# Batteries in Series and Parallel: Student Activity Lesson Plan

**Subject/Strand/Topic:** Science / Physics: Electricity  
**Grade(s) / Course(s):** 9 / SNC1D  
**Ontario Expectations:** PH1.09, PH1.10

**Key Concepts:** batteries, parallel circuits, series circuits, current, voltage

**Link:** [http://phet-web.colorado.edu/web-pages/simulations-base.html](http://phet-web.colorado.edu/web-pages/simulations-base.html) Click on “Circuit Construction Kit”.

**Required Materials:**  
- Pre-Assessment/Answer Key  
- Student Activity Handout  
- Student Activity Answer Key
- Post-Assessment/Answer Key  
- Data Projector (Optional)  
- Flashlight (Optional)

**Before Starting:**  
1. Students should be familiar with simple electric circuits, current, voltage and using ammeters and voltmeters.  
2. This activity works best with students in pairs.

**Introduction (~ 10 minutes including pre-assessment)**  
1. Go to computer lab, put students in pairs.  
2. Distribute the pre-assessment to each student; collect when complete (5 min).  
3. Introduce the learning object to the class:  
   a. Review voltage and what series and parallel circuits look like.  
4. Think-Pair-Share: Q – How are the batteries in a flashlight are arranged? Series or Parallel. (series) Why do you think this is the case? (Gives more voltage).

**Student Activity Handout Explanation (~ 5 minutes)**  
1. Distribute activity sheet to each student. Students use the learning object to complete the activity.  
2. Go over the organization of the activity sheet. Ensure students know where and how to record the data.

**Use of Learning Object with Student Activity Handout (~ 20-30 minutes)**  
1. Give students 2-3 minutes to explore the learning object in their pairs. See if students can make a simple circuit.  
2. Stop students. Get students to explain aloud the purpose of the learning object, where the options panel is, where to find instructions, help, how to build a circuit, etc.  
3. If a data projector is available, demonstrate how to build a circuit and use the ammeter and voltmeter. Address issues that came up when students were explaining what to do (1-2 minutes). If a data projector is not available, explain verbally.  
4. Give students 20-30 minutes to work through the activity in their pairs.  
5. If students finish early, have students use the learning object to explore other aspects of batteries in series and parallel. E.g. change the voltage of one of the batteries and repeat the experiment.

**Tips and Tricks**  
- Circulate to ensure students are progressing through the learning object and activity sheet.  
- Remind students to share control of the computer and switch roles half way through.  
- Switching often between small, medium and large view can cause the voltmeter to get ‘lost’ off screen. Close and reload the program if this happens.  
- Ensure the battery terminals are oriented correctly or students will not obtain correct results.  
- Battery default voltage is 9 volts. To change the voltage, right click on the battery, select, “Change Voltage” and enter the voltage value you want.

**Consolidation (~ 10 minutes including post-assessment)**  
1. Once students are finished, distribute the Post-Assessment; collect (5 minutes).  
2. Take up activity sheet and / or collect as a ticket-out-the-door.  
3. Ask students follow up questions, e.g., Q: If you had many small 1.5 V batteries, but need a voltage of 6 volts, what could you do? (connect four 1.5 V batteries in series). Q: What do you think might happen if you had one of the batteries going the wrong way? (You wouldn’t get enough voltage anymore, the voltage would be 1.5 + 1.5 -1.5 + 1.5 = 3V).
1. In general, what happens to the total voltage across the source as you add more batteries in SERIES? [2 marks]

2. What is the total voltage for the following circuit? Each battery has a voltage of 9 volts. Explain your answer. [2 marks]

3. What is the total voltage for the following circuit? Each battery has a voltage of 9 volts. Explain your answer. [2 marks]
1. In general, what happens to the total voltage across the source as you add more batteries in SERIES? [2 marks]
   The voltage across all the batteries, the total voltage at the source, is the sum of the voltages of all the batteries.

2. What is the total voltage for the following circuit? Each battery has a voltage of 9 volts. Explain your answer. [2 marks]
   Total voltage is 9 Volts. The voltage of the batteries do NOT add when connected in parallel.

3. What is the total voltage for the following circuit? Each battery has a voltage of 9 volts. Explain your answer. [2 marks]
   Total voltage is 27 volts. The voltage of each battery add when connected in parallel.
Batteries in Series and Parallel

INSTRUCTIONS:
- Use the Circuit Construction Kit to complete the activity sheet.
- Read “How to use the Circuit Construction Kit” before you begin.

