

Lesson 4: Heat and the Sun (2 Days)

☐ Getting Started

In this lesson you will explore heat as a form of energy and will examine the role the Sun plays as a light and heat source. You will also learn the laws that govern energy.

Stuff You Need

- *Let's Explore Energy* by Moving Beyond the Page
- 3 glasses or cups
- alligator clips (kit)
- battery (kit)
- buzzer (kit)
- cardboard (kit)
- color wheel (kit)
- dark colored clothing
- dowel rods (kit)
- gears (kit)
- hot glue gun or strong fast tack craft glue
- lids (kit)
- light colored clothing
- magnifying glass (kit)
- markers
- motor (kit)
- solar panel (kit)
- straws (kit)
- tape
- white paper

Ideas to Think About

- What is the unique relationship between the Sun and living things?
- What is the Sun's relationship to different types of energy?
- How does energy change?

Things to Know

- **Thermodynamics** is a branch of science that focuses on heat and how it is related to work, energy, temperature, and matter.
- The first law of thermodynamics states that energy cannot be created or destroyed, but it can be changed.
- The second law of thermodynamics states that energy always moves from hot things to cold things.
- The third law of thermodynamics states that nothing can be colder than absolute zero (-276.16 degrees C / - 459.67 degrees F).
- The Sun's energy can be used to do work and to heat our homes.

☐ **Reading and Questions**

Read about the laws of energy on pages 13-14 of the *Let's Explore Energy* booklet. Then answer these questions.

1. What topics scientists study if they were interested in thermodynamics?

2. At what temperature do atoms have no thermal energy?

3. What else, besides energy, does the first law of thermodynamics apply to?

Activities☐ **Activity 1: The Laws of Thermodynamics**

Thermodynamics is a branch of science that focuses on heat and how it is related to work, energy, temperature, and matter.

Investigate the first two laws of thermodynamics with the demonstrations on the "Laws of Thermodynamics" activity pages. Then explore the third law by watching the video.

**What Is Absolute Zero Temperature?**

www.beyondthepage.com/link/11848/

The third law of thermodynamics says that you cannot have anything colder than absolute zero (-273.15°C , or -459.67°F). What is absolute zero like? Watch the video to find out!

Day 2☐ **Activity 2: The Sun and Heat**

NOTE: Have a parent help you with this activity.

There are many sources of energy, but most energy comes to us directly or indirectly from the Sun. Energy from the Sun heats the Earth's surface and the air above it. Sometimes this causes wind. Water evaporated by the Sun forms clouds and rain to give us flowing rivers and streams. Both wind and flowing water are sources of energy.

The energy from the Sun that we can see is light. Plants need this light energy to make their food, and we need energy from plants for our bodies.

Solar energy is becoming a popular way to harness energy that is environmentally friendly. Solar panels convert light energy into electricity that can be used to heat water and cook food.

Sunlight can also heat homes and water directly, without electricity, through special solar air and water heating systems. Even sunlight shining through windows can help warm houses and buildings.

In your own home, how is heat created to warm the water you use? How is heat created to cook your food? How is heat created to warm your home? Is energy from the Sun used in some way? Do certain windows allow enough sunlight in to noticeably warm the room?

In this activity you will change light energy into thermal energy and find out how the Sun heats the Earth. You will need a sunny day! Have a parent with you, too.

☐ **Activity 3: Solar Car**

Radiant energy from the Sun is often referred to as *solar energy*. Build a solar car to see that solar energy really can provide valuable energy for work. This activity works best on a really sunny day. Try to run your car when the sunlight is strongest (depending on the season and where you live, this is often during the middle of the day). Follow the instructions on the "Solar Car" activity pages.

Wrapping Up

Think about the relationship between the Sun and living things. How are living things dependent on the Sun? In what way are most forms of energy related to the Sun? What if the sun cooled down? How would life on Earth change?

The Laws of Thermodynamics

Materials:

- motor (kit)
- battery (kit)
- buzzer (kit)
- alligator clips (kit)
- color wheel (kit)
- 3 glasses

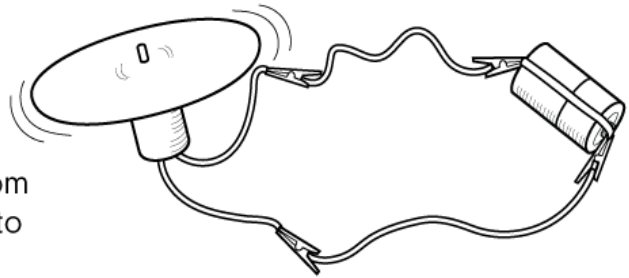
Explore the first two laws of thermodynamics with these demonstrations.

