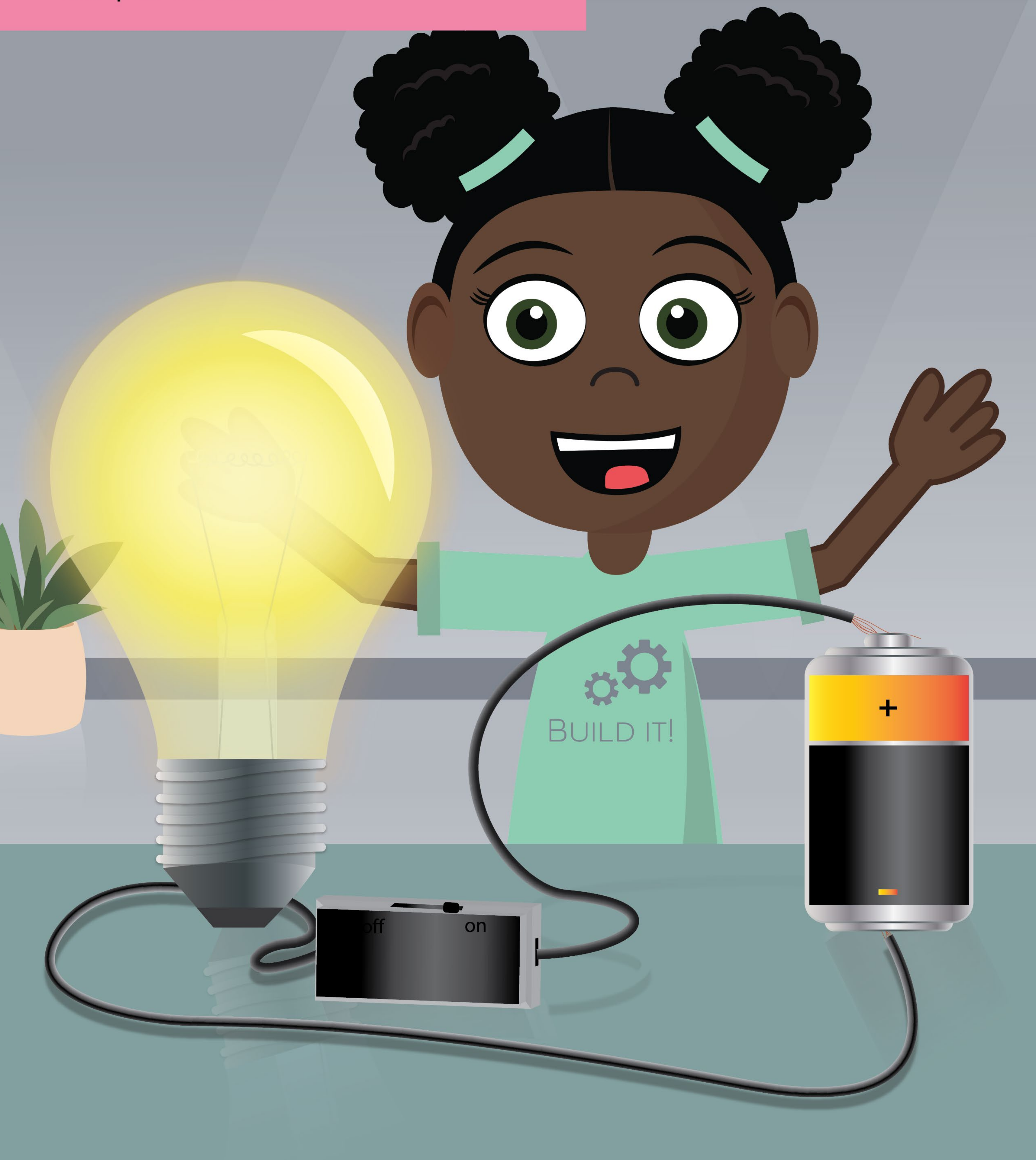
# PHYSICS

Simple Circuits



# Simple Circuits

## NGSS

4-PS3-4; MS-PS3-2

## Objective

**The student will understand** the difference between series and parallel circuits, as well as how different circuit setups change power through a circuit.