HOW TO USE THE CIRCUIT CONSTRUCTION KIT

<table>
<thead>
<tr>
<th>Action</th>
<th>How to do the action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selecting and moving a piece:</td>
<td>To MOVE any piece (wire, battery, etc.) CLICK it, and HOLD. When you release, the piece will stay where you dropped it. Click and hold to move it again.</td>
</tr>
<tr>
<td>Removing a piece:</td>
<td>To remove an item, RIGHT CLICK, and select “REMOVE”</td>
</tr>
<tr>
<td>Resizing wire:</td>
<td>To RESIZE a wire, CLICK and HOLD one of the RED circles at the end of the wire.</td>
</tr>
<tr>
<td>Attaching pieces:</td>
<td>To ATTACH pieces together, OVERLAP RED circles.</td>
</tr>
<tr>
<td>Splitting pieces apart:</td>
<td>To SPLIT pieces apart. RIGHT CLICK on the junction of the pieces (grey circle), and select “SPLIT JUNCTION”</td>
</tr>
<tr>
<td>Battery voltage (changing)</td>
<td>Once the battery is in the circuit, RIGHT CLICK on the BATTERY, select “CHANGE VOLTAGE”, enter in the voltage value you wish in the box.</td>
</tr>
<tr>
<td>Options panel:</td>
<td>Right side of screen. Allows you to select different views (schematic or lifelike), sizes, types of resistors, tools, etc. You will be told what options to select.</td>
</tr>
<tr>
<td>Using the ammeter:</td>
<td>In the OPTIONS panel, check the “NON-CONTACT AMMETER” box. The ammeter will appear. Move the ammeter over the area you wish to know the current.</td>
</tr>
<tr>
<td>Using the voltmeter:</td>
<td>In the OPTIONS panel, check the “VOLTMETER” box. The voltmeter will appear. Move the leads of the voltmeter over the area you wish to know the potential drop (voltage).</td>
</tr>
<tr>
<td>Help:</td>
<td>See bottom of OPTIONS panel. Click “HELP” for generalized instructions on the screen. Click “MEGA HELP” for a detailed screen shot describing how to use the features.</td>
</tr>
</tbody>
</table>

![Diagram of Circuit Construction Kit with labels for Construction area, Options panel, Circuit components, Ammeter (non-contact), and Voltmeter.](image-url)
PROCEDURE: BATTERIES CONNECTED IN SERIES

1. Construct the circuit shown in Figure 1 A. Note the direction the electrons (blue dots) are moving.

2. Reverse the direction of the battery. To do this: Right Click on the battery, select “Reverse”. Note the direction the electrons are moving now.

3. Reverse the direction of the battery again. It should be in the original position now.

4. With the voltmeter, measure the potential difference across the battery. Record the results in Table 1.

5. Construct the circuit shown in Figure 1 B.

6. With the voltmeter, measure the potential difference across EACH battery AND then across BOTH at the same time. Record the results in Table 1.

7. Construct the circuit shown in Figure 1 C.

8. With the voltmeter, measure the potential difference across EACH battery and across ALL batteries at the same time. Record the results in Table 1.

PROCEDURE: BATTERIES CONNECTED IN PARALLEL

1. Construct the circuit shown in Figure 2 A.

2. With the voltmeter, measure the potential difference across the battery. Record the results in Table 2.

3. Construct the circuit shown in Figure 2 B.

4. With the voltmeter, measure the potential difference across EACH battery AND then across BOTH at the same time. Record the results in Table 2.

5. Construct the circuit shown in Figure 2 C.

6. With the voltmeter, measure the potential difference across EACH battery AND then across ALL batteries at the same time. Record the results in Table 2.
## Batteries in Series and Parallel

**Student Activity Handout**

Name: ___________________________

Date: ___________________________

### Record Your Results: [18 marks]

**Table 1. Potential difference as the Number of Batteries in SERIES Increases [9 marks]**

<table>
<thead>
<tr>
<th>Number of Batteries</th>
<th>Across ALL Batteries (Source)</th>
<th>Potential difference, V, (Volts)</th>
<th>Across EACH Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>#2</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>N/a</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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</tbody>
</table>

**Table 2. Potential difference as the Number of Batteries in PARALLEL Increases [9 marks]**

<table>
<thead>
<tr>
<th>Number of Batteries</th>
<th>Across ALL Batteries (Source)</th>
<th>Potential difference, V, (Volts)</th>
<th>Across EACH Battery</th>
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<td>2</td>
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<td></td>
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<tr>
<td>3</td>
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</table>

### What Does It All Mean? [15 marks]

1. **What happens when you reverse the direction of the battery?** [1 mark]

   Look at your results from **Table 1**. The following questions relate to batteries connected in SERIES.

