

Cooking with the Sun

Activity 1: Heat from the Sun



Name: _____

Date: _____

Materials List

- Infrared thermometer
- Standard thermometer
- Black spray paint
- 2 Silver pans

Procedure

1. Which pan do you think will be hotter: black or silver? Explain.
2. Measure the surface temperature of one of the pans, by pointing the thermometer toward the pan, holding it a few inches away, and pressing the button on the thermometer. The controls on the thermometers may vary.
3. Measure the temperature at several locations on each pan and record on the table below. Average the results.

	Black Pan	White Pan
Location 1		
Location 2		
Location 3		
Location 4		
Average		

Exploration Questions

1. When you go outside on a hot day, would you feel cooler wearing a white shirt or a black shirt (assuming both were made of the same fabric)?

2. If an object appears blue in the presence of white light, which colors is it reflecting and which colors is it absorbing?

Activity 1: Heat from the Sun

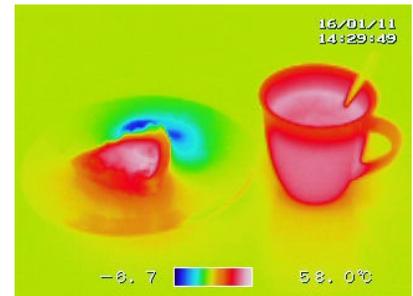


3. What color does a red object appear if the lights are turned off and the room is completely dark? What about a green object?

Apply

Infrared light is produced by the vibration of atoms in an object. The higher the temperature, the more the atoms vibrate and the more infrared light they produce. Atoms only stop vibrating at absolute zero (-459.67°F or -273.15°C). Therefore, any object with a temperature above absolute zero radiates infrared light. Although invisible to the human eye, infrared cameras allow us to detect infrared light, convert it into an electrical signal, and process the information to produce a thermal image.

What do you think would be some uses for an infrared (or heat-detecting) camera?



Activity 2: Where is the Sun?



Name: _____

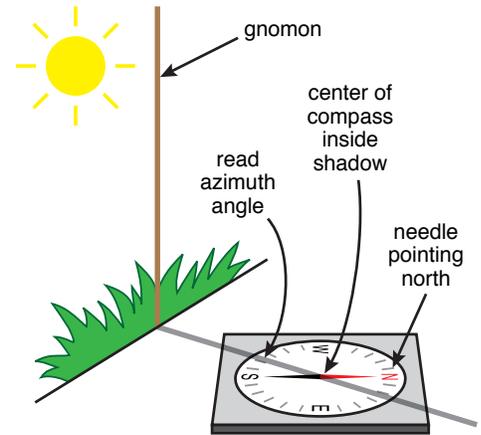
Date: _____

Materials List

- Level
- Wooden skewer
- Compass
- Ruler
- Scientific calculator

Procedure

1. Use the level to find a flat place on the ground.
2. Stick your gnomon (wooden skewer) into the ground and make sure the gnomon is perpendicular (at a 90 degree angle) to the ground. It is important for the gnomon to be straight up and down and for the shadow to be clearly visible.
3. Rotate the compass dial or body until the needle is lined up with the "N" at 0 degrees.
4. Place the compass on the ground inside the shadow of the gnomon and adjust it until the center of compass is in the middle of the shadow.
5. Read the angle inside shadow closest to the gnomon (see diagram). Record the solar azimuth angle in the table below.

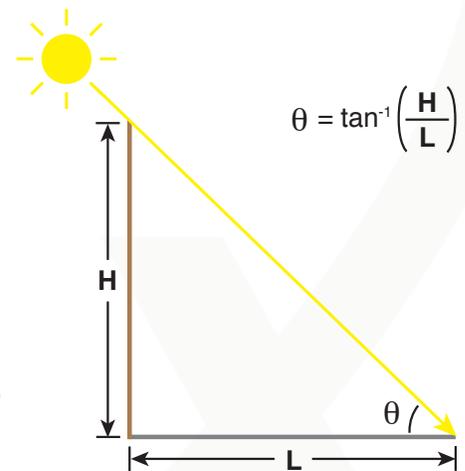


6. To calculate the solar elevation angle, use a ruler to measure the height of the gnomon sticking up out of the ground and the length of the shadow. Then, plug the two measurements into the following formula:

$$\text{elevation angle} = \tan^{-1} \left(\frac{\text{height of gnomon}}{\text{length of shadow}} \right)$$

Note: Make sure the calculator is in degrees, not radians.

7. If time allows, take measurements for the azimuth and elevation angle every hour (or half hour) throughout the day. If it's not possible to take hourly readings, just try to take at least one more set of readings at a different time of day.
8. Use the data compiled by the U.S. Naval Observatory (<http://aa.usno.navy.mil/data/docs/AltAz.php>) to look up the azimuth and elevation (altitude) angle for the day and location the activity was completed. Compare the generated data to your own observations and calculations.



Note: If the activity is performed in the summer and daylight savings time is in effect, add 1 hour to each of the times on the table generated by the website.