Law #1: Energy cannot be created or destroyed, but it can be changed.

1. Find your motor, battery, alligator clips, and color wheel from Lesson 2. If needed, reconnect the battery and motor, and put the color wheel back on the motor. Run the motor.

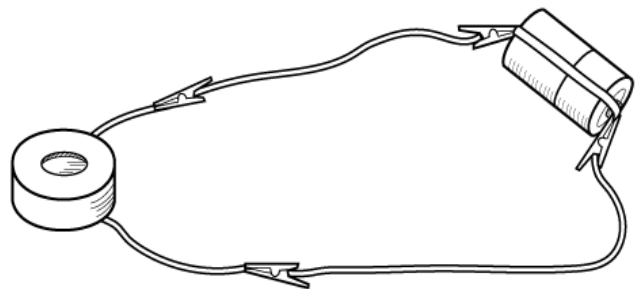
Can you identify how energy is being changed from one form to another as it passes from the battery to the motor to the color wheel?

Draw a diagram of the battery, motor, and color wheel. Fill in the blanks to identify how energy was changed. (Hint: Remember that a battery uses chemical energy to generate electrical energy.)



2. Disconnect the motor from the battery. Find the buzzer from your science kit and attach it to the battery.

How is energy being changed from one form to another now? Draw a diagram in the box on page 2 and fill in the blanks.





Law #2: Heat energy always moves from hot things to cold things.

To observe this phenomenon, follow these steps.

1. Fill three glasses with water. Make the first glass very cold, the second as warm as you can without hurting yourself when you touch it, and the third comfortably warm.
2. For three minutes put your right index finger in the cold water and the left index finger in the hot water.
3. After three minutes remove both fingers and put them in the warm water.
4. Write down your observations:

What Happened?

You probably noticed that the finger that had been in the cold water got warmer, and the finger that had been in the hot water got cooler. Heat from the finger that was in the hot water traveled from your hand to the water, so your finger felt cold. The heat from the warm water traveled to the finger that had been immersed in cold water, so it felt warmer.

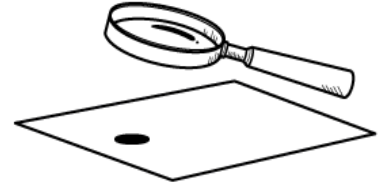
The Sun and Heat

Materials:

- dark colored piece of clothing
- light colored piece of clothing
- half a sheet of white paper
- magnifying glass (kit)
- black marker

Directions:

1. Make a solid black dot toward one end of the paper.
2. Take the paper and magnifying glass and go outside into direct sunlight. This experiment works best when the Sun is at its strongest in the afternoon and there are no clouds blocking the light.
3. Use the magnifying glass to focus sunlight onto the black dot. **Note:** Have a parent with you for this step. Also, the reflection of the sunlight off the white paper will be bright! Wear sunglasses, or avoid looking at it.
4. Keep the light focused on the dot and wait a minute. If nothing happens, adjust the angle of the magnifying glass and try again.



What Happened?

Try this demonstration. Put a piece of dark colored clothing and a piece of light colored clothing into sunlight and let them sit for 5-10 minutes. Which piece of clothing feels warmer?



The dark colored clothing should feel warmer. Why? Remember from Lesson 3 that the colors we see are actually the colors that are being reflected. A white item is reflecting all colors, while a dark item is reflecting no colors (or very little). This means that dark colored items are absorbing more light, more of the Sun's energy. The Sun also gives off *infrared* light, which we cannot see. And while both light and dark colors absorb the Sun's infrared energy and convert it to thermal energy, darker colored items absorb more of it.

When an object feels warm, that means the atoms in the object are moving faster than they would be if the object felt cold. The atoms in the dark colored clothing are moving faster because they have absorbed more of the Sun's energy. Warm objects then give off energy as infrared energy, which we feel as heat. This is how the Sun's energy heats the Earth. Light energy is converted into thermal energy when it is absorbed by the ground and objects on the Earth's surface, energy radiates back out from the warm objects in the form of infrared energy, and that energy gets trapped by the Earth's atmosphere to keep Earth warm.

Now see if you can explain what happened to the paper.

