

Solar Kit Lesson #2

Sunshine Timer

TEACHER INFORMATION

LEARNING OUTCOME

After collecting data on cloud cover using a simple instrument and displaying data through graphs, tables, and charts, students interpret data for patterns of cloud cover that affect solar-powered energy production and predict energy production under given cloud conditions.

LESSON OVERVIEW

Students use a simple and easy-to-understand homemade technological device, the sunshine timer, to monitor cloud cover over an extended study period. They become habituated to observing conditions in the sky such as location of the Sun and types of clouds present. This study provides daily and weekly opportunities for students to collect and display data; use graphs, tables, and charts to interpret data; make predictions; and relate patterns of cloud cover to their effect on solar energy production.

GRADE-LEVEL APPROPRIATENESS

This lesson is intended for use in grades 2–6. (See Curriculum Standards Section at the bottom of the document)

(For the grades 9-10, you may want your students to calculate the minimum light threshold of the solar panels. This would require your students to perform various trials of this experiment to measure the minimum solar radiation needed for the solar panel to function to allow the clock to tick.)

MATERIALS

- Student handouts
- 1 V, 400 mA mini–solar panel* (preferably with alligator clips)
- Analog DC-powered clock (must run on one AA battery)
- Highlighter (optional)
- Vernier Labquest*
- Vernier light sensor*

* Available on our [website](#) to reserve the materials; other materials are to be supplied by the teacher

SAFETY

Tell students not to look directly at the Sun. Permanent eye damage can result.

TEACHING THE LESSON

This lesson could easily be adapted to encompass fractions and percentages. It could readily be transferred to computer data-management software such as spreadsheets.

Preparation—Set up the sunshine timer: Remove the AA battery from the DC-powered clock. Use alligator clips to connect the mini-solar panel's red lead to the clock's positive (+) battery terminal and black lead to the negative (-). The clock will run when the mini-solar panel is aimed at the Sun unless a cloud obscures the Sun. Set the clock to noon at the start of a data collection period. The clock will advance as long as clouds do not cover the Sun. In this way, the clock will record the number of hours of unobscured sunlight. Students can subtract the number of hours the clock advances from the number of hours of data collection to get the number of hours of cloud cover.

The clock can be powered by a mini-solar panel that is aimed within 45 degrees of facing the Sun directly. From August through April the Sun is within 45 degrees east of south to 45 degrees west of south for a three-hour period centered on noon. From May through July you will need to shorten the daily data collection period to two hours because the Sun will be at too great an angle from due south during the three-hour period centered on noon. Alternatively, you can extend the daily data collection period by adjusting the direction of the sunshine timer to track the Sun.

Use the Vernier Labquest in combination with the light sensor to record the luminance for the three-hour period. The light sensor should be pointing in the same direction as the mini solar panel and will record the data and graph the variance in the luminance.

Integrating Light Sensor:

1. (For each group) Obtain a Vernier Labquest and a light sensor.
2. Connect the light sensor to the Vernier Labquest
3. Flip the light sensor range switch on the box so that it will record in the 0-150,000 lux range (mainly used for measurements of sunlight).
4. Using the pen, click the Rate button to the right of the screen.
5. Adjust the length to 1 hour (or how ever many hours/minutes you desire)
6. Choose the amount of samples per interval of time desired using the screen pad.
7. Adjust the rate (samples/hr or samples/min). We recommend at least 12 samples/hr (corresponding to one measurement every 5 minutes).
8. Click the OK button.
9. Make sure the mode reads time based and click the play panel (green play button) on the bottom left of the screen and start recording.
10. The sensor should record and graph the luminance vs. time.

