

SOURCE Lesson Plans Detail

Electricity

Topic	Electricity
Program	Brown Science Prep
Developed by	Brown Science Prep
Developer Type	Elementary students

Overview / Purpose / Essential Questions

To understand static electricity, electric current, and simple circuits

Lesson Materials

Balloons
Circuitry wires
Batteries
Resistors
LEDs or small light bulbs
Pennies (copper coated)
Galvanized Nails (zinc coated)
Lemons

Lesson Activities

(See the Electricity Presentation Document Below for the corresponding slides).

PART ONE

Opening Demonstration: rub a balloon on your hair, a willing student's hair, or a piece of wool clothing so that it becomes negatively charged. You can then show that the balloon will stick to a wall, or someone's hair.

[Slide 2] Ask the students if they have guesses of what caused the balloon to stick. Have they heard of static electricity before? What is the cause of this phenomenon?

[Slide 3] You can explain that when you were rubbing the balloon it was becoming negatively charged. When you bring the balloon near another surface it attracts the positive charge within that surface. The force of attraction causes the balloon and other object to stick to each other.

[Slide 4] Explain the physical basis behind charge. Charge is actually a property of particles in atoms called protons and electrons. Electrons are inherently negatively charged and protons are inherently positively charged. The electrons orbit the protons in the nucleus and depending on the type of atom (element) some electrons are bound more tightly than others. The strength of an electron's charge is exactly equal to the strength of a proton's charge. Normally these charges are balanced. Neutrons do not contribute to charge.

[Slide 5] There is a force between any two charges called an "electrostatic force." This means that a positively charged object will be attracted to a negatively charged one and vice versa. (Opposite charges attract, like charges repel). Show that a mathematical equation (Coulomb's Law) can predict the magnitude of this force. The force depends on the sizes of the charges and how far apart they are.

[Slide 6] Some materials don't hold onto their electrons as well as others. When create friction between one of these materials and the surface of another object, electrons can transfer over, unbalancing the charges. Thus, friction usually is the cause of static electricity (just like the balloon).

[Slide 7] Triboelectric series! Different electron affinities of different materials.

[Slide 8] Can the students predict what will happen in the unknown scenarios?
(1. Sticks, 2. Nothing 3. Sticks, 4. Nothing). Can they come up with their own?

[Slide 9] If the charges built up on objects were never able to become neutral again, eventually lots of things would start clumping together. Why doesn't this happen? Just as they can charge, materials can also discharge. Ask if anyone has ever seen the machine in the pictures... This is called a Van de Graaff generator. This kind of Van de Graaff generator is made up of: a motor, a belt, two brushes, two rollers, and two metal spheres. When the motor is turned on, the lower roller (charger) begins turning the belt. Since the belt is made of rubber and the lower roller is covered in silicon tape, the lower roller begins to build a negative charge and the belt builds a positive charge. You can understand why this charge imbalance occurs by looking at the triboelectric series: Silicon is more negative than rubber; therefore, the lower roller is capturing electrons from the belt as it passes over the roller. The belt is positively charged and rolling toward the upper roller and upper brush assembly. The upper brush assembly is connected to the inside of the sphere and hangs near the upper roller and belt location. The electrons in the brush move to the tips of the wires because they are attracted to the positively charged belt. Once the air breaks down as before, the positive atomic nuclei of air are attracted to the brush. At the same time, the free electrons in the air move to the belt. The charged belt touches the inside of the metal sphere, which takes all the charge, leaving the belt neutral. The excess charge then shows up on the outside surface of sphere. It is through this effect that the Van de Graaff generator is able to achieve its huge voltages. For the Van de Graaff generator, the belt is the charged object, delivering a continuous positive charge to the sphere.

[Slide 10] Museum of Science Van de Graaff.

[Slide 11] See if the students can figure out what causes an occasional shock between them and another person. Typically, by walking on a surface with loose electrons (such as carpeting) one person has built up an excess positive charge. When you get close enough to the other person you discharge by contact producing a shock! Just like the Van de Graaff generator...

[Slide 12] Explain that perhaps the last examples of static electricity discharge aren't very impressive. The power of this phenomenon can be seen in lightning. When the atmosphere becomes negatively charged it can discharge into the ground producing impressive lightning bolts.

[Slide 13] Some tips on lightning safety. Can you think of why each one makes sense?

PART TWO (the parts of circuits)

Let the students take time as a group to build circuits that show the concepts (19-21).

