EXPERIMENT MANUAL

POWER HOUSE

THAMES & KOSMOS

WARNING — Science Education Set. This set contains chemicals and/or 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.

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Safety Information

WARNING. Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Store the experimental material out of the reach of small children.

WARNING. This kit contains functional sharp pointed wires. Do not injure yourself!

WARNING. Only for use by children aged 10 years and older. Instructions for parents or other supervising adults are included and have to be observed. Keep packaging and instructions as they contain important information.

Please note all of the safety information throughout the manual.

We reserve the right to make technical changes.

Rules for Safe Experimentation

- Prepare a dedicated work area for the experiments. Give yourself adequate space to lay out all of the materials you will need and conduct all of the experiments.
- Do not use equipment other than that provided with the kit or the acquisition of which is expressly recommended for particular experiments.
- Read the instructions before use, follow them, and keep them for reference.
- Clean all containers and tools after use.
- When an experiment calls for foods and food products (e.g., table salt), fill the required amount into a clean bowl and use this as the supply for your experiment, instead of using the substance directly out of its original packaging. Do not return foods and food products to their original packaging and do not consume any leftovers. Discard them immediately (in the household trash or the sink).
- Keep small children and pets away from the experiment area.
- Keep the experiment kit and additional materials out of the reach of young children.
- If you accidentally get something in your eye, such as a splash of vinegar, rinse the eye with plenty of water. An adult should assist you.

Safety for Experiments with Batteries

- You will need one button cell battery (type LR44, 1.5 volt) for the digital thermometer. The battery is included; it is already inside the thermometer. See page 3 for more information.
- Instructions for removing and inserting the battery can be found on page 3.
- Non-rechargeable batteries are not to be recharged. They could explode!
- Rechargeable batteries are only to be charged under adult supervision.
- Rechargeable batteries are to be removed from the toy before being charged.
- Different types of batteries or new and used batteries are not to be mixed.
- The battery is to be inserted with the correct polarity.
- Exhausted batteries are to be removed from the toy.
- The supply terminals are not to be short-circuited. A short circuit can cause the wires to overheat and the batteries to explode.
- Never perform experiments using household current! The wires are not to be inserted into socket-outlets. The high voltage can be extremely dangerous or fatal!
- Avoid deforming the battery.

Notes on Disposal of Electrical and Electronic Components

The electronic components of this product are recyclable. For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:

Please contact your local authorities for the appropriate disposal location.

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Information for Parents and Adults

On thousands and thousands of rooftops, shiny blue solar cells are generating electricity from sunlight. On hills, along the coast, and now in offshore wind farms too, wind turbines are busy at work producing electricity as well. Solar collectors convert the sun's heat into hot water. And more and more homeowners are wrapping their houses in insulating materials in order to save precious heat, or even building energy-efficient houses that can keep their occupants comfortable with a reduced outside energy supply.

It's no wonder: Word has gotten around that the traditional energy sources of coal and petroleum are becoming scarce and more expensive. That's why our energy supply is now in a state of turmoil. Over the next few decades, things will shift more and more from coal and oil to renewable energy sources such as solar, wind, and biomass. This massive reorganization is a task that will preoccupy humanity for decades, but it is also expected to create millions of new jobs. That is another reason it's important for our children to start working on this highly pertinent issue right away. This experiment kit uses safe and fun experiments to help your child learn how energy is obtained from renewable sources, particularly from the energy of the sun. In the process, your child will learn how to capture the sun's heat and use it to warm water or even to desalinate ocean water. He or she will find out why houses should be insulated against heat loss and how to do it. Your child will see how sunlight is converted into electricity. And finally, he or she will learn to see the wind as a useful energy source and to understand the effect of light and water on plants. Naturally, your child will learn a lot in the process about the properties of heat, light, and electricity.

Please be ready to stand by, support, and accompany your child as he or she works on these extremely important and timely experiments. Read through the manual together before starting the experiments and follow its instructions. Please also be careful not to let any parts from the kit get into the hands of young children.

Kit Contents

The Power House experiment kit contains the following parts:

	Description	*Qty.*	*Item No.*
1	Power House polystyrene parts:		708662
	a) Base, roof sections, inserts		
	b) Wall (pointed) with house door		
	c) Wall (pointed) with window		
	d) Wall with solarium		
	e) Wall with window		
2	Solar cell	1	708678
3	Solar motor	1	709143
4	Contact clips	4	708664
5	Digital thermometer	1	712120
6	Black bottle		
	(Solar collector)	1	263160
7	Lid	1	709131
8	Large dowel	1	263118
9	LED	1	000145
10	Solarium cover	1	708665
11	Long wooden sticks	2	020042
12	Black paper sheet	1	702303
13	Propeller	1	263143
14	Sandpaper	1	700881
15	Plastic pot	3	705804
16	Disk	1	708666
17	Short wooden sticks	8	705296
18	Die-cut sheet	1	708663
19	Cut-out sheet	1	709170
20	Connecting wire, black	1	263140
21	Connecting wire, red	1	263139
22	Small dowel	1	709140
23	Straight drinking straw	1	707597
24	Bendable drinking straw	1	529118
25	Fastening clips	3	020039

Additional Items Needed

You will also need various household items for some of your experiments. These items are highlighted in *italics* in the individual experiments. Before beginning an experiment, carefully read through the list of all the things you will need, and make sure to get anything that might be missing.

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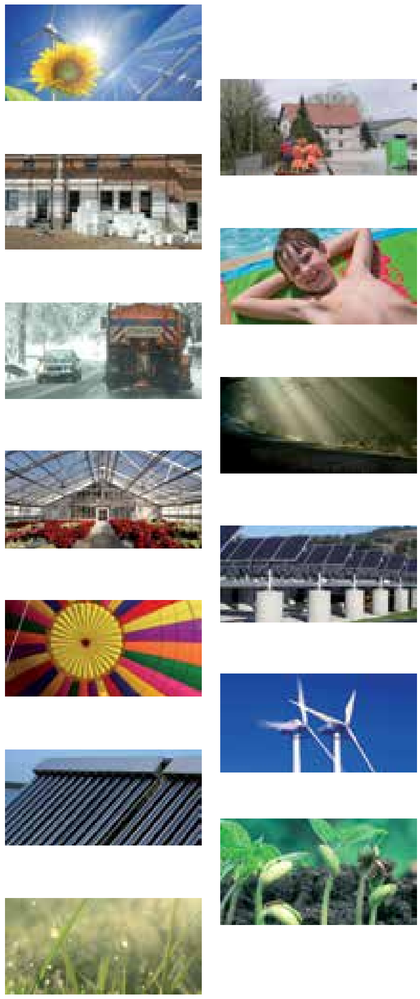


Good Advice

How to use the digital thermometer

Before you start using your new thermometer to measure temperature, please note the following:

1. Remove the clear film that is inserted as insulation between the battery and contacts inside the battery compartment by pulling on the small tab. The temperature in degrees Celsius (abbreviated as °C) is immediately displayed. This is the room temperature of the room you're currently in.

2. Press the button labeled "°C/°F" on the back of the thermometer to toggle the display between degrees Celsius and degrees Fahrenheit.

3. To save battery life, you should always turn off your thermometer when you do not need it. To do this, simply press on the little "ON / OFF" button on the back.

Battery: If the battery is dead, you can replace it. Carefully unscrew the two little screws on the back of the thermometer. Be careful here that you do not lose the little screws, as they are very small! Slide the cover off sideways. Now you can see the small battery. To remove it, use a flat screwdriver to carefully pry it up from below. It will come out and you can insert a fresh battery (LR44, 1.5 volt button cell). Make sure that the text along with the plus sign is visible on the top of the button cell after it is installed. Close the cover and retighten the two little screws.

Research for the future

You have probably heard reports of energy issues and climate change in newspapers or on television. For years, human civilization has been living beyond its means. We have been consuming too much energy, resources, and land. Our energy supply poses particularly serious problems. Without energy, we cannot heat our homes or produce electricity, run factories, or power cars. And we even need energy to produce and distribute food.

