

# Electricity

Dr. Dave's Teaching Manual

Second Edition

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# Introduction

This manual will give you, the teacher, everything you need to teach a unit on electricity. From the first topic to the last class, it describes how to set up teaching presentations so that they are dynamic, exciting, and meaningful for students. You will see how easy it is to prepare for classes, and you will discover that this teaching approach allows students to experience real learning and real academic success.

Science is a wonderful topic to teach to children. Instead of lecturing for long periods or bogging students down with an avalanche of worksheets, this manual shows you how to make your presentations interesting and challenging to the mind of a child. This is easy to do—once you know how to do it. Children already possess a natural curiosity for science. This manual shows you how to take advantage of their curiosity and to present lessons in a way that creates an exciting learning environment in your classroom.

This manual describes easy teacher demonstrations that use basic materials such as water, paper towel tubes, batteries, and balloons. Most of them take only minutes to set up. Use an eraser and chalk to demonstrate how electrons are transferred to a balloon when you statically charge the balloon by rubbing it on your head, or use a Slinky and an energy ball to teach the characteristics of circuits. You can be sure that the students will be watching you as you power a clock with an orange juice battery.

In most books that deal with electricity, static electricity is taught first, probably because it is perceived as being a “simpler” form of electricity than battery-powered electricity. In actuality, static electricity is a more difficult concept for students to learn, as it requires knowledge of atomic structure and atomic charges. Students must know about electrons and protons and that opposite charges attract and similar charges repel one another. In contrast, you can teach about circuits, switches, batteries, insulators, and conductors without the students understanding atomic structure (the exception to this is teaching about current, for which students do need to know about electrons). Thus, static electricity is dealt with later in this manual. However, you can always present this topic earlier in the unit if you choose.

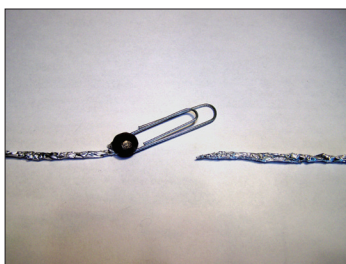
Following the teacher presentations, you can run various student activities at levels that are appropriate for your students’ abilities. This manual is flexible, and there are several opportunities for integration of core subjects. In addition, you can choose from many demonstrations, visual projects, experiments, group projects, and research projects.

This manual also offers suggestions for assessment and shows examples of exemplary student work. In addition, it provides tips on classroom management, critical thinking questions, modifications, clean-up, and safety. The Teacher Resources section contains a variety of downloadable worksheets that you can use as homework or as in-class assignments; these are available from the Royal Fireworks Press website ([rfwp.com](http://rfwp.com)). Many of the images in this book can be projected for the students to see and will help them to understand and internalize the concepts being taught; these are available for download as well.

The internet is a rich source of animations and short video clips. If you have the technology available in your classroom, you can use the keywords provided to search the internet to find websites that you can project during your teaching presentations. For example, you could

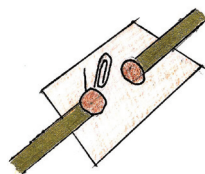
## Student Activity: Switches

A switch is a device that safely opens and closes an electrical circuit. The students can add a simple switch to their aluminum foil circuits using a paper clip. Have them cut the aluminum foil in their circuit and carefully wrap one end of it around the end of a paper clip. When the free end of the paper clip is not touching the aluminum foil, the light bulb will not light, but when the paper clip touches the aluminum foil so that the circuit is complete, the light bulb will light up. Students can make simple switches like this and place them into any circuit that they construct.



Tell the students that these switches are simple versions of a light switch on a wall. The principles of “on” and “off” are exactly the same. Remind the students of the energy ball activity. Explain that the students who broke the circuit by letting go of their hands were actually acting as a switch.

One possible assignment for students who finish early is to have them draw a picture of a switch, as shown at right. This diagram was made using colored pencils on a piece of paper. Establish high expectations for the assignment by requiring students to use a straight edge as they draw their version of a switch.



## Student Activity: Art Circuit

### Materials

aluminum foil	glue
construction paper	light bulb
manila folder	battery

Incorporate art into a simple circuit to make an art project that the students will enjoy. A manila folder makes a good backing to glue construction paper onto. The circuit is made on the back of the folder, with two strips of aluminum foil attached to a battery and the ends of the light bulb. The light bulb sticks through the folder, forming the nose of a clown, the light in a lighthouse, or anything else that the students think of.

