"So Much Snow, So Little Light!"

Teacher's Guide:

Materials:
.5 volt, 200 milliamp solar cells can be purchased from H&R Co. (1-800-848-8001) for $5.50. Catalog # SW-004.

Or

Kelvin.com solar cells (260098) $2.45 each, meters (990177) $7.95 each

Set Up:
Your lab equipment and configuration will dictate how you direct students to set up the materials pictured on p. 2. Flashlights or sunlight can be substitutes for the light source and ring stand pictured in the diagram.

Calibrating:
The student directions instruct them to adjust the distance between the light source and solar cells so that any angles between 0 and 90 will produce electric currents within the range of the milliamp meter used. Students might need help with this calibration.

Standards

VT:
Inquiry: 7.1 cc Inquiry **GCEs All**
Notation and Representation: 1.17 aaa, ccc
Universe, Earth, Environment: 7.15 dd ee
NSES:

Scientific Inquiry: (5-8) 1.2, 1.3, 1.4, 1.5
Physical Science (5-8) 3.1, 3.6
Earth Science: (5-8) 3.4

Grade Cluster Expectations:
S : 23 (Physical Science--Heat Energy)
S : 48(Universe, Earth & Environment--Seasons)

Score Guide

1a. Make a hypothesis that answers the question **What effect does the angle of sunlight hitting a surface have on the energy received by that surface?** Justify your hypothesis by using your knowledge of earth movements and seasons.

Key Elements:

- Hypothesis includes cause (angle of light) and effect (energy received by the surface)
- A rationale is stated, based on the scenario or on prior knowledge.

1b. If your hypothesis is correct, make a prediction as to how changes in the angle of the light hitting the solar cell will affect the amount of energy (milliamps) produced by the solar cell.

- Prediction includes cause (angle of light) and effect (milliamps produced)

2. Record the results of your experiment in the table on the next page.

Key Elements:

- All data points are entered for the 3 trials
- Average milliamps calculated correctly

3. Use the data from your table to graph the angle tilt vs. electrical energy produced and draw a best-fit curve.

Key Elements:

- Student accurately labels the independent variable (angle-degrees) on the X-axis and the dependant variable (energy - milliamps) on the Y-axis.
- Student accurately assigns a scale for the axes.
- Units are provided for each axis.
- Student accurately plots data points.
- Student draws best-fit curve.

4. Use your graph to explain the relationship between the angle of light tilt and the electricity produced

Key Element:

- As the angle that the light strikes the solar cell increases, the amt. of energy (electricity) also increases

or

- The solar cell produces more electricity when the light strikes it directly and less electricity when the light strikes it at a slant.

5. Examine your experimental set up and data collection carefully. Name at least 3 possible errors an experimenter could make and explain how these errors could change the data.

Key Elements: Three key elements and affect on data.

- light is not in same position for all trials:
- intensity of the light fluctuates
- angles were not measured accurately
- any reasonable answer with an explanation

6. Do the results of your experiment provide evidence that supports your hypothesis?

☐ **Evidence <u>Does</u> Support Hypothesis** ☐ **Evidence <u>Does Not</u> Support Hypothesis**

Explain how you know

Key Elements:

- Response states whether or not their hypothesis is supported.
- Response cites data from the experiment.
- Response connects the results of the experiment to the changes in temperature on the Earth's surface due to the angle that sunlight strikes the Earth.

7. Why are milliamps an appropriate unit to use in this investigation?

Key Element:

- light energy is transferred to electrical energy

or

- The small amount of light hitting the solar cell produces a small amount of electricity that can be measured only in milliamps.

This experiment uses a model of the earth-sun system.

8a. Draw a labeled diagram of your setup, explaining all parts and what they represent in the earth-sun system.

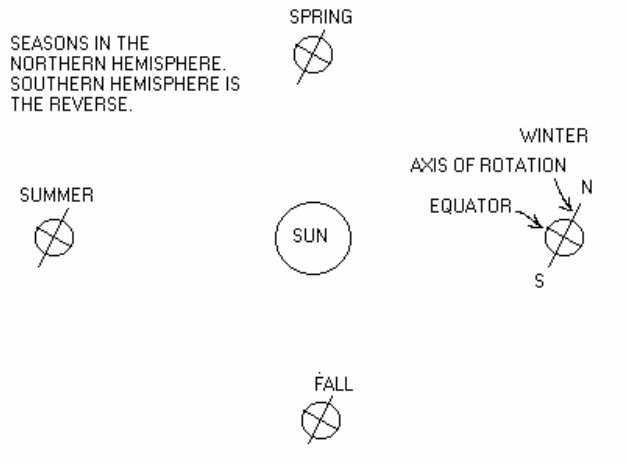
Key Elements: Setup

- Light/lamp – Sun
- Solar cell – Earth
- Milliamp meter – Transfer of light energy that strikes Earth.

