Solar-Powered Battery Charger

Suggested Level: Grades 3 through 7

LEARNING OUTCOME

After designing and testing a solar-powered battery charger, students are able to describe the relationship between the direction of electrons flowing through a battery and a change in the battery's voltage.

LESSON OVERVIEW

In this lesson, students design and construct their proposals intended to show the way solar cells must be connected to produce adequate voltage to recharge a battery.

In doing so, students may use the simple ammeter they designed and built in the Solar Kit lesson *Build a Simple Ammeter* or a digital multimeter.

MATERIALS

Per work group

- Digital multimeter
- "Dead" rechargeable D lithium ion battery of any size
- Battery holder to fit the battery selected
- Alligator clip wires
- Electromagnet-and-compass ammeter from the lesson *Build a Simple Ammeter*
- Masking tape
- Two 1 V, 400 mA mini–solar panels
- Gooseneck lamp with 100-watt incandescent bulb

SAFETY

Warn students that the bulb will become hot enough to cause a burn if touched. If a charged battery powers the electromagnet, it should remain connected for only a short period of time. Warn students that if it is connected over a longer period, the battery or wire may get hot enough to cause a burn, and the battery will discharge quickly.

TEACHING THE LESSON

Preferably, this lesson directly follows the lesson *Build a Simple Ammeter*. Students should work in groups of two or more. Set out all materials at the workstations.

The basic concepts of recharging a battery are described in the student handout. If you are unfamiliar with these concepts, read the handout before the classroom discussion. Ask students to describe what they know about batteries and recharging batteries. Tell students that in this lesson they will use these concepts to design and test a solar-powered battery charger.

Show students how to use a digital multimeter to read voltages. If they do not have access to the electromagnet-and-compass ammeters from *Build a Simple Ammeter*, show them how to use the digital multimeter to read current in milliamps. Make sure they understand that if the ammeter reading is positive, the electrons are flowing into the negative terminal of the meter. You may want them to determine this by using the digital ammeter to complete a modified version of Step 5 in *Build a Simple Ammeter*.

Pass out the handout and have students follow the directions.

Review Discussion:

Use a drawing or schematic to review with students why placing the solar panels in series was necessary to provide the electromotive force to drive electrons into the negative terminal of the battery.

Have students compare what they learned about placing solar panels in series in this lesson with what they learned about placing solar panels in parallel in *Build a Simple Ammeter*.

Review how to tell if a battery is recharged. (The battery will stop drawing current from the solar panels.)

You may want to set some of the charging circuits in direct sunlight for a day so students can see that the solar panels can fully recharge the batteries.

ACCEPTABLE STUDENT RESPONSES

1) Lamp and solar cell positioned as described in handout.

2) Measurements as follows:

Source	Voltage
Solar Panel 1	.9 V to 1.0 V
Solar Panel 2	.9 V to 1.0 V
Dead Battery	.3 V to.8 V
Charged Battery	1.5 V

3) Electromagnet-and-compass ammeter working as described.

4) Responses will vary. The final design, however, should show the two mini–solar panels, the dead battery, and the ammeter all wired in series with the negative terminal of the battery connected to the negative terminal of the series solar panels, perhaps through the ammeter. Students can demonstrate how the ammeter indicates that electrons are flowing into the negative terminal of the battery.

5) The solar panels are connected in series so their combined voltage can provide the force needed to push electrons into the negative terminal of the battery, even when it is almost recharged.

The battery is recharged when the ammeter stops indicating that any electrons are moving. (The battery has stopped drawing current for the solar panels.)

BACKGROUND INFORMATION

Building a solar-powered battery charger is an inherently safe activity for students because of the way solar cells self-limit the amount of current they produce. Recharging a battery at too fast a rate (too high a current) might cause a buildup of gas inside the battery, potentially causing it to explode. Charging batteries with mini–solar panels eliminates this potential safety hazard.

If a charging battery is left connected with no light source on the solar panels, it will leak current through the panels and slowly discharge. This leakage can be avoided by placing a diode in series in such a way as to block this reverse current. If this is done, another solar panel will be needed to overcome the voltage drop across the diode during charging.

(STUDENT HANDOUT FOLLOWS)

Name ____ Date ______________

Solar-Powered Battery Charger

In this activity you will design and test a solar-powered battery charger.

Introduction

The voltage of a power source indicates its ability to force electrons through an electrical circuit. When a battery is connected to a circuit (such as when you turn on the switch of a flashlight to connect its battery to its light bulb), it forces electrons out of its negative terminal (marked with a minus [-] sign), through the circuit, and into its positive terminal (marked with a plus [+] sign). This action slowly changes the chemical makeup of the battery. With use, this change reduces the voltage of the battery and eventually, the battery can no longer force the electrons through the circuit. At this point we say the battery is "dead."

For some dead batteries, another power source can be used to force the electrons to flow in the opposite direction and cause the chemical makeup of the battery to return to its original state. The battery is then "recharged." In order to do this, the voltage of the other power source must be greater than the charged voltage of the battery.

In this lab you will use two mini–solar panels as a power source to recharge your battery.

1) **Power Source:** Tape two mini–solar panels to the table and position the 100-watt lamp 20 cm above the panels. Do not place the lamp any closer because it may melt a panel's plastic cover. Position the lamp so it is the same distance from both panels. Turn the lamp on only when taking a measurement or testing your design.

2) **Measure voltages:** Follow your teacher's instructions on how to measure the open circuit output voltage of each solar panel and the dead battery. Record these measurements in Table 1.

Table 1

Source	Voltage
Solar Panel 1	
Solar Panel 2	
Dead Battery	
Charged Battery	1.5 V

3) **Set up an ammeter:** Set up the electromagnet-and-compass ammeter your team built. Using one solar panel, test the ammeter to ensure it is still operational. The needle should deflect 15 to 20 degrees when the lamp is turned on.

4) **Design and test the battery charger:** On paper, draw a diagram showing how to connect the two solar panels, the dead battery, and the ammeter so that when the light is turned on, electrons will flow from the solar panels into the negative terminal (-) of the battery. Remember, your ammeter has been calibrated to tell you the direction in which electrons are flowing.

   Once you have drawn a circuit you believe will work, build and test it. If your ammeter does not show you that electrons are flowing into the negative terminal of the battery, check all of your connections. If this is not the problem, redesign your circuit. Then rebuild and retest it.

   When you have a working circuit, ask your teacher to confirm it.

5) **Complete the following:**
   Explain WHY you connected the two solar panels in the way you did in hopes of producing a working battery charger.

   Without touching the circuit, how would you know when your battery is recharged?