**The student will be able to** build an operational simple circuit.

## Vocabulary

**Power:** Electrical power is really the product of voltage and current. Power, in general, is the amount of energy that is consumed per unit of time.

**Circuit:** For the sake of this lesson, a circuit is defined as being composed of a source of current (battery) that has at least one complete path from the positive terminal to the negative terminal.

**Series:** Series circuits are arranged in such a way that multiple resistors are hooked together in a chain and form a complete loop with the battery.

**Parallel Circuit:** Circuit arranged in such a way that multiple resistors, each with an A and B side, are connected such that all of the A sides are hooked together, and all of the B sides are hooked together. The A and B sides are then hooked to opposite ends of the battery. The total resistance of parallel circuits is less than the resistance of any one resistor used in the circuit.

**Battery:** Power source that creates a flow of electricity due to a difference in potential between a positive and negative terminal.

**Light Bulb:** Electric light with a small filament (thin piece of wire) that connects one end of the lightbulb to the other inside a glass bulb.

## Background

Circuits are a critical component that allow for the lights in our homes to turn on. In order to understand this process, we must dive into the various components that allow for our lights to turn on and off within our homes.

Resistance quantifies the resistance to the flow of electrical charge through an electrical component and is measured in ohms (W). Resistors can be thought of as any component that has resistance. The only components used in these experiments are light bulbs (cut from a strand of holiday lights) and batteries. For the sake of these experiments, batteries have no resistance and light bulbs have resistance. We do not count wires as components because their effect on the actual functioning of the circuit is negligible. In other words, the only purpose of wires is to connect the significant components.

Power is simply the rate of flowing electricity flowing through a circuit. The amount of power that is consumed by a circuit is inversely proportional to the resistance of that circuit, assuming constant voltage.  If resistance is high, it will take longer for the charge to flow through the circuit, therefore less power is dissipated. If resistance is low, more electricity will be able to flow in a shorter amount of time, and power is increased.

For circuits, the path or paths can travel through wires and various components that conduct electricity (light bulbs). A circuit with one end of the battery connected to a light bulb and nothing connected to the other end of the battery is not a complete circuit because there is not a complete path from the positive terminal of the battery to the negative terminal. A circuit with one end of the battery connected to a light bulb and the other end connected to the same lightbulb is a circuit because there is a complete path (albeit through the lightbulb) connecting both sides of the battery. You can use the analogy of a track around a football field and an airport runway as an example. The track is a circuit because there is a complete path connecting both ends. The runway is not a circuit because the ends are not connected.

The total resistance of series circuits is the sum of resistances among all the resistors. This is so because there is only one path for electricity to travel; therefore, the resistance of each resistor slows down the electricity like heavy traffic through a narrow street. In a parallel circuit, adding multiple resistors, one effectively creates more paths for electricity to flow, so instead of traffic being forced down one narrow street, the traffic can be split between 1, 2, 3, 4, ... streets and, therefore, moves much faster.

For example, someone has taken a bunch of electricity and stuffed it into one end of the battery and that electricity wants to get to the other side. The only way it can get there is by traveling through a complete circuit to the other end. You can also explain that the more resistance there is in the circuit, the slower the electricity will travel to the other end.

Due to resistance, the filament in light bulbs does not let electricity pass as easily as the other connecting wires. When electricity is passed through the filament, it gets very hot and glows brightly. The more electricity passes through the light bulb, the brighter it shines.

