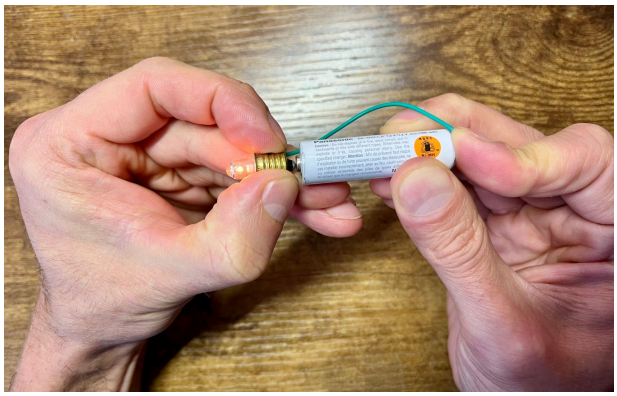
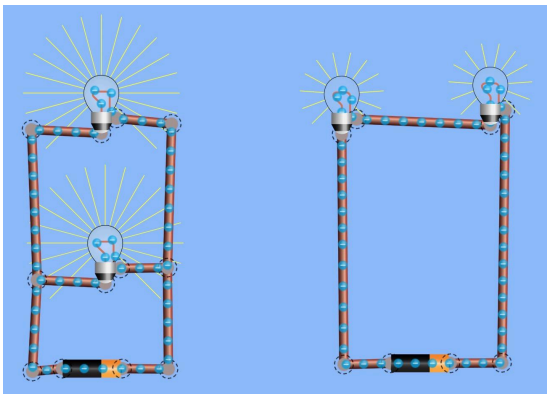
MAKING WAVES with radio

# FACILITATOR GUIDE
# Exploring Circuits

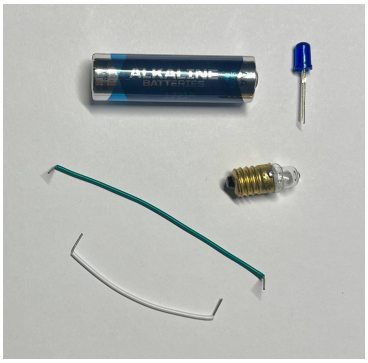




## Learning Objectives

This activity introduces learners to the concept of circuits through hands-on exploration. Learners will construct physical circuits and use a computer simulation to investigate the flow of energy, learn about the differences between series and parallel circuits, and explore how voltage and current influence circuit behavior.

## Materials



**Physical Circuit Activity:**

- Batteries (AA or D-cell)
- E10 mini lightbulbs
- Insulated wires
- Additional materials for challenges (e.g., additional batteries)

**Simulation Activity:**

- Access to the PhET Circuit Construction Kit simulation (via computers or tablets)
- Projector or screen for teacher demonstration (optional)

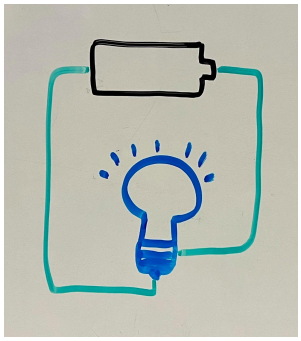
## Activity procedure Part 1: Building a physical circuit

1. **Organize learners:** Arrange learners into groups of 2-3. Avoid groups larger than three to ensure active participation.

2. **Distribute materials:** Provide each group with the materials needed to create a physical circuit.

3. **Introduce initial challenge:** Ask groups to light the bulb using all the materials provided. Allow sufficient time for all groups to accomplish the task.

4. **Debrief designs**
    - Facilitate a whole-group discussion to share how groups succeeded in lighting the bulb. Use prompts such as:
        - *Who would like to describe the steps you took and how you connected the materials?*
        - *Did anyone else use a similar method? How was it the same or different?*
    - As learners share their ideas, create a **diagrammatic model** on the board based on their input, beginning with a lightbulb and a battery. Use these guiding questions:
        - *How are the elements connected?*
        - *Did the cables need to touch specific parts?*
        - *Who found similar connections? Who found something different?*



5. **Introduce additional challenges**
    - Ask learners to try one of both of the following ideas:
        - *Light the bulb using **only one cable and one battery.***
        - *Light the bulb using **two batteries and 2 cables.***
    - Use the following prompts to encourage reflection:
        - *What did you observe when you connected the materials?*
        - *What changed when using two batteries?*
        - *How did the brightness of the bulb compare?*
    - If students encounter difficulties, refer them back to the diagrammatic model you created together and remind them of how the components need to be connected.

