# Nailing Down Energy

**Hands-on Activity for Understanding Photovoltaic Cells**

### Time
10-15 minutes

### Materials and Preparation
- Clay
- 2" Nail
- Photovoltaic cell
- Digital volt meter. Should be able to take readings to three decimals
- Light source
- Sheet marked with printed circles

### Key Question
How does the efficiency of photovoltaic cells change based on the angle of the light source?

### Background
The physical process by which a photovoltaic (PV) cell changes light energy into electrical energy is called the Photovoltaic Effect. The light rays from the sun are made up of packets of solar energy called "photons". The photons contain different amounts of electrical energy. When a PV cell is exposed to photons the energy can either be reflected by the material or absorbed by the material. The amount of energy absorbed depends on the intensity and orientation of the light energy source with the PV arrays. PV cells operate at their highest efficiency when the light rays are directly hitting the solar cells' perpendicular with the surface of the panels. If the position of the solar panel changes causing the angle of the light rays to be less than 90 degrees, the output voltage of the PV cells will be reduced.

This is sort of like the automobile crash tests we have seen on TV. If the car hits a wall directly all of the energy is transferred into the wall. If a car hits a wall at an angle only a portion of the energy is transferred into the wall.

When fully extended, the solar arrays on the space station are as large as a football field. Computer-controlled motors constantly adjust the position of the solar arrays so that they remain perpendicular to the sun's light rays. If the angle of orientation is not constantly adjusted, power generation decreases dramatically. When the station is in the Earth's shadow, the ISS uses electricity generated by rechargeable Nickel-Hydrogen batteries.

## Part One-Setting Up the Experiment

### PROCEDURE FOR PART ONE

1. Place the sheet with printed circles on the table in front of you.
2. Stick a small piece of clay in the center of the smallest circle.
3. Press the head of the nail into the clay, so that the nail is standing as straight as possible.
4. Locate the small X at the other end of the paper. Center the photovoltaic cell upon this X.
5. Using masking or electrical tape, connect the ends of both wires from the photovoltaic cell to the ends of both wires from the volt meter.

6 With your light source off, note the measurement on the volt meter. Make sure the volt meter is adjusted to take readings to three decimals with milliamps. This is the charge due to the background light.

7 Turn on your light source. Make sure to use a light source with as focused a light as possible

## Part Two-Performing the Experiment

| Angle | Milliamps |
|---|---|
| | |
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### PROCEDURE FOR PART TWO

1 Begin by shining your light source at the photovoltaic cell from directly behind the nail. Move the light source until the tip of the nail's shadow touches the rim of the outside circle.

2 Note the angle reading located next to the outer circle. Record this number in the left column.

3 Record the volt meter reading in the right column next to the correct angle.

4 Move your light source until the tip of the nail's shadow touches the rim of the next largest circle. Record the angle and the volt meter reading in the columns.

5 Repeat Step 4 until you reach the innermost circle. Continue to record all angles and corresponding volt meter readings.

### DATA ANALYSIS

Design a graph to plot your data. Plot the angles in degrees on the x-axis and the readings from the volt meter in milliamps on the y-axis.

### Closure Questions

1. Using the graph, at what angle did you record the most milliamps?
2. Use this information to determine how the space station can use the solar array panels to provide enough energy for vital station functions