Name: ____ Per. __________

Portable Solar Battery Charger Challenge

What's the Problem?

Scenario
A major clothing designer has requested an efficient portable solar battery charger made with flexible solar modules, which is necessary for a renewable energy wearable garment.

Design Challenge
Design and build the smallest, cheapest, most efficient portable solar battery charger that produces adequate voltage to recharge 3 - 1.5 volt rechargeable batteries.

Criteria
All designs must:
- Include one or more flexible solar modules
- Be able to charge 3 - 1.5 volt rechargeable NiMH batteries
- Be powered by sunlight or a 100-watt incandescent bulb

Constraints
- Testing should be done with sunlight or in the classroom with a 100W incandescent bulb in a lamp ***no closer than 120 cm***.
- Since the solar modules will be placed on a curved surface in the final design, testing should be conducted on an outside curved surface i.e., a bowl or your helmet with the same directional placement each time.

Materials
Each partner group will need:
- 1, digital multimeter
- 3, "dead", discharged, rechargeable AAA-NiMH batteries
- 1, AAA-battery holder with alligator clip leads
- Diode
- 2-6, Alligator clips
- 1, clip-on clamp light or gooseneck lamp with 100-watt incandescent bulb
- 1, file folder, plastic bowl, or bicycle helmet
- 1, roll of electrical tape
- Various sizes of flexible solar modules for testing
  (example: SolarMade.com makes PowerFilm® modules (1.8-15.4 V))
- Wire strippers

You may want to solder your wires instead of using alligator clips, in which case you will additionally need:
- Soldering iron if you plan on soldering wires to solar panels
- Red and black 14 gauge wire for soldering to solar modules
- Goggles

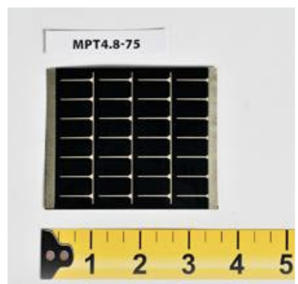
STEP 1: Background Information

In this activity you will design and test a portable solar-powered battery charger.
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), electrons leave from the negative terminal (marked with a minus [-] sign), through the circuit, and flow into the positive terminal (marked with a plus [+] sign). This action slowly changes the chemical makeup of the battery. With use, this change slowly reduces the voltage of the battery until, and at some point, there isn't enough electric "force" drawing (pushing) electrons from the positive to the negative terminal of the battery. At this point we say the battery is "dead." Note that we consider batteries "dead" once they no longer work in the circuit they are designed for. This doesn't actually mean that the batteries become *fully* discharged, but that the "push" from the smaller voltage isn't enough to get the electrons to move through the circuit.

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.

Additional Information on Solar Panels:

Read the information on the flexible solar panels before you start. This information is from the Solarmade.com website. You may need to read more information on this site in order to get more background information for your final project. (http://www.solarmade.com/resources/powerfilm-information/powerfilm-oem-instructions)



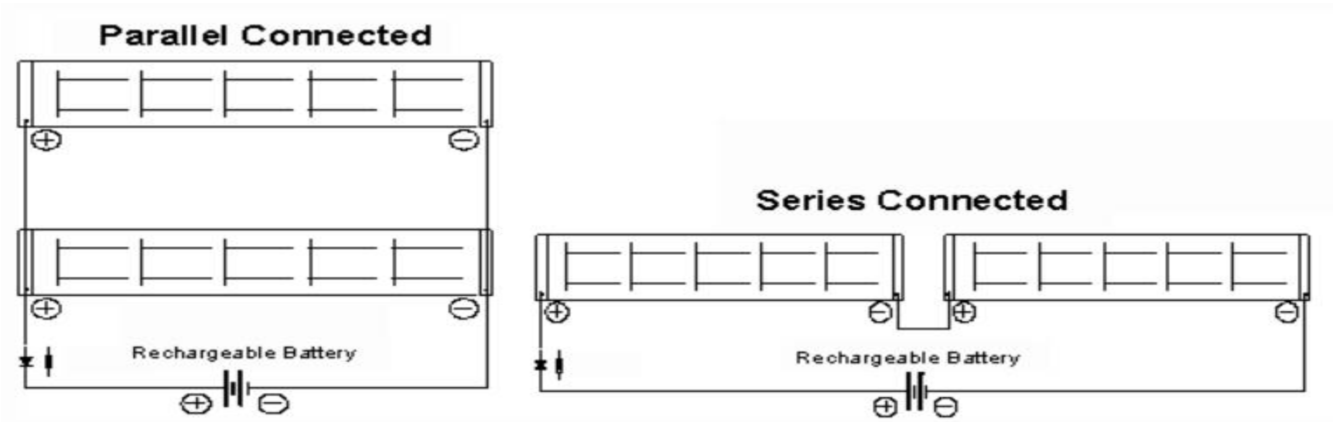
Operating Voltage: 4.8 Volts; Operating current: 50 milliAmps

Operating Voltage: 3.0 Volts; Operating current: 50 milliAmps

It is extremely important to recognize the correct polarity of the PowerFilm ® modules!

