EXPERIMENT MANUAL

IGNITION SERIES

SOLAR THERMAL LAB

THAMES & KOSMOS

WARNING — Science Education Set. This set contains chemicals and parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.

Contents

- 4 Colored die-cut card sheets
- 2 White die-cut card sheets
- 1 Solar wheel die-cut sheet
- 1 Sheet of clear plastic film
- 2 Wooden sticks
- 1 Piece of clay
- 2 Needles
- 2 Metal caps
- 1 Tracing paper cutout sheet

You will also need:
- *Glue*
- *Tape*
- *Scissors*
- *Aluminum tealight candle holder*

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General Instructions

DEAR PARENTS: With this experiment kit, children as young as seven years of age will be able to perform experiments with the power of the sun. The comparative experiments, which use two sets of components and two different mounted solar attachments, will help them learn about solar energy, thermal lift, and solar updraft towers in a fun and playful way. When assembling the solar towers, wheels, and constructing their own attachments, they will be actively and creatively engaged. Please help your young investigators, since the curiosity and comprehension powers of young children are often better developed than their manual abilities, and make sure to provide them with any additional materials that are not contained in the kit. **Have fun with the experiments!**

Safety Information

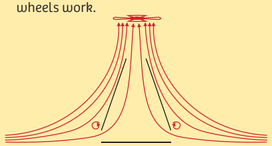
NOTE! Not suitable for children under 3 years of age. There is a risk of suffocation due to small parts that might be swallowed or inhaled.
Save the packaging and instructions, which contain important information.

Before You Start: What Makes the Solar Wheels Turn?

The wheels at the top of your **solar updraft towers** turn with the help of a stream of **warm air**. Most substances "expand" when they are heated. Heat makes air and other gases expand quite a bit. You can actually feel that air is not "nothing," but is actually a **substance**, when you ride your bicycle against the wind or when you stretch your hand out the car window while driving along.

Air gets **lighter** when it expands and rises upward through colder air. This kind of "air elevator" is known as an **updraft** or **thermal**. Birds and hang gliders use **thermal lift** to climb upward. The term comes from Classical Greek *therme*, meaning "heat."

You can intensify thermal lift through something called the **"stack effect,"** which narrows the stream of air through a cone or pipe, just like a chimney. **The higher the chimney, the stronger the upward flow of air.** And that is exactly how your solar wheels work.



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How to Assemble Your Solar Updraft Towers

YOU WILL NEED:
- Colored die-cut card sheet, clay, wooden sticks, needles, metal caps
- *Glue, tape*

STEP 1

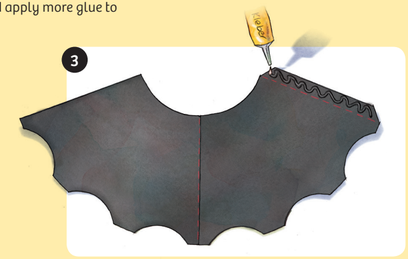
Remove the black card sections from the die-cut sheets and lay them out in front of you as shown in the picture. You will need two card sections for each solar wheel cone.

STEP 2

Apply glue to the right edge of one card section.

STEP 3

Affix the left edge of your other card section to the glued edge, and apply more glue to the right edge.



>>> Solar Updraft Tower Assembly, Continued

STEP 4

Glue the cone together.

Tip! If your cone isn't perfectly round, carefully bend it into shape with your hands.

STEP 5

Divide the clay into two equal-sized pieces, shape them into disks about 2 cm thick, and insert the wooden sticks into them flat-end first.

STEP 6

Tape the needle pointy-end up to the top end of the wooden stick. Place the metal cap on the needle. **Be careful not to stick yourself with the needle! Never let the wooden stick sit around without a cap over the needle!**

STEP 7

Place the clay disk with the wooden stick, needle, and metal cap in the center of the cone.

Now the base of your solar updraft tower is complete.

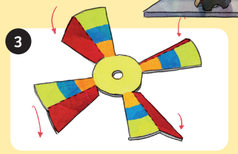
Which Wheel Turns Faster?

EXPERIMENT 1

YOU WILL NEED:
› Basic solar tower assembly, solar wheel die-cut sheet

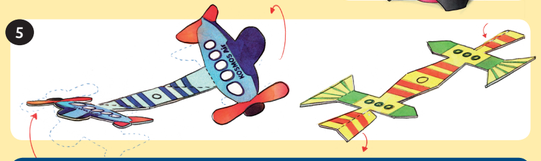
1. Remove the 2 solar wheel attachments from the die-cut sheet.
2. Place your solar towers in a sunny spot that is sheltered from the wind. You can perform your experiments either outside or inside near a window.
3. Bend the flaps of the wheels down along the marked lines.
4. Insert each metal cap through the little hole in the center of the solar wheel attachment.

Now you can do an experiment to see which wheel turns faster.



Tip! Bend all of the flaps on the solar wheel attachment the same amount.

5. Test the spiral and the airplanes to see how they turn too. Bend the blue airplane upward along the dotted line, and the wings of the yellow airplane downward. Who wins the race?



WHY? The heated air streams upward and hits the solar wheels. Because their blades are slightly angled against the stream of air, they move away from it. The stream of air is also deflected a little as it winds its way through the blades. That slows the air down, and it transfers some of its force — which becomes rotational force — to the solar wheel. With the four-bladed wheel, there is more space between the blades than with the wheel with eleven blades. So it produces less resistance with each rotation, and can turn faster than the eleven-bladed wheel, which turns more slowly but with greater rotational force.

