
Electricity

Science Force Grade 4

The purpose of this visit is to explore how batteries work, how current flowing through a wire will pull the needle of a compass, and to experiment with circuits and static electricity.

The lesson plan begins with a ten-minute introduction by the Science Leader. The students will break up into three groups, rotating between three centers every ten minutes. The Science Assistants and the classroom teacher will help the students investigate each center. Directions for each center's activity will be reviewed during the Leader's initial presentation to the students. The Science Leader will gather the class together for the last five minutes of the visit, briefly reviewing and asking the students to explain current flow, how batteries work and static electricity.

Classroom Teacher Prep and Follow-up: Classroom teachers - *please assign the students to group #1, #2 or #3 before entering the lab.* Students do not need to bring anything with them, and they will not bring anything back to the classroom from the lab. As a follow-up, please distribute the parent take-home letter you will receive in your mailbox at the end of the week. If a photographer is in the lab during your visit, please be prepared to identify students who may not be photographed. We will be sending candid photos to the newspapers, and posting photos on our web page, so it is very important that we do not include these students in the photos.

Science Assistant Prep: Parents assisting the class - please read this material, and arrive at the lab 15-minutes early to familiarize yourself with the centers. Your roll will be to ensure safety and prompt the students to investigate the concepts presented by the Science Leader. You will not be responsible for presenting this material, but you will be responsible for facilitating one of the centers. It would be helpful if you read the presentation before coming to the lab.

Suggested Introduction by the Science Leader:

(Pull information from this write up to allow about a total of 10 minutes for the introduction, then rotate centers for ten minutes each, then come together and ask the students to describe their experiments.)

Welcome to the Science Force Lab. This is a special time for you and our parent volunteers to investigate the exciting things you are learning in your classroom. The experiments you do during your Science Force visits are prepared and taught by your parents, and the equipment you use in this lab is purchased using the money from PTA, like the money you made selling Sally Foster gift wrap. (Introduce yourselves and the parent volunteers.)

I know that you are studying Electricity in Science now. In our visit to Science Force today we are going to put what you have already learned to good use as we investigate how batteries, magnets and electricity are similar, how batteries are made, how circuits work, and we will watch some spectacular displays of static electricity.

Center 1 – Magnets & Batteries- How they are Alike and How they Work

Brainstorm with students... What is a force? (A push or pull - Like charges will push away (repel); opposite charges will pull together (attract)). How can a magnet create a push or a pull? (Magnet have North and South seeking poles) That's right! A compass is also a magnet. The magnetized needle seeks the North and South poles of the earth. Did you know a battery could pull a compass needle? How is a battery similar to a magnet? (Positive & Negative charged ends) When the ends of a battery are connected say by a wire this battery, which is an electric cell, supplies energy to move negative charges through the circuit or wire to the positive end of the battery. (Opposites attract) This energy is measured in *volts* so the scientific name for a battery is a *voltaic cell*.

The voltaic cell is named after Count Alessandro Volta who is the inventor. Back in 1790, a biologist was dissecting frog legs. He was surprised when the dead frog legs, hanging from a copper wire, twitched as if alive when touched by an iron knife. The biologist concluded that electricity was stored in the frog's muscles. Volta didn't agree. He determined that the twitching was caused by a chemical reaction between the frog's body fluids and the metals in the copper wire and iron knife. He invented the battery based upon this finding.

How does a battery work: Batteries are used for lots of things. Can you name some? What is the difference for example between AA, D and 9Volt batteries? What about car batteries? What about rechargeable batteries? What makes any battery wear out? You'll explore this in center-1.

All metals tend to dissolve slightly in liquids. Some dissolve faster than others. When a metal atom dissolves, it loses electrons, and forms a charged particle called an ion. These lost electrons collect around the metal and form a negative charge. The liquid around the metal becomes more positive. Not all metals have then same tendency to dissolve, so if you add different metal to the liquid. The charge on that metal and around the liquid around it will be slightly different. When the two metals are connected by a wire, which is a good *conductor* of electrical charges, the charge will flow from the most negatively charged metal to the least. This flow of electrons produces *electric current*.