Up to now, we have met almost all our energy needs with materials such as coal, petroleum, or natural gas. These materials have formed and accumulated in the Earth over the course of millions of years. But their quantities are limited. If our consumption of them continues as before, our supply of oil will be used up within a few decades, and coal supplies will be exhausted within a few centuries. On top of that, energy prices are rising as the easily located deposits are used up and a lot more effort has to be put into finding new ones. And finally, it has been shown that the gas know as carbon dioxide, which is released when coal, oil, and gas are burned, has been accumulating in Earth's atmosphere and affecting Earth's climate in undesirable ways. So it's high time that we developed other energy options. A particular problem is the rapid population increase in certain countries. In the last 60 years, Earth's population has tripled! Of course, all these people also consume resources.

Sustainability is the solution

The solution for our future lies in what is called a "sustainable economy." The term comes from the field of forestry, where it means something very sensible: Over the long run, you shouldn't chop down more wood than can grow back in the same period of time. Otherwise, sooner or later, the forest will be used up.

So sustainability means that instead of plundering our planet's supplies today in order to make as much money as possible in the short run, we should save as many of our resources as possible for future generations. We should take care of our air, water, and climate, protect biodiversity, be frugal with Earth's resources, and promote the quality of life of all people on the planet — not just those who live in the wealthy industrialized nations. Developing the economy while maintaining respect for the environment and nature, protecting the climate, conserving resources — the meaning of the word "sustainability" includes all these things.

It also includes the idea that we should save as much energy as possible. At present, we still waste a lot of precious heat and electricity. And we have to end our dependence on petroleum, natural gas, and coal, and switch to renewable energy sources. Those are sources that are practically inexhaustible, because the sun keeps on renewing them. The sun, after all, supplies Earth with more than enough energy — around 6,000 times more than all of humanity consumes in any given period of time. And it will keep doing this for billions of more years.

Hydropower and wind power are examples of renewable energy sources. Rain supplies water to rivers and the wind blows thanks to the sun's heat. Green plants also rely on sunlight for their growth, and for converting their energy into biomass. A small part of that biomass serves as food for animals and people. But that still leaves plenty for people to use as energy.

The exploitation of coal and petroleum fossil fuels was a prerequisite for industrialization. The negative consequences include environmental pollution and damage to the climate.

A force of nature turned into a source of energy: offshore wind farms on the open seas make use of strong, constantly blowing winds to supply electricity to the land.

The offshore substation at Sweden's Lillgrund wind farm gathers the generated energy and a 120-MVA power transformer converts the voltage from 33 kilovolts to a transmission voltage of 138 kilovolts so that the energy produced at the wind farm can be fed into the Swedish electrical grid. The wind farm generates enough electricity to supply 60,000 Swedish households. (Siemens press photo)

"Renewable energies" research project

With the appropriate technology, you can "tap" the sun directly and use its radiation to produce heat and electricity. Our methods for obtaining energy from such sources as wind and sunlight have improved dramatically in recent years, and continue to be developed in laboratories and firms in many countries.

This kit's components will help you perform experiments in this interesting and highly important field. You will create electricity from wind and sunlight and use it to power an LED, an electric motor, and even a small solar boat. You will discover how much heat the sun can supply, as long as you know what tricks to use. You will investigate the ways that plants are dependent on light and water. On top of all that, you will use your Power House to research how to protect a building from heat loss and thereby save on heating costs. In all these experiments, you will learn a lot of interesting things about air currents, heat, electricity, sunlight, and plants. Have fun with your experiments and research!

Energy Saving Tip

With this experiment kit, you will be learning a lot about alternative forms of energy and how they can help to preserve our supplies of natural resources. But you don't have to use new cutting-edge technology to save energy and money. Throughout this manual, you will find simple tips that can help you start saving right away.

Good Advice

For some of the experiments, you will need to have a sunny day as free of clouds as possible. These experiments are marked with a sun symbol.

You can still carry out all of the experiments even if the weather is bad. Just use a strong incandescent light bulb (at least 60 W) as your energy source instead of the sun. However, you should be aware that, on energy-conservation grounds, conventional light bulbs of this wattage are starting to be phased out and are being replaced with energy-efficient bulbs. Unfortunately, most of the experiments will not work with energy-efficient bulbs. At the time that this manual is going to print, we do not know of an equivalent alternative to conventional incandescent bulbs. If you have a very strong flashlight, you can also use that.

Energy sources such as wind, sun, and biomass are always available and will never run out.

Construction Material

Before assembling your Power House, first look more closely at the polystyrene foam construction material that the house parts are made of.

EXP. 01

Lightweight polystyrene foam

Polystyrene foam is unbelievably light. Do you think it might even float?

You will need

Wall (d) polystyrene section, *bathtub or large bowl*

Experiment

Fill the bathtub or bowl with several centimeters of cold water and toss in the polystyrene piece. It floats on the surface of the water and hardly sinks at all. You can even lay things on top of it, and it will carry them.

Explanation

Polystyrene is a foamed material, primarily composed of small bubbles of air surrounded by an extremely thin skin of plastic. So it's no wonder that it is so light that it floats. That is why a lot of life preservers are filled with polystyrene foam, which is more stable but almost as light as air alone.

EXP. 02

Polystyrene foam stops noise

Noise is a major problem today. Can polystyrene foam dampen the noise?

You will need

Polystyrene wall section (d), *source of noise*

Experiment

Switch on the radio or TV and put a finger over one ear. Over the other ear, hold the polystyrene just tight enough to pretty much seal off the ear. Compare the noise level with and without the polystyrene covering your ear.

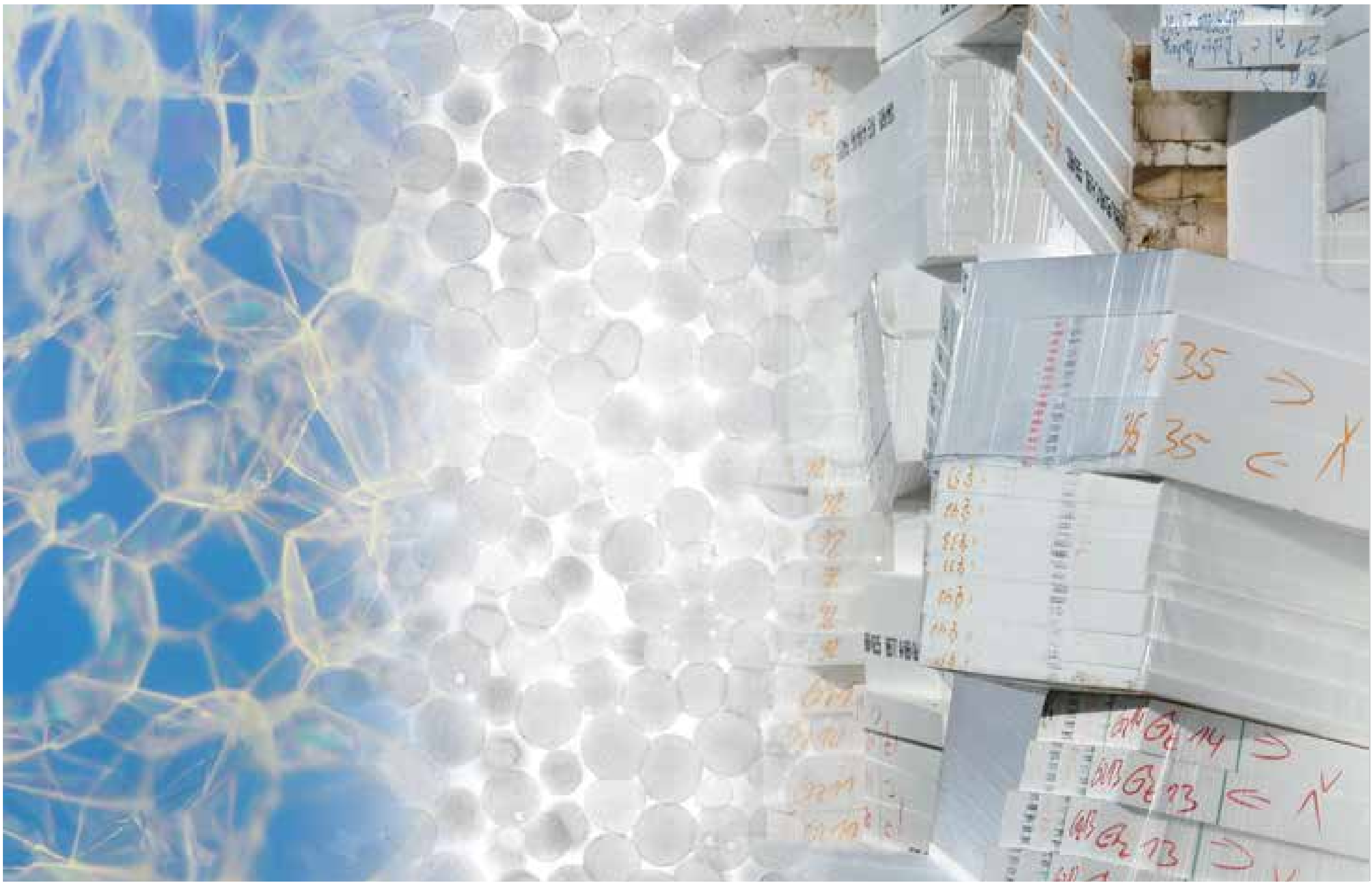
Explanation

The polystyrene noticeably muffles the noise, which is partially absorbed by the many air bubbles and their walls. There are, however, better materials designed specially for noise insulation.

Energy Saving Tip

Always fill washing machines to capacity (according to manufacturer's instructions) — half-empty drums consume unnecessary energy and water.

Packaging, sound-proofing, insulation — polystyrene has lots of uses.



EXP. 03 Captured heat

But polystyrene doesn't just protect against noise. It can keep other things from getting in or out as well.

You will need

Polystyrene base section and pointed wall, thermometer, *2 cups of very warm water (as hot as it comes out of the hot water tap)*

Experiment

1. Fill the two cups equally high with hot water. Set one by itself on the table, and the other in the appropriate depression in the base section and cover it as well as possible with the wall.
2. After an hour, check the temperatures of both cups with your finger. In which cup is the water warmer?

Explanation

Polystyrene is a very bad heat conductor. So the water in the wrapped-up cup stays warmer longer.

Energy Saving Tip

Check to see that windows and doors are sealed tightly. Drafts of air can cost you a lot of heat.

Good Advice

Sometimes it can take time for the effects you're looking for in an experiment to show up. It might be necessary to observe an experiment for a long while. To help you plan more or less how much time you will need for an experiment, this symbol is placed next to the longer ones. It indicates the amount of time the experiment requires.

1 Hr.

KEYWORD

Temperature-blocking air

Polystyrene foam consists of lots of trapped air bubbles. Air, however, is a bad heat conductor. That is why cold things will stay cold in polystyrene containers and hot things will stay hot. This property is used to good advantage in, for example, insulated containers for foods and drinks, coolers, and in the insulation for buildings, where an insulating layer of polystyrene is often installed between the wall and the outer siding.

Good insulation saves enormously on heating costs.

Cold, warmer, hot

There are times when you might want to measure the temperature — that is, determine exactly how hot or cold something is. For that, you use a thermometer. As a good researcher, you first have to find out how to handle that kind of device correctly.

EXP. 04 Warm or cold?

Do you even need a thermometer? You can also just use your hand to feel how warm or cold something is, can't you? Try it yourself…

You will need

3 bowls, ice cubes

Experiment

1. Set the three bowls in front of you on the table. Fill one with water and add a few ice cubes. To the second bowl, add warm water about the temperature of bath water. And add lukewarm water to the third.
2. Now put your left hand into the ice water for a few seconds, and put your right hand in the warmest water. Then dip both hands together into the lukewarm water. Is it warm or cold?

Explanation

Surprise: The left hand tells you the water is warm, while the right perceives the same water as cool. So the heat sensors in your skin won't work very well as temperature gauges.

EXP. 05 The warmer it is, the more there is

In order to avoid having to use your hands as temperature sensors, the experiment kit includes a digital thermometer. You are probably also familiar with conventional glass tube thermometers with red liquid inside them. Let's explore how thermometers work.

You will need

Black bottle, *plastic wrap from the kitchen, cup of hot water, scissors*

Experiment

1. Place the open black bottle in the fridge or freezer for an hour.
2. Cut off a piece of plastic wrap and use it to make an airtight seal over the bottle opening.
3. Set the bottle in the cup of warm water. Watch the plastic wrap.

Explanation

The plastic wrap bulges outward because the air in the bottle expands, or increases its volume, as it warms. Almost all materials demonstrate this same property. The red-colored fluid in conventional thermometers also takes up more space as it warms, and it therefore rises higher and higher in the thin tube as it fills it up. Then, you can read the temperature on the scale.

The digital thermometer in this kit works a little differently. In the thermometer's metal probe, there is a temperature-sensitive electronic resistor. The resistor conducts more electricity when it is hot, and less when it is cold. A little microcontroller inside the thermometer body converts the resistance into a numeric temperature and displays it on the digital readout.

EXP. 06 How to measure temperature correctly

1 Hr.

Even though it looks like a simple matter to measure the temperature with a thermometer, you still have to pay attention to a few things if you want to get an accurate temperature reading. This experiment works best outside on a sunny day.

You will need

Thermometer, *paper, pencil*

Experiment

1. Place the thermometer in the shade, wait half an hour, and then check the number on the digital display. Make a note of the number.
2. Now move the thermometer so it's completely in the sun and, after half an hour, note the number on the digital display again.
3. Is it enough for just part of the thermometer to get sunshine? Place it so that just the metal sensor end has the sun shining on it while the rest is in the shade, and take a look again after another half hour.

Explanation

If you want to measure the air temperature, the thermometer has to be in the shade, because otherwise it will be heated directly by the sun and it will display too high a temperature.

Sensor

EXP. 07 Where ice melts and water boils

Try determining various temperatures with the thermometer. How cold is ice, for example? And how hot is boiling water?

You will need

Thermometer, *ice cubes, cup, pot*

Experiment

1. Let the thermometer sit in a room for a few minutes, but not in the sun or under a lamp. Read the temperature on the digital display.
2. Add a few ice cubes to a little cold water in the cup and stir for about 5 minutes. Then immerse the thermometer sensor into the water-ice mixture and read the temperature.
3. Bring some water to a boil in the pot and hold the thermometer sensor in the steam directly above the water's surface. What does it show?

You should have an adult help you with this part of the experiment. Be careful not to scald yourself with the hot steam or water!

Explanation

In the ice-water mixture, the thermometer indicates "0 °C," while in the steam it indicates around "100 °C." In your room, on the other hand, the temperature presumably lies somewhere between "18 °C" and "20 °C," or maybe higher in summer.

It's no coincidence that ice melts right at 0 and water boils at 100. By default, our thermometer uses a scale named after the physicist Anders Celsius. In order to be able to compare temperature measurements taken with different kinds of thermometers, he specified these two temperature points as 0 and 100 and divided the range between them into 100 equal-sized sections, or degrees. So water freezes at 0 degrees Celsius (°C for short) and boils at 100 °C. Water from the hot water tap is usually between around 50 and 70 °C, depending on the heater thermostat setting. And when people talk about "room temperature," they mean around 20 °C.

EXP. 08 Salt makes ice colder

Of course, your thermometer wouldn't be able to show the point of absolute zero. But even in summer, you can get temperatures lower than zero degrees Celsius.

You will need

Thermometer, *ice cubes, table salt, cup*

Experiment

1. Mix the ice cubes with two full tablespoons of salt and some water, and stir several minutes.
2. Immerse the thermometer and take a reading after a few minutes.

KEYWORD

Temperature scales: Celsius, Fahrenheit, and Kelvin

Have you ever wondered why people say "Fahrenheit" when they specify a temperature? It's because there are other scales as well. Scientists and most people around the world use the Celsius scale. Mostly in the USA and also in England, people also use the Fahrenheit scale. On the Fahrenheit scale, ice melts at 32 degrees Fahrenheit (°F for short), and water boils at 212 degrees Fahrenheit. Scientists often use the Kelvin scale. People have discovered that there is a point of "absolute zero" temperature, which is as cold as anything can be. This point lies at -273.15 degrees Celsius. The Kelvin scale starts at this temperature as zero and then counts upward from there, but in other respects it uses the same degree divisions as the Celsius scale. So water freezes at 273 Kelvin (K for short, and with Kelvin you can omit the "degrees") and boils at 373 Kelvin.

Anders Celsius (1701-1744) defined the "degree Celsius" temperature divisions named after him. (Image: Uppsala Astronomical Observatory)

Explanation

Normally, ice melts at 0 degrees Celsius. But the salt lowers the melting point — now the ice is liquid at temperatures well below zero. Thus, the temperature drops to below the freezing point without freezing the liquid.