1. When you directed the Sun's energy onto the black dot, did the white paper get hot? Why or why not?

2. Why did the black dot burn?

3. If you wish, try this experiment again with different colored dots. Share your results with a parent.

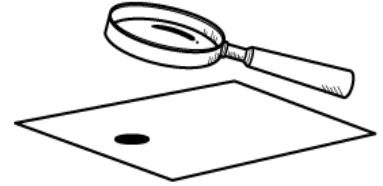
The Sun and Heat

Materials:

- dark colored piece of clothing
- light colored piece of clothing
- half a sheet of white paper
- magnifying glass (kit)
- black marker

Directions:

1. Make a solid black dot toward one end of the paper.
2. Take the card and magnifying glass and go outside into direct sunlight. This experiment works best when the Sun is at its strongest in the afternoon and there are no clouds blocking the light.
3. Use the magnifying glass to focus sunlight onto the black dot. **Note:** Have a parent with you for this step. Also, the reflection of the sunlight off the white paper will be bright! Wear sunglasses, or avoid looking at it.
4. Keep the light focused on the dot and wait a minute. If nothing happens, adjust the angle of the magnifying glass and try again.



What Happened?

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The dark colored clothing should feel warmer. Why? Remember from Lesson 3 that the colors we see are actually the colors that are being reflected. A white item is reflecting all colors, while a dark item is reflecting no colors (or very little). This means that dark colored items are absorbing more light, more of the Sun's energy. The Sun also gives off *infrared* light, which we cannot see. And while both light and dark colors absorb the Sun's infrared energy and convert it to thermal energy, darker colored items absorb more of it.

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Now see if you can explain what happened to the card.

1. When you directed the Sun's energy onto the black dot, did the white paper get hot? Why or why not?

2. Why did the black dot burn?

3. If you wish, try this experiment again with different colored dots. Share your results with a parent.

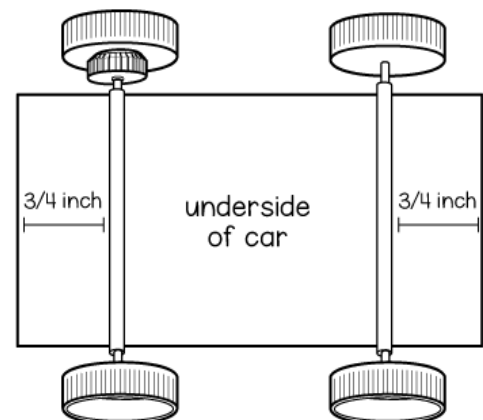
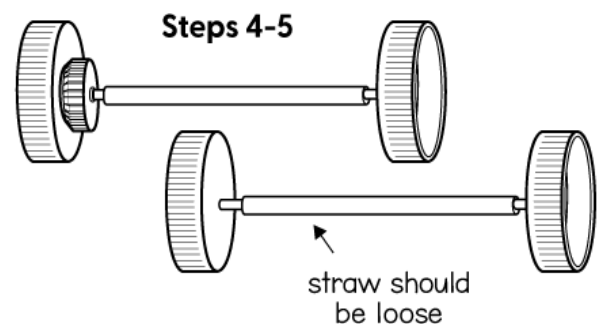
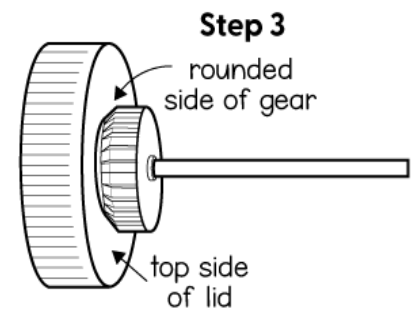
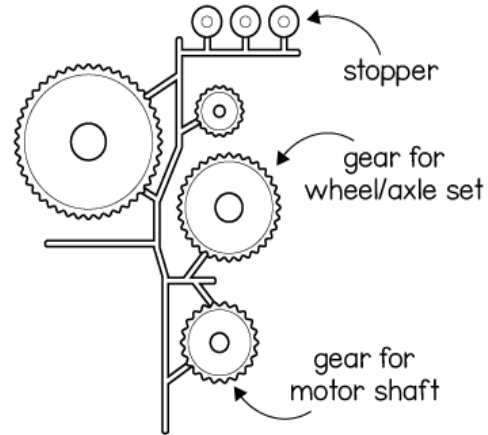
Solar Car

Materials:

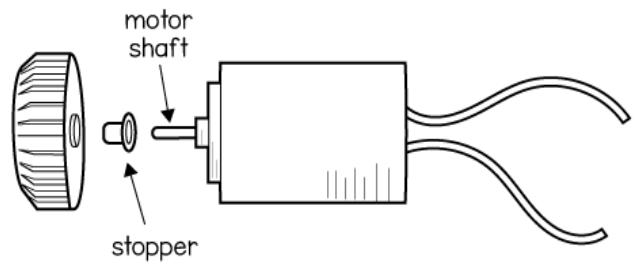
- gears (kit)
- 2 straws (kit)
- 1 solar panel (kit)
- 1 motor (kit)
- 2 pieces of cardboard (kit)
- hot glue gun or a strong, fast tack craft glue
- 4 lids (kit)
- 2 dowel rods (kit)
- tape