Batteries can be made of many types of metals and liquids. A car battery is a wet cell; the liquid is a strong acid. A gameboy battery is a dry cell, made with a chemical paste instead of a liquid. The amount and type of chemicals in the battery determine the amount of electricity it will produce, or Voltage. A battery contains the stored energy that turns a chemical reaction into electrical current. A rechargeable battery does not produce a chemical reaction on its own, so is not a Voltaic cell. When charging a rechargeable battery, the electric charge causes a chemical reaction that is reversed when the battery is used or discharged. Forcing electrons to enter the battery backwards recharges it, thus reversing the chemical reaction. This is like winding up a toy. Energy goes in by winding, and then it is released to make the toy work.

What you will do in this center: 1) You will create a magnetic pull stronger then gravity! 2) You will build a voltaic cell using two different metals, copper and zinc and placing them in a 5% acetic acid solution. Smell the solution and guess another name for acetic acid. (Parent hint: Vinegar) Most batteries you use contain much stronger

chemicals, so you would never want to try and open a real battery. Our battery will not generate enough electricity to even light a light bulb, let alone run a gameboy, but it will make the needle of a compass move. 3) Finally, you will see the impact of a D- battery on the compass. After placing it on and off the *circuit* you will discuss the results between the experiments with the battery you made and the D-battery.

Center 2 – Van de Graff Generator

Brainstorm: Can charged particles of matter only move through wires? Have you ever walked across the carpet only to get to the doorknob and be zapped? What's it called? That's right, our next center involves static electricity. What is static electricity? What is the biggest static electric zap you have ever seen? (Lightning) Can you hear static electricity? Why? Give me an example of how you can generate static electricity? Why is friction important?

Matter is made of particles that have mass and volume. These particles have a property called electrical charge. (Positive, negative or neutral) Normally matter is neutral because it has the same number of positive and negative particles. But in this case when we rub 2 objects together (*friction*) the negative charges (*electrons*) can move. The object the electrons moved to becomes negatively charged and the object they left becomes positively charged. (It lost electrons so it has more positive charges than negative). The charge once there stays on the object, which is why it is called *static electricity*. The push and pull between the objects is called an electrical force. The space around this force is an electric field. Sometimes you walk across the carpet and you touch the doorknob and zap! Why? When you walk across the floor, you slowly transfer electrons from the carpet to your shoes. The electrons move as far away from the carpet as possible to your fingers. When you touch a grounded object, like a doorknob, the electrons move so your body will once again be neutral, or without charge. You get a shock as the electrons jump from your finger to the doorknob. The static electricity has become a moving charge or an electrical current. The path this current takes is with out a wire!

I'll demonstrate the transfer of electrons through friction with this balloon and my hair, creating an *electrical force*. (Leader to demonstrate on himself /herself or a child. Best with a person with shoulder length fine hair).

Static electricity has been understood for many years. Benjamin Franklin performed his early experiments in static electricity. The most easily observed static electricity is lightning. Rapid air movement causes static charge to accumulate on the ground and objects. A similar, but opposite charge accumulates in the air. When the two charges become great enough, the positive and negative charges discharge across the gap in the air. This causes lightning. The force of the lightning also sends out compression waves in the air, causing the thunder. The snap of static electricity on a doorknob is just the same, on a smaller scale. We use static electricity for some of our important machines. A laser printer and a photocopier use static charge, too. The photo drum is coated with a special surface that holds a static charge in the dark, but loses the charge when exposed to light. After exposure to a pattern of light, a fine black powder (toner) is sprayed across the drum and the powder only sticks to the drum where it wasn't

exposed to light, the powder is then transfer onto as sheet of paper and then fused (or ironed) on to the paper by heat.

What you will do in this center. You will get a chance to try the balloon demonstration but we also have a machine called a Van de Graff Generator that is a great collector of static charge. A large rubber band moves in circle to rub electric charges and send them to the dome. This electric charge can then be transferred to you through your hand. Place your hand on top of the dome and watch how you become negatively charged. You may need to stand on a plastic stool to make sure the charge is not lost to the ground. If someone touches you while you are charged, it will affect you the same way as it would if you touched a doorknob after scooting across the carpet! You will also make a string dance over the dome by induction. (Induction is the attraction of opposite charges. This is also what made the balloon stick to the wall) As soon as it touches the dome, it becomes negatively charged and is quickly repelled away from the dome. The string is a poor geometric shape for retaining a charge, so it loses its charge quickly, and is once again attracted to the dome. The more humid it is the more quickly the string will snap back and forth. The humidity causes it to lose its charge faster.