Road salt is used to prevent ice.

Energy Saving Tip
Turn down the heat in little-used rooms.

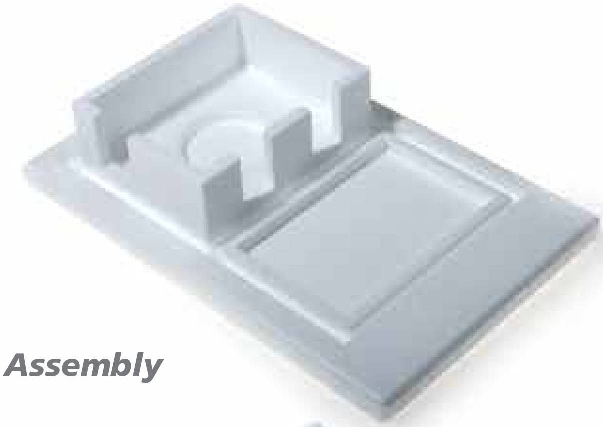
Project Power House

Now that the preliminary experiments are done, it is time to assemble your Power House. To start, you will need the polystyrene house pieces, some of which you may need to separate with a knife. Use the sandpaper to rub the roof and base edges smooth. Also remove the windows and doors from the die-cut sheet. Fold the large cardboard pieces down the middle and glue them together to create a double piece. When the house is standing, insert the two triangular film pieces into the solarium annex — they will stay firmly in place during all the experiments. Finally, place the covering over the solarium. Your Power House is ready!

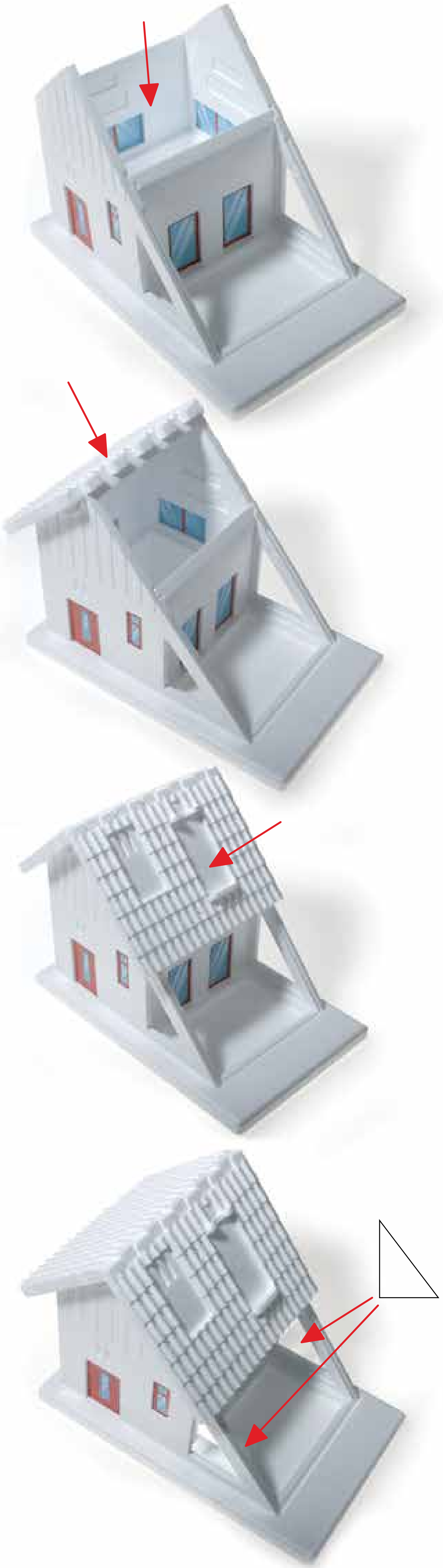
The parts sit firmly in the frame so that you can be sure that all the gaps of the house can be well sealed. You can carefully use your fingernail to help nudge all the pieces into place.

Good Advice

Save the polystyrene foam frame that you removed the roof pieces from. You will need it for other experiments!



Assembly



Power House in the sunshine

The sun is a prerequisite for all life on Earth. Without its warmth and light, nothing could live here. That's reason enough to study the sun's rays a little more carefully.

You will need sunshine for many of the experiments to follow, which you will recognize by the shining sun symbol. A few of them will also take some time, since you will have to check your measurements again and again. So take some time to experiment on a sunny day and take a look at all the things you can discover about the sun.

EXP. 09

The path of the sun

1 Day

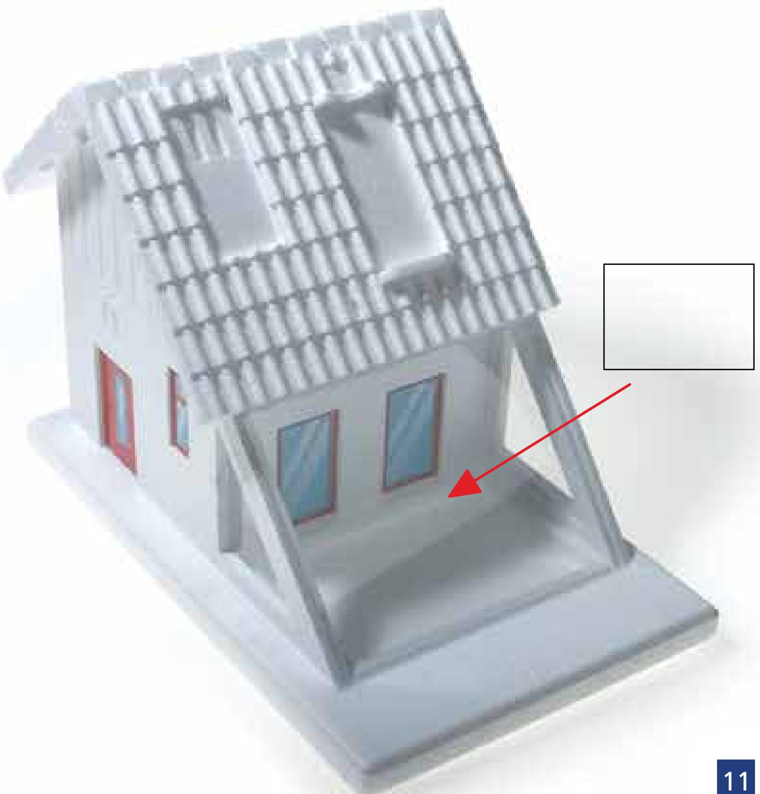
It probably won't be news to you that the sun moves across the sky during the day. But try studying this daily movement a little more precisely.

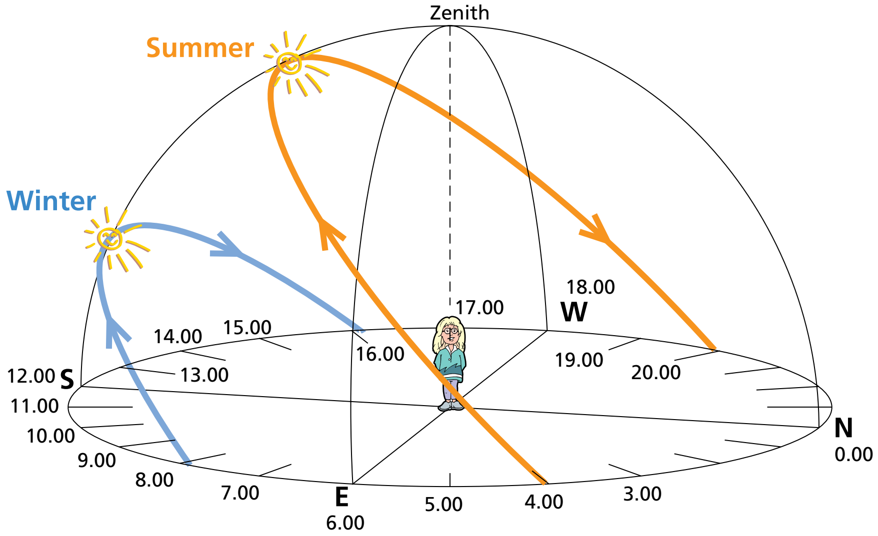
You will need

Dowel, *empty bottle, several sheets of paper, pencil, watch, adhesive tape*

Experiment

1. Insert the dowel into the bottle and place the bottle in a location where the sun will shine on it all day long.
2. Tape several sheets of paper together and lay the large assembled sheet under the bottle. About every half hour from morning until late afternoon, mark the end of the shadow cast by the dowel on the paper, and write the time next to each mark.
3. As you do that, watch the path of the sun across the sky, and make note of about where it rises, where it stands at noon, and where it stands in the evening.





The daily arc of the sun is higher and longer in summer than in winter.

KEYWORD

Living conditions

When planning a house, a builder should give some thought to how the house will be positioned with respect to the sun. After all, that will affect the quality of life in the house, and it will hardly be possible to change the rooms around later on. For example, it is good to face the bedrooms toward the east so they can get morning sun. The southern side would not be good because the summer sun would heat the rooms too much. Living rooms, balconies and verandas, on the other hand, should be oriented toward the south, with direct access to the garden if possible. For the kitchen, by contrast, where too much of the sun's warmth would be a nuisance, a northerly or easterly orientation is preferable.

Explanation

If you connect the marked points together, you will get a crooked line that comes very close to the bottle at one spot. That has to do with the fact that the sun doesn't just move sideways across the sky, but also changes its height over the horizon: Its highest point is at noon, and that is when it casts the shortest shadows. The direction in which it stands at that point is called south. Directly opposite is north, and east and west are to the right and left of it.

EXP. 10 A lot of light also makes a lot of shade

1 Day

You already know that shadows are a lot longer in the morning and evening than at noon, and that they are also longer in winter than in summer at the same time of day. Investigate the way your Power House casts shadows and how that affects its surroundings.

You will need

Power House, *newspaper, felt tip pen*

Experiment

1. Spread out the newspaper outside on a sunny day, such as on a patio table, and set your Power House on the newspaper.
2. At noon, use the felt tip pen to draw a line around the edge of the entire shadow, and repeat this during the afternoon when the sun has dropped noticeably lower toward the horizon but is still shining on the house.
3. Compare the size of the areas within the two outlines.

Explanation

In places where houses are built very high or are packed closely together, they can completely shade one another. That is why it is important to allow enough distance between them in the planning stage, or the neighbors will complain. Paying attention to any possible shading is especially important if — as will presumably become more common in the future — energy is to be obtained from sunshine.

EXP. 11 Car furnace

Sunshine is warm, as you know. But you only really notice how well the sun can heat something after you have gotten into a car that has been parked for hours in the full sun. Try measuring the temperatures reached inside it.

You should perform this experiment with an adult!

You will need

Thermometer, *car*

Experiment

1. First set the thermometer in the shade of the car and note the temperature. Then move it into the closed car parked in the full sun, but put the thermometer in a shaded location. Take a temperature reading after about half an hour. It can easily be twice as high as outside the car.
2. Repeat the experiment with a car that has been parked in the shade for a while. Also try measuring the temperature changes during a longer drive.

Explanation

Gardeners have long used this effect to heat their greenhouses and make their plants grow faster. That is why it's known as the greenhouse effect. The cause is a build-up of heat, as the inside surfaces absorb heat energy from the sun. Some parts get so hot that you can hardly even touch them! And they also heat the inside air. Outside, hot air would rise off and be replaced by cooler surrounding air. But inside the car, the air is trapped and the temperature rises. If you drive the car, it cools off in spite of the sunshine, because the air that flows through also carries off the heat.

Energy Saving Tip

Don't leave any doors open unnecessarily, particularly on cool days.

EXP. 12 Black absorbs heat

Cars that are dark in color or that have dark upholstery get particularly hot. Does black collect more heat than white?

1 Hr.

You will need

Thermometer, black paper, *white paper, pencil*

Experiment

1. Spread out the white paper in the sunshine on a day that isn't too windy, and place the thermometer on top of it. After about half an hour, make a note of the temperature.
2. Repeat the experiment with the black paper under about the same sun conditions. What does the thermometer show now?

Explanation

The temperate climbs several degrees higher against the dark background than it does against the white paper. That is because black surfaces absorb a lot of light — which is exactly why they look dark to us. The absorbed light energy is converted into heat. Light-colored surfaces, on the other hand, reflect back a lot of the light that hits them and therefore heat up a lot less. That is also the reason why people prefer to wear light-colored clothes in summer.

EXP. 13 The sun heats the house

If the sun heats up cars, maybe it will also do that to your Power House. Try it!

1 Hr.

You will need

Power House, thermometer, *pencil, paper*

Experiment

1. Place the thermometer in the shade for a few minutes in order to determine the temperature. Note it down.
2. Set the house in the full sun with its windows open. Do not mount the transparent pane on the solarium annex. Insert the thermometer into the hole at the top of the roof, so that the sensor is in the apex of the house.
3. After about an hour, take a temperature reading and compare it with the air temperature you measured in the shade.
4. Now insert the thermometer through one of the window openings so that the sensor is near the floor inside the house, but in a shady spot. Wait about 30 minutes and read the thermometer again.

Good Advice

Normally, the holes in the roof should be just large enough for the thermometer to be in the right position and just the sensor projects into the house. With the upper hole, it helps if you insert the thermometer at a slant, rather than straight down. If it still slips through (maybe because the holes have been widened through repeated use), try wrapping a little tape around the section just above the sensor.

Explanation

Sunlight, and therefore also the heat of the sun, will penetrate the openings of the house and warm its interior. A lot of the heat collects under the roof, while it is somewhat cooler lower down.

EXP. 14 Warm annex

Inside a closed car, as you saw in Experiment 12, the temperature rises higher than outside it. Will the solarium annex with its transparent roof capture heat as well?

1 Hr.

You will need

Power House, thermometer, *pencil, note pad*

Experiment

1. Set the Power House for a few minutes in a shady spot with its roof off, so it can cool to room temperature.
2. Close all the windows between the solarium annex and the inside of the house, put the roof back on, and set the Power House back in the sunshine, with the solarium section pointed toward the sun. Insert the thermometer into the hole lower down in the roof, so the sensor projects into the solarium area.
3. Note the temperature after an hour and compare it to the temperature from the last experiment. Also, as an added comparison, note how much the inside of the house has warmed up by inserting the thermometer into the upper hole for a few minutes.

Explanation

The greenhouse effect is clearly at work as the air is heated up in the house's solarium annex. It also gets warmer inside the house, but to a lesser degree.

EXP. 15 Black flooring in the solarium

1 Hr.

If dark materials absorb heat better than light ones, a dark floor in the solarium should intensify the heat-collecting effect even more.

You will need

Power House, black paper, thermometer, *pencil, note pad, scissors*

Experiment

1. Repeat the last experiment under about the same sun conditions, but first spread a piece of black paper, cut to the appropriate size, over the floor of the solarium annex.
2. Compare the temperatures with the readings from the last experiment.

Explanation

The black paper captures the sun's heat much more effectively than the light-colored polystyrene. That is why the temperature rises several degrees higher.

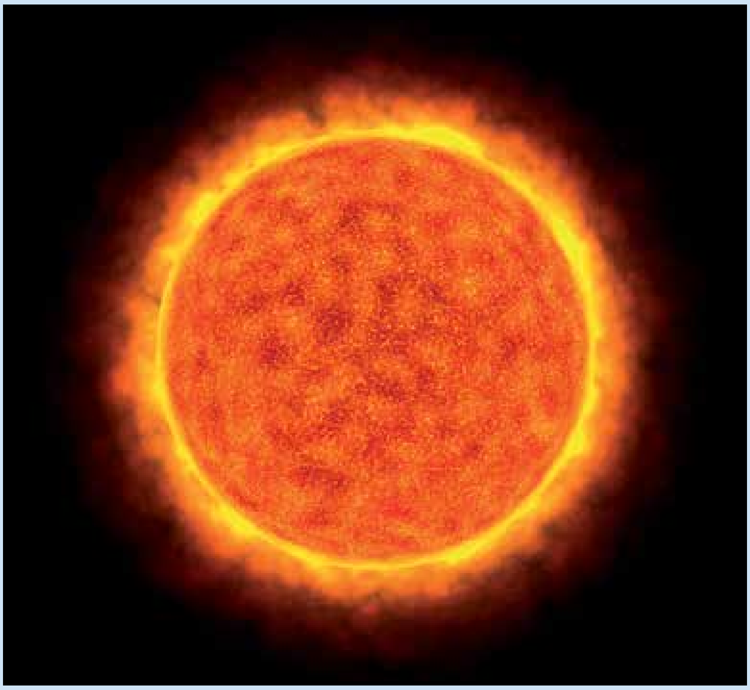
KEYWORD

Our Sun

Without the heat of the sun, Earth would be nothing but a barren, lifeless clump of ice. In the sky, the sun seems rather small despite its gigantic actual size. That has to do with its enormous distance from us — around 150 million kilometers. A fast plane would need to fly over 17 years non-stop to reach the sun. You can stretch out a line of 109 Earths across the diameter of the sun, and the sun's volume would hold 1.3 million globes the size of our Earth.

The sun is a slowly rotating ball of glowing, seething gases. The energy that is constantly produced by the sun is enormous. Its source lies in the sun's core, where material is compressed to an unimaginable density. The relatively small core holds half of the sun's entire mass! Within the core, an atomic inferno holds sway, with a temperature of 15 million degrees Celsius and a pressure that is about 250 billion times greater than the air pressure at Earth's surface. In this scorching sphere, hydrogen atom nuclei melt into helium atom nuclei. This nuclear fusion process releases a massive quantity of energy, which moves through the sun's mass to its surface and is radiated off as heat, light, x-ray radiation, and numerous other forms of energy. Only a fraction of this energy reaches Earth, but when it does so, it determines all our weather patterns and provides green plants with solar energy.

The largest and most important heavenly body in our system: the sun.



EXP. 16 Open window in the summer sun

In the last experiment, thanks to the closed window between the solarium and the house, the warming of the house was kept within limits. What would happen if you opened the window?

You will need

Power House, thermometer, *pencil, note pad*

Experiment

1. Let the Power House cool off again in the shade with its roof and solarium annex open.
2. Open the window between house and solarium, put the polystyrene roof in place, and cover the annex with the transparent film. Leave all other windows closed. Insert the thermometer into the hole near the peak of the roof.
3. Set the house in the full sun again, with the solarium annex pointed toward the sun. After half an hour, take a reading of the temperature in the house.

Explanation

An effective heat trap, such as the "glass-roofed" annex, will heat the entire house.

A solarium will bring light and warmth into the house.

EXP. 17 Ice in the house

The sun doesn't always shine when you need it. In this experiment, you can test the heat insulation of the Power House even when the weather is bad.

You will need

Power House, thermometer, *ice cubes or snow, small bowl, pencil, note pad*

Experiment

1. Count out about 20 ice cubes, place them in the bowl, and place the bowl in the house.
2. Set the Power House in a warm room, leaving the windows and doors of the house open. Insert the thermometer into the hole near the peak of the roof. Write down the time at which you start the experiment.
3. About every quarter of an hour, check whether there is any ice left. Note how long the ice takes to melt.
4. Repeat the experiment with the same quantity of ice, but this time close all the windows and doors of the Power House. After the same amount of time has passed that the ice needed to melt when the windows and doors were open, check to see whether there is any ice left.

Explanation

Ice requires a lot of warmth to melt, and can act as an indicator of how quickly heat is flowing through the house walls or openings to the inside.

EXP. 18 The heat has to stay outside

The polystyrene proved to be a good heat insulator in the last experiment. Are there other materials that you can use to keep out heat energy?

You will need

Thermometer, roof film piece from solarium annex, roof polystyrene piece, *plate, aluminum foil, note pad, pencil*

Experiment

1. Set the thermometer on a sheet of white paper in the full sun, and start by placing the roof section over it. It should completely shade the thermometer sensor.
2. After half an hour, read the thermometer and make a note of the reading.
3. Repeat the experiment with a plate, with the clear film, and with the aluminum foil instead of the polystyrene, and compare the temperature measurements.

Explanation

As expected, polystyrene keeps away the heat radiation a lot better than the porcelain of the plate or even the transparent plastic. The best insulator, though, is the aluminum foil. The reason is its shininess: It reflects back almost all the light and heat rays that strike it, and it therefore doesn't warm up. This effect is used in insulating containers as well as in windows in a lot of high-rise buildings, where the silver color acts as a heat insulator.

EXP. 19 Home-made insulating flask

The effect you just discovered can be put to good use in the construction of a small insulating flask.

> ***Energy Saving Tip***
> Always open the refrigerator door as briefly as possible and close it properly, or the refrigerator will needlessly consume electricity.

You will need

Thermometer, aluminum foil, *large jar, 2 small jars with lids, newspaper or paper towels*

Experiment

1. Cover the bottom of the large jar with several smooth layers of newspaper.
2. Pour a warm liquid (such as tea) into both small jars and close them. Let one jar sit in a quiet place.
3. Wrap the other jar completely with aluminum foil (shiny side in). Set it inside the large jar and stuff the space between the small and large jar with newspaper.
4. After 12 hours, compare the temperatures in the small jars.

Explanation

Insulating flasks (commonly named Thermos flasks after one manufacturer) will keep hot things hot and cold things cold for a long time. They contain a double-walled glass vessel with the internal space pumped free of air so that it conducts heat poorly. Also, the inside surfaces are given a mirror coating so that they reflect back thermal radiation — just like the aluminum foil in your experiment. A protective plastic layer is often inserted between the glass container and outer wall as well.

EXP. 20 That's the limit!

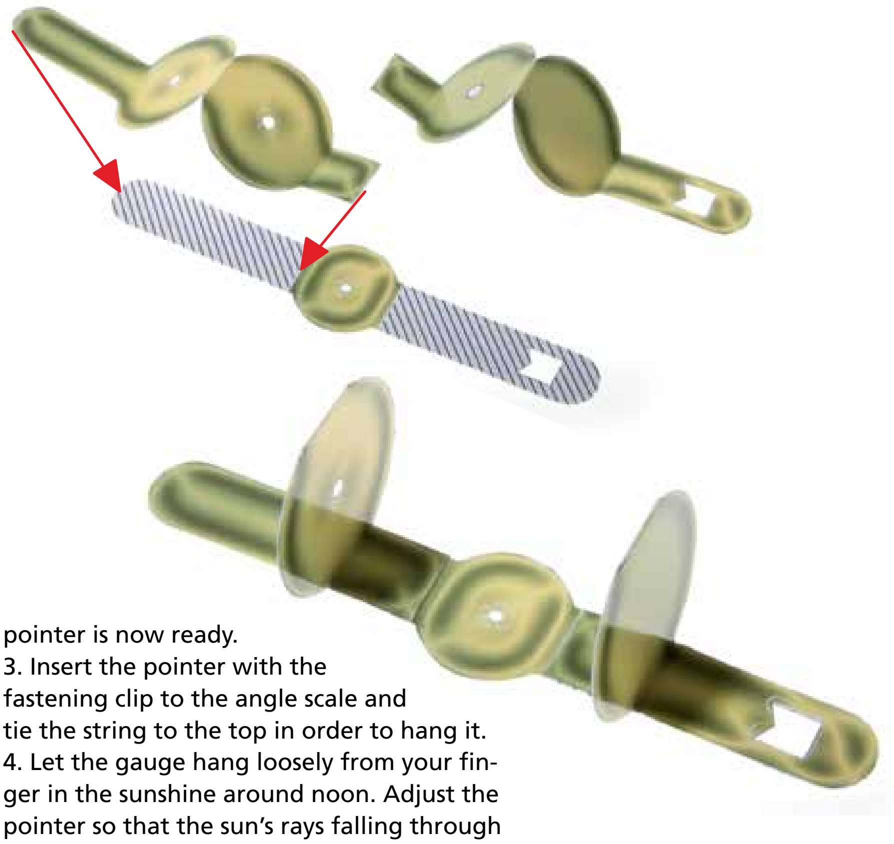
As you have already seen, the length of the sun's shadow depends on, among other things, the height of the sun above the horizon. Sailors used to measure the sun's height on a daily basis in order to determine their location. You can also measure the approximate height of the sun using simple tools.

You will need

"Solar altitude measuring gauge" die-cut parts, fastening clip, *string*

Experiment

1. Remove the four parts of the measuring gauge from the die-cut sheet and push out the pre-cut areas on the inside.
2. Bend the two parts with the double circles as shown in the illustration and glue the circles together on the rear side. Then, glue both pieces to the shaded surfaces of the long strip. The



pointer is now ready.
3. Insert the pointer with the fastening clip to the angle scale and tie the string to the top in order to hang it.
4. Let the gauge hang loosely from your finger in the sunshine around noon. Adjust the pointer so that the sun's rays falling through the hole in the upper pane of the pointer fall exactly onto the circle on the lower pane. Then you can read the sun's angle on the scale.

Explanation

The number on your angle scale stands for the height of the sun above the horizon. The difference between the sun's height in winter and summer is quite large. In winter, the sun only rises about 30 degrees, while in summer it rises almost 75, depending on where you live.

Energy Saving Tip

Ventilate the house only a few minutes a day, with the windows wide open — leaving the windows cracked wastes a lot of heat energy!

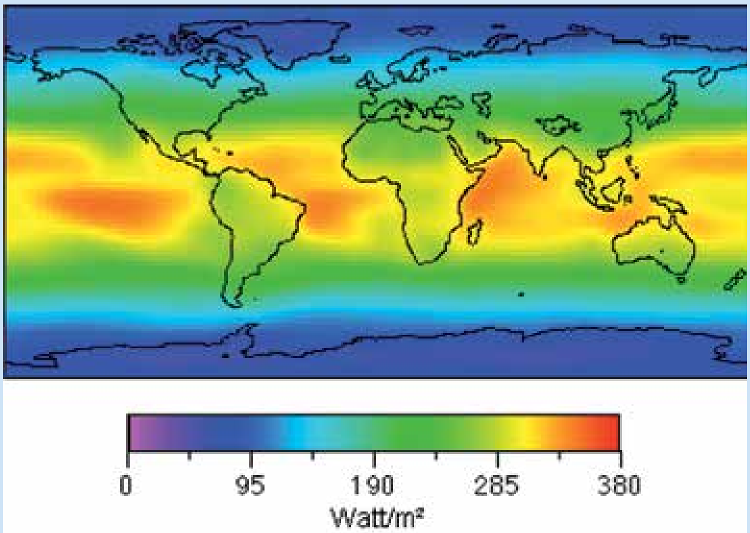
KEYWORD

Solar energy

Each year, the sun radiates enough energy onto Earth to satisfy 6,000 times the energy needs of all of humanity. Not only that, it is practically inexhaustible. The sun will keep on shining for another several billion years. On the other hand, the sun's energy is only available during the day, so you need to have ways of storing it.

The sun's energy is spread out over a large area, so complex and expensive technical devices are needed to capture it in usable quantities. The closer you get to the equator, the higher the quantity of energy per unit of area. In central Europe, for example, it is barely half as much as in the Sahara, where huge expanses of land are available on which large solar power plants are now being planned. These plants are supposed to supply even far-away areas in Europe, for example, with energy.

The colors indicate variations in solar radiation over the planet. (Illus. Encyclopedia of Earth)



Experiment

1. Connect the two parts of the angle gauge from the die-cut sheet with a metal fastener. Lean the angle gauge arm against the side wall of the house.

2. Open the two large windows and cut a section of yarn about 1 m in length. Tie one end to the angle gauge pointer, and the other end to a flashlight. Have an assistant shine the flashlight onto the house at a 60-degree angle, on the side of the house with the living room window. You will be able to tell by looking through the side window whether the flashlight beam is lighting the floor.

3. Cut a strip of paper about 8 cm wide and 20 cm long and secure it to the roof with tape in such a way that it extends past the roof's overhang by about 6 cm.
4. Once again, test the height at which the flashlight — i.e., the sun — shines into the living room and the height at which the roof overhang blocks it.

EXP. 21

Natural climate control

No matter how nice the sunshine might be, you don't want it to provide your house with added heat in the summertime, when it is warm enough anyway. In the winter, on the other hand, it is a welcome source of inexpensive heating. There are simple construction tricks that can be used to ensure that the noonday sun will shine into the house only in winter.

You will need

Power House, angle gauge from the die-cut sheet, metal fastener, *yarn or string, paper, scissors, flashlight, tape, assistant*

Explanation

Heating fuels have always been expensive. That is why, for many hundreds of years, clever architects have known this trick for using the heat of the winter sun without letting things get too hot in summer. It is only in winter, when the sun is low and shines at a flat angle, that the sun's rays will shine into the house.

Your Power House also protects against the cold

Polystyrene keeps the sun's heat from getting into the house so quickly when the windows are closed. But in winter, a heated house is warmer on the inside than the outside. Can the heat-blocking function also work in reverse?

EXP. 22 Home water heater (2 Hrs.)

Most houses today have hot water provided by a water heater powered by oil, gas, or electricity. For the following experiments, we will also equip the Power House with a water heater, albeit of the simplest kind.

You will need

Power House, thermometer, *2 jars or glasses (0.2 – 0.3 liters each), warm water (about 50 °C), pencil, note pad*

You should perform this and the next experiment in a cool environment, such as a cool basement room — or outside on a cold day.

Experiment

1. First measure the outside temperature and make a note of it.
2. Fill both jars with the warmest water possible (about 50 °C) and set them inside the house. Measure the temperature of the water in the jars.
3. Close all openings in the house, including the one to the solarium annex. Insert the thermometer into the top hole and note the temperature after half an hour, one hour, and two hours.
4. At the end of the experiment, measure the temperature of the water in the jars.

Time	Outside Temperature	Water Temperature	Inside Temperature

Explanation

The hot water in the jars heats the inside of the house, just like a heater does, and cools itself down in the process. In time, of course, the interior of the house will cool off too, as heat flows away through the walls.

With a central heating system, the warm water is led through pipes into the individual heaters.

EXP. 23 It gets cold faster with the window open (2 Hrs.)

If you leave the window open for a while in the winter you will soon be sitting in a cold room. How quickly will the Power House cool off?

You will need

Power House, thermometer, *2 jars or glasses (0.2 – 0.3 liters each), warm water (about 50 °C), pencil, note pad*

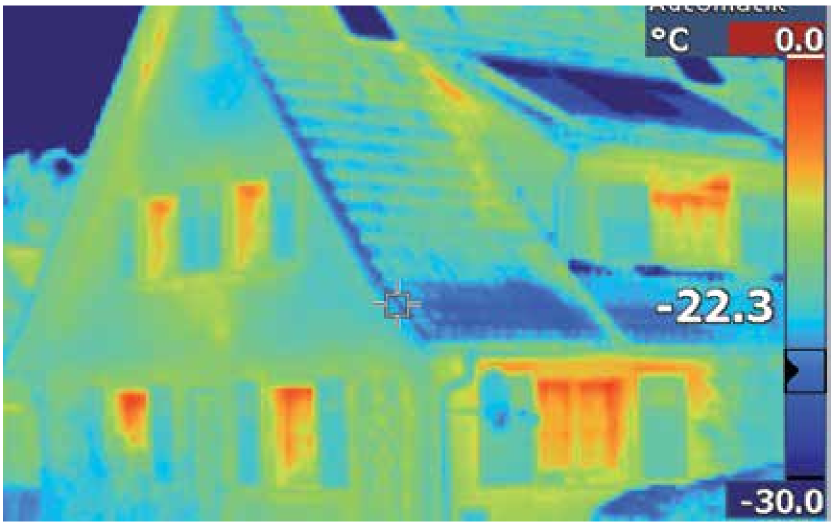
Experiment

Repeat the previous experiment, but first open all the doors and windows in the house. Record the temperature again.

Explanation

The house does not heat up nearly as well with its windows open. Also, the inside of the house and the water cool off much more quickly. So good insulation in the walls, windows, and outer doors can save money, because precious heat will otherwise flow quickly out of the house.

Infrared heat cameras render building heat losses visible. (Illus. Bund Nature Conservation Alliance, Bad Kissingen)



Heat — familiar yet mysterious

In several of these experiments, heat plays an important role — the heat of the sun, for example, or of hot water. But what exactly is this mysterious, invisible thing? Is heat the same thing as temperature?

EXP. 24

Mixing secrets

You can't heat a cold room with a single candle flame, even though the flame is just as hot as the flames in a gas oven. Nor can you heat a basin of cold water by adding a few tablespoons of hot water. Apparently, it's not just a matter of temperature, but the "amount of heat" as well. How does it work?