Activity 2: Where is the Sun?



Date/Time	Gnomon Height	Shadow Length	Sun's Location	
			Elevation Angle	Azimuth Angle

Exploration Questions

1. If you want to get the most power out of a solar panel, what angle should it be at relative to the sun's rays?

2. What time of day will the sun reach it's maximum elevation angle? Does this maximum angle stay the same or change throughout the year?

3. Will the shadow of an object at a given location and time of day be longer in the winter or the summer? Why?

Activity 2: Where is the Sun?



Apply

If your solar oven were fixed and could only be adjusted a couple times a year, how would you position it? Why?

Activity 3: Create a TechXcite Thermos



Name: _____

Date: _____

Materials List

- Standard thermometer
- 2 Soda cans
- Scissors
- Duct tape
- Hot water
- Small funnel
- Stopwatch
- Newspaper
- Cardboard
- Assorted insulating materials

Engineering Design Challenge

Design a thermos that will keep warm water in an aluminum soda can as hot as possible for at least half an hour.

Design Constraints

- Only use materials provided by your instructor
- Thermometer must be inside the can and easy to read
- Must be able to remove the can from your thermos
- Must not spill water when inserting the can in the thermos

Testing Procedure

1. Place at least one or two extra water-filled cans in a central location. These will serve as the control. Monitor the temperature in these cans throughout the experiment and record in the table below.
2. Switch out your empty can for the water-filled can and place the thermometer inside. After about 2 minutes, take your first measurement ($t = 0$) and start the clock.
3. Take a measurement every 5 minutes and record the temperature in the table.
4. After 30 minutes, plot the data from the control can and the can inside your thermos on a graph.

Activity 3: Create a TechXcite Thermos

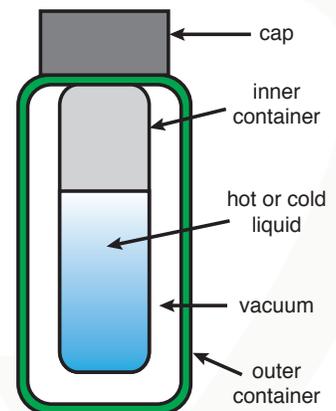


Exploration Questions

1. What are some materials that would work well as an insulator?
2. How did you try to reduce heat transfer in your thermos via conduction and radiation? Was it effective?

Apply

Commercial thermoses are *very* good at keeping hot things hot and cold things cold. The secret is removing all of the air from between the inner walls, creating a vacuum, or completely empty space. Why do you think a vacuum is the best insulator?



Activity 4: Building a Solar Oven



Name: _____

Date: _____

Materials List

- 2 Cardboard boxes
- Cardboard scraps
- Aluminum foil
- Oven bag
- Thermometer
- Newspaper and other insulating materials
- Black spray paint
- Black construction paper
- Black duct tape

Engineering Design Challenge

Use what you've learned about heat transfer to build a solar oven that will reach the highest temperature possible.

Design Constraints

- Oven interior must be large enough to hold your cooking container and a thermometer (at least 6" x 6" and 4" tall)
- Must open and close to allow you insert/remove the food and thermometer
- Use oven bag to create a transparent window in the lid

Tips

Reduce heat loss through conduction and convection

- Place insulating material in the space between the inner and outer walls to reduce heat loss. Use the results from your experiments in Activity 3 as a guide. If you have limited amounts of the best insulation materials, be sure to use them to your advantage.
- Construct a secure lid to keep heat from escaping. Although you must be able to open and close the lid, you want it to seal as tight as possible when shut.

Increase heat gain from solar radiation

- The color of the interior surfaces affects the amount of energy converted from radiant energy (sunlight) to heat.
- Move your oven during cooking so that the sun is always directed into the oven. You may also want to use blocks to prop the oven up to point it at the sun.
- Reflect sunlight toward the cooking area. You can place panels outside the oven to catch and reflect light.

Activity 4: Building a Solar Oven



Testing Procedure

1. To test your oven, place it outside on a sunny day.
2. Measure the initial air temperature inside the oven and record. Continue measuring the temperature every 10 minutes. After the first 30 minutes, you may take measurements less often.
3. Graph your results and compile your data with the rest of the class so that everyone can observe each group's heating curves.

Time (mins)	Solar Oven Temperature (°C)					
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
0						
10						
20						
30						
40						
50						
60						

Was it cloudy, partly cloudy, or sunny when you tested your solar oven? _____

What time of day did you perform your test? _____

What was the temperature outdoors during your test? _____

Activity 4: Building a Solar Oven



Exploration Questions

1. Describe which parts of your oven are designed to increase the heat input from the sun.

2. Which parts of your oven are designed to reduce heat loss?

Activity 4: Building a Solar Oven



3. What would you do differently if you were to repeat the experiment?

Apply

If you were a real engineer and could create a solar oven of any size with any materials, what would it look like and what materials would you use? Sketch your idea. Label and describe its features.