



Physics

Series and Parallel Circuits

Duration of Lesson: This lesson is designed for one 50-60 minute class period.

Overview and Context:

- In this lesson students will begin by briefly reviewing concepts of voltage, current, and resistance. Introduction to these concepts should have already taken place prior to this point. Students should recall formulas such as $V=IR$ and $P=IV$. This is necessary to build upon in creating and understanding series and parallel circuits. In this lesson, solar panels will be used in making the circuits.

Standards

- **NGSS HS-PS3-5**
 - Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Lesson Objectives:

- Students will be able to build series and parallel circuits using solar panels during the lab activity.
- Students will be able to measure and record open-circuit voltage and short-circuit current for series and parallel circuits.
- Students will be able to collaborate and communicate advantages and disadvantages of solar panels wired in series or parallel.
- Students will be able to analyze the design of the school's solar farm, locating series and parallel circuits on each row as they feed into the inverter

Background:

- **Voltage** is the potential difference across two points. **Current** is the amount of charge moving from one place to another in a circuit. **Resistance** is the opposition to the flow of current in a circuit. A **series circuit** connects all elements according to one path. A **parallel circuit** has multiple paths for current to travel.



Materials and Resources:

- **Teacher**
 - Ph L1 Solar Panels in Series and Parallel
- **Student Groups**
 - Ph L1 Series and Parallel Shading Lab Sheet
- **Links**
 - <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc>
 - There is a download option for a circuit construction software within this link.
- **Safety**
 - If using a lamp, be sure not to touch the bulb, as it will be hot. Handle solar panels carefully.

Preparation:

- Each lab group should be given the following materials:
 - 5x5" squares of cardboard (4)
 - 12V mini solar panels (2)
 - Wires
 - Lamp
 - Multimeter
- Be sure to download the PhET software from the above link prior to class.

Procedures:

1. **Engage:** ~3 minutes
 - a. Slide 1: Have two students come to the front to draw a series and parallel circuit from memory. Call on other students to share what they remember regarding trends of voltage and current with the different wiring setups.
 - b. Transition: *Now that we are recalling this prior knowledge about circuits, let's try making circuits in a more in-depth manner.*
2. **Explore:** ~3 minutes

- a. Slide 2: Open the link, and have the class talk you through building a series circuit first, and then a parallel circuit. Be sure to use multiple elements so you can see how current and voltage is affected by the different wiring setups.
3. **Explain:** ~5 minutes
 - a. Slide 3-4: Remind the students of the concrete information we know regarding series and parallel. In series, there is one path with constant current and varying voltage drops across resistors. In parallel, there are multiple paths with varying current, but the voltage drops should be equal for the different paths.
 - b. Transition: *This model of circuits includes resistors in series/parallel, but today we will be putting solar panels in series/parallel with each other, which produce a voltage and thus act like a battery. Let's see if these rules still apply.*
4. **Elaborate:** ~30 minutes
 - a. Slide 5-6: This is the section of the lesson in which students apply what they've learned about series and parallel. First, students will get into groups and go to their lab station, where their materials should already be organized. Before beginning on the investigation, students should demonstrate their understanding of how to set up solar panels in series as well as in parallel to the teacher. Then, students should measure current and voltage for the circuits, varying the amount of shading the panels receive.
5. **Evaluate:** ~9 minutes
 - a. Slide 7: Have the students think critically about optimum conditions for residential solar panels, considering the data they've acquired regarding shading (assume the house has some shading from trees).
 - b. Slide 8-10: Use this section to share key points regarding advantages and disadvantages of series and parallel: Disruption in series connection can disrupt entire sequence of elements while parallel connection allows for disruption of one element while others continue working.