*Safety Tip: Use a thumbtack to make a starter hole that you can push a pencil through to make a larger hole.*



*Teaching Tip: It helps to show the students an example to give them an idea of the assignment before they create their own. This also sets the standards that you have for their work. In this case, you want to stress the neatness of cutting and gluing the pieces of construction paper.*



*Teaching Tip: As with the prior activities, the students should not tape the batteries down because they must remove them when the activity is complete.*

# Insulators and Conductors

## Objectives

- Students will define the terms *insulator* and *conductor*.
- Students will compare and contrast insulators and conductors.
- Students will discover which materials are insulators and which are conductors.

## Key Points

- Conductors are materials that allow electricity to pass through them; insulators are materials that do not allow electricity to pass through them.
- All metals are conductors of electricity.
- Common metals include aluminum, copper, steel, iron, and zinc.
- Insulators include materials such as rubber, plastic, glass, and wood.
- Most household wires contain a copper wire surrounded by a plastic or rubber insulator.
- A small pencil without an eraser acts as a wire; the graphite is a conductor, while the wood is an insulator.

## Vocabulary Words

Conductor

Insulator

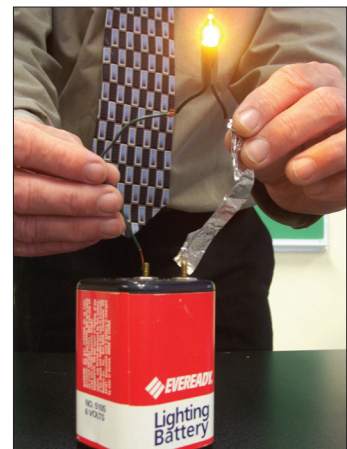
Aluminum

Copper

## Start the Class

Begin this lesson by reviewing with the students what a circuit is. Use a battery, a light bulb, a wire, and a piece of aluminum foil to make a circuit, putting the wire on one side of the circuit and the foil on the other. Remind the students that they can know that electricity is going through the wire and the aluminum foil because they can see the light bulb light up. Define the wire and the aluminum as *conductors* of electricity. Conductors are materials that allow electricity to pass through them.

Remove the aluminum foil, and insert a strip of construction paper into the circuit. Point out how the light bulb does not light up. The paper is therefore an *insulator*. An insulator is something that does not allow electricity to pass through it. Everything is either a conductor or an insulator.



# Batteries

## Objectives

- Students will list the parts of a battery.
- Students will be able to define the term *voltage*.
- Student will relate battery voltage to the intensity of a light bulb.
- Students will understand why batteries should be disposed of properly.

## Key Points

- Batteries store electricity.
- Batteries have a positive end and a negative end.
- Most batteries are made of two different metals separated by a corrosive solution.
- Typical D-cell batteries are made of zinc, carbon, and black electrolytic paste.
- Voltage can be thought of as a type of pressure that pushes electricity through a circuit.
- As long as you have two different metals, you can make a battery out of lemons, potatoes, orange juice, or bleach.

## Vocabulary Words

Battery	Terminal	Positive
Volt	Rechargeable	Negative

## Start the Class

Show a battery to the students. Explain that batteries store electricity and that they release this energy when a circuit is connected to them. Remind the students that batteries have two different ends, or *terminals*.



*Fact: Batteries convert potential chemical energy into electrical energy when a circuit is connected to them.*

Batteries are simple. Explain that a traditional battery is made of two different metals suspended in an acid or base. For example, a common D-cell battery is made of a zinc shell with a carbon rod down the center. The rest of the battery is filled with an acid paste. If you are feeling adventurous, cut open a regular carbon-zinc battery, and show the components to the students. Do not cut open an alkaline or any other kind of battery, as these batteries contain substances that are more toxic. If you do not want to cut a battery in half, simply project the diagram on the next page of a typical D-cell battery for the students to see.

*Safety Tip: Wear gloves if you intend to cut open a D-cell battery.*

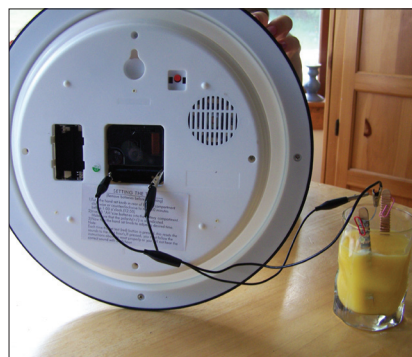
## Teacher Demonstration: Orange Juice Battery

You can also make a battery out of orange juice. This battery uses orange juice as the connection between strips of two different metals (magnesium and copper wire). As with lemons and potatoes, an orange juice battery is low-voltage and doesn't supply enough current to light a traditional light bulb. However, it is possible to connect this battery (as well as lemon and potato batteries) to low-voltage devices such as calculators or clocks that are normally powered by a battery. In fact, you can purchase an orange juice clock kit from select science suppliers.