6. **Introduce the term “Circuit”**
    - Ask: *What do all successful designs have in common?*

- If learners identify the term “circuit,” confirm and discuss. If not, introduce it, emphasizing the idea of a complete loop allowing energy to flow.

7. **Problematize how energy flows in the circuit**
    - Remind students that light is a form of energy.
    - Ask: *If energy cannot be created, where does the light’s energy come from?* (Answer: the battery).
    - Ask: *How does the circuit allow energy to move from the battery to the lightbulb?*
    - Encourage discussion and mention that a **simulation** will help them visualize energy movement.

## Activity procedure Part 2: Building a circuit with a simulation

1. **Introduce the simulation**
    - Guide learners to open the PhET Circuit Construction Kit by Googling “PhET circuits” and selecting the first link.
    - Briefly demonstrate how to drag and connect components (e.g., battery, wires, resistors, lightbulbs). Alternatively, allow learners to explore the intuitive interface independently.

2. **Recreate the physical circuits with the simulation**
    - Ask learners to build circuits resembling the ones they created physically.
    - Prompt reflection: *What differences do you notice between the physical and simulated circuits?*
    - Discuss observations about **electron speed** and **bulb brightness**, introducing the concept of **current**.

3. **Explore Series and Parallel circuits**
    - Challenge learners to build a circuit with **one battery and two lightbulbs.**
    - Encourage exploration of different setups (e.g., series and parallel circuits).
    - If a group builds only one type, suggest trying another configuration.
    - Invite learners to share their designs using a classroom projector or by drawing them on the board.

- Optionally introduce electrical circuit symbols (though not essential at this stage).
- Define **series and parallel circuits** based on learner designs.
- Ask learners to compare both types of circuits by asking: How does the brightness of the bulbs in a series circuit compare to those in a parallel circuit with the same number of bulbs?
- Invite them to attempt to explain this difference in brightness using the movement of the electrons in their explanation.
- Suggest they use a couple of different tools provided by the simulation: the current and voltage meter

4. **Explore Voltage and Current**
    - Ask learners to use the voltmeter tool in the simulation to measure the voltage across each bulb.
    - Use the following prompts to encourage reflection:
        - *What do you notice in a series circuit? What about in a parallel circuit?*
        - *Does the voltage across the battery match the total voltage across all the bulbs in a series circuit? What about in a parallel circuit?*
    - Then ask learners to use the ammeter tool to measure the current in a series circuit and a parallel circuit. Use the following prompts:
        - *How does the total current from the battery compare in each case?*
        - *How does the current through each bulb compare in a series circuit versus a parallel circuit?*

## Content Background

Electrical circuits consist of components like a power source (battery), conductive wires, and devices like lightbulbs that use energy. For a circuit to function, it must be a closed loop, allowing energy to transfer continuously. Voltage provides the “push” needed for electrons to move through the circuit, and the current is the flow of these electrons.
The brightness of a lightbulb in a circuit depends on the current flowing through it, which is directly influenced by the motion of electrons. In a circuit with higher voltage, electrons move faster, delivering more energy to the bulb, making it brighter. Conversely, in circuits with lower voltage or more resistance, electrons move slower, resulting in dimmer light. Using simulations, learners can visualize the invisible movement of electrons and explore how changes in voltage and configuration affect circuit behavior.

- **Series circuits:** Components are connected in a single path. The **current is the same** through all components, but the **voltage is divided** among them.
- **Parallel circuits:** Components are connected across multiple paths. **Voltage remains the same** across all branches, but the **current splits** between paths.

## List of Terms Related to this Activity

**Circuit:** A complete loop through which electricity flows.

**Current:** The flow of electrons through a circuit, measured in amperes (A).

**Voltage:** The "push" provided by the power source to move electrons, measured in volts (V).

**Series Circuit:** A type of circuit where all components are connected in a single path, one after another. The same current flows through every part, but the more components you add, the dimmer things like lightbulbs get because the voltage is shared between them.

**Parallel Circuit:** A type of circuit where components are connected on separate paths. The voltage stays the same on each path, but the current splits between the different paths. This way, each lightbulb gets the same brightness, even if more are added.

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