The pretend popcorn works the same way. Induction draws it close to the dome, it becomes negatively charged when it touches the dome, and it flies away (repels). It may circle the dome longer or be attracted longer because a sphere is the best shape for retaining a charge.

Center 3 – Making an Electric Circuit

Brainstorm: In your class, you have studied parallel and series circuits. In this center you will use special snap-together components to create parallel and series circuits. We will follow special circuit diagrams and put together the components like a puzzle. The clear plastic base sits over the top of the circuit diagram. Begin placing the components on the base beginning with pieces in layer 1, as indicated by numbered diamonds on the circuit diagram. Then complete the next layers until your circuit is complete.

Circuit #3 is a series circuit. In this series circuit, the fan and the light are along the same current path. Notice that the light only works better if you press your finger gently on the fan to stop or slow the motor. Why?

Circuit #4 is a parallel circuit. Notice the difference this makes when operating the fan and the light, when the current flows through a parallel circuit. Remove the light from the circuit and scoot it so it crosses the circuit before the switch. Think about what this does to your circuit.

Circuit #13 is lots of fun. After you complete this circuit, place a light component on top of the alarm component and notice the difference that the added resistance makes in your circuit. Think about what is happening and try to explain what makes the circuit work this way.

Assistant Instructions:

Center 1- Magnets & Batteries- How they are Alike and How they Work

1. You will demonstrate a compass with no pull other than the Earth's gravity. Line up the needle with the red tip on N. Have a student place the N end of the bar magnet on the N end of the compass. Then switch ends to S magnet on the N end of the Compass. What happens? (The pull of the magnet is stronger than the gravitational pull of the earth.)
2. Building a Voltaic Cell (Battery). In the battery cup, have a student pour enough vinegar to cover an inch of the zinc and copper strips. (Have them guess by smelling the liquid what type of acetic acid solution it is.) Move the compass next to the battery cup and line up the red tip of the needle on the N. Connect the wire with the alligator clips to the terminals attached to the strip. (Zinc then copper) The compass needle should move slightly as the electrical current flowing through the wire pulls it. How could we tell which is the positive and negative terminals in this battery? (Parent hint: The zinc strip is more negative than the copper strip, so determine the flow of electricity by observing the compass. The zinc is the negative terminal and the copper is the positive terminal. The compass may move only very slightly. You can compare it to the way the compass moves with the regular battery in the next activity.) We know that a force is a push or a pull. In this case, the push or pull is very small, but it can be used for many purposes. We call this an electromotive force and it is measured in Volts.
3. Pull out the cardboard that has the D battery the wire and the compass taped on it. Ask the students what they think will happen if the end of the wire is touched to the positive end of the battery? Have a student by holding on to the insulated portion of the wire (plastic coating) touch the free end of the battery with the wire. Observe the compass needle and discuss. Now what will happen if you move the compass below the wire? Carefully remove the taped compass. Have a student place the compass underneath the wire so that both line up along the north-south line. Touch the free end of the battery again. Using what you know about compasses in magnetic fields what can you infer about an electrically charged *current* in a wire? (Opposite charges attract so the electrons move along the wire from the negative end of the battery to the positive.)

Assistant Instructions: Best with 2 volunteers at each group. Rotate groups in this center when each is done.

Center 2 – Static Electricity - Van de Graff Generator (VDG)

Have the students divide into 2 small groups; one group working with the balloon and one with the VDG. Mix boys and girls together because longer hair works better with the balloon.

