Solar Tracker Challenge

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DESCRIPTION: Students will build a simple circuit that can be used to track a light source. This circuit will be used as a springboard for discussion into the engineering design process, solar tracking, and basic electricity and circuits. The simple solar tracker operates by providing two current sources, the solar cells, which are wired to work against each other. The larger current will win over the smaller and their sum current will drive the motor attached to the scaffolding holding the solar modules. In this manner the modules will be rotated clockwise or counter-clockwise until they each are receiving equal intensity of light.

GRADE LEVEL(S): 5, 6, 7

SUBJECT AREA(S): Engineering, science

ACTIVITY LENGTH: 1 hour, 30 minutes

LEARNING GOAL(S): Students observe and replicate a simple solar tracker; learn basic electric circuits and terminology; reflect on possible improvements for solar tracker; and reflect on how the engineering design process is used daily.

STANDARDS MET:
Next Generation Science Standards:

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- NGSS 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- NGSS 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

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Student Background:

- Prior knowledge of the scientific method/engineering loop

Educator Background:

- Basic knowledge of how to connect a DC circuit and how a solar module works

Science Kit Materials List:

- Individual Solar Module, 2 Volt, 500 mA (4 / group)

Other Materials List:

- “3D Model of a Solar Cell” handout
- “3D Solar Panel Model” student handout
- “Solar Tracker Student Directions” handout
- “Solar Tracker Worksheet”
- Work lamps
- 9V battery
- DC powered fan
- Popsicle sticks
- Glue gun
- Sticky back Velcro squares
- DC motor
- Wood blocks
- White/black wire, stripped at both ends
- Electrical tape
- Masking tape

Vocabulary:

- Photovoltaic
- Electrons
- Circuit

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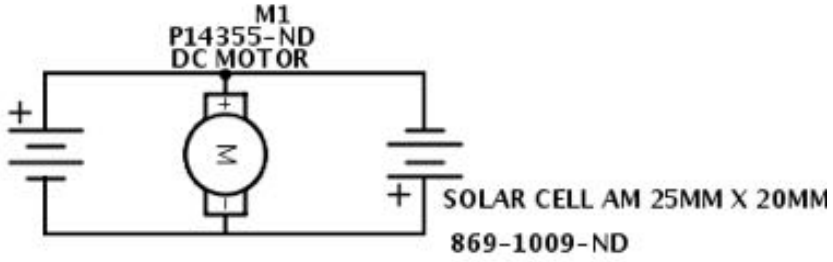
Lesson Details:

Background Information/Circuit Diagram:

Below is the circuit diagram for the simple tracker. Part numbers are from Digi-Key’s web site, but you can use any source. Notice that the solar cells are reverse polarized. This means that the cells that get more incident light will drive the current against the other, making the motor turn. The reverse happens when the other cell receives more light. If the cells are mounted on a superstructure, which is on top of the motor, and allowed to rotate, then this simple device will track a light source.



Circuit 1: Simple Solar Tracker

Figure 1, below, is a top view of how to arrange the cells on their superstructure. The varying angle allows for different cells to receive variable sunlight. Thus, in the morning the sun will come up on the extreme left of the tracker. This light will hit the left rear cell causing the tracker to rotate counterclockwise.

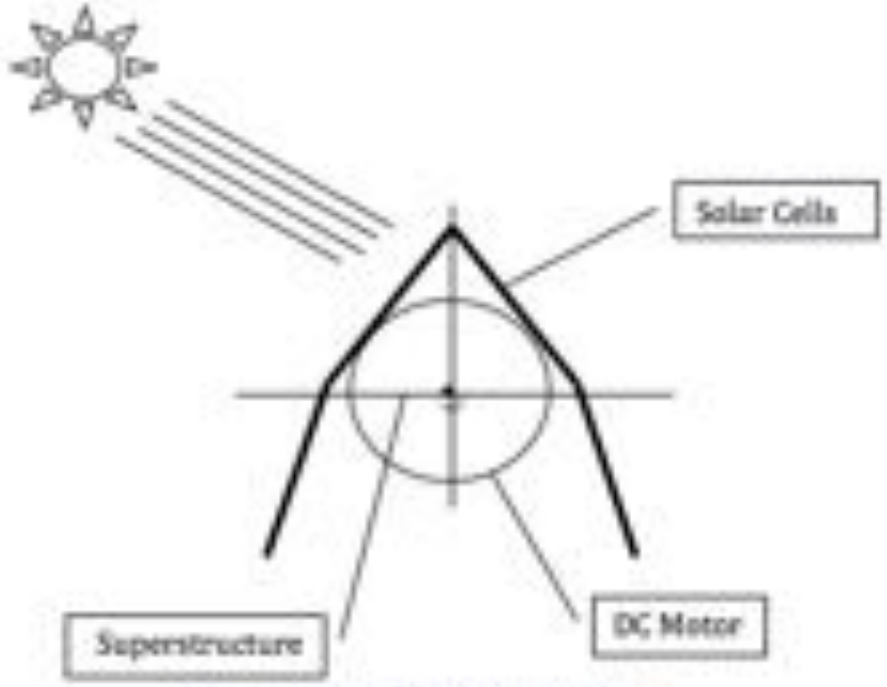


Figure 1: Top View of Simple Solar Tracker

Class Plan

Goal: The student will learn what a solar cell looks like and how light energy causes negative charges to move toward the positive side, transforming the light energy into electrical energy as it moves from one side to the other.

