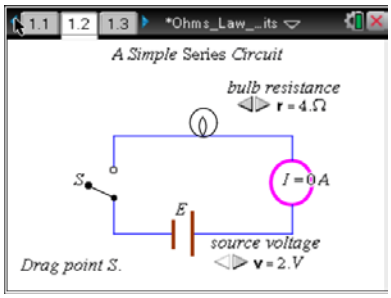
Science Objectives

- Students will explore and apply components of a simple series circuit.
- Students will explore and apply characteristics of the circuit.
- Student will collect voltage, current, and resistance data in a series circuit simulation.
- Students will analyze data to develop and apply Ohm's Law.



Vocabulary

- circuit
- current
- load
- Ohm's Law
- pathway
- polarity
- resistance
- source
- voltage

About the Lesson

- This lesson simulates a simple series circuit.
- As a result, students will:
  - Identify and use components of the circuit.
  - Set values for source voltage and resistances.
  - Connect a voltmeter properly to measure voltages across resistors.
  - Use data to develop Ohm's Law.
  - Apply circuit knowledge and Ohm's Law to sketch and calculate current flow.

TI-Nspire™ Navigator™

- Send out the *Ohms_Law_&_Series_Circuit.tns* file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- *Ohms_Law_&_Series_Circuit.tns* documents
- TI-Nspire™ Technology

TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Use minimized sliders
- Capture data
- Plot data & analyze plots

Tech Tips:

Slider use:

- go to a page with sliders
- tab until slider is selected and press enter to activate slider
- use arrow keys to change values or just type value
- esc esc to release slider

Lesson Materials:

Student Activity

- Ohms_Law_&_Series_Circuit_Student.doc
- Ohms_Law_&_Series_Circuit_Student.pdf

TI-Nspire document

- Ohms_Law_&_Series_Circuit.tns

Discussion Points and Possible Answers

Move to page 1.2.

As students explore the circuit, they can open and close the switch and change values for the voltage and resistance. Encourage them to share observations about the brightness of the bulb and the current.

> **Tech Tip:** If students tab too often, the Entry Line may appear at the bottom of the screen. Press ctrl G to hide it. To hide the chevron, move the cursor over the chevron and press ctrl menu **> Hide Chevron.**

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

Have students answer the questions on either the handheld, on the activity sheet, or both.

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

Answer: The bulb lights up and the ammeter shows current value.

Q2. What would you call the device at point S?

Answer: switch

Q3. The part of the circuit labeled E represents_____.

Answer: B. a battery

Q4. What component represents the load in this circuit?

Answer: D. the bulb

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

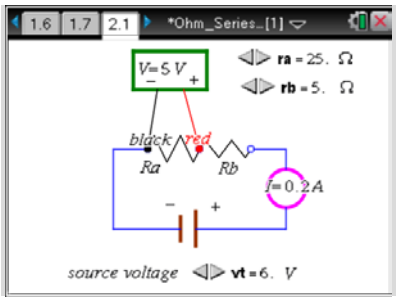
Answer: A. the straight wires

> **Teaching Tip:** Discuss the circuit components and associated quantities and units as printed in the Student document. Relate these to real world situations.

Move to page 2.1.

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

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. Then measure voltages across resistors by connecting wires properly.



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.

   Tech Tip: Students will collect data by pressing ctrl . each time they change a voltage value in the experiment. The data will automatically appear in a spreadsheet on a later page, and they can be plotted and analyzed on yet another page in the .tns document.

Move to page 2.5 and 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.

Have students answer the questions on either the handheld, on the activity sheet, or both.

Q8. Which plots give a linear relationship?

Answer: D. All of the voltage vs. current plots are linear.

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

Answer: Slope values are the corresponding resistance values: vtotal vs current -> Rab or Rtotal; volta vs current -> Ra; voltb vs current -> Rb as set by students.

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

Answer: slope values are the corresponding resistances.

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

Answer: y axis represents voltage; *x* axis represents current.

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

Answer: $y = mx + b$ (b=0), thus voltage = resistance x current for each plot. V = RI or V = IR: Vtotal = IRtotal; Va = IRa; Vb = IRb

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

Answer: resistances add to total resistance for circuit

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

Answer: voltages add to give total voltage

Teaching Tip: Emphasize the three (so far) characteristics of simple series circuits.