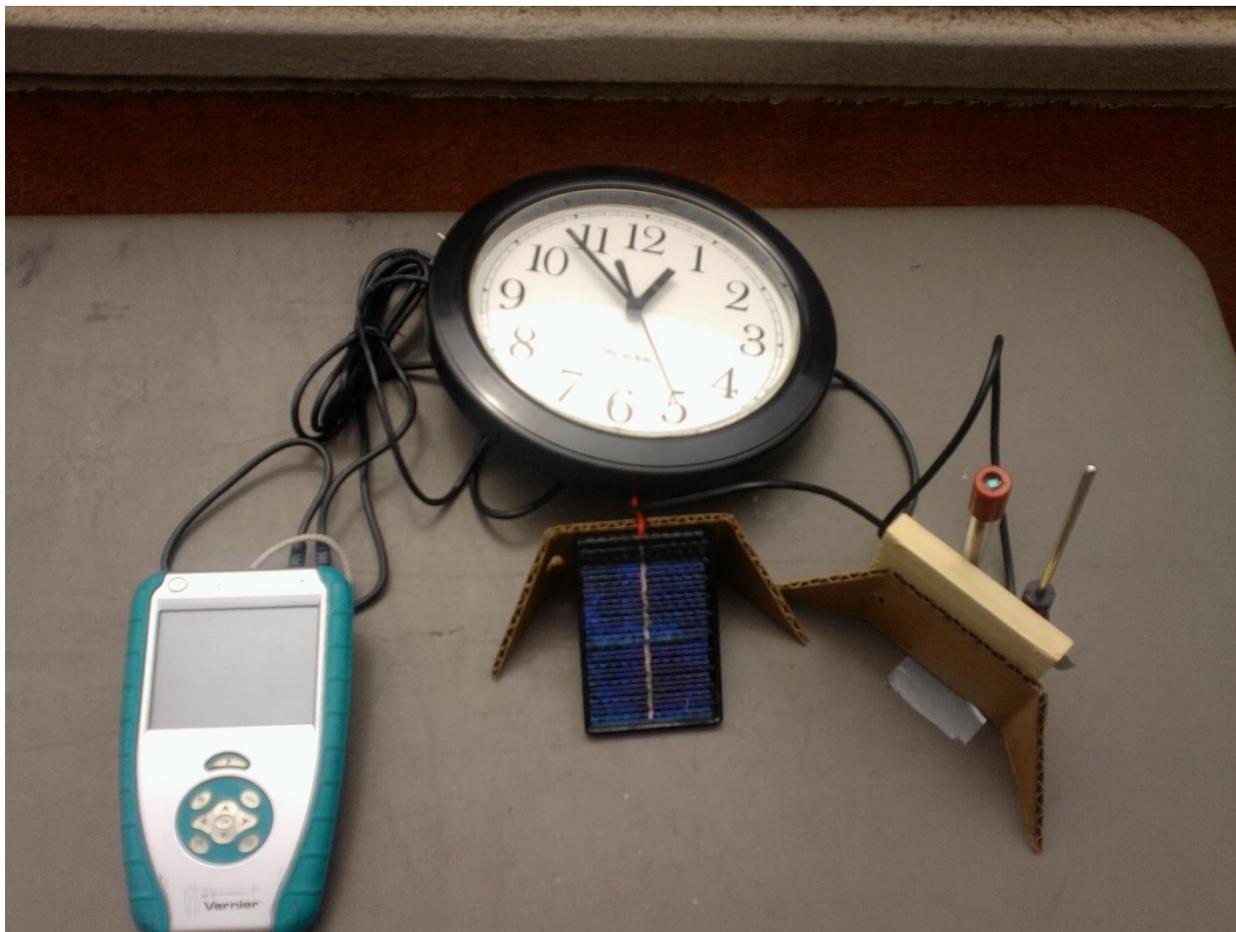


Figure 1A: Test setup with Vernier labquest, 400 mW solar panel, light sensor, and temperature sensor. (We need a new picture without the temperature sensor. We also need to make sure the light sure and the solar panel are facing the same direction)

Additional Preparation:

1. Go to the website: <http://maeresearch.ucsd.edu/kleissl/demroes/>
2. Click on the ‘Solar Radiation and Rain’ image thumbnail to view the radiation from the sun on different areas of the UCSD campus
3. Using the Solar Radiation chart helps the student have a visual comparison of the solar radiation at your school’s location vs. the solar radiation at the UCSD campus. This chart will provide a full 2 day history of the solar radiation at UCSD. You may use this to show your students the difference in readings based on the different times of day. The readings from your light sensor can be converted to the $W\ m^{-2}$ displayed on the UCSD graph. If you want to convert the luminance from lux to W/m^2 , you must divide the lux value by 343 Lumens/Watt (an average conversion value representing 380-770 nm) to obtain the equivalent irradiance value W/M^2 .

Opening Discussion: Begin by discussing how solar electric systems depend on radiation from the Sun to produce power. Demonstrate a mini-solar panel powering a small motor. Explain that solar electricity is a growing energy source throughout California and the United States, for example through <http://www.californiasolarstatistics.ca.gov>. Use information from the [Background Information section](#) at the bottom of this document to introduce the idea of peak

electrical demand and the fact that the highest demand for electricity occurs during hot summer days when there are large amounts of sunshine.

Ask students what might hinder our using sunshine for electricity. What might California decision makers want scientists to study to determine if solar electric panels are a good way to supply electricity in the middle of the day?

How does California's daily sun hours compare to its neighboring states? How about Seattle?

Tell the students that they will conduct a long-term study of middle-of-the-day cloud cover. Demonstrate how the sunshine timer works and give students an opportunity to handle the timer and become familiar with it.

Help students determine where in the school or in the classroom they can place the cloud meter. It must receive sunlight for one to three hours around noontime unobscured by the shadows of trees, buildings, or other objects. It must face due south and tilt up at an angle to face the Sun at around noon. It must be protected from the weather.

Data Collection: Distribute the student handouts and explain the daily cloud logs. Have students record the length of the data collection period for each day and convert the time to minutes. At set intervals during the daily data collection period, have students check off the box that best fits the current cloud conditions. Have students use the "Weather Notes" section to record daily peak temperature. They could also use it for additional work involving cloud identification or to record experiences for other weather observation opportunities that you may want them to have.

Prediction: At or before the end of the data collection period, but before students check the sunshine timer, have them make a prediction on how many minutes of sunshine will have been recorded.

Data Collection: Have students record the length of sunshine for each day and convert it to minutes. Have students also record the average luminance for each day and convert it from lux to W/m^2 .

[For example, if we want to convert the luminance from lux to W/m^2 , we must divide the lux value by 343 Lumens/Watt (an average conversion value representing 380-770 nm) to obtain the equivalent irradiance value W/M^2]

Data Calculation: Have students subtract the number of minutes of sunshine from the number of minutes for the data collection period to get the number of minutes of cloud cover. Students who would benefit from additional work with fractions or percentages might use these numbers for daily practice and to form additional weekly graphs. Estimate the average luminance from the UCSD graphs and compare to your measurements.

Graphing: Distribute and explain graphs 1–3. Help students label the x - and y -axes. In the title of graph 2, students must fill in the number of minutes of the daily data collection. Have students fill in these graphs on a regular basis—for instance, daily or once a week.

Graph 1: This graph is actually five bar graphs on top of one another. Students should use a different color for each weather condition. For each day, have students record the number of times each weather condition is observed.

Graph 2: Have students graph their predictions with a pencil dot and the measured value as a bar colored with a highlighter.

Review Questions: Go over appropriate review questions daily, weekly, or at the end of the data collection period.

Have your predictions on the amount of sunshine improved over time? Have students discuss why.

What types of clouds or cloud cover seem to affect solar energy production the most?

What types affect it the least?

To compare your data to other systems, visit <http://www.solarschoolhouse.org/> then click on the link on the page that directs you to <http://view2.fatspaniel.net/SSH/MainView.jsp>. This will show you the live data of PV systems for schools all over the nation with gridtie solar systems. Evaluate geography and weather and output and compare your data and location to the various PV systems.

How do the solar intensity readings collected by the UCSD compare to your daily sunshine readings? Have students discuss why these may be the same or different. Have them consider the length of time of daily data collection and the location of the schools.

How could solar electric power help provide electricity for the high midday demand of high-temperature days?

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

The results will vary depending on the kind and extent of cloud cover during the data collection period.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

This lesson plan was developed by School Power Naturally project sponsored by NYSERDA. It was adapted for California by Brent Lee.

The idea of using a solar-powered clock as a sunshine timer came from *Science Projects in Renewable Energy and Energy Efficiency*, written and designed by the National Renewable Energy Laboratory and published by the American Solar Energy Society, 1991.

The organization of classroom activities was adapted from *Renewable Energy Activities for Earth Science* prepared for the U.S. Department of Energy by the Solar Energy Project in cooperation with the New York State Education Department and the University at Albany Atmospheric Sciences Research Center (out of print).

BACKGROUND INFORMATION

Daily peak needs for electrical power in California State's large metropolitan areas are closely coincident with available sunlight. California's highest power demands occur during summer heat waves, when there are large amounts of sunshine.

Studies conducted by Itron for the California Public Utilities Commission show at the time of peak energy use which is usually between 1 pm and 4 pm, solar power contributed 60% of its maximum potential in California. Consequently, when much energy is needed, sunlight is usually available to power solar panels.

Together with very small amounts of backup power (such as batteries) and/or programs to reduce peak demand for electricity, solar electric panels could provide a guaranteed peak power source for California's metropolitan areas.

Produced by the Northeast Sustainable Energy Association in coordination with the Research Foundation of the State University of New York with funding from the New York State Energy Research and Development Authority (NYSERDA)

www.nyserdera.org

Should you have questions about this activity or suggestions for improvement, please contact Professor Jan Kleissl at jkleissl@ucsd.edu.

(STUDENT HANDOUT SECTION FOLLOWS)

Calculated Data

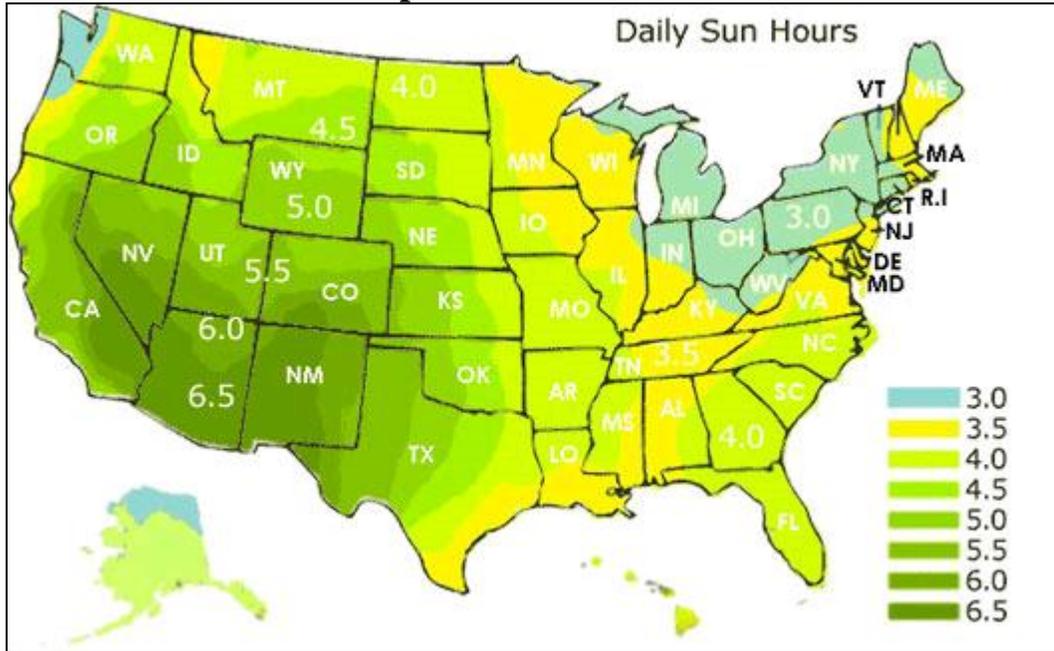
number of minutes of the data collection period _____ min.

minus number of minutes of sunshine — _____ min.

number of minutes of cloud cover _____ min.

For Grades 9 & 10:

Chart of "peak sun hours" in the U.S.



Source: [Mother Nature Network](#)

Numerical equivalent for the amount of time that the sun averages 1000 Wh per m² of intensity per day on a horizontal surface. This is how many hours your solar clock would run per day if you set it up before sunrise and measured the time after sunset.

Using the chart above, calculate the daily and yearly production of a standard 220 watt solar panel in an optimum location in California, given the following: The rating of the solar panel (220 Watt) is measured for conditions of 1000 Wh per m² of intensity. Assume 15% solar conversion efficiency for the panels, inverter, and wiring.

If there were no clouds in San Diego, we would receive 6.4 peak sun hours per day. Given the figure above, calculate the average amount of cloud cover in San Diego

Compare California's daily and yearly production to New York and Florida. Discuss why there is such a large discrepancy.

New York:

Florida:

Calculate the light threshold of the mini-solar panel by placing light sensor and solar panel next to each other. Then take a large cardboard piece and shade the sun from far away and move progressively closer. Observe when the clock stops and record the luminance.

luminance: lux _____
converted to W/m^2 _____

Now using your light sensor's luminance measurements, find the light threshold of the solar panel clock using the graph of collected data. To calculate the light threshold of the mini solar panel, use the total cloud cover time, the total sunshine time, and the luminance measurements. (Remember the definition of light threshold is the minimal amount of light from the sun capable of producing enough power to run the clock.)

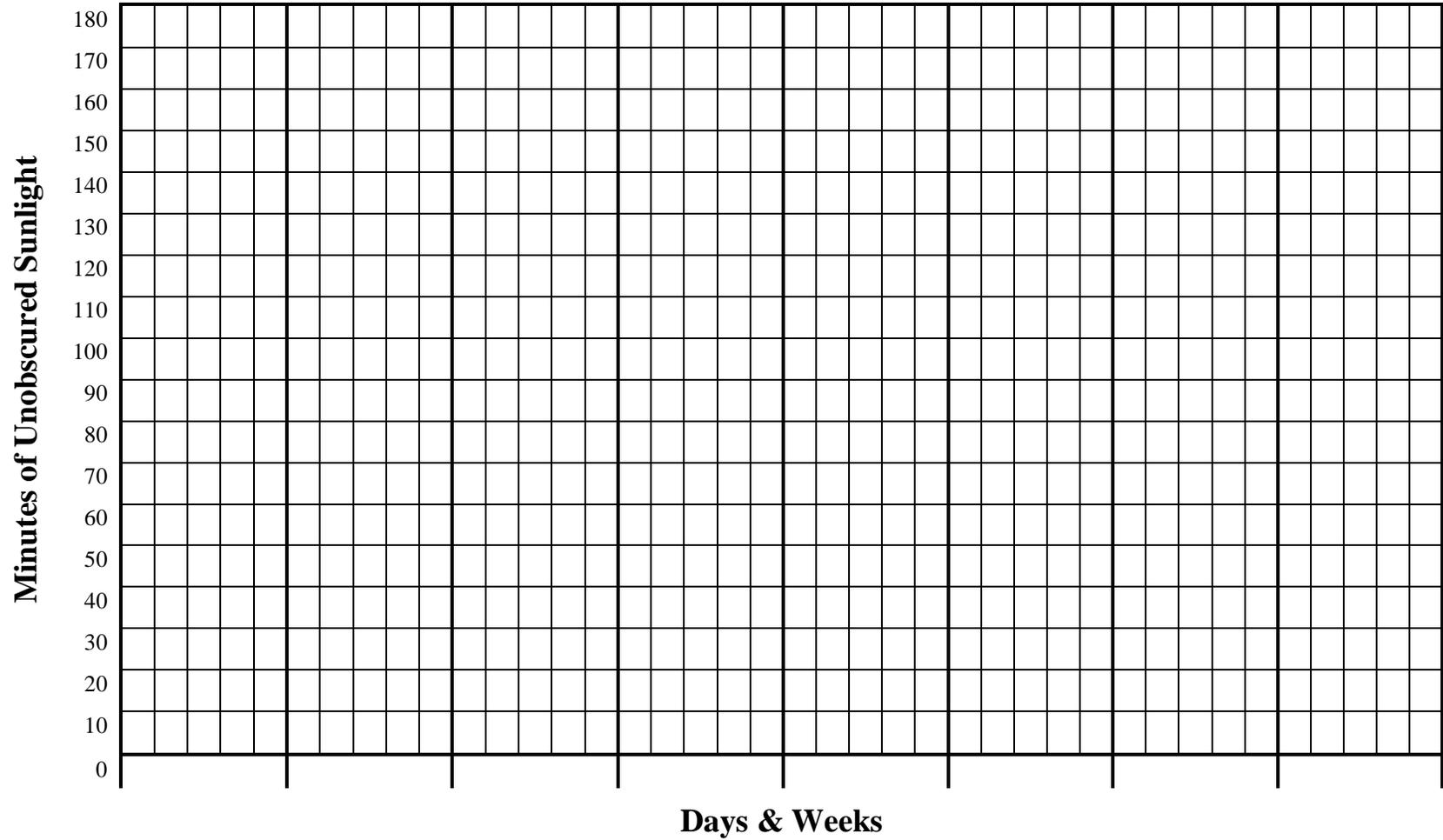
Name _____

Graph 1
Cloud Cover Conditions Over the Sun

Days & Weeks								
Clear blue sky								
Heavy clouds passing by								
Thin clouds passing by								
Heavily overcast sky								
Light hazy sky								

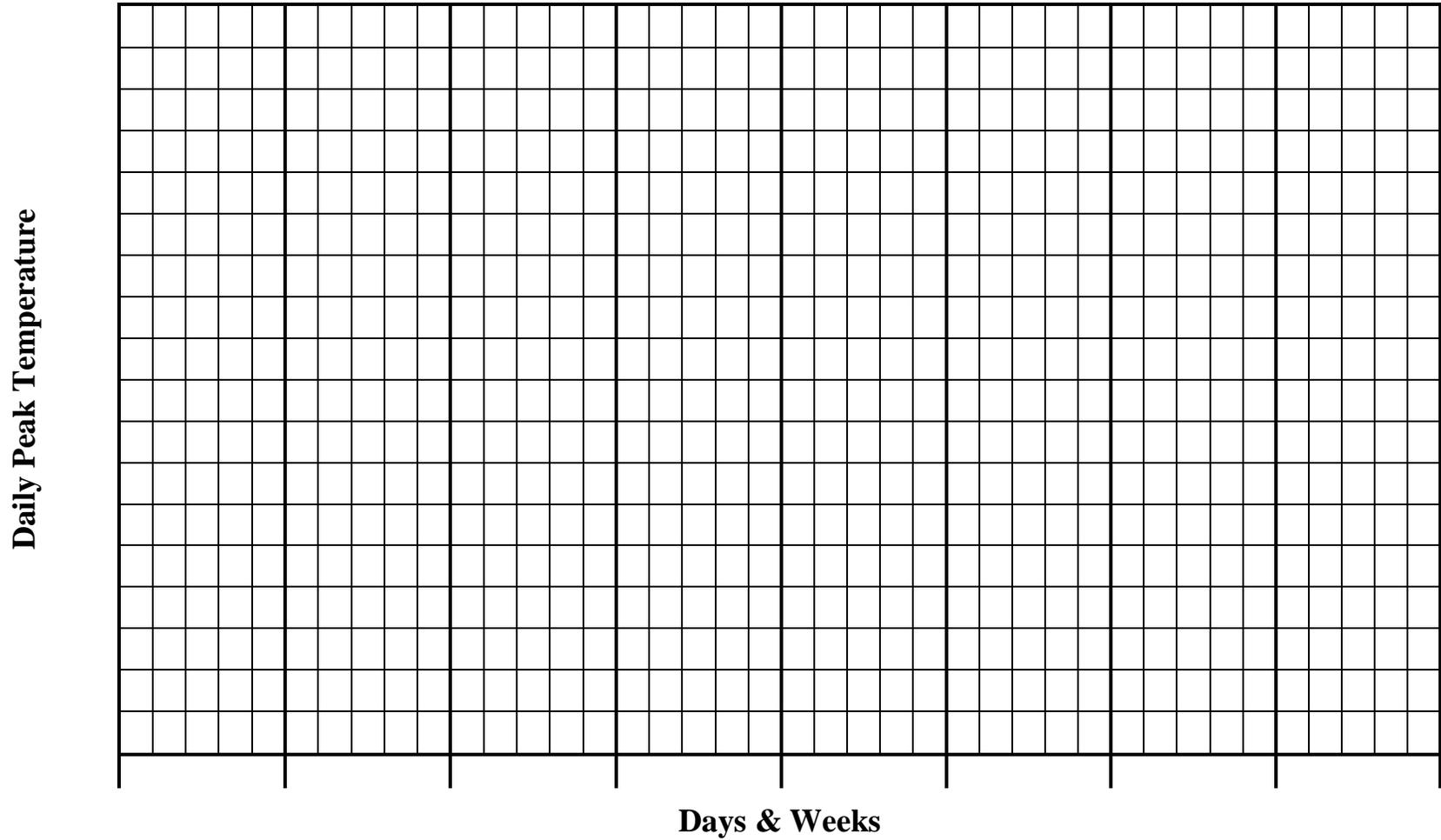
Name _____

Graph 2
Minutes of Sunshine per _____-minute Period



Name _____

Graph 3 Daily Peak Temperature



Solar Lesson Plan 2: Sunshine Timer

Potential problems you may have with this lesson plan:

- Make sure the mini-solar panel and the light sensor are pointing in the same direction.
- Due to San Diego's thin cloud cover the solar clock may still run even if clouds obscure the sun. This is because sufficient sunlight penetrates the clouds to produce power with the mini-solar panels that is sufficient to power the clock. The thin cloud cover (~40,000 Lux in our experiment) still made the clock tick. The 'risk' is especially great in the summer months. It is best to try this lesson during the rainy season of November through March when clouds are thicker. On the other hand the experience of recording more sunhours than observed with the eye can to teach the kids that even if clouds are present solar panels can still produce substantial amounts of power. You can also discuss weather conditions (heavily overcast skies or clear sunny days) and how they will affect the production of solar panels.

APPLICABILITY TO THE CALIFORNIA STANDARD CURRICULUM

Grade Two

Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.
 - a. Make predictions based on observed patterns and not random guessing.
 - d. Write or draw descriptions of a sequence of steps, events, and observations.
 - c. Construct bar graphs to record data, using appropriately labeled axes.
 - e. Follow oral instructions for a scientific investigation.

Grade Three

Physical Sciences

1. Energy and matter have multiple forms and can be changed from one form to another.
 - a. Students know energy comes from the Sun to Earth in the form of light.
 - b. Students know sources of stored energy take many forms, such as food, fuel, and batteries.
 - c. Students know machines and living things convert stored energy to motion and heat.
 - d. Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.
2. Light has a source and travels in a direction.
 - a. Students know sunlight can be blocked to create shadows.
 - b. Students know light is reflected from mirrors and other surfaces.

Investigation and Experimentation

3. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.
 - a. Repeat observations to improve accuracy and know that the results of similar scientific investigations seldom turn out exactly the same because of differences in the things being investigated, methods being used, or uncertainty in the observation.
 - b. Differentiate evidence from opinion and know that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.
 - c. Use numerical data in describing and comparing objects, events, and measurements.
 - d. Predict the outcome of a simple investigation and compare the result with the prediction.
 - e. Collect data in an investigation and analyze those data to develop a logical conclusion.

Grade Four

Physical Sciences

1. Electricity and magnetism are related effects that have many useful applications in everyday life.

- a. Students know how to design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.
- b. Students know electrical energy can be converted to heat, light, and motion.

Investigation and Experimentation

- 2. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.
 - a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
 - c. Formulate and justify predictions based on cause-and-effect relationships.
 - d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
 - e. Construct and interpret graphs from measurements.
 - f. Follow a set of written instructions for a scientific investigation.

Grade Five

Earth Sciences

- 1. Energy from the Sun heats Earth unevenly, causing air movements that result in changing weather patterns
 - a. Students know the causes and effects of different types of severe weather
 - b. Students know how to use weather maps and data to predict local weather and know that weather forecasts depend on many variables

Investigation and Experimentation

- 2. Scientific Process is made by asking meaningful questions and conducting careful investigations. As a basic for understanding this concept and addressing the content in the other three strands, student should develop their own questions and perform investigations
 - a. Develop a testable question
 - b. Plan and conduct a simple investigation based on a student-developed question and write instructions others can follow to carry out the procedure.
 - c. Select appropriate tools (e.g. thermometers, meter sticks...) and make quantitative results
 - d. Record data by using appropriate graphic representations and make inferences based on those data
 - e. Draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion
 - f. Write a report of an investigation that includes conducting tests, collecting data or examining evidence, and drawing conclusions

Grade six

Earth Sciences (main focus)

Heat (Thermal Energy)

1. Heat moves in a predictable flow from warmer to cooler objects until all the objects are at the same temperature.
 - a. Students know heat energy is also transferred between objects by radiation (radiation can travel through space)

Energy in the Earth System

2. Many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents
 - a. Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle
 - b. Students know solar energy reaches Earth through radiation, mostly in the form of visible light.

Resources

3. Sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation
 - a. Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.
 - b. Students know different natural energy and material resources and know how to classify them as renewable or nonrenewable

Investigation and Experimentation

4. Scientific Process is made by asking meaningful questions and conducting careful investigations. As a basic for understanding this concept and addressing the content in the other three strands, student should develop their own questions and perform investigations
 - a. Develop a hypothesis
 - b. Select and use appropriate tools and technology to perform tests, collect data, and display data
 - c. Construct appropriate graphs from data and develop qualitative statements about the relationship between variables
 - d. Communicate the steps and results from an investigation in written reports and oral presentations
 - e. Recognize whether evidence is consistent with a proposed explanation

Grade Seven

Focus on Life Sciences

Investigation and Experimentation

1. Scientific Process is made by asking meaningful questions and conducting careful investigations. As a basic for understanding this concept and addressing the content in the other three strands, student should develop their own questions and perform investigations
 - a. Select and use appropriate tools and technology to perform tests, collect data (Vernier), and display data
 - b. Use a variety of print and electric resources (World Wide Web) to collect information and evidence as part of a research project
 - c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from scientific evidence
 - d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge
 - e. Communicate the steps and results from an investigation in written reports and oral presentations

Grade Eight

Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

- a. Plan and conduct a scientific investigation to test a hypothesis.
- b. Evaluate the accuracy and reproducibility of data.
- c. Distinguish between variable and controlled parameters in a test.
- d. Recognize the slope of the linear graph as the constant in the relationship $y = kx$ and apply this principle in interpreting graphs constructed from data.