Science Objectives

- Students will explore an animation of particle flow in a battery.
- Students will vary the electron flow in a DC circuit with a battery of varying voltages and one, two, and three resistors.
- Students will observe changes in current (milliamps) with varying voltage and resistance.
- Students will describe a direct current both qualitatively and quantitatively.
  Students will use the formula Voltage = Current • Resistance (V=IR).

Vocabulary

- Current
- DC Circuit
- Battery

- Resistance
- Amps and milliamps
- Resistors

- Ohms
- Voltage
- Volts

About the Lesson

This lesson addresses the fact that a direct current flowing in a conductor is directly proportional to the potential difference between its ends ($V = I \cdot R$, where V is the potential difference, or voltage, I is the current, and R is the resistance of the conductor).

- As a result, students will:
  - Explore the simulation of a DC Circuit.
  - Develop the relationship $V = I \cdot R$ with a simulated DC Circuit.
  - Calculate voltage, resistance, or current of several DC Circuits.
  - Explore the formula beyond the simulation and use the simulation to verify.
 - Discuss the rate and direction of the flow of electrons in the DC Circuit.

TI-Nspire™ Navigator™

- Send out the DC_Circuits.tns file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Enter items as appropriate for use of TI-Navigator.

Activity Materials

- Compatible TI Technologies: TI- Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software
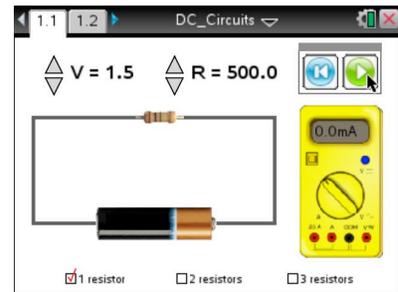
Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- DC_Circuits_Student.doc
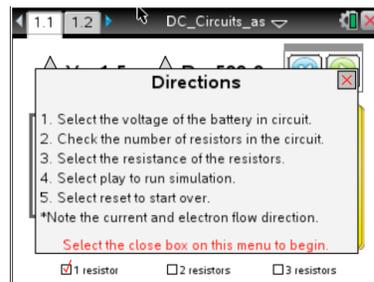- DC_Circuits_Student.pdf

TI-Nspire document

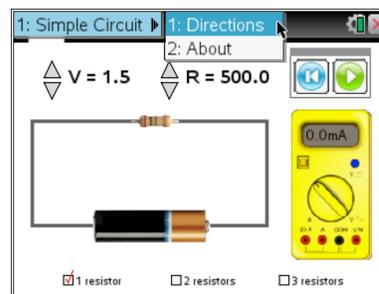- DC_Circuits.tns

Discussion Points and Possible Answers

Have students read the background information stated on their activity sheet.

Part 1: Exploring the DC Circuit

1. When students first open the Nspire document they will see a Directions window explaining how to use the simulation. Be prepared to answer any questions students have regarding the directions.

2. Have them close the pop-up window when they are finished reading the directions. Students can select [menu] to view the directions at any time.

> **Tech Tip:** To bring up the directions again, students will need to select ✎ > **DC Circuits > Directions**. Note that in some cases, a student may need to back-out to the main Tools Menu ✎ to see the desired menu option.

3. Have students select the Play button 🔘 and observe.

Q1. What do you see? Share this with another student and the class as requested.

> **Sample Answer:** Answers may vary. The flow of electrons from the bottom of the battery to the top, the reading on the current meter in mA.
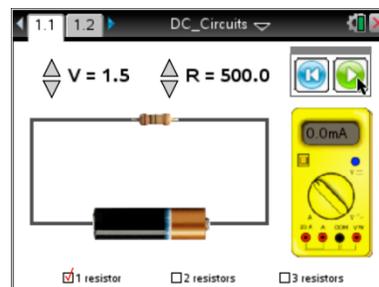
To Pause the simulation select 🔘. To Reset select 🔘.

Q2. Make a list of the variables that can be controlled in the simulation:

> **Answer:**

– Number of resistors

– Voltage of the battery

– The resistance of the resistors (All are the same value when using more than one.)

> **Teacher Note:** Assign student groups. Have each group hold a different variable constant. By adjusting the other variables, groups should observe the current and keep track of their findings. Have the students use the spreadsheet on page 1.2 to report the values. In the example shown below, the voltage was held at 1.5 volts. Depending on the size of your class and other considerations you may only be able to sample the possibilities. Have the students look for patterns.

Move to page 1.2.

4. Assign variables (to hold constant) to student groups. Now students will observe what happens to the current as they systematically adjust the other variables. Have them note the rate of electron flow, the direction, and record the reading on the meter for each scenario. Be careful to set all the possible combinations of the other variables. Please note that "number_r" on page 1.2 stands for the number of resistors.
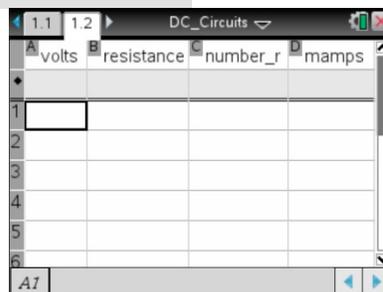
> **Tech Tip:** To add or modify data in a spreadsheet cell, double-tap the cell. The keyboard will appear. Enter the numerical value and then select enter.

5. Have students fill in the rows in the spreadsheet as they collect data.

6. Share your data with a student near you and the whole class as instructed.
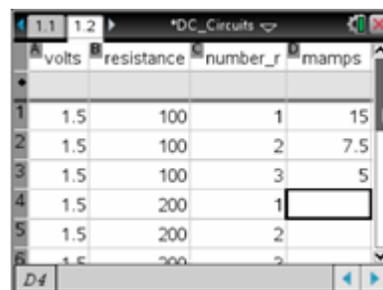
> **Teacher Note:** All the data will have a similar pattern with $V = I \cdot R$.
>
> Students may see this relationship in the form: $I = \dfrac{V}{R}$.

