



CONNECTICUT
CLEAN ENERGY FUND

SOLAR ENERGY LESSON

ANSWER GUIDE



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BATTERIES AND BULBS

You have been given a battery, a wire, and a light bulb. Your task is to light up the bulb and to document the different battery/bulb/wire configurations you test.

* Note - for this activity, do NOT give students a battery holder

- A. Show, as completely as you can, **4 different** arrangements that DID NOT light the bulb.

Answers will vary.

- B. Show, as completely as you can, **4 different** arrangements that DID light the bulb.

A correct diagram will show a complete circuit that includes connections to both terminals of the battery and both the bottom and side of the light bulb base.

1. Bottom of light bulb base touching positive battery terminal and a wire connecting the side of the light bulb base to the negative battery terminal.
2. Side of light bulb base touching positive battery terminal and a wire connecting the bottom of the light bulb base to the negative battery terminal.
3. Bottom of light bulb base touching negative battery terminal and a wire connecting the side of the light bulb base to the positive battery terminal.
4. Side of light bulb base touching negative battery terminal and a wire connecting the bottom of the light bulb base to the positive battery terminal.



ANALYSIS QUESTIONS

1. Based on your observations, list as many rules as possible that must be followed in order to light up the bulb.

Answers will vary.

2. Based on your observations of what worked and what did not work, what do you think the wiring inside of a light bulb looks like? Draw an outline of the light bulb, and inside of it, show what you think the wiring might look like.

A correct answer will include internal wiring that shows a wire going to the side of the base of the bulb and to the bottom of the bulb.

3. Explain how your rules relate to your idea of what the wiring inside a light bulb looks like.

Answers will depend on rules and diagram.

4. Think about the arrangements that worked. What do you think would happen if the wires you used were much longer – would it take the bulb more time, less time, or the same time to light up compared to when the wire was shorter? Explain why.

It takes the same amount of time because the electrons that are needed to move through the circuit are already a part of the wire. That is, one does not need to 'wait' for the electrons to travel to the filament part of the bulb – they are already there, they just need the voltage to get them to move!



MEASURING CURRENT AND VOLTAGE

Make a working simple circuit using one battery, some connecting wires, and a motor. Place the battery in the battery holder and connect one wire (using the alligator clip) to each side of the battery. Then, connect each 'free end' of the wire to a wire coming out of the motor (again, use the alligator clips). It *does not* matter which side of the battery is connected to which wire on the motor.

1. Using the multimeter, measure the voltage **across** the battery. Record the voltage in the table below. **(The multimeter must be 'in parallel' with the battery).**
2. Measure the current **through** the circuit. Record the current in the table below.
3. Calculate the resistance of the circuit using Ohms Law ($V = IR$). Record the resistance in the table below. **(The multimeter must be 'in series' with the circuit components – the circuit must be broken and the multimeter inserted).**
4. Calculate the power output of the circuit ($P = IV$) Record the power in the table below.

Add a second battery to your circuit.

1. Measure and record the voltage across the two batteries.
2. Measure and record the current through the circuit.
3. Calculate and record the resistance of the circuit.
4. Calculate and record the power output of the circuit.

Remove the batteries from your circuit. Replace them with a solar cell. Using the light source provided, shine light on your solar cell so that the motor runs.

1. Measure and record the voltage across the solar cell.
2. Measure and record the current through the circuit.
3. Calculate and record the resistance of the circuit.
4. Calculate and record the power output of the circuit.

| Voltage Source | Voltage (V) | Current (A) | Resistance (Ω) | Power (W) |
|----------------|-------------|-------------|-------------------------|-----------|
| 1 Battery | | | | |
| 2 Batteries | | | | |
| 1 Solar Cell | | | | |



ANALYSIS QUESTIONS

1. What happened to the current in your circuit when a second battery was added? Why did this happen?

The current increases because there is more voltage.

2. What do you think would happen to the current in your circuit if the number of batteries (or solar cells) remained the same but more motors were added?

The current would decrease as more circuit elements are added. Each additional motor increases the overall resistance, which decreases the current.

3. How is a solar cell like a battery? How is it different?

Answers will vary.

4. Compare the power output of the solar cell to the power output of the battery.

Answers will vary based on data.

5. What are the advantages and disadvantages of using a solar cell to power your motor instead of a battery?

Answers will vary.

6. What factors do you think might effect the power output of a solar cell?

Answers will vary.



FACTORS THAT EFFECT THE POWER OUTPUT OF A SOLAR CELL

The object of this experiment is to investigate the factors that affect the power output of a solar cell.

You may have seen solar cells and modules on people's homes and businesses or even your school. These cells are capturing the sun's energy and changing it into electricity for us to use. You may be asking yourself why we would want to use the sun's light for electricity when we have so many other energy resources. The answer is that every day more solar energy falls to the Earth than the total amount of energy the planet's 6.1 billion inhabitants would consume in 27 years! In other words, there is plenty of sunlight to go around and we won't run out of it until the sun dies (which is not expected to happen for another 4.5 billion years!). This makes the sun a renewable resource. Every day scientists are researching ways to make solar energy easier and less expensive to use. They want to find ways to make energy from the sun more economical for us to use in our communities so that we can decrease our nonrenewable energy use. Thus, scientists are continually investigating ways to increase the efficiency and power output of solar cells.

The first step in this investigation is for your group to brainstorm what factors you think might affect the power output of a solar cell. Some factors you may wish to consider are the distance of the cell from a light source, the wattage of the light source, the wavelength of the light source, or the angle at which the light hits the cell. You may also think of other ideas! After you have decided what you think will make a difference, your group is going to test your predictions. Remember that once you have determined that one factor does make a difference, there is no reason to test it again with the next factor. For example, if you found that color does or does not make a difference, there is no reason to test the next factor that you think has an effect for all the different colors, because you already know the effect of color.

Your experiment should include:

- A clear problem statement that includes the independent and dependent variables in your experiment.
- A description of the experiment you carried out. Your procedure should be clear and complete so that someone else could easily replicate your experiment.
- The results of your experiment. All data tables and/or appropriate graphs should be properly labeled.
- Conclusions from the experiment. All of your conclusions should be clearly supported by data.
- Comments about the validity of your results. Any factors that contribute to confidence (or a lack of confidence) in your results or conclusions should be discussed. Also indicate ways that your experiment could be improved if you were to do it again.