## Materials

Per group of 2-3 students:

- 9-volt battery
- 2-5 mini incandescent lights (Lights can be cut from a strand. Cut leads to about 3 cm and trim insulation about 1 cm).
- 2 longer pieces of the cut wire from the Christmas lights for connecting the circuit.
- Strip of electrical tape

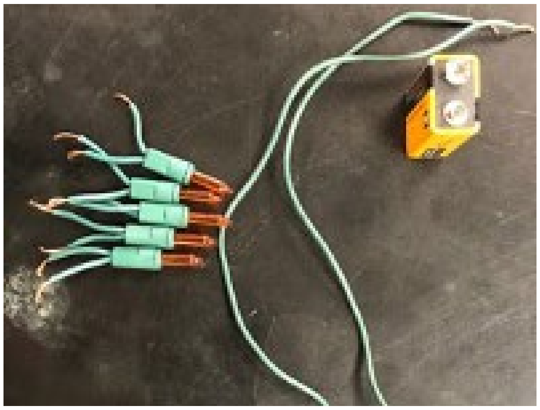


*Figure 1. Circuit components.*

## Procedure

Electrical connections to the battery can be made by sandwiching each of the two leads between a battery post and a piece of electrical tape.

Connections among lightbulbs can be made by twisting the exposed copper together.

**Activity 1 (Complete the Circuit):**

Describe the characteristics of a complete circuit. Students should experiment with connecting the lights to the batteries in different ways. Emphasize that when there is not a traceable path from one end of the battery to the other and through a light bulb, the light bulbs will not shine.

**Activity 2 (Series and Parallel):**

Instruct the students to first make a series circuit with their lights and battery. You can draw a diagram on the board or make up an example to help them out. Tell the students to take note of how bright the bulbs are.

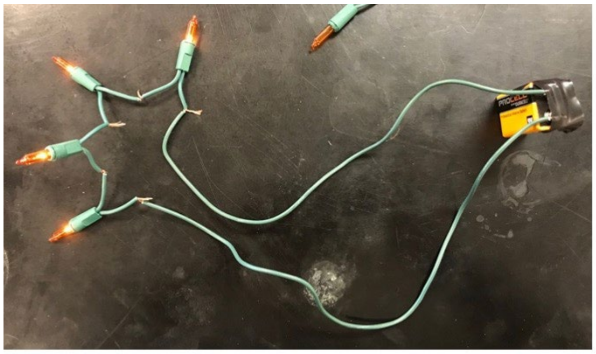


*Figure 2. Series Circuit*

Next, have the students make a parallel circuit. The lights should be much brighter in the parallel circuit than the series circuit. Ask students to explain why the lights on the parallel circuit are brighter.

*Figure 3. Parallel Circuit.*

**Activity 3 (Combination Circuits):**

Instruct the students to make up their own circuits with varying amounts of bulbs and to observe how some of the lights have different brightness. If the students are having trouble getting creative, you can demonstrate different circuits, like the one pictured below.

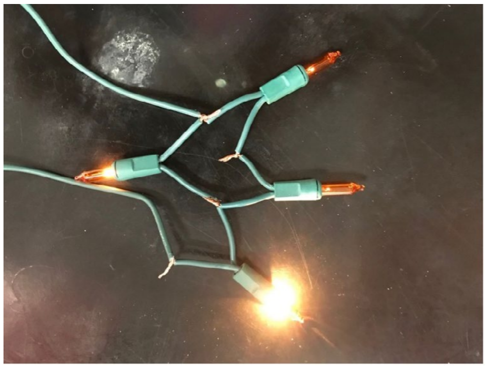


*Figure 4. Combination Circuit.*

**Activity 4 (Large groups/class activities):**

Students can pool their materials to make larger circuits with multiple batteries. If larger circuits are assembled with many lightbulbs, you can explain how adding batteries in series makes the bulbs brighter. If batteries are added in series, they should be added + to -, otherwise they will not conduct electricity.

It is not recommended that batteries be connected in parallel (+ to +, - to -) because doing so is not likely to have any noticeable effect on the brightness of the bulbs. However, if this is done, make sure the batteries are not connected (+ to -, - to +) or the batteries could overheat.

## Guiding Questions

- Continually ask the students why the circuit is behaving the way it is. Lead them to answer questions about how electricity flows in series and parallel circuits.
- What happened when you had a large group try to make the bulbs turn on?
- How did you modify the experiment? How do you think scientists or engineers use similar creativity?

## Career/Future Application

Electrical engineering, Electrical Contracting, Computer Science

## Sources

https://www.edinformatics.com/math_science/what-is-an-electric-circuit.html