Directions:

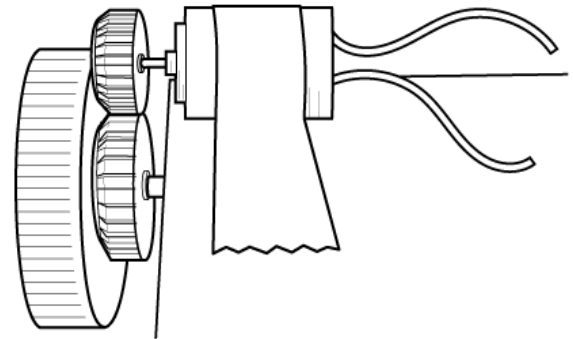
1. Cut two 5.5-inch sections from two of the straws.
2. Take the second-smallest gear and place it on one end of a dowel rod with the more rounded side facing that end of the dowel.
3. Using a hot glue gun or a strong craft glue, glue the end of the dowel and the more rounded side of the gear to the center of one of the lids (the top side of the lid, not the inside). Make sure the glue is completely dry and that the dowel rod and gear are securely attached to the lid before moving to the next step. (See diagram.)
4. Slip the cut straw piece onto the dowel rod and glue the other end of the dowel to the top side of a lid. Make sure the straw is loose in the center. Don't let the straw get glued to the dowel. It needs to be able to spin freely.
5. Make a second wheel-and-axle set (this time without the gear) by slipping the other straw piece onto a dowel and gluing the dowel to the top side of two lids. Make sure the straw on both sets can spin easily.
6. Find the two pieces of cardboard. Glue one piece directly on top of the other to create a firm base for the car.
7. Glue the wheel-and-axle sets about 3/4 of an inch from each end of your cardboard base. The glue should only be touching the straws, not the dowels. (See diagram.)



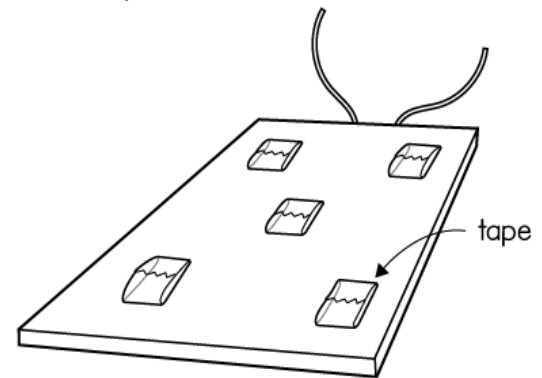
8. Find the stopper and the gear for the motor (see the gear diagram from Step 2). Firmly push the stopper into the hole in the middle of the larger, flat side of the gear. (The stopper only goes in one way.) Then place glue in the hole of the stopper and press the stopper and gear onto the end of the motor shaft. Make sure the gear is glued only to the shaft and not to the motor itself! The shaft and gear need to be able to spin when the motor is on.



9. Position the motor on the cardboard base so that the two gears are lined up and engaging. Securely tape the motor to the cardboard base. Check that the gears are still lined up and adjust the position of the motor as needed.

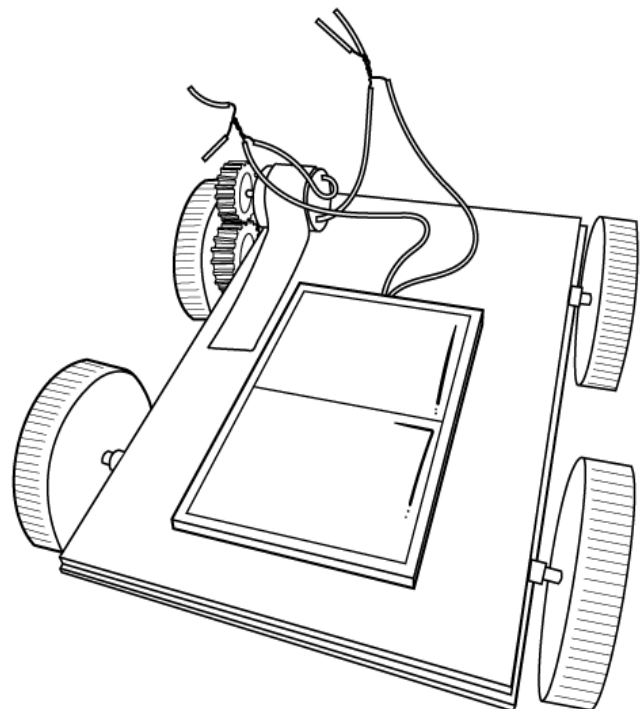


10. Create several loops of tape (sticky side out) and put them on the underside of the solar panel. Place the solar panel near the middle of the cardboard base and press it down firmly. Add more loops of tape if needed until the solar panel feels secure. (You can also glue the solar panel to the cardboard if you prefer.)



