Batteries and the Flow of Charge
"How to Power your Smartphone for a Week"

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Target Grades: High School Physics

Time Required: 50 minutes

Materials Needed:
Activity One (Per group of students)
- One lemon, one apple, one zinc coated nail, one 3.5 inch #12 copper wire, and one multimeter.

Activity Two
- Batteries.pptx

Background Information
Students will have been previously introduced to atoms, insulators and charge conductors.

Atoms are the basic unit of a chemical element. They consist of electrons surrounding a nucleus of protons and neutrons. The movement of these subatomic particles results in electricity. Electricity is a type of energy that can build up in one place (static) or flow from one place to another (current).

Static electricity, like what happens when you rub a balloon on your head, is caused by electrons, which are negatively charged, being transferred from one thing to another. This results in 1 item that is negatively charged (having extra electrons) and 1 item that is positively charged (having too few electrons). Opposite charges attract resulting in static electricity.

Current electricity, like what happens when you put a battery into a toy, is caused by electrons moving from one place to another. When you put a battery (potential energy) into a flashlight and turn it on, the electrons begin to flow through a circuit consisting of the switch, lamp, and battery connected by wire.

Copper wire, like that in a flashlight, is a very good conductor. Conductors are materials that allow the flow of electrical current. Examples include: aqueous salt solutions, the human body, and metals. Insulators are materials that stop the flow of electrical current. Examples include: wood, glass, rubber, and Styrofoam.

Lesson Objective: Students will learn that free electrons are the method of which charge flows. Students will learn that voltage is only a part of the requirements to power objects.

- Students will be able to explain electron flow.
- Students will apply the concept of equilibrium to develop a solution of the problem of why do the electrons stop flowing.
- Students will be able to describe the fundamentals of battery technology and discuss current battery technology.
- Students will be able to discuss relative power storage options.

Instructional Process

How will you begin?
• Before the first activity, the instructor pulls out a cell phone and exclaims that his or her cell phone battery is dead.
  ○ "With no charger, what are we going to do? All of my important numbers are on this phone."
• Students should be grouped in groups of 3 students to a maximum of 5 students.
  ○ Student roles should include a group leader, and experimenters.
	Time
	10 min
		Beginning

Transition		

Activity One
Each student team gets a lemon, an apple, a zinc coated nail, and a 3.5 inch long piece of 12 gage copper wire.
• Students push the nail and the copper wire and the nail through the skin of the fruit.
• Students use a galvanometer or multi-meter and touch one lead to the nail and the other to the copper wire.
• Did the meter move to the right or try and move to the left?
  ○ If the meter moves to the left, then the students should swap the meter leads.
• Critical questions:
  ○ What did your team need to do in order to make the meter move?
  ○ What is happened if you reverse the meter leads?
  ○ Which pole (nail or copper wire) did you put the red lead of the meter?
  ▪ What do you think that means with regard to the flow of electrons?
  ○ Knowing what you know about electrons, describe what happened to the electrons in the lemon?
  ○ Now switch the multi-meter to current mode and determine the current of the apple or lemon. What is the current of each of these?
  ○ Power = Voltage x Current; if light bulbs require between 60 watts and 100 watts of power. How many lemons would you need to power a light bulb?
  ○ What research is being done on Batteries?
Activity one will be assessed for misconceptions. Concerns with student work should be addressed by re-teaching.
 	
Activity Two
• Instructor to show the PowerPoint "batteries.pptx"
 	
During the activities the instructor should circulate and ask key questions.
• Things tend to balance out. If smoke comes into a room; the smoke spreads out equally in the room. The idea is called equilibrium. If we think about electrons in that way, electrons are attracted to one of the posts and we send them back to the other post through the meter. Why would the electrons ever stop flowing?
• Why don't we use stored battery power for all of our vehicles?
	Time
	30 min
		Middle

Transition		
How will you close the lesson? At class end the teacher will summarize the lesson and students will write a quick exit ticket describing three things they learned. Subsequent quizzes will assess if this material has been retained. • All batteries have available electrons. These electrons are attracted to one "pole" of the battery and are available to move through a wire to power a cell phone, turn on a light or other device. The electrons return to the other pole of the battery. • There is a distinct difference between batteries that are for a single use and those that recharge.	Time 10 min	**End**

Assessment/Follow-up: Activity one will be assessed for misconceptions. Concerns with student work should be addressed by re-teaching.
The PowerPoint on batteries will be assessed by the exit ticket questions.
Subsequent quizzes will assess if this material has been retained.

Key Vocabulary: electrons, voltage, battery, anode, cathode, primary batteries, secondary batteries, cell potential, cell capacity, cell energy

Safety and Cleanup Required: Students should be aware of the following safety concerns:
Sharps (nail & wire) – avoid pricking yourself or others
Electricity (wire and multimeter)- Avoid contact with water. Do not put parts into your mouth.
Food (apple and lemon) – Lab equipment should not be eaten, even when it may be considered food outside of the lab environment. Do not eat the fruit.
Used apples and lemons can be disposed in the trash. The nail and wire can be reused for future classes.

Alignment with the Next Generation Science Standards:
HS-PS3-1 Energy - Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-3. Energy - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy