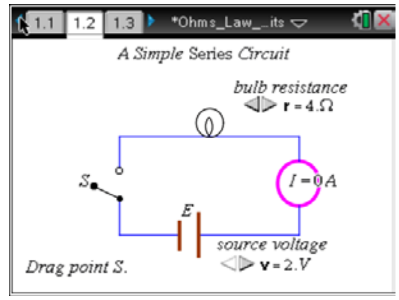
Ohm's Law & Series Circuit
Student Activity

Name _______________
Class _______________

Open the TI-Nspire document *Ohms_Law_&_Series_Circuit.tns.*



We all use and rely on electric circuits every day by flipping a switch, turning up the volume, or operating a computer or calculator. Even the most complicated circuits are built from basic circuit components. In this activity we will explore the basic quantities of electrical circuits in the simplest form of a series circuit.

Problem 1: Circuit Components

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

Every circuit has three requirements:

•a source of electrical energy,
•a continuous pathway to carry the electric current,
•and a load to use the energy and prevent immediate discharge.

There are many different types of sources, pathways, and loads. A circuit may have other components, such as switches to control current or meters to measure quantities. Each circuit requirement has an electrical quantity associated with it.

Move to page 1.2.
Play with the simulation and see what you can discover.

Move to pages 1.3–1.7. Answer the following questions here or in the .tns file.

Q1 What happens in the circuit on page 1.2 when you drag point S to the right as far as you can?

Q2 What would you call the device at point S?

Q3. The part of the circuit labeled E represents

A. a motor
B. a battery
C. a heater
D. a meter

Q4. What component represents the load in this circuit?

A. the current meter
B. the switch
C. the wires
D. the bulb

Q5. What component represents the pathway to carry the current?

A. the straight wires
B. the source
C. the light from the bulb
D. the current meter

Name ______________
Class ______________

Move to 2.1

Circuit Components

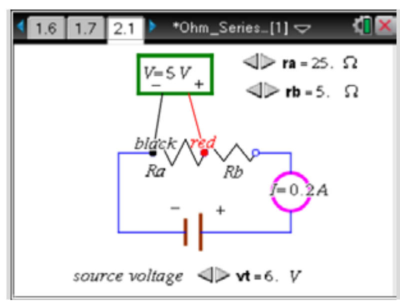
Sources: provide the electrical energy to run the circuit. Sources could be electrochemical cells (batteries), photovoltaic cells (solar panels), generators, capacitors…

The sources provide the voltage which is the change in energy per electrical charge that flows when the circuit operates. Voltage (V) is measured in volts (V). 1 V = 1 J/C (1 joule of energy per coulomb of charge) In this circuit, the voltage is provided by batteries of from 2 V to 6 V.

Pathways: provide the conducting path for the electrical charges to carry the electric current. Pathways can be conductive wires, ionic liquids or gases, or sometimes empty space. The pathway carries the current (I) which is measured in amperes (A). 1 A = 1 C/s (1 coulomb of charge per second)

Loads: use the electrical energy by transforming it into some other form of energy such as heat, light, or mechanical work. Some examples of loads include light bulbs (used in this circuit), resistors, heating coils (specially designed resistors), motors, and speakers. Loads in simple circuits are measured by their resistance (R) measured in ohms (Ω). The Ω is defined in relation to voltage and current according to Ohm's Law. You will discover this relationship in the rest of this activity.

Problem 2: Circuit Quantities: V vs I with constant R



In this problem is a simulation of a circuit containing a battery (source) and two resistors (load) connected by wires (pathway). There is also a current meter to measure the current (I) in the circuit and a voltmeter to measure the voltage (V) across the resistors. You can change the battery and the resistors with the appropriate sliders and measure voltages across resistors by connecting wires properly.

Polarity: all circuit components have a polarity designated positive (+) and negative (-). The polarity is determined with reference to the source; from any component end go straight back to the source to find the polarity. To measure voltage across a resistor, drag the ends of the voltmeter wires to the ends of the resistors. It will only work if it is connected with the correct polarity.

Move to pages 2.2–2.4

6. Vary the voltage and resistances of the circuit on page 2.1 and note what happens. Measure voltages Va, Vb, and Vab across resistor A, B, and both. Watch the current values when you change Vt, Ra or Rb. When you have an idea what goes on, set the resistance values Ra and Rb at some convenient values (5Ω and 25Ω works well). Note the values and leave them constant for the rest of this part of the experiment.

   Measure I, Va, Vb, and Vab by dragging the ends of the voltmeter wires to the end points of the resistors and note the values. To capture this data, press [ctrl] [.]. Change the battery. Again measure I, Va, Vb, and Vab and capture the data with [ctrl] [.]. Repeat for a wide range of battery values of Vt.

Move to pages 2.5–2.6.

7. Plot the different voltages versus current to find the simplest relationships. Analyze the plots to find any linear equations and determine the slope for each linear plot.

Move to pages 2.7–2.15. Answer the following questions here or in the .tns file.

Q8. Which plots give a linear relationship?

Q9. What are the numeric values of the slopes of the linear plots?

Q10. In terms of other circuit quantities, what do the slope values represent?

Q11. What variables are represented on the *y* and *x* axes respectively?

Q12. Rewrite the linear equations substituting the quantities representing *y*, *x*, and the slope. This equation is called Ohm's Law.

Q13. What do you notice about the sum of the two resistances in series?

