# Nailing Down Energy

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

### Time
10-15 minutes

### Materials and Preparation
- Clay
- 2" Nail
- Photovoltaic cell
- Digital voltmeter. Should be able to take readings of milliamps up to three decimal places (1/1000's).
- A flashlight with a beam that can be focused.
- Sheet with concentric circles drawn at one end, in one-inch increments, up to a circle 8" in diameter. Place an x at the other end of the sheet of paper.
- Ruler

### Key Question
How does the location (the orientation) of a light source affect the efficiency of photovoltaic (PV) cells?

### 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 circles and "x" on the table in front of you.
2. Place a small piece of clay in the center of the smallest concentric circle.
3. Press the head of the nail into the clay, so that the nail is standing as vertically as possible. The nail's shadow will be used to measure the angle at which the light hits the photovoltaic cell.
4. Place the photovoltaic cell flat upon the X at the other end of the paper.
5. Using masking or electrical tape, connect the ends of both wires from

the photovoltaic cell to the ends of both wires from the voltmeter. Set the voltmeter to read milliamps to the third decimal place. (thousandths of a milliamp).

6 Record the milliamps of electrical current produced by the photovoltaic cell using only the ambient light available in the room.

7 Turn on your light source. Make sure the light from the light source is as focused as possible.

## Part Two-Performing the Experiment

### PROCEDURE FOR PART TWO

1 Position the light source at the end of the paper opposite where the photovoltaic cell is located, 12" from the nail. The tip of the nail's shadow should be on the edge of the largest concentric circle.

2 Measure the angle of the light source's orientation to the photovoltaic cell. Record this angle in the left column of the table.

3 Record the voltmeter's milliamp reading in the right column next to the angle in #2 above.

4 Keeping the light source the same distance from the nail, move your light source up until the tip of the nail's shadow touches the rim of the next largest circle. Record the angle and the voltmeter's milliamp reading in the next row.

5 Repeat Step 4 until the nail's shadow touches the edge of the innermost circle. Record all angles and corresponding milliamp readings.

| Angle | Milliamps |
|---|---|
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### 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 of the light source did the voltmeter record the most milliamps?
2. Use this information to describe under what conditions the space station's Photovoltaic Arrays will provide maximum electricity for vital space station functions.