The positive end of the solar module is shown in the diagram below. A diode, such as 1N5817, is recommended to prevent the solar module from draining the battery when the solar module is in the dark. A diode is not required for a battery-free electrical device. The positive end of the module connects to the positive end of the load. The negative end of the module is also shown in the diagram and should be connected to the negative end of the load. The recommended connector wire size is a minimum size of 24-gauge. As an extra measure, connect the solar module to a digital multimeter for polarity (+,-) identification. On solar modules with copper tape leads, remove a small piece of the clear coating that is on top of the copper tape to ensure good contact between the alligator clips of the digital multimeter and the copper tape.

Warning! Do not connect a *charged* battery backwards or reverse polarity to the solar module; this will destroy the solar module and may cause the battery to explode, causing bodily harm, even death!



STEP 2: Setting up a Solar Testing Station

Guiding Question: How does increasing the ***voltage*** *or* ***current (****number of solar modules in series times V of solar module) affect the charging time for* ***three*** *AAA NiMH rechargeable* batteries*?*

Your team's task is to set up a system of a combination of flexible solar panels attached to a bike helmet test strip (file folder). Place the helmet test strip in a set position in the sun or under a light stand for voltage testing. You will be assigned certain sizes, voltage, and amps of solar panels to test. You will also be asked to set the system up in series or parallel. Be sure to label next to your panels. **Your station team will need to report your findings to the group.**

(Note: Turn the lamp on *only* when testing your design and taking measurements.)

1. Gather your materials and decide which item will be your testing surface (file folder, bowl, bike helmet, or other material).
2. If testing inside, position a Clamp Light and 100W incandescent bulb 120cm from the surface of your testing surface. *Leave off for now.*
3. Use electrical tape to attach your mini flexible solar modules to a test surface in the correct positive/negative position(s).
4. Connect wires or alligator clips to the conductive tape leads on the solar panel (you may need to remove a small piece of the clear coating that is on top of the conductive tape on the side of the solar module, if necessary, to ensure a good connection).
5. Connect the negative wire to the negative prong on your multimeter and the positive end on the positive prong on your multimeter for testing. Make and record an initial reading.
6. Connect the positive end of the battery holder with discharged batteries to the positive lead from the solar panels. Then attach the negative lead from the battery holder to the negative lead.

7. Go out in the sun or position the 100-watt lamp 120 cm above the panels. ***Do not place the lamp any closer***, as it may melt the solar panel's plastic cover.
8. Turn on the light (if testing inside), begin your first test, and watch for the set amount of time. When the time is up, record the voltage with a multimeter. Record results in the data table.

STEP 3: Collecting Data

Write down your assigned combination of solar panels in the box to the left. Record your initial measurements from the solar panels at your station using a multimeter and record measurements in table 1. Measure at the set increments set by the class.

Table 1

Solar Panel Test Set-up:	**Start time:**	**Check time:**	**Voltage:**
Number of Solar panel (s):_________ **Sizes:___________________________**			

STEP 4: Class Discussion of results

Be ready to share your results. Each group will report their findings and discuss which combination of solar panels will work best for the battery recharger project. Recall our guiding question, "*How does increasing the **voltage** or **current** affect the charging time for **three** AAA NiMH rechargeable* batteries*?"* Think about your research. Think back to your original questions and fill out the C-E-R chart.

Claim/Evidence/Reasoning Chart.

Claim	Evidence	Reasoning
What claim can you make about our original question?	What evidence in your data supports your claim?	What reason supports your claim and evidence?

STEP 5: Design your flexible solar module battery charger

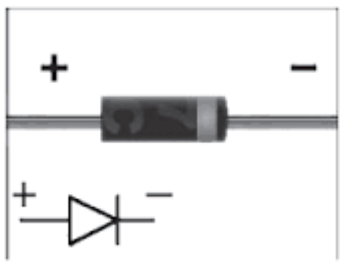
Now that you have figured out what you feel is the best combination of solar panels, you will need to draw a diagram (below) showing how to connect the solar modules, the “dead” batteries, and battery holder using alligator clips and wires. You will use your bicycle helmet or an upside down bowl for your testing surface. Be sure to include the sun location (or lamp if indoors) and label all parts of your system.

Sample set up:

Do you think you need a diode in the circuit?

What's going to happen when we ride our bike in a tunnel, we need to go inside, or class is over for the day and the lights go off?

If a charging battery is left connected with no light source on the solar modules, it may leak current through the modules 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 module will be needed to overcome the voltage drop across the diode during charging.



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Do you need to place your diode in a certain position?
The diode is like a one-way valve. It allows current to flow from the solar module into the batteries but prevents current from the batteries to flow back into the solar module.