Black and White

EXPERIMENT 2

YOU WILL NEED:
› Basic solar tower assembly, solar wheel attachments, white die-cut sheet
› *Glue*

1. Glue together the white card exactly as you did with the black one. Now you have a white solar tower cone as well.
2. Set one wooden stick with clay, needle, and attachment in the white cone and one in the black cone.

Does a wheel placed on the white cone turn too?

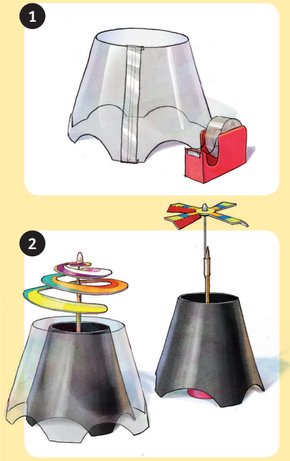
WHY? Dark objects absorb more heat radiation than light-colored ones, and emit heat more readily as well. Light surfaces, on the other hand, reflect almost all the heat radiation that reaches them. That is why black objects become warmer in the sun than white ones do. The black cone uses this heat to make its wheel turn. Nothing moves above the white cone, by contrast.

A See-Through Coat

EXPERIMENT 3

YOU WILL NEED:
› Basic solar tower assembly, solar wheel attachments, clear plastic film
› *Tape*

1. Remove the rubber band from the sheet of film, unroll it, and tape its ends together to form a cone.
2. Place the cone of film over one of the solar tower cones. Set the other solar tower cone next to it.
Which wheel turns faster — the one with or without the film?



WHY? The cone under the film suddenly finds itself inside a miniature greenhouse. In other words, you are making use of the greenhouse effect: The glass or clear plastic roof of a greenhouse lets more solar radiation in than it lets back out, so the heat accumulates under the roof. That is why it is always warmer inside a greenhouse than it is in the outside air.

Light Versus Heavy

EXPERIMENT 4

YOU WILL NEED:
› Basic solar tower assembly, solar wheel attachments, tracing paper cutout sheet
› *Scissors*

1. Cut the solar wheels out of the tracing paper sheet and bend them along the dotted lines as you did with the other attachments.
Be sure that you only cut along the black lines! Do not cut into the dotted or colored lines!
2. Insert the needle into the hole in the center of the attachments, and then mount the metal cap.
3. Test a normal wheel attachment along with an attachment made of tracing paper.

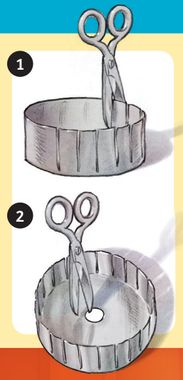
Which wheel turns faster?

WHY? The tracing paper attachments are lighter, and they therefore produce less friction resistance between the needle and the metal cap. That means that more power remains for the rotation. In addition, some solar radiation passes through the tracing paper to the cone. The normal wheels, by contrast, don't let any sunlight through.

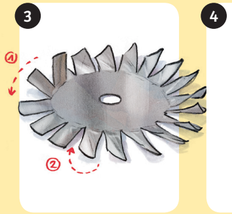
Homemade Wheel

EXPERIMENT 5

YOU WILL NEED:
› Basic solar tower assembly
› *Empty aluminum tealight candle holder, scissors*



1. Make 16 cuts in the side wall of the tealight candle holder from the top edge to the bottom.
2. Use a scissors or needle to puncture a hole in the center of the bottom section for the metal cap. **Be careful not to injure yourself! It's best to have an adult help you with this part.**



3. Press the cut tealight cup wall flat and bend one edge of each blade slightly up.
4. Insert the metal cap through the hole in the center of the tealight wheel, mount it on the tower assembly, and set it in the sun.

Tip! Now that you have made your own solar wheel attachment, you will probably have more ideas for other great attachments. How about a yogurt container wheel, or a glider? First sketch the shape on a piece of paper, cut it out, make a hole in the center, and off you go. Just be sure that each attachment looks identical on the opposite side, or it won't be in proper balance.

Check It Out

PLANES IN THE UPDRAFT

Gliders cannot climb by their own power, and they will naturally descend through the air on a gradual downward path to the ground. In order to climb back up again, pilots look for thermals, which are chimneys of updraft thousands of meters high that form over warm regions (such as fields of ripening grain or mountain masses). These updrafts can attain speeds of over 30 km/h. Gliders can use them to spiral upward, and then coast along to the next thermal.

SOLAR UPDRAFT TOWER

A **solar updraft tower** converts the energy of an updraft into electricity.

This kind of power plant consists of a large collector and a chimney inside of which a turbine and an electrical generator rotate.

An early example of a solar updraft tower was in operation in Manzanares, Spain, from 1986 to 1989. Its collector had a diameter of 240 meters, and its chimney was 10 meters wide and 195 meters high. This prototype was able to supply 40 households with electricity.

Other solar updraft towers with chimney heights of up to 1000 meters and capable of providing electricity to 200,000 households are in the planning stages in the U.S. and Africa.

HOT AIR BALLOON

This is nothing more than a "packet" of hot air rising up through cooler air. When the balloon's air cools off, a gas flame is used to heat it back up again.