SOLAR ENERGY: THAT'S HOT
Grades 4 - 6

NJCCCS: 5.1, 5.2, 5.4

Field Trip Overview:

This program illuminates the various ways in which our nearest star affects life on Earth. Students will learn about the apparent motion of the Sun and how we use that motion to heat and/or cool our habitats. The tilt, rotation, and orbital pattern of the Earth around the Sun, along with the reasons for seasons, will also be discussed. Utilizing what the students learned about solar energy, they will participate in a hands-on, team-building activity of designing a passive solar house. Weather permitting, students will also view our star with safe solar viewing equipment.

Background Information:

Life on Earth is dependent on the energy radiated by the Sun. It helps to heat the air, water, land and organisms to create a livable temperature. It drives the weather systems and water cycles that are necessary for life on Earth. Green plants and phytoplankton absorb sunlight to help them produce food (through the process of photosynthesis) to grow and become the base of the food web. Humans have strived to understand the Sun and how to harness its energy to benefit our society.

Since the Sun has provided an opportunity for life to develop and continue to survive on Earth, and without it, life as we know it would cease to exist, it is no wonder our ancestors considered it a god. If shaded by clouds, the Sun appears to be a perfect, unflawed circle of white light. Eventually, ancient Chinese astronomers saw dark spots (sun spots) on the surface of the Sun, which were rediscovered by Galileo, advancing our understanding of the Sun. Now with modern technology, we can measure the intensity of the energy radiated from the Sun, its size, mass, composition, distance from the Earth, and even how long it will exist.

We can track the apparent path of the Sun across the sky in a very predictable way for any day of the year. Due to the rotation of the Earth on its axis, the Sun appears to rise in East, reach its maximum height at noon to the South (in the Northern Hemisphere), and sets in the West. Because the Earth's axis is tilted approximately 23.5°, it causes the apparent path of the Sun to change over the course of the year, resulting in the seasons.

One of the purposes of science is to describe natural phenomena in order to make predictions to benefit humankind. How can we apply our scientific understanding of the Sun to benefit us? We are currently dependent on fossil fuels and other non-renewable resources to maintain our lifestyles. We can decrease our dependence on fossil fuels by increasing our use of clean, free, renewable resources like solar energy. A great place to use solar energy is in a home. The design of a house that utilizes solar energy must demonstrate a clear understanding of the Sun's energy, the apparent motion of the Sun over the course of a year, and the reasons for seasons.

Vocabulary:

Active Solar Energy: The process of obtaining, transforming (e.g., electricity), and transferring sunlight for use in a building.

Apparent Motion of the Sun: The path of the Sun across the sky from sunrise to sunset, caused by the rotation of the Earth on its axis.

Autumnal (Fall) Equinox: The day in which the sun crosses the celestial equator moving southward; on this day there are 12 hours of daylight/darkness across the globe, it occurs on or about September 21.

Axial Tilt: The degree to which the Earth's axis (imaginary line running through the Earth from the South Pole to the North Pole) is inclined compared to the plane of the solar system (and that of the Sun). It is 23.5°.

Deciduous Tree: A tree that drops leaves during unfavorable, winter conditions (e.g., oak, maple, hickory).

Electromagnetic Radiation: Changing electric and magnetic fields that travel through space (and from the Sun) and transfer energy from one place to another; examples are radio, micro, infrared, visible, ultraviolet, x-ray, and gamma ray waves.

Light Wave: An electromagnetic disturbance that consists of rapidly changing electric and magnetic effects; transferring energy from a source (e.g., Sun) to a receiver (e.g., your eye). It can travel through the vacuum of space and does not require a medium to move through.

Mechanical Wave: Waves which require movement through a material medium (solid, liquid, or gas); e.g., sound and water waves.

Natural Resource: A substance or source that exists naturally on Earth that humans can use to satisfy their needs.

Non-renewable Resource: A natural resource that cannot be replenished (made again) in a relatively short period of time; e.g., coal, oil, natural gas.

Overhang: The part of a building that extends passed the exterior wall in order to provide shading.

Passive Solar Energy: The use of sunlight for heating, cooling and day-lighting of living spaces; it is simple with no moving parts or mechanical systems.

Renewable Resource: A natural resource that can be replenished (made again) naturally or will exist for a very long time; e.g., air, water, Sun.

Summer Solstice: The day in which the Sun has the most northern position of the year and has the most daylight hours; it occurs on or around June 21.

Sundial: The oldest astronomical instrument used to tell time with the apparent motion of the Sun. As the Sun moves across the sky, a shadow is cast along hour markings.

Vernal (Spring) Equinox: The day in which the sun crosses the celestial equator moving northward; on this day there are 12 hours of daylight/darkness across the globe, it occurs on or about March 21.

Winter Solstice: The day in which the Sun has the most southern position of the year and has the least amount of daylight hours; it occurs on or around December 21.

References / Resources:

- Odum, E. P., G. W. Barrett. 2005. Fundamentals of Ecology. 5th Edition. Brooks/Cole, a division of Thomson Learning, Inc.

- Moche, D. L. 2004. Astronomy: A Self-Teaching Guide. 6th Edition. John Wiley & Sons, Inc.

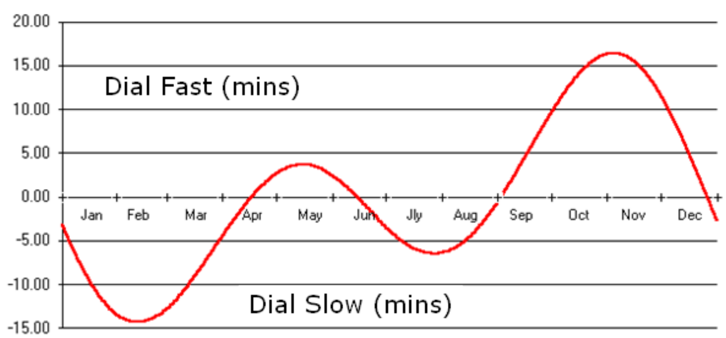
- Seeds, M. A. 2001. Foundations of Astronomy. 6th Edition. Brooks/Cole, a division of Thomson Learning, Inc.

Pre-Trip Activities

1. Make a Mini Sundial (template on page 5)

A sundial is any device that uses a shadow caused by the apparent motion of the Sun to track the passage of time. To someone on Earth, the Sun appears to move across the sky everyday (the Sun rises in the East, reaches a maximum altitude to the South in the Northern Hemisphere, and sets in the West). However, because the axis of the Earth is tilted and its orbit is an ellipse, the exact path of the Sun changes slowly throughout the year. As a result, sundials don't keep the same time everyday like a modern clock or watch. In fact, "solar time" can be off from "clock time" by as much as 16 minutes some days of the year! We can correct a sundial reading with this graph:

The Equation of Time

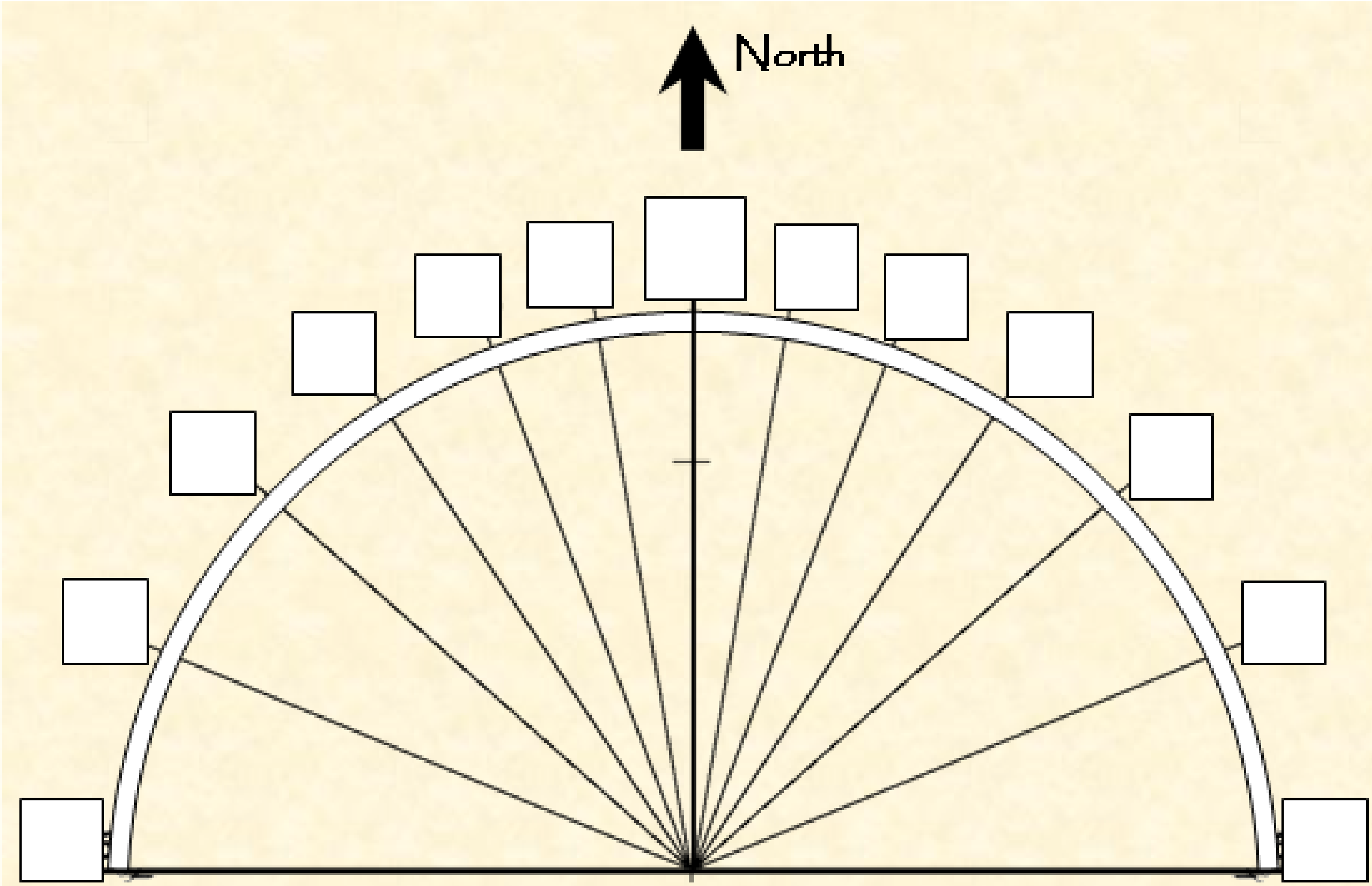


For example, in mid February, if your sundial reads 10:00 AM, you subtract 14 minutes (based on the Equation of Time graph) to get the actual time of 9:46 AM.

The dial face is the surface with all the hours of the day marked on it, the gnomon is the shadow-casting stick, and the style is the angled, top-edge of the gnomon and casts the edge of the shadow that should be read on the dial face. For a flat sundial to track time correctly, its gnomon must be aligned with the Earth's axis of rotation. The Style must be angled up from the dial face the same number of degrees as your latitude.

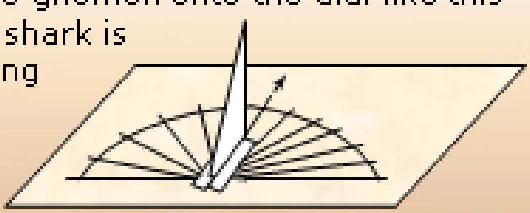
Use the template and follow the directions on the next page (5) to make a mini sundial. Align the arrow with true (not magnetic) North.

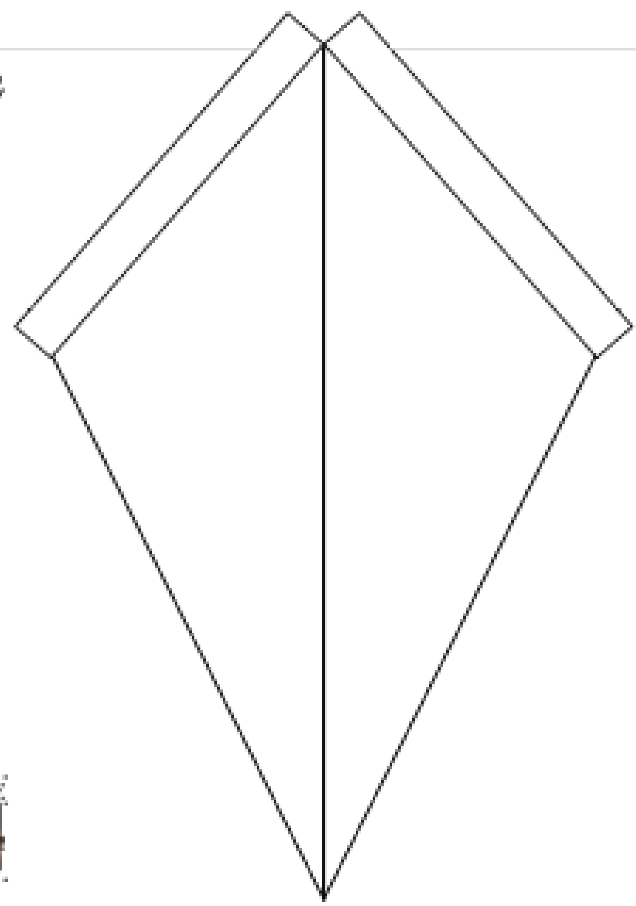
References/Resources:
[YouTube: Setup a Sundial]



Make Your Own SUNDIAL

1. Cut the sheet in half at the dotted line.
2. The top half is your **dial face**. Fill in the small boxes with the times from 6 am (on the left), moving *clockwise* upwards to 12 pm (noon), and on to 6 pm (on the right).
3. Cut out the shape to the right. This is your **gnomon.** Fold it in half tightly down the center line. Then fold the two rectangular tabs in the opposite direction. It will look like a tall, pointy shark fin. Tape the back edge of the fin shut with tape.
4. Tape the gnomon onto the dial like this (so the shark is swimming south):





Solar Energy That's Hot
Post-Trip Activities

1. Solar Pizza Box Cooker

Project #5 — Solar Pizza Box Cooker

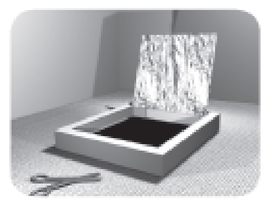
Have you noticed how a car parked in the sun stays warm inside, even on cold days? That's because clear materials like glass and plastic trap the heat from the sun. We can use this principle to make solar powered ovens.

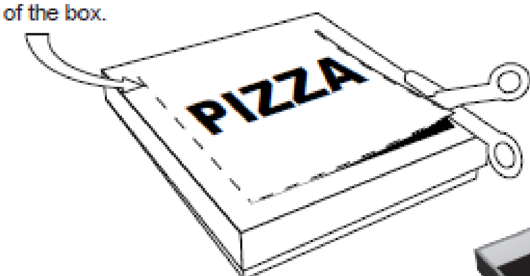
Materials

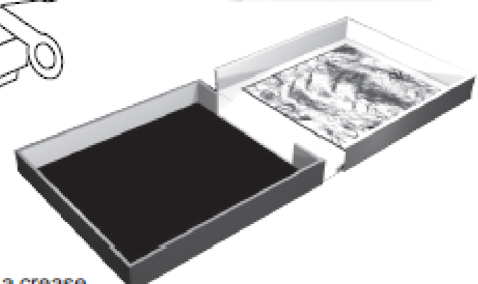
- 1 Medium Sized Pizza Box
- Black Construction Paper
- Aluminum Foil
- 1 Reynolds Oven Cooking Bag (made of nylon that can take up to 400 degrees F.) You can get 8 windows out of each bag.
- Masking Tape, Clear Tape (about 1" wide), Glue (optional)
- Scissors (or Craft Knife if an adult helps)
- Pie Tins to fit inside box
- String (yarn) or kabob stick to hold flap open
- Newspaper for insulation
- Oven Thermometer (optional)

