Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

# Solar Energy

***A Solidify Understanding Task***

**Purpose:** To determine which solar panel mounting bracket to use for your school, how many panels to purchase, and how to arrange them to maximize annual energy output.

**Career Field:**

Architecture
Moseley Architects

In partnership with

WAKE TECH

**WTCC Associate Program of Study and Contact Person:**

Architectural Technology
Phillip Jefferson
phjefferson@waketech.edu

919-866-5353

WAKE COUNTY PUBLIC SCHOOL SYSTEM

WakeEd PARTNERSHIP

**NC Math 4 Standards:**

**AF.2.2:** Implement Law of Sines and Law of Cosines to solve problems.

**Unit Alignment:**
NC Math 4 - Unit 4: Law of Sines and Cosines
MAT 121 – Unit 4: Law of Sines and Cosines

**Common Core State Standards for Mathematical Practice**

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
5. Use appropriate tools strategically.
7. Look for and make use of structure.

**Prerequisite Skills**

*These skills could be reviewed in a warm-up and are addressed in the Desmos Activity*

- Using right triangle trig and the Laws of Sine and Cosine to solve triangle problems.
- Evaluating Trig Functions
- Converting inches to feet.
- Read a compass.

**Time Required**
The time required to complete this activity is approximately **180** minutes.

**Materials Needed**
- Student Activity Sheet
- Internet access
- Calculator
- PV Watts Tutorial PDF File
- PV Array Image

**The Teaching Cycle**
**Launch:** Have students complete the Desmos Launch Activity (opens in a new window) [plain text link: https://teacher.desmos.com/activitybuilder/custom/5f88a5e382804c2909b02993?collections=5f6cae0049988f0bfcd6f9f8] which will review prerequisite skills and includes the launch video which highlights an architecture firm, details the advantages of solar panels and their uses, and assigns students their tasks. Possible questions to discuss before assigning the project:
- How do we mount solar panels so they receive the optimal amount of sunlight?
- Can you mount solar panels all the way to the edge of a space? Why might you need space between/around them?

This activity will have students investigate different ways to arrange solar panels on a flat roof, the goal of which is to maximize the annual energy output. You can customize this to your specific location by doing the following ahead of time:
- Use https://keisan.casio.com/exec/system/1224682277 to determine the solar radiation angle for your location (Use shortest day of the year as the date).
- Use your location's latitude to create a bracket length and angle option to match. This can be searched in google.
- Use PVWatts tutorial instructions to create an Annual Energy Output chart for your location.

Have students read the task. You may want to use the 3 Reads protocol. The first read is to understand the context. The second read is to understand the mathematics. The third read is to elicit inquiry questions based on the scenario.

**Explore 1:** Have students work in groups of 2-3 students to work through all five mounting bracket options and select the option that is best for their location. The tilt angle desired is the one closest to the latitude for your location.

**Discuss 1:** Groups will present their findings and which mounting bracket they thought was suitable for their location. As a class, groups decide which mounting bracket length would work best moving forward.
Also, discuss how the orientation of the actual panels looks i.e. how rows are connected to each other, what a "north facing panel" means, as well as the compass orientation etc. The orientation they chose will change how many panels they can fit. You can also discuss how changing the orientation of the panels might affect the energy output. You could choose to have students generate the table of energy outputs per panel by giving them the instructions provided for the PVWatt's website.

**Explore 2:** Have students work with their original groups to try and answer the overarching question: "What is the maximum annual energy output?" based on their selected mounting bracket. Circulate and monitor groups to ensure that they are analyzing the PV array row spacing properly; i.e. utilizing the given formula correctly to find the Lmin, giving suggestions such as split the triangle into 2 right triangles to help find the proper row spacing. As students are working on their calculations, circulate and monitor their work. Look for groups that use different approaches to highlight during the discuss phase.

**Discuss 2:** Choose groups to present their findings that chose different orientations for the panels (north, south, east, west). Have each group share how they came to their conclusion and why they think their orientation is best. As a class, decide which orientation would produce the most energy.

*Honors Extension*: Use a composite figure as the roof shape, include energy output per panel for southeast, southwest, northeast, and northwest.

**Exit Ticket:** How do you think the annual energy output would change if the panels were mounted flat on the roof (no tilt angle).