[Slide 14] Most batteries that we use today create a potential through opposing chemical reactions—one reaction consumes electrons and the other reaction releases electrons.

[Slide 15] Voltage. The “desire” or “pressure” for a charge to move can be related to voltage. Batteries have voltages because electrons want to flow from the negative terminal to the positive terminal as if there is a pressure behind them. The stronger the desire for charge to flow from one place to another the stronger the voltage will be.

ANALOGY: voltage is like pressure in a water pipe; a battery is like a pump.

[Slide 16] Electric Field.

[Slide 17] Current is simply the flow of charge. When the terminals of a battery are connected by a wire current is produced. ANALOGY: current is the water flowing in the pipe. A strong current means lots of water (charge) flowing.

[Slide 18] The difference between a conductor and an insulator. See if the students can think of other examples. Are people conductors? (yes—that's how we can be struck by lightning). Is water a conductor? (ionized water is a good conductor, while deionized water is a very poor conductor) The ground? (good conductor, indeed—this is how “grounding” works).

[Slide 19] Circuit: a complete path for current to flow through with an emf device. Show how circuits are normally drawn following the template on the slide.

[Slide 20] Resistors. Slow down current. The resistance is a property of the path of the circuit. It can depend on the material and the specifics of the shape of the conductor (i.e. type of metal and wire width).

[Slide 21] Discuss the difference between a parallel and series circuit. What happens if a bulb dies in parallel? (nothing) In series? (the other bulb goes out). If you arranged lightbulbs in the circuits as shown, how would the brightness of the bulbs change? (the light bulbs in parallel stay at constant brightness while the ones in series dim). Why is this? Brightness is dependent on power which depends on current ($P = i \cdot i \cdot R$). From Ohm's law ($V = IR$), we know that the current depends on voltage. If the battery supplies a constant voltage of 9V, this voltage drop is split into two for the bulbs in series, whereas it stays whole for the bulbs in parallel.

[Slide 20] Lemon batteries!!! Push a zinc coated nail and penny into the citrus fruit. A redox reaction takes place which produces an electric potential. Show that the end with the nail produces extra electrons, while the end with the penny desires electrons. Each group's battery isn't sufficient to power a

light bulb, but when together in series they will hopefully light a 1.5V bulb!

Wrap up / Conclusion

Slide 19, "Circuits"

Slide 20, "Resistors"

If you have two resistors of different resistances (the color codings look different), see if you can determine which one has a higher resistance.

Slide 20/21

Show that an extra light bulb acts as a resistor.

Next, point out that all of these circuits are parallel circuits.

Slide 21, "Series vs. Parallel"

Discuss the questions on the slides before you build the parallel circuit.

Predict what will happen for the next two circuits:

Supporting Web Information

Electricity Presentation Document

Pre Assessment Plan

1. What is a charge?
2. Explain the concept of electrostatic force
3. What is electric field?
4. Draw a diagram showing the direction of electric field like for a positive charge, a negative charge, positive and negative charge separated by a 100cm.
5. What is the relationship between the direction of electric field and electrostatic force?
6. What happen when two identical charge sphere touches?

Post Assessment Plan

1. What is a charge?
2. Explain the concept of electrostatic force
3. What is electric field?
4. Draw a diagram showing the direction of electric field like for a positive charge, a negative charge, positive and negative charge separated by a 100cm.
5. What is the relationship between the direction of electric field and electrostatic force?
6. What happen when two identical charge sphere touches?

Supplies List

QTY	UNIT	ITEM
1	Each	Balloons
2	Each	Batteries
2	Each	Resistors (labeled 2, 10, 40, 70, 100, and 500 mi)
2	Each	Light bulbs
1	Each	Penny

Alignment Info

Audience(s)	High school students
STEM Area(s)	Physics
Standard(s)	<i>Physical Sciences (RI GSE) PS2.9–11.7a</i> Students demonstrate an understanding of electromagnetism by... explaining through words, diagrams, models, or electrostatic demonstrations the principle that like charges repel and unlike charges attract. <i>Physical Sciences (RI GSE) PS2.9–11.7b</i> Students demonstrate an understanding of electromagnetism by... explaining through words, charts, diagrams, and models the effects of distance and the amount of charge on the strength of the electrical force present. <i>Physical Sciences (RI GSE) PS2.9–11.7c</i> Students demonstrate an understanding of electromagnetism by... describing the relationship between moving electric charges and magnetic fields.
Activity Type(s)	Lecture
Grade Level(s)	High School
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