TI-Nspire Navigator Opportunities

Collect screenshots of the results and make the student as Presenter to have them explore their list as it was developed.

7. Look for a pattern within individual student and class results.

Q3. What is the range of voltages (V) available in the simulation?

Answer: 1.0 to 9.0 V

Q4   What is the range of resistances (R)?

Answer: 100.0 to 1000.0 ohms

Q5. What is the range of current (I) as shown by the meter in milliamps?

Answer: 0.3 mA to 90.0 mA

Q6. What combination of values of the variables will give you the smallest current?

Possible Answer: Low voltage and three resistors with high resistance

Q7. What combination of values of the variables will give you the largest current?

Possible Answer: High voltage and one resistor with low resistance

8. Can students determine a relationship between voltage (V), current (I), and resistance (R)? Have them look at the numbers for a mathematical pattern. Discuss with another student and/or the class.

Q8. What combination of values of the variables appears to make the electrons flow faster? Slower?

Answers: High voltage and one resistor with low resistance will make the electrons flow faster. Low voltage and three resistors with high resistance will make the electrons flow slower.

Q9. Describe the direction of the flow of electrons.

Answer: From the negative end to the positive end.

Part 2: The Formula $V = I \cdot R$

9. The relationship between voltage, current and the resistance is given by the formula **V = I • R**. Have students use the formula to calculate the missing values in the table below. They may verify their answers by using the simulation, but should do their own calculations first.

From row 1 in the table: *V* = 2.0 Volts   *R* = 200.0 Ω   1 Resistor

To find the value of the current:

- $\dfrac{2.0}{200.0}$ = 0.01 Amps

- 0.01 Amps • 1000 mA/Amps = 10.0 mA

- The current is 10.0 mA.
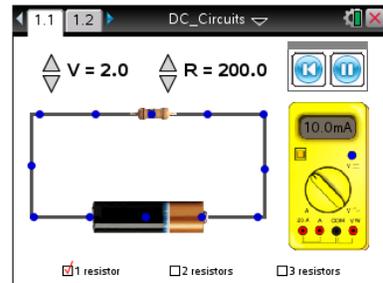
Q10. Calculate the missing values in the table.

Volts	Resistance	# of Resistors	Current
2.0 V	200.0 Ω	1	$\dfrac{2.0}{200.0}$ = 0.01 and 0.01 • 1000 = 10 mA
1.0 V			1.0 mA
	300.0 Ω	1	20.0 mA
7.0 V			10.0 mA
6.5 V	400.0 Ω	1	
4.5 V			7.5 mA
	600.0 Ω	2	1.7 mA
	500.0 Ω	3	2.3 mA
1.5 V	800.0 Ω	3	
You Pick One			

Answer Key

Volts	Resistance	# of Resistors	Current
2.0 V	200.0 Ω	1	$\frac{2.0}{200.0}$ = 0.01 and 0.01 • 1000 = 10 mA
1.0 V	500.0 Ω	2	1.0 mA
6.0V	300.0 Ω	1	20.0 mA
7.0 V	700.0 Ω	1	10.0 mA
6.5 V	400.0 Ω	1	16.3 mA
4.5 V	(A) 600.0 Ω (B) 300.0 Ω (C) 200.0 Ω	(A) 1 (B) 2 (C) 3	7.5 mA
2.0 V	600.0 Ω	2	1.7 mA
3.5 V	500.0 Ω	3	2.3 mA
1.5 V	800.0 Ω	3	0.6 mA

Q11. What is the relationship between amps (A) and milliamps (mA)?

Sample Answer: 1000 mA = 1 A

Q12. Rewrite the formula $V = I \cdot R$ to solve for current (I).

Answer: $I = \dfrac{V}{R}$

Q13. What happens to the resistance in the circuit when you have more than one resistor?

Sample Answer: The total resistance increases as a multiple of the number of resistors. So if you have 3 resistors with 250 Ohms each the total resistance would be 750Ω.

Q14. Rewrite the formula $V = I \cdot R$ to solve for resistance (R).

Answer: $R = \dfrac{V}{I}$

Part 3: Predicting and Exploring

10. Now let students use their knowledge of DC Circuits in order to get readings for circuits that cannot be made with the simulation.

Q15. What value would you get for current if the voltage was set to 1.65 V and there was 1 resistor of 200Ω? Test your answer by setting the voltage for the one resistor to 1.5 V and then 2.0 V.

   Answer: 8.25 mA

Q16. What value would you get for current if the voltage was set to 5.5 V and there were two resistors of 330.0Ω each? Test your results by setting the two resistors to 300Ω and then to 400Ω.

   Answer: 8.3 mA

Q17. What voltage would you expect if you set up a circuit with 3 resistors at 450Ω each and it had a current of 5.7 mA? Set up the circuit to test your results.

   Answer: 7.7 V

Q18. In which direction does the current flow? Can you change it?

   Sample Answer: Clockwise, from the bottom to the top, from (-) to (+). Switch the battery in the circuit.

Q19. Which end of the battery do you think is negative? Why?

   Sample Answer: The bottom because electrons are negative.

TI-Nspire Navigator Opportunities

Allow a student to volunteer to be the Live Presenter and demonstrate how they set up their spreadsheet and how they change the parameters in the circuit. Choose questions from the Student activity sheet and send Quick Polls to the students. Have the students show their calculations with a Screenshot or make the student a Presenter.

Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. If you sent a Quick Poll to the class, or if you added Questions into the tns file, then save the grades to Portfolio. Discuss activity questions using the Review and look at individual files as a class.