*Fact: Orange juice contains two acids: citric acid and ascorbic acid (vitamin C).*

An orange juice battery is easy to make, although you do need to use magnesium as one of the metals. Take two popsicle sticks, and wrap one with magnesium and the other with copper wire—the thicker the copper wire, the better. Place both metals (not touching each other) into a glass of orange juice. It helps to attach the sticks to the sides of the glass so that they don't slip in and touch each other. Don't use anything metal to secure the popsicle sticks; plastic-coated paper clips work well.

If you are going to power a clock with the orange juice, remove the AA battery from the clock, and attach the ends of the wires to the connections where the battery would be. This is easy to do using alligator clips. If the clock doesn't work at first, then switch the leads around. The students will be surprised to see the clock start ticking. For fun, leave this experiment set up, and see how long the battery can provide energy to power the clock.



## Teacher Demonstration: Bleach Battery

You can make a more powerful battery that can light a holiday light bulb using a strip of magnesium, some copper wire, and bleach. If you don't have magnesium, you can try strips of tin cut from an aluminum can. Because of the toxic nature of bleach, this battery should not be made by the students.

### Materials

bleach  
strip of magnesium  
copper wire  
cup or beaker  
holiday light bulb

*Materials Tip: Try asking a high school chemistry teacher for a strip of magnesium, as this material is often sold only as a secondary science supply.*





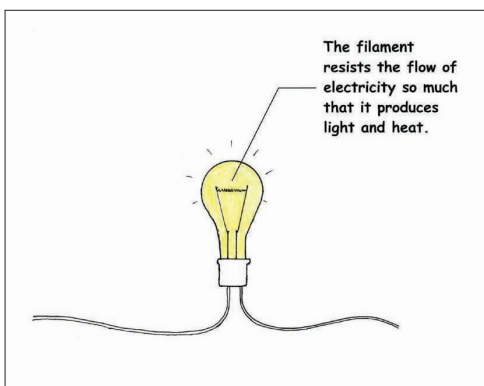
*Extension: Some students will have experienced wires getting hot if they are left connected to a battery for too long. You can demonstrate this for the students by performing the last teacher demonstration in this lesson, which uses a wire wrapped around a thermometer.*

*History Integration: Contrary to popular belief, Thomas Edison did not invent the light bulb but instead designed the first practical light bulb that could glow for weeks instead of hours.*

*Fact: Superconductive materials conduct electricity with no electrical resistance below a critical temperature.*

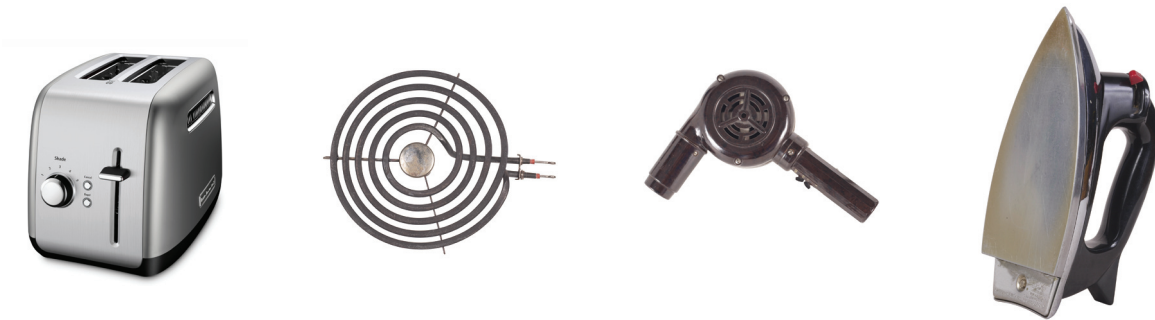
## Teacher Demonstration: Light Bulb

Understanding how a light bulb works is easy and is a topic that connects science to everyday life. A light bulb converts electricity into light. The filament inside a light bulb is made of an incredibly thin metal (tungsten) that has a high resistance. When electrons flow through the filament, a tremendous amount of light (and heat) is generated.



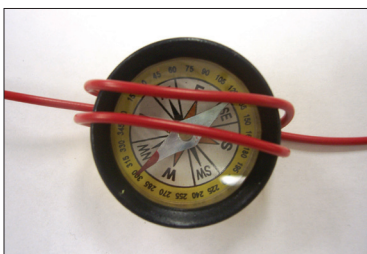
If you have a lamp, plug it in, and display the lit bulb to attract attention. Point out that light bulbs get hot. Project the image at left of a light bulb. With your finger or a pointer, follow the flow of electricity into the bulb, through the filament, and out of the bulb again. Tell the students that the electricity has an easy time flowing through the copper wire circuit until it gets to the filament. Stress how the filament is a special piece of metal that produces a lot of light and heat when electricity passes through it.