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.

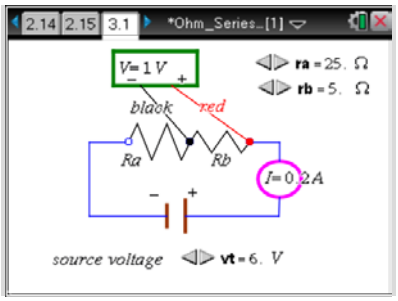
Q15. When connecting wires in a simple direct current circuit, remember the saying, "Red to …"

Answer: A. positive. (A good example of this is when boosting a car with a dead battery).

Teaching Tip: The next part is the same as the last, except that students set a fixed voltage and vary resistances (either or both).

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

Move to page 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?

Answer: va + vb = vab; voltages add to give total voltage

Move to page 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.

> **Tech Tip:** The data spreadsheet was set up to automatically calculate inverse values.

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

Have students answer the questions on either the handheld, on the activity sheet, or both.

Q19. Which plots give a linear relationship?

Answer: only current vs. invrab gives a linear plot

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

Answer: slope value will be vts set by student

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

Answer: slope = Vtotal (or Vab)

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

Answer: *y* -> current (I)

x -> invrab (1/Rab or 1/Rtotal)

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

Answer: $y = mx + b$ $(b = 0)$

$I = Vt \times 1/Rt$ or $I = V/R$

This is a rearrangement of Ohm's Law

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

Answer: Ra + Rb = Rab or total resistance; resistances add in series

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

Answer: Va + Vb = Vab or total voltage; voltages add in series

Move to page 3.13
Have students read the three important characteristics of simple series circuits.

Move to page 3:14
Have students answer the following questions on either the handheld, on the activity sheet, or both.

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

Answer: B. negative

Circuits can be very complicated. This activity illustrates the characteristics of a simple direct current circuit with two loads in series. A series circuit may also have sources in series. The same characteristics would apply. A simple circuit means that Ohm's Law applies to the entire circuit and to the individual components even though the components might have different values of resistance and voltage.

Problem 4: Apply Circuit Characteristics and Ohm's Law
Move to pages 4.1–4.7.
Have students answer the questions on either the handheld, on the activity sheet, or both.

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

Answer: B. 1

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

Answer: C. can be placed anywhere in the circuit.

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

Answer: D. negative

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

Answer: C. add to give the total voltage of the circuit.

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

Answer: B. add to give the total circuit resistance.

Q32. In a simple series circuit, the current

Answer: B. increases with an increase in source voltage.

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

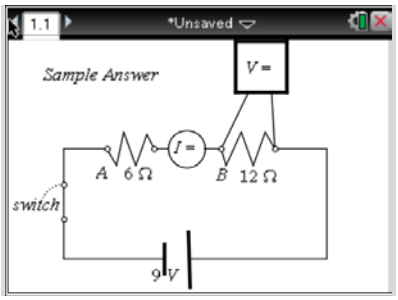
Answer: D. is the sum of the individual resistances.

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 page 4.9– 4.12. Answer the following questions here or in the .tns file.
Have students answer the questions on either the handheld, on the activity sheet, or both.

Q34. The total resistance of the circuit is

Answer: D. 18 Ω

Q35. The total voltage of the circuit is

Answer: C. 9 V

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

Answer: B. 0.5 A

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

Answer: C. 3 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.

TI-Nspire Navigator Opportunities

Use TI-Nspire Navigator Screen Capture to monitor student progress and to retrieve the file from each student at the end of the class period. Many of the student questions can be electronically graded and added to the student portfolio. During the lesson, Screen Capture can be used to illustrate examples of student work as a focus for discussing concepts or difficulties.

Wrap Up

When students are finished with the activity, Collect from Class the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using TI-Nspire Navigator Review features.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions can be graded when the .tns file is retrieved. The TI-Nspire Navigator Review features can be utilized to give students immediate feedback on their assessment.
- Summative assessment may consist of questions/problems on a chapter test or practical skill assessment with a real circuit in the lab.