Phet Electricity Lab – Virtual Electricity

Part II: Series and Parallel Circuits

Purpose: To use the Phet DC electricity program to produce virtual series and parallel circuits and to understand how Ohm’s Law applies to their components.

Materials: A computer capable of running the Phet DC electricity program, the internet, and the Phet DC electricity program.

Method: Follow the instructions below and fill in the blanks from what you observe in the program, information your book, or from calculations you complete.

1. Set the visual mode in the toolbox to schematics instead of lifelike. Obtain the voltmeter and the noncontact ammeter and store them off to the side for use later.

Construct a circuit similar to the one to the right.

a) How many paths are there for the electricity to follow (1, 2, 3, or 4)? _____

b) What kind of circuit is the one above (series or parallel)? ____________

c) Define series circuit (glossary). ___________________________________________

   __________________________________________

   __________________________________________

d) Explain how you know it is that kind. _______________________________________

2. Right click on the battery and set the voltage to 24 volts (type it in the field). Use the voltmeter and determine the voltage across each load (bulb) and the battery. Record:

   Voltage: \( V_{\text{battery}} \): _____ \( V_{\text{load} 1} \): _____ \( V_{\text{load} 2} \): _____ \( V_{\text{load} 3} \): _____

   Close the switch. Add the values of the loads together. Show your work below.

   \( V_T = V_{\text{load} 1} + V_{\text{load} 2} + V_{\text{load} 3} \) in a series circuit.

3. Use the no contact ammeter and place the crosshairs over the wire at various points around the circuit. What do you notice about the current? _______________________

   Record the value of the current here: _____ \( I_1 = I_2 = I_3 \) in a series circuit.

   Calculate the total resistance in the circuit using ohm’s law. Show work, include units.

   \[ R = \frac{V_T}{I} \quad R_T = \]

4. Right click on each light bulb and record the resistance below.

   a) \( R_1 \): _____ \( R_2 \): _____ \( R_3 \): _____

   b) Add the resistance values up. What do you notice about the values of each resistor and the total resistance in a series circuit? Write the formula for resistance as done in question #3 above:
5. Right click on a light bulb. You can change the value of resistance in each light. Pick any one light and double the resistance value.

a) What happens to the brightness of the other two lights? ____________________________

b) Determine total voltage again and the voltage across each load. Record below.

Voltage:  \( V_{\text{battery}}: \) \( V_{\text{load} \, 1}: \) \( V_{\text{load} \, 2}: \) \( V_{\text{load} \, 3}: \) __________

Do the voltages add up as before? Show it in the space below (use formula).

c) Determine the total resistance in the circuit (add \( R_1 + R_2 + R_3 \)).

\[
R_T = R_1 + R_2 + R_3 \quad \text{in a series circuit.}
\]

\( R_T = \)

d) Use the current of the whole circuit and the voltage of the battery to determine total resistance (\( R \)) in the circuit. Show formula and calculation. Does \( R = R_T \) above? ____

e) Split the circuit in any place, observe the results then fix it and do it again in another place. What are the results? ____________________________

6. Write the formulas for determining total voltage and total resistance in a series circuit in the space below.

7. A series circuit has three loads. Two loads are 15 \( \Omega \) and the third one is unknown. The circuit has a current of 0.5 A. The voltage across the source is 30 V. What is the resistance of the unknown load? (Hint: Determine \( R \) first through Ohm’s law then use the \( R_T = R_1 + R_2 + R_3 \) formula. Show all work.

8. Press the “Reset All” button and build the circuit as shown to the right.

a) How many paths are there? _____

b) What kind of circuit is it? _______________

c) Define the word you used in (b) above.

_________________________________________
9. Set the voltage of the battery to 12 volts. Measure the current of the wire just in front of the battery. Record it: \( I_T = \) ___. Record the current along the path directly part of each of the loads. Record the currents: \( I_1 = \) ___; \( I_2 = \) ____; \( I_3 = \) ____
   a) In a parallel circuit \( I_T = I_1 + I_2 + I_3 \). Use that formula see if the values of the circuit agree with it. Show your work.

   b) State how a series circuit is different from a parallel circuit when it comes to current. **Use formulas in your answer.**

10. Measure the voltage across the source and record it: \( V_{\text{battery}} = \) ___. Measure the voltage across each load and record it: \( V_1 = \) ____; \( V_2 = \) ____; \( V_3 = \) ____
    a) In a parallel circuit, \( V_1 = V_2 = V_3 \). Do your measurements agree with that? ____
    b) State how a series circuit is different from a parallel circuit when it comes to voltage. **Use formulas in your answer.**

11. Right click on any one terminal for the three loads. Sever the connection while the switch is on. Observe the results. Repair the connection then sever the connection on a different load. Do the same and repeat for the last load.
   a) Record your results: ________________________________

   b) How is a series circuit different from a parallel circuit when a direct path breaks?

12. Use Ohm's law to calculate the resistance across each load in the parallel circuit. Since all the loads are the same, you only have to show 1 calculation.

13. Set the resistance of all 3 loads to different values; use 10, 15, and 20 \( \Omega \). **Calculate** the current through each load (Use \( I = V \div R \)). Then use the ammeter to validate your calculations. Show work below. Were your calculations correct? ____
    \( I_1 = \) ___, \( I_2 = \) ___, \( I_3 = \) ___
14. Measure the current near the battery. $I_T$ should add up to the sum of the current through the loads. Determine the total resistance for the circuit using Ohm’s law. Show your work.

Note: the formula for calculating total resistance in a parallel circuit is more difficult than any of the other formulas we have looked at. We will not be examining it here.

15. In the space below, draw the series circuit on the left and the parallel circuit on the right. Use proper schematic symbols for each diagram. Write the formulas we have used in the proper area (all formulas are written in boxes).

Series Circuit

Parallel Circuit

Voltage:
Current:
Resistance:

16. Determine the unknown values. Show all work. Remember to include units.

a) A series circuit has two loads, each with a voltage drop of 4.0 volts. What is the voltage of the source?

b) A series circuit with a 5 V source has a 0.25 A current and two loads. If one load is 12\,\Omega, what is the resistance of the other load?

c) A parallel circuit has an $I_T$ of 45 mA. If three loads all have the same resistance, what is the resistance of each load if the source is 75 volts?

d) A parallel circuit has a resistor which is 20\,\Omega. There is 0.1 A of current through it. A second resistor has 50 mA of current. What is it’s resistance?

e) A circuit has 2 resistors; one is 120 \,\Omega and the other 80 \,\Omega. If the source is 10V and the total current is 50 mA, is the circuit series or parallel? Prove it.