Q14. What do you notice about the sum of the voltages across the two resistors in series?

Three important characteristics of simple series circuits are:

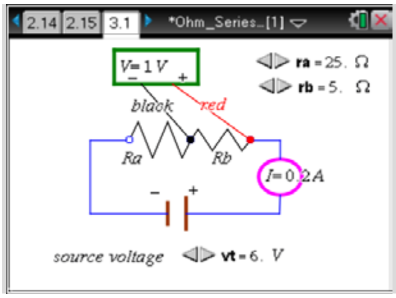
- Resistances add to give the total resistance.
- Voltages across loads add to give total voltage.
- Ohm's Law applies to the entire circuit and to each component.

Q15. When connecting wires in a simple direct current circuit, remember the saying, "Red to …"

A. positive
B. negative
C. battery
D. meter

Problem 3: Circuit Quantities: I vs R with constant V

Move to pages 3.1–3.3.



16. In this part is the same circuit simulation. This time, set the source voltage (Vt) to a convenient value and leave it constant for the rest of this part of the experiment. Measure I, Va, Vb, and Vab and note the values. Capture this data by pressing ctrl . . Change the resistance of Ra or Rb. Again measure I, Va, Vb, and Vab and capture the data by pressing ctrl . . Repeat for a wide range of resistance values for Ra and Rb.

Q17. What do you notice about the measured voltages va, vb, and vab?

Move to pages 3.4–3.5.

18. Plot the current versus different resistance variables and note the shape indicating an inverse relation. Plot current vs. 1/resistance values (variables called invrab, invra, and invrb. Analyze the plots to find any linear equations and determine the slopes.

Move to pages 3.6–3.12. Answer the following questions here or in the .tns file.

Q19. Which plots give a linear relationship?

Q20. What are the slope values of the linear plots?

Q21. What other quantities from this experiment are the same as the slope value?

Q22. What quantities are represented on the *y* and *x* axes respectively?

Q23. Rewrite the linear equations substituting the quantities representing *y*, *x*, and the slope. How does this equation compare to Ohm's Law?

Q24. What do you notice about the values of the two resistances in series?

Q25. What do you notice about the voltages across the two resistors in series?

Name _______________
Class _______________

Again, three important characteristics of simple series circuits are:

- Resistances add to give the total resistance.
- Voltages across loads add to give total voltage.
- Ohm's Law applies to the entire circuit and to each component.

Q26. When connecting wires in a simple direct current circuit, remember the saying, "Black to …"

A. positive
B. negative
C. battery
D. meter

Problem 4: Apply Circuit Characteristics and Ohm's Law

Move to pages 4.1–4.7. Answer the following questions here or in the .tns file.

Q27. Through how many pathways does the current flow in the series circuits?

A. 0
B. 1
C. 2
D. 4

Q28. Because of the number of pathways in a series circuit, the current meter

A. always reads 0.
B. reads different values at different places.
C. can be placed anywhere in the circuit.
D. must be a special kind because current oscillates back and forth.

Q29. In the circuit for Problem 3, the side of the ammeter connected to Rb should be:

A. red
B. green
C. positive
D. negative

Q30. In a series circuit, voltages across the resistors in series

A. are measured in ohms.
B. are equal to each other.
C. add to give the total voltage of the circuit.
D. are greater than the source voltage.

Q31. In a series circuit, resistances of the resistors in series

A. are measured by the voltmeter.
B. add to give the total circuit resistance.
C. are equal to each other.
D. depend on the source voltage.

Q32. In a simple series circuit, the current

A. increases with an increase in resistance values.
B. increases with an increase in source voltage.
C. increases when the switch is opened.
D. must be measured through the source.

Q33. In a simple series circuit, the total circuit resistance

A. depends on the current that is flowing.
B. increases with an increase of source voltage.
C. decreases with an increase of source voltage.
D. is the sum of the individual resistances.

Five important characteristics of simple series circuits are:

•Current is the same everywhere.

•A single switch will work anywhere.

•Resistances add to give the total resistance: Ra + Rb… = Rtotal

•Voltages across loads add to give total voltage: Va + Vb… = Vtotal

•Ohm's Law applies to the entire circuit and to each component: Vt = I x Rt; Va = I x Ra; Vb = I x Rb …

Use this information to find the circuit values requested in the next several questions:

A simple circuit has a 9 V battery connected to a switch and two resistors in series. Ra = 12 Ω and Rb = 6 Ω. An ammeter is connected between the two resistors and a voltmeter is connected across resistor B. Sketch the diagram on paper and show the switch closed.

Move to pages 4.9–4.12. Answer the following questions here or in the .tns file.

Q34. The total resistance of the circuit is

A. 6 Ω C. 12 Ω
B. 9 Ω D. 18 Ω

Q35. The total voltage of the circuit is

A. 3 V C. 9 V
B. 6 V D. 18 V

Q36. The reading on the ammeter when the switch is closed will be

A. 0 C. 12 A
B. 0.5 A D. 30 A

Q37. When the voltmeter is connected across resistor B, the meter will read

A. 12 V C. 3 V
B. 9 V D. 0.5 V

Extension

Other types of circuits may have components in parallel (separate pathways), components or conditions for which Ohm's Law does not apply completely. Examples are semiconductors, inductors, alternating current, or combinations of series and parallel parts. Some of these circuit types will be studied later.

Name _______________
Class _______________