Ask the students for examples of other household devices that produce heat. Toasters, hair dryers, coffee makers, water heaters, and electric stoves all take advantage of resistance and produce heat when electricity passes through their heating elements. Define a heating element as being equivalent to the filament in a light bulb, except a heating element produces much more heat than light. Heating elements are also much bigger and are made of different materials than light bulb filaments. Project the following images for the students to see.





*Teaching Tip: Students in the back may not be able to see the needle of the ammeter move. Don't be afraid to have them move closer to see.*



If you don't have an ammeter, simply wrap the wire around a compass, and watch the needle deflect as you pass the magnet in and out of the coils, as shown in the image at left.

Describe to the students how a generator produces electricity either by spinning a magnet inside a coil of wire or by spinning a coil of wire close to some magnets—either way works.

*History Integration: Michael Faraday was a scientist in the 1800s who discovered that magnetism could create electricity. He was the first to create electricity by moving a magnet inside a metal coil. This is arguably one of the greatest scientific discoveries in modern science. In addition, he also designed the first generator, electric motor, and transformer.*

## Teacher Demonstration: Generator



With a little work, you can make a realistic generator. Poke a hole in a small cardboard box, and stick a nail through it. Attach two strong magnets to the nail (use ceramic magnets). Wrap lots of fine copper wire around the box, strip off the insulation on both ends of the wire if it is insulated, and attach the ends to an ammeter. Spin the nail, making sure that the magnets inside the box don't hit the sides of the box. An easy way of spinning

the magnets is by attaching them to an electric drill bit, which allows you to spin the magnets at relatively high speeds.

A generator is an example of how energy can be converted into different forms. In this case, mechanical energy is converted into electrical energy. As an extension, some of the students could learn more about how the energy in a generator is produced.

*Technology Tip: Search the internet for “generator” and “animation” to find websites that show animated videos of magnets spinning in a generator.*

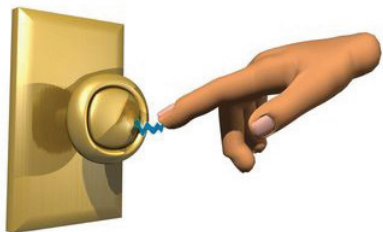
Explain to the students that generators in power plants produce enough electricity for whole towns and cities. Understanding what makes the coils or magnets spin in big generators is a key concept. Big generators have turbines; these are basically big fan blades. When the turbines turn, the generator spins and produces electricity.

In power plants that burn fossil fuels, the turbines are turned by steam produced from boiling water. Similarly, in nuclear power plants, the heat produced from nuclear reactions is used to boil water, which produces steam that turns the turbine. The need to boil water is why all power plants are located next to a body of water. Ask the students if they can think of other ways of making turbines spin. Water and wind are examples of renewable, non-polluting energy sources.

Why did the foolish gardener plant a magnet?  
**He wanted to grow a power plant.**

## Static Shocks

Most students are interested in learning about why they sometimes get shocked on objects. When you walk across a carpet, electrons are transferred from the carpet to you. Now you are negatively charged because you have extra electrons, just like the balloon. When you touch any kind of conductor, such as a metal door knob, instead of simply being attracted to the protons of the knob, the electrons jump from you to the knob. A mini-bolt of lightning forms, and you get a shock. Project the image below as you explain this.



*Teaching Tip: The expression “getting a shock” is misleading. In actuality, you are “giving a shock” when you experience this sensation. As with all static electricity events, this occurs much more frequently in the drier months of winter.*

Ask the students if any of them has ever rubbed his or her hair while underneath a blanket and seen the sparks that are produced in the darkness. This happens because the blanket has extra electrons from their hair.

*Technology Tip: Search the internet for “static electricity” and “animation” to find websites that show animated videos of static electricity that you can play for the students.*

## Lightning

Lightning is the most powerful example of static electricity. Inform the students that we do not completely understand how a bolt of lightning forms. Most scientists believe that the lightning bolt that the human eye sees actually travels from the ground to the cloud. That event, however, is the last in a complicated series of events that starts in the charged cloud. Project the images below so that the students can see them.



*Technology Tip: Search the internet for “lightning” and “animation” to find websites that play interesting lightning animations that you can show to the students.*

As an extension, students could learn more about how the negative charges in the bottom of a cloud pulse down to the earth until a visible bolt of lightning forms from the ground to the cloud.

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