1. Balloon. Rub the balloon back and forth quickly on your hair. Slowly pull the balloon away from your hair and watch what happens. It sticks to the balloon because your hair gave up negative charged particles (electrons) to the balloon making the balloon negatively charged and your hair positively charged. So why does it stick? (Opposites attract). Now, take the balloon side that you rubbed and place it against the wall. Hold it for a few seconds and let go. (If the student has played with the balloon and their hair too much, the balloon may have lost its charge and you have to rub it against their hair again.) What is happening? The wall was neutrally charged but the negatively charged balloon causes many of the electrons in the wall to move away from the balloon. (Like charges repel). As the negatively charged balloon moves close to the surface of the wall, it pushes some of the electrons on the surface deeper into the wall making the wall positively charged. Because the charges are opposite they now stick. *(Note that the wall was originally neutral. It didn't get any more electrons. The balloon forced some of the wall's electrons to move, leaving behind a positive charge. The balloon was responsible for making the wall "attractive. This type of charging is called **induction**. This is similar to the reason why a magnet can be attracted to a non-magnetic piece of metal ...iron and steel.)*
2. VDG. (a) Find out who might want to feel a little shock? Have one student place their hand softly on the top of the dome. Turn the VDG on. (That student won't be shocked by the VDG). He/she will become negatively charged. When the next student touches the student who had their hand on the VDG, then you'll get a shock like the zap by a doorknob. Why? (Electrons generated by the VDG "charged" the 1st student and those electrons moved out to the grounded student to zap them.) You can create a chain of students to see how far the negative charge will travel. (Start the chain from one hand on the VDG dome and all the students in the chain touching only each other. The "grounded student", the one not connected will touch the last person). What do they feel and why?
(b) Have a student hold the plastic megaphone with the string dangling down over the running VDG. You will see it dance. It snaps back and forth. *(induction)*
(c) Next have student place the packing peanuts on top of the VDG when it is off. What will happen? Why? Turn it on. (Some will jump off some are attracted. Why? Because of their shape they don't loose their charge as quickly and stay attracted).
(d) Other activities, they can put their arm near the VDG when on and feel their hairs pulled toward the dome. They can touch the dome softly with the wand and get a small zap. They may hear the static electricity pop and see sparks like small little lightening bolts. (For every inch of spark it takes a potential of 50,000 volts of electrical charge. That's why lightening can be so dangerous!)

Assistant Instructions: Best with 2 volunteers at each group. The groups **do not** need to rotate.

Center 3 – Making an Electric Circuit: (Divide into 2 smaller groups to work with the 2 kits. Please do not mix up your components with other groups and make sure all the pieces are back in the correct slots in the box.) We will follow special circuit diagrams and put together the components like a puzzle. The clear plastic base sits over the top of the circuit diagram. Line up the dots on the plastic with the dots on the diagram. Begin placing the components on the base beginning with pieces in layer 1, as indicated by numbered diamonds on the circuit diagram. Then complete the next layers until your circuit is complete. (Have different students in each group build each one of the circuits.)

Circuit #3 is a series circuit. In this series circuit, the fan and the light along the same current path. Notice that the light only works or works much brighter if you press your finger gently on the fan to stop or slow the motor. When you release your finger, the fan uses the energy before it reaches the light. You can press the green wire between the motor and the light to more evenly distribute the flow of the current. The fan will spin a little slower and the light will burn a little brighter.

Circuit #4 is a parallel circuit. Notice the difference this makes when operating the fan and the light, when the current flows through a parallel circuit. Remove the light from the circuit and scoot it so it crosses the circuit before the switch. Think about what this does to your circuit.

Circuit #13 is lots of fun. After you complete this circuit, place a light component on top of the alarm component and notice the difference that the added resistance makes in your circuit. Think about what is happening and try to explain what makes the circuit work this way. (The light only gets current when the alarm is resting and drawing no energy.)

3. Lab Materials and Set-up:

- Center 1: Vinegar
 Voltaic cell kit with zinc and copper strips
 Compasses
 D-cell batteries taped on cardboard. (See page f23 of their text book for the setup.)
 Alligator clip wires
 Bar Magnet
- Center 2: Van de Graff Generator
 Extension cord
 Accessories for Van de Graff Generator (String, packing peanuts)
 Plastic box or stool to stand on
 Mirror
 Ballon
- Center 3: AA Batteries
 Switched On circuit kits