2. **What happens to the voltage across EACH battery as you add more batteries in SERIES? Use your data to justify your answer.** [2 marks]
3. What happens to the voltage across ALL the batteries as you add more batteries in series? Use your data to justify your answer. [2 marks]

4. Imagine you have a 6 volt battery, a 9 volt battery and a 1.5 volt battery connected in series. What is the total voltage? [1 mark]

5. The total voltage for 3 batteries connected in series is 25 volts. One of the batteries has a voltage of 9 volts, and the other a voltage of 3 volts. What is the voltage of the third battery? [1 mark]

Look at your results from Table 2. The following questions relate to batteries connected in PARALLEL.

6. What happens to the voltage across EACH battery as you add more batteries in PARALLEL? Use your data to justify your answer. [2 marks]

7. What happens to the voltage across ALL the batteries as you add more batteries in PARALLEL? Use your data to justify your answer. [2 marks]

8. Two 6 volt batteries are connected in parallel. What is the total voltage of the circuit? Explain. [2 marks]

9. Do you think the batteries of most household items, such as a digital camera, a flashlight, or a television remote control, are connected in series or parallel? Explain. [2 marks]
Batteries in Series and Parallel
Student Activity Handout Answer Key

Table 1. Potential difference as the Number of Batteries in SERIES Increases [9 marks]

<table>
<thead>
<tr>
<th>Number of Batteries</th>
<th>Across ALL Batteries (Source)</th>
<th>Potential difference, ( V ), (Volts)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>#1</td>
</tr>
<tr>
<td>1</td>
<td>9.0</td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>2</td>
<td>18.0</td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>3</td>
<td>27.0</td>
<td></td>
<td>9.0</td>
</tr>
</tbody>
</table>

Table 2. Potential difference as the Number of Batteries in PARALLEL Increases [9 marks]

<table>
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<td>9.0</td>
<td></td>
<td>9.0</td>
</tr>
</tbody>
</table>

1. What happens when you reverse the direction of the battery? [1 mark]
The current flows in the opposite direction.

2. What happens to the voltage across EACH battery as you add more batteries in SERIES? Use your data to justify your answer. [2 marks]
The voltage across each battery stays the same. For 3 batteries, the voltage across each of the 3 batteries is 9 volts.

3. What happens to the voltage across ALL the batteries as you add more batteries in series? Use your data to justify your answer. [2 marks]
As you add more batteries in series, the total voltage of the battery increases by the sum of each individual battery. The voltage across all 3 of the batteries is 27 volts; individually each battery is only 9.

4. Imagine you have a 6 volt battery, a 9 volt battery and a 1.5 volt battery connected in series. What is the total voltage? [1 mark]
The total voltage is 16.5 volts.

5. The total voltage for 3 batteries connected in series is 25 volts. One of the batteries has a voltage of 9 volts, and the other a voltage of 3 volts. What is the voltage of the third battery? [1 mark]
The voltage of the third battery is 11 volts.

6. What happens to the voltage across EACH battery as you add more batteries in PARALLEL? Use your data to justify your answer. [2 marks]
The voltage across each battery stays the same. For 3 batteries, the voltage across each is 9 volts.
7. **What happens to the voltage across ALL the batteries as you add more batteries in PARALLEL? Use your data to justify your answer.** [2 marks]
   When more batteries are added in parallel, the total voltage does NOT increase. The voltage across all of the 3 batteries is still 9 volts.

8. **Two 6 volt batteries are connected in parallel. What is the total voltage of the circuit? Explain.** [2 marks]
   6 volts. Batteries connected in parallel do not lead to an increase in voltage.

9. **Do you think the batteries of most household items, such as a digital camera, a flashlight, a television remote control, are connected in series or parallel? Explain.** [2 marks]
   Series, so you can get a higher voltage to run the device.
1. In general, what happens to the total voltage across the source as you add more batteries in SERIES? [2 marks]

2. What is the total voltage for the following circuit? Each battery has a voltage of 6 volts. Explain your answer. [2 marks]

![Circuit Diagram](image)

3. What is the total voltage for the following circuit? Each battery has a voltage of 10 volts. Explain your answer. [2 marks]

![Circuit Diagram](image)
1. In general, what happens to the total voltage across the source as you add more batteries in SERIES? [2 marks]
   The voltage across all the batteries, the total voltage at the source, is the sum of the voltages of all the batteries.

2. What is the total voltage for the following circuit? Each battery has a voltage of 6 volts. Explain your answer. [2 marks]
   Total voltage is 18 volts. The voltage of each battery add when connected in parallel.

3. What is the total voltage for the following circuit? Each battery has a voltage of 10 volts. Explain your answer. [2 marks]
   Total voltage is 10 volts. The voltage of the batteries do NOT add when connected in parallel.