11. Twist the red wire from the solar panel and the red wire from the motor together (twist them 2-3 times) so that the metal parts of the wires are touching. Repeat with the black wires.

12. Now that your car is set up, take it onto a flat surface in the sunlight and watch it move! You may need to give it a little push to start or double check that you are not on an incline.



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Getting Started

? Ideas to Think About

- What is the unique relationship between the Sun and living things?
- What is the Sun's relationship to different types of energy?
- How does energy change?



Things to Know

- **Thermodynamics** is a branch of science that focuses on heat and how it is related to work, energy, temperature, and matter.
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- The second law of thermodynamics states that energy always moves from hot things to cold things.
- The third law of thermodynamics states that nothing can be colder than absolute zero (-273.15 degrees C / -459.67 degrees F).
- The Sun's energy can be used to do work and to heat our homes.

⦿ Skills

- Recognize that energy comes from the Sun to the Earth in the form of light. (S)
- Identify sources of stored energy, such as food, fuel, and batteries. (S)
- Understand that heat is transferred from hot things to cool things. (S)
- Identify and explain the laws of thermodynamics. (S)

Introducing the Lesson

Explain to your child that in this lesson she will explore the Sun's role as a source of energy. The activities for Day 2 require a sunny day. If you don't have the proper weather conditions, move on to the next lesson and complete this lesson on your next sunny day.

Reading and Questions

1. What topics scientists study if they were interested in thermodynamics?

They would study the following topics and the relationships between them: heat, temperature, matter, energy, and work.

2. At what temperature do atoms have no thermal energy?

Absolute zero. This equates to -459.67°F, or -273.15°C.

3. What else, besides energy, does the first law of thermodynamics apply to?

It also applies to matter.

Activities**Activity 1: The Laws of Thermodynamics**

Assist your child as needed with connecting the battery to the motor and the buzzer.

For the first law of thermodynamics:

- In the first demonstration, chemical energy is being converted into electrical energy in the battery. The motor converts electrical energy into kinetic energy to spin the color wheel.
- In the second demonstration, chemical energy is being converted into electrical energy in the battery again, and the buzzer converts electricity into sound energy.

For the demonstration of the second law of thermodynamics, talk with your child about the explanation (the "What Happened?" section) on the activity page.

When your child has finished watching the video about absolute zero, ask her why being able to identify the temperature of absolute zero is helpful to scientists. (It gives scientists a number that means "no thermal energy" and is helpful for calculations involving thermal energy.)

Day 2**Activity 2: The Sun and Heat**

NOTE: As a precaution, supervise your child while she completes this activity. The paper will smoke lightly as it burns through where the black dot is, but there should be no flame.

In this activity your child will experiment with changing light energy into thermal energy. As the sunlight is focused onto the black dot, the light energy will create enough heat in the black dot to burn a hole through the paper.

Answers to questions:

1. When you directed the Sun's energy onto the black dot, did the white paper get hot? Why or why not? (Not really, because it reflected a lot of the Sun's energy.)
2. Why did the black dot burn? (The black color absorbed a lot of the Sun's energy, enough to cause the paper to burn.)
3. If you wish, try this experiment again with different colored dots. Share your results with a parent. (Colors that are very close to black should absorb enough energy to burn through the paper.)

Activity 3: Solar Car

For this activity your child will make a solar car. Help her troubleshoot if she is not able to get her car to run. This activity works best on a very sunny day, so if your child's car doesn't run as well as she would like, have her try again on a brighter day, at a time when sunlight is at its most intense.

Wrapping Up**Questions to Discuss**

- Can you describe the three laws of thermodynamics in your own words? (Encourage your child to use her own words. The laws are: 1. Energy can't be created or destroyed, but it can be changed. 2. Heat energy always moves from hot things to cold things. 3. You can't have anything colder than absolute zero.)
- Why is solar power an environmentally friendly form of power? (It is renewable and it produces no pollution. Sunlight can be used to make electricity for heating homes and water, and it can also be used to heat homes and water directly.)

Things to Review

Review the three laws of thermodynamics. Review reasons that people continue to research ways to use the Sun for energy. Review that energy from the Sun is called radiant energy.