8b. Draw a labeled diagram of the earth-sun system including the equator and axis of rotation, and all four seasons for northern and southern hemispheres.

Key Elements: Earth-Sun System

- equator and axis of rotation correctly drawn on Earth diagrams
- Earth equator-axis oriented to indicate tilt
- Earth diagrams correctly positioned and labeled for the four seasons



9. Compare your experiments with the real world system. Fill out the following chart with similarities and differences between the two systems

	SIMILARITIES	**DIFFERENCES**
LIGHT COMPARED TO SUN	1. GIVES OFF LIGHT 2. GIVES OFF HEAT 3. GIVES OFF RELATIVELY CONSTANT ENERGY	1. SUN GETS ENERGY FROM NUCLEAR FUSION 2. SUN'S ENERGY GOES THROUGH OUTER SPACE 3. SUN IS MUCH LARGER
SOLAR CELLS COMPARED TO EARTHSYSTEM	1. POSITIONED AT AN ANGLE 2. CONVERTS LIGHT TO ELECTRICITY	1. CONVERTS LIGHT TO ELECTRICITY 2. EARTH IS CURVED 3. EARTH IS MUCH LARGER

Key Elements: Accept any scientifically accurate similarity or difference

- LIGHT COMPARED TO SUN – Similarity
- LIGHT COMPARED TO SUN – Difference
- SOLAR CELLS COMPARED TO EARTH SYSTEM – Similarity
- SOLAR CELLS COMPARED TO EARTH SYSTEM – Difference

10. At 45 degrees north latitude, compare the length of daylight and angle of the sun on Dec 21 to the length of daylight and angle of the sun on Jun 21st

Key Elements:

- On Dec. 21st, the length of daylight is shorter than it is on June 21st.
- On Dec. 21st, the angle of the sunlight hitting the Earth is lower than it is on June 21st.

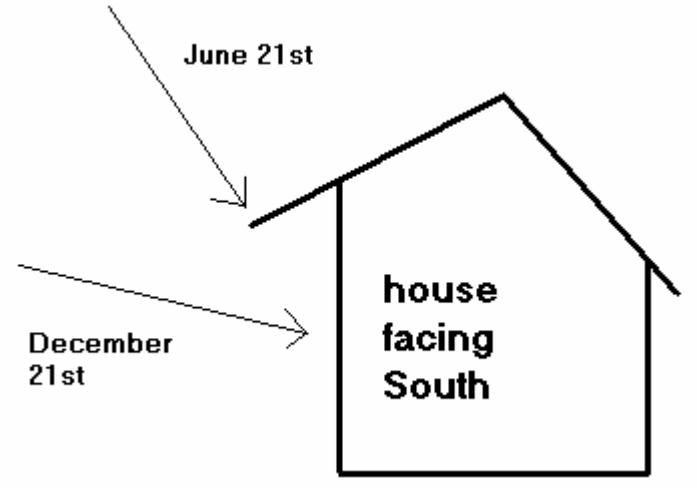
11 a. Which direction does the house below need to face in order to get the maximum amount of light in the winter and the minimum amount of light in the summer?

☐ **North** ☐ **South** ☐ **East** ☐ **West**

Key Element:

- South

11 b. Draw and label the sun's rays hitting or entering the house on June 21st and December 21st.



Key Elements:

- Dec. 21st labeled and sun ray drawn at a greater angle between the house surface and the ray than on June 21st.
- June 21st labeled and sun ray drawn at a smaller angle than on Dec. 21st.

12. How can house designs that make use of the sun and are well insulated conserve natural resources and improve the environment?

Key Element:

- use less fossil fuels (oil, gas, coal, etc.) and renewable resource (wood)

or

- less air pollution produced directly

or

- lessens need to mine and drill-could have consequences for wildlife

or

- less air pollution and energy use of transporting fuels

13. Use your understanding of the earth-sun system to explain why Hannah and Eldred will never be able to ski in Vermont at 9 pm in July.

Key Elements:

- longer period of daylight will transfer more heat energy to the surface.
- higher angle (less slant) will transfer more heat energy to the surface
- amount of heat energy in July in Vermont will cause the average temperature to be above the freezing point of water.