Module 7: Electricity: Electric Charge & Current
Topic 4 Content: Resistors in Series and Parallel Circuits Answer Key

I. Series Circuit

Construct the circuit figure 1 using The Circuit Construction Kit (CCK) simulation at the PhET site. Make the resistors have different resistances and record the each value. Use the ammeter, moving it to take readings in the different places seen in figure 2. Then use the voltmeter to take voltage readings. Calculate R using Ohm's Law (V=IR) for the total resistance in last column.

Figure 1

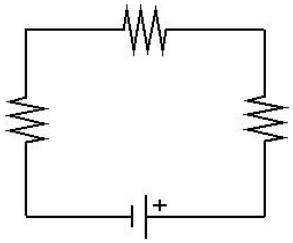
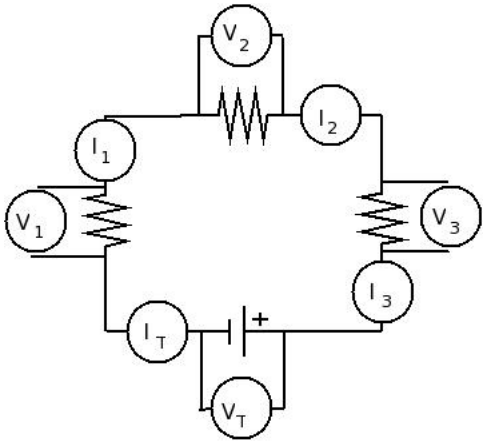


Figure 2



Resistor	Voltage (V)	Current (A)	Resistance (Ω) (from Ohm's Law) R=V/I (column 2 divided by column 3)
1			
2			
3			
Total	V_T reading (Battery Voltage)	I_T reading (Battery Current)	$R_T=V_T/I_T$

a. How is the total resistance related to the individual resistances? Total current to the individual currents? Total voltage to the individual voltages?

The total resistance is the sum of the individual resistances. The total current is the same as the individual currents. The total voltage is the sum of the individual voltages.

b. Write a paragraph explaining what you think is happening in series circuits to cause the above relationships to occur. (*You made a similar circuit with light bulbs using CCK. You may want to experiment with the sim again, keeping in mind that light bulbs are just resistors that glow.*).

Answers will vary. The resistances add because the length of the path is longer, creating more resistance. The current is the same because there is only one path for current to follow. The voltage gained by a charge when it goes through the battery is equal to how much voltage it loses as it travels through all three resistors.

II. Parallel Circuits

Wire the circuit in figure 3 with the same value resistors that you used in Part 1. Take readings in different places shown in figure 4 by moving the meters. Make a table like the one below, calculating resistances using Ohm's Law in the last column. For each entry in column four you will divide the entry in column two by the entry in column three.

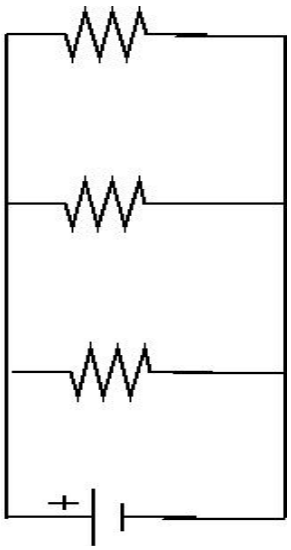


Figure 3

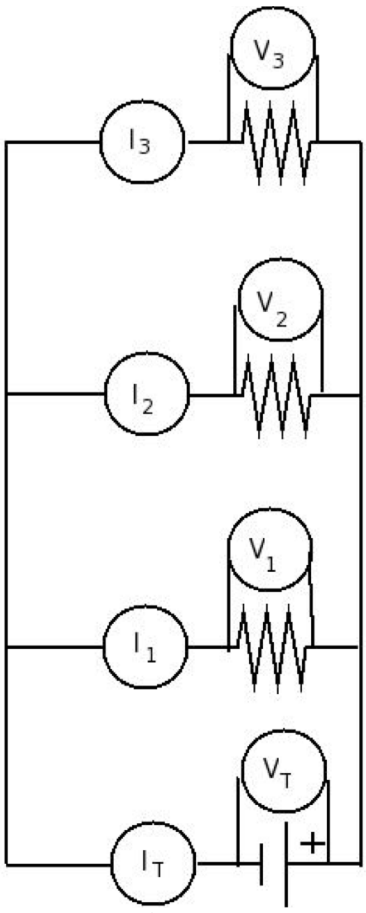


Figure 4

Resistor	Voltage (V)	Current(A)	Resistance(Ω) (from Ohm's Law) R=V/I (column 2
1			
2			
3			
Total	V_T reading (Battery Voltage)	I_T reading (Battery Current)	$R_T=V_T/I_T$

a. How is the total resistance related to the individual resistances? Explain what you think is happening.

The total resistance is less than each individual resistance. Adding multiple pathways for current is like increasing the area for flow which decreases resistance.

b. The mathematical relationship for finding total resistance in a parallel circuit is given by:

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ Show that your data fits the equation.

Answers will vary. Students should substitute their data into the equation.

c. Imagine you and your friends are running in the neighborhood like electrons flowing through a circuit. Make up stories that would serve as analogies for a parallel versus series circuits. Share your stories on the discussion board to see if they make sense.

Answers will vary. Look for single vs. multiple pathways.

d. Summarize the similarities and differences between the series and parallel circuits. Include your reasoning about what you think is happening.

Similarities:
Individual elements obey Ohm's Law.
The battery current and voltage can be used to find the total resistance of the circuit.

Differences:
Voltages add in series circuits, voltages are the same in parallel circuits.

> **Reasoning – In series circuits, individual charges have to go through all the elements, in parallel circuits, individual charges choose one path.**

Current is the same in series circuits, currents add up to the total in parallel circuits.

> **Reasoning – In series circuits there is only one path so all the charge that goes through one element must go through another. In parallel circuits, the charges choose one path then all come back together to go to the battery.**

Adding additional resistors in series increases total resistance, adding additional resistors in parallel decreases total resistance.

> **Reasoning – adding resistors in series increases length which increases resistance. Adding resistors in parallel increases area which decreases resistance.**