What to Do

1. Draw a line about 2" in from the edges of the box.



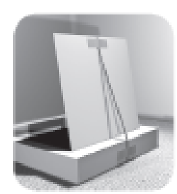




2. Cut along the line. *Don't cut along the top edge where the hinge of the box is!*

3. Gently fold the flap back along the uncut edge to form a crease.

4. Put a piece of aluminum foil on the inside of the flap, and fold the edges around the backside of the flap. Use the shinier side of the foil facing up, and try to smooth the foil. Tape the foil edges on the back of the flap with masking tape, keeping the tape from showing on the front side of the flap. This foil will reflect sunlight into the box.



5. Open the box and put a piece of black paper in the bottom of the box to help absorb the sun's heat.

6. Close the box, roll up some newspaper, and fit it around the inside edges of the box top. This is the insulation to hold the sun's heat. It should be 1" to 1.5" thick. Use tape to hold it in place.

7. Cut a square of Oven Bag plastic that's about 1/2" bigger on all sides than the flap opening in the box top. Tape to the inside of the box top with clear tape. Tape one side, *then pull the plastic tight* and tape the other three sides. It must be airtight!

References / Resources:
[Solar Schoolhouse: Solar Pizza Box Cooker Video Tutorial]

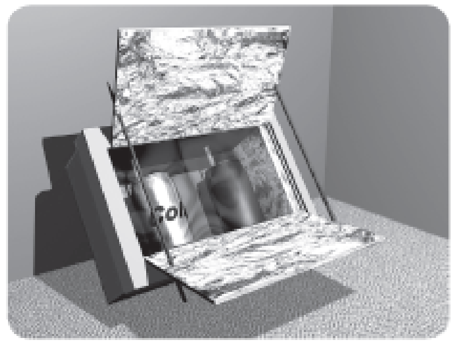
2. Shoebox Solar Water Heater

Project #7 Shoebox Solar Water Heater

The Shoebox Cooker in Project #5 can be used as a solar water heater too. Just put soda cans filled with water inside the cooker.

Materials

- 1 Shoebox Cooker (see Project #5)
- Oven Thermometer
- Soda Cans
- Black Paint (or wide tipped felt marker)
  OR
- Black Paper & Rubber Bands
- Extra kabob stick to hold flap open
- Aluminum Foil
- Masking Tape
- Scissors (or Craft Knife if an adult helps)
- Newspaper & carboard for insulation



What to Do

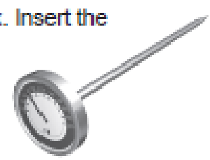
1. Paint a soda can black. If you don't have paint you can use a felt marker, or even wrap the can with black paper. Secure the paper with tape or rubber bands. This helps the can absorb heat.

2. Use kabob stick to punch a hole through one of the long sides of the shoebox. The hole should be about 2" from the back of the box. This is for the thermometer.

3. You may have to add several layers of cardboard inside. This lets the thermom-eter reach the inside of the can. It also adds insulation. Try wrapping the cardboard with aluminum foil to reflect heat onto the can.

4. (Optional) Attach another reflector with tape. Puncture the reflectors with kabob sticks, and and slide them through the reflectors. use the sticks to hold the reflectors open.

5. Lay the shoebox on its side in the sun. You can lean it against a wall to face the sun. Fill the soda can about 3/4 full with water, and place it in the box. Insert the thermometer, and record the temperature. record the temperature again at regular intervals (15 minutes or more).



6. Try using a black-painted can and a plain can to see how fast each heats up. Make a chart to record your results.

References / Resources:
[Solar Schoolhouse]