1. The key word is photovoltaic - sometimes called PV – which is the process of converting sunlight into electricity. Ask the student to repeat the word with you.

   Photo = light and voltaic = electricity

2. The module consists of two layers.
   - One with available electrons (n, or negative layer).
   - One that needs more electrons (p, or positive layer).
   - Both layers are separated by a junction that is like a one-way door. Electrons can move from the lower p-layer to the upper n-layer through the junction, but not back the other way.

3. Think of the electrons as food.
   - The n-layer has lot of food that it wants to deliver to the p-layer but it doesn't have permission to leave its layer.
   - When energy from the sunlight hits the solar module, it gives the n-layer permission to leave its layer to deliver the food to the p-layer.
   - Because the door between the layers is one-way, the food can't be delivered downward through the junction. Therefore, the food must travel through another path—in reality, through the wire connecting the top and bottom layers. This creates the circuit.
   - On the way, the current caused by the " food delivery" creates electricity, which can be used to power a light bulb.
   - Eventually the food/extra electrons move back to the n-layer through the one-way door of the junction and the system is ready to go again.

4. Before the lesson, I built a 3D model to show my students. At this point, you could let your class look at the model as you explain how the system works with the accompanying worksheet.
   - In the 3D model, the sun (their hand) will contact the top layer, releasing energy to the n-layer.
   - The n-layer has extra electrons (colored beads) that now have the energy to move (create a current) to the fan. This is the electricity that powers the fan.
   - The extra electrons would then move to the p-layer and then back up (through the p-n-junction layer cardboard) to the n-layer. The process can start again.

5. Demonstrate how the 9V battery or a solar cell can power the fan.
   - Show how to use alligator clips.
   - Explain how the circuit needs to be complete.

- Show how changing the red and black connection can change the direction of the rotation

6. Show students a completed simple solar tracker and use a light source to demonstrate the tracker operation.
   - Demonstrate how the 9V battery can power the motor, causing it to spin clockwise or counterclockwise.

7. Review safety rules, including proper use of the glue gun.
   - Tell students to try to only place the glue on the parts of the solar module that has tape so that we can reuse it for other activities.

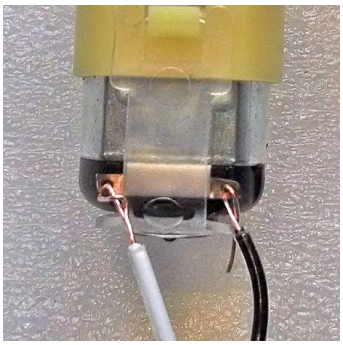
8. Instruct students that they are to build a working model with the materials you are handing out. Demonstrate how to use the solar tracker worksheet to record their solution and the outcome of each trial.

9. Resist the urge to show them how to complete the tracker. In this activity students are to work together in deciding how to get the tracker to work. There is a built-in discrepant event with regard to the circuit hook up. Most students will likely hook all the positive leads (red) together and the negative leads (black) together. This will allow the motor to turn in one direction only. They must figure out to reverse the polarity from each side of the tracker in order to get the motor to move in both directions.

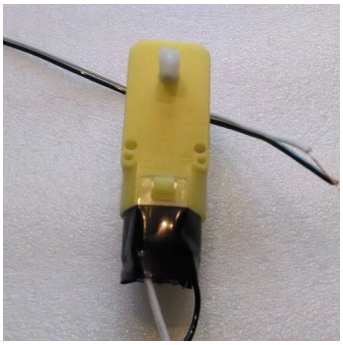
10. Once each group has a successful tracker, ask the students how they would make the tracker better. What limitation can the group see with their design? Most classes should come up with limitations such as cloudy days, night, vertical tracking in addition to horizontal, etc. Discuss with students that as design constraints grow in both complexity and number that having a (or mechanism) helps to sort things out.

Prep Before Class

1. Wrap the white and black wires around the two leads on the motor. It doesn't matter which wire attaches to either the left or right lead, just make sure each motor has the white on the same lead.

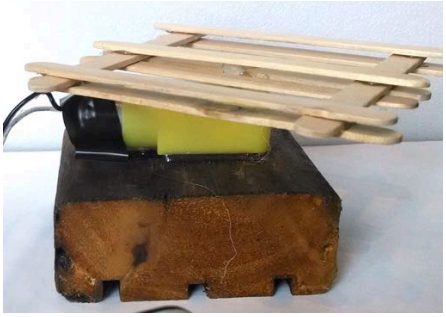


2. Cover the leads with electrical tape to prevent the connection from being pulled off during the students' work.



3. Drill a hole in a small wood block big enough for the white motor stick. The motor should still be able to rotate in the hole.

4. Use a glue gun to secure the motor to the block. Make sure the motor is level.



5. Place masking tape on the back of the solar modules where hot glue is to be applied. This allows you to remove the glue later for reuse in subsequent years.