predict*, when the switch is closed, whether the brightness of bulb B2 will *increase*, *decrease*, or *stay the same*?

Construct the circuit above with the simulator.

Use a battery and 3 *identical* bulbs to test your predictions.

- R3.1: Rank the brightness of the bulbs when the switch is open?

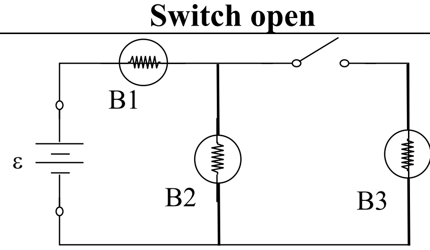
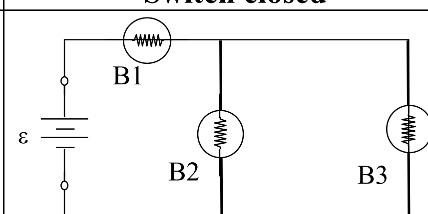
- R3.2: Rank the brightness of the bulbs when the switch is closed?

- R3.3: When the switch was closed did the brightness of bulb B1 *increase*, *decrease*, or *stay the same*?

- R3.4: When the switch was closed did the brightness of bulb B2 *increase*, *decrease*, or *stay the same*?

Make the appropriate (current/voltage) measurements and fill in the following table. (You will need to use both the ammeter and voltmeter to do this.)

Table III.

	Switch open	**Switch closed**
		
I_1		
I_2		
I_3		
ΔV_1		
ΔV_2		
ΔV_3		

- Q3.1: Does current through bulb B_1 *increase*, *decrease*, or *stay the same* when the switch is closed? Explain.

- Q3.2: Does the potential difference (voltage) across resistor B_1 *increase*, *decrease*, or *stay the same* when the switch is closed? Explain.

- Q3.3: Does current through resistor B_2 *increase*, *decrease*, or *stay the same* when the switch is closed? Explain.

- Q3.4: Does the potential difference (voltage) across resistor B_2 *increase*, *decrease*, or *stay the same* when the switch is closed? Explain.

Kirchoff's Loop Rule: There are three possible complete loops when the **switch is closed**.

1. Symbolically write down the equation for summing the potential differences using ε or IR terms. (for example: $\varepsilon - I_1R_1 + I_3R_2$ - …)
   Note: Be careful to use the correct sign (+/-) for each term, and subscript for each variable.
2. Verify that Kirchhoff's loop rule is satisfied for each loop when the switch is closed.

	Symbolic	**Experimental**
Loop outer:		
Loop left:		
Loop right:		

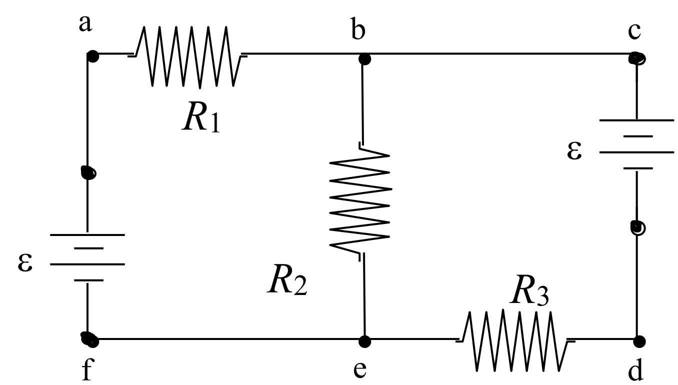
Kirchoff's Junction Rule: There are two possible current junctions when the switch is closed.

3. Using the junction rule, $\sum I_{\text{in}} = \sum I_{\text{out}}$, symbolically write down the sum of the currents at each junction when the switch is closed. ($I_1 + I_3 = \ldots$)
4. Verify that Kirchhoff's current rule is satisfied for each junction when the switch is closed.

	Symbolic	**Experimental**
Junction top:		
Junction bottom:		

Activity 4: Apply what you've learned.

Build the circuit shown using the ***same voltage*** for each battery. Choose any three ***different resistances***.



Kirchoff's Loop Rule: There are three possible complete loops.

1. Identify the three loops, and draw them.
2. Symbolically write down the sum of the potential differences for each loop ($\Delta V_{battery} + \Delta V_1 + \ldots$) in going around the loop.
3. Plug in particular values for your loop ($6 - 10\, I_1 + \ldots$)
4. Using the simulation *measure* and verify that Kirchhoff's loop rule is satisfied for each loop.

<u>**Draw loop**</u>	<u>**Symbolic**</u>	<u>**Values for your loop**</u>

Loop 1:

Loop 2:

Loop 3:

Kirchoff's Junction Rule: There are two possible current junctions.

4. Identify the two junctions.
5. Symbolically write down the sum of the currents at each junction. ($I_1 - I_3 = \ldots$)
6. Using the simulation *measure* and verify that Kirchhoff's junction rule is satisfied for each junction.

Junction 1:

Junction 2: