

# SOLAR PANEL PERFORMANCE

## Driving Question | Objective

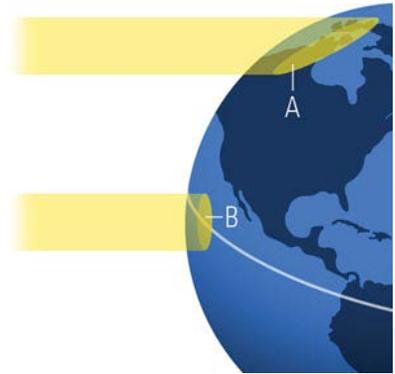
How do angle, cloud cover, and dust affect solar panel voltage output?

Solar panels are a source of alternative energy for homes. As the preferred location for solar panels, rooftops tend to be out of the way, unshaded, and tilted. Owners must consider many factors such as the path the sun follows each day, roof pitch (angle of tilt), and latitude when making installation decisions.

The angle at which sunlight strikes the Earth (angle of insolation) varies with latitude. The sun's angle of insolation is greatest at the equator and decreases towards the poles. If greater angles of insolation result in greater amounts of direct sunlight, how might tilt angle affect solar panel voltage output?

### angle of insolation

Area A and B receive the same amount of sunlight, but A is cooler than B because the light travels further and is distributed over a larger surface area.



## Materials

- Data collection system
- Voltage sensor with red and black banana plug leads
- Solar panel
- Adjustable lamp with minimum 60-W (incandescent) or 23-W (CFL) bulb
- Toothpicks (2)
- Ruler
- Scissors
- Transparent protractor
- 30-cm x 30-cm sheets of wax paper (5)
- 6-cm x 6-cm pieces of cardboard (2)
- 6-cm x 13-cm piece of cardboard (1)
- Tape
- Flour

## Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Use caution with the lamp. It may become very hot.

## Consider

- ❓ 1. How might tilt angle affect solar panel voltage output?

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- ❓ 2. Do solar panels produce electricity when it is cloudy? Why or why not?

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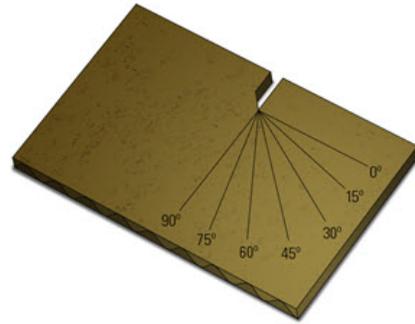
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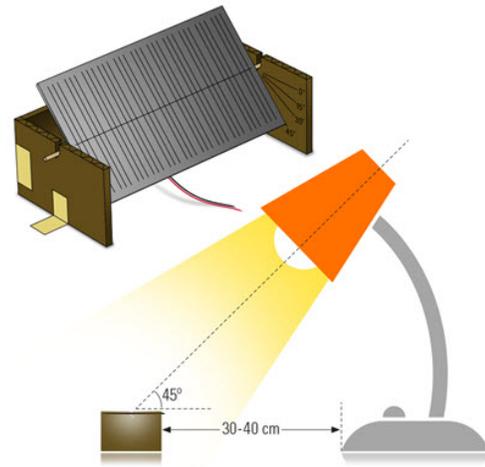
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## Investigate Tilt Angle

1. Connect the voltage sensor. Use **Help (?)** if necessary.
2. Attach the solar panel alligator clips to the voltage sensor plugs (match colors). Do not allow red and black to contact.
3. Cut a 1-cm deep notch through the long edge of both 6-cm x 9-cm pieces in the center as shown.
4. Align the protractor to the notch point on one piece of cardboard. Mark the following angles as shown:  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$ ,  $45^\circ$ ,  $60^\circ$ ,  $75^\circ$ ,  $90^\circ$ .



5. Build the solar panel holder. Position the labeled piece as shown.
6. Tape the toothpicks to the back of the solar panel. Allow 2 cm to extend from the sides as shown.
7. Set the panel in the holder. Allow wires to come through the opening below the panel.
8. Place the lamp 30-40 cm away from the panel. Point the lamp towards the open side of the panel holder as shown.
9. Align the center of the bulb exactly  $45^\circ$  from the middle of the panel's silver center line at  $0^\circ$ . You will need to carefully adjust the height and angle of the lamp to accomplish this.



*Note: The bulb-panel alignment MUST be EXACTLY at  $45^\circ$  as shown.*

10. Turn the lamp on.
11. Build a page with a digits display. Use **Help (?)** if necessary. Start collecting data.
12. Use the toothpicks to help you rotate the panel to the angles indicated in the table. Record the voltage for each angle in the table. Complete three runs.

Table 1: Voltage produced when light source is set to  $45^\circ$

Tilt Angle ( $^\circ$ )	Voltage (V), Run 1	Voltage (V), Run 2	Voltage (V), Run 3
0			
15			
30			
45			
60			
75			
90			

13. Stop collecting data.

## Analyze Tilt Angle

1. Which panel tilt angle produced the highest voltage? How does this panel angle compare to the lamp angle (set at  $45^\circ$ )?

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2. How does panel tilt angle affect voltage produced? Use data to support your answer.

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3. Predict the panel tilt angle that will produce the highest voltage when the lamp is positioned at  $60^\circ$  instead of  $45^\circ$ . Explain your prediction.

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## Investigate Cloud Cover

- Allow the panel to rest in a stable position in the holder.
- Turn the lamp on.
- Start collecting data.
- The first data point contains no layers of clouds as a control. Record the first reading in the table below.
- Hold a sheet of wax paper 20 cm above the panel to simulate a thin cloud layer. Record the voltage for 1 layer.
- Increase layers one at a time until you reach 5 layers. Record voltage for each new cloud layer.

Table 2: Voltage with increasing cloud cover.

Number of Layers	Voltage (V)
0	
1	
2	
3	
4	
5	

- 7. Stop collecting data.
- 8. Save the cardboard panel holder for future activities.

### Analyze Cloud Cover

- 1. What happens to voltage as the cloud layer thickens? Use data to support your answer.  

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- 2. Suppose you live where it rains frequently and latitude is between the north pole and the equator. What advice would you give your neighbors about how to set up rooftop solar panels for the best voltage output?  

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- 3. Does solar panel voltage output depend on the time of year? Why or why not?  

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### Extend

Write a testable question to investigate the effect of dust on voltage output. Design an experiment to answer your testable question. Use flour to simulate dust. After completing your investigation, compare another group's experimental design with your own. Which design better reflects a scientific approach? Why? Which better models real-world conditions? Why?