You will need

Thermometer, *pot, measuring cup, note pad, pencil*

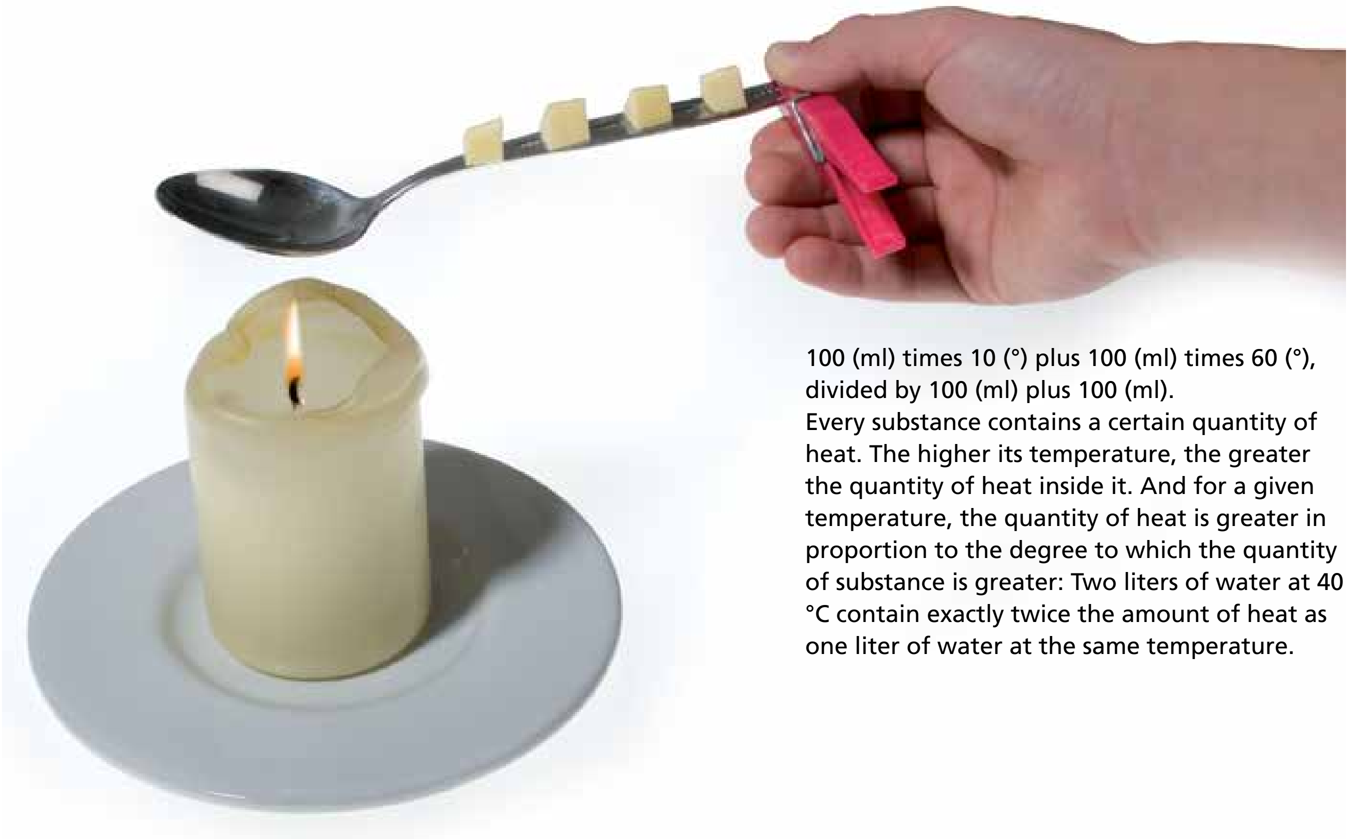
Experiment

1. First, measure the temperature of the cold water from the tap, and note it down.
2. Also measure how warm the water is that comes out of the hot water tap, and note this down as well.
3. Pour 100 ml of cold tap water and 100 ml of hot tap water into the pot. Mix thoroughly and measure the temperature of the mixture.
4. Repeat the experiment with 50 ml of cold water and 150 ml of hot water.
5. Repeat the experiment one more time with 150 ml of cold water and 50 ml of hot water.

A continuous flow water heater only prepares hot water when it is needed.

Explanation

If the cold water is 10 °C and the hot water is 60 °C, in the first part of the experiment you will get a mixture of 35 °C, a mixture of 48 °C in the second part, and 23 °C in the third. You can easily calculate the temperature of the mixture by multiplying each quantity by the relevant temperature, adding them together and dividing by the total quantity of water. So, for the first part,



100 (ml) times 10 (°) plus 100 (ml) times 60 (°), divided by 100 (ml) plus 100 (ml).
Every substance contains a certain quantity of heat. The higher its temperature, the greater the quantity of heat inside it. And for a given temperature, the quantity of heat is greater in proportion to the degree to which the quantity of substance is greater: Two liters of water at 40 °C contain exactly twice the amount of heat as one liter of water at the same temperature.

EXP. 25 Invisible movement

This heat that is hiding inside objects — can it move?

You will need

Candle, matches, old metal spoon, butter, clothespin or pot holder

Have an adult help you with this experiment!

Experiment

1. Space several little pieces of butter along the handle of the spoon. They should be small enough to stay stuck to the metal. Leave the end of the handle free.
2. Light the candle. Grab the end of the handle with a clothespin or pot holder and hold the bowl of the spoon over the candle flame.
3. Watch how the butter pieces gradually melt. Do they do it in any particular order?

Explanation

The heat conveyed from the candle flame to the spoon spreads slowly along the handle, similarly to the way a wave spreads along a channel. You can see this as the temperature gradually rises sufficiently high along the spoon's handle for the butter to melt. The heat flows from areas of high temperature toward regions with lower temperatures.

EXP. 26 Conductor and non-conductor

Does heat flow equally in all materials?

You will need

Metal spoon, wooden spoon, pot

Experiment

1. Fill the pot with hot water. Immerse both spoons in the water, holding them by their very ends.
2. Which spoon is the first to get so hot that you have to let it go?

Explanation

There are materials, such as metal, that conduct heat well. Some other materials, by contrast, such as wood, porcelain, and plastic, are much poorer heat conductors. This knowledge can be used to insulate a house against heat losses: The metal frames of windows and doors work as cold bridges — in winter, heat flows practically unhindered through them. Insulators such as wood and plastics, on the other hand, hold the heat in place. And foam materials, as you know from Experiment 4, do it even better.

EXP. 27 Cold metal

Have you ever noticed that metal usually feels cold? A door handle inside a warm room feels cool. Let's investigate more closely.

You will need

Thermometer, polystyrene piece, *wooden spoon, metal spoon, pot with tap water*

Experiment

1. Leave the spoons, water pot, and polystyrene in the room for a few minutes. That way, you can be sure that they are all the same temperature. Measure the temperature in the room.
2. Measure the temperature of your hand by wrapping your fingers around the thermometer's sensor for a few minutes. Be careful not to break it!
3. Touch each object in turn and note how it feels.
4. Set the thermometer in the pot of water. Leave your hand in the water for about two minutes without moving it. What do you feel? Does the thermometer indicate that the water temperature is rising?

Explanation

Despite their equal temperatures, the metal and the water feel noticeably cooler than, say, the wood or polystyrene. The explanation is provided by your temperature measurement. The room and the objects in it are a few degrees cooler than your skin. Because heat always flows from warm to cold, it flows from your skin into the object. With the metal spoon, it spreads out quickly, which your skin senses as cooling. Wood and polystyrene, on the other hand, are poor heat conductors and feel warmer. Still water, too, is a rather poor heat conductor. It does absorb a lot of heat at first, but only passes it on slowly. That is why, after you have gotten used to it a little, you no longer feel it as cold, even though the water temperature has hardly risen. If you pay attention, you'll notice that this effect also works in a swimming pool.

A frying pan handle made of wood keeps you from burning your fingers.

EXP. 28

Heat provides lift

You will often see fine black soot particles rising vertically above a candle flame. What is it that actually carries them upward?

You will need

Spiral from the die-cut sheet, *yarn or string, tape, scissors, candle or warm heater, matches*

If you use a candle, have an adult help you! Be careful not to move the cardboard too close to the flame.

Experiment

1. Remove the spiral from the die-cut sheet. Tie a piece of yarn about 40 cm in length to its center.
2. Light the candle or go to a warm heater. Hold the yarn high enough for the spiral to be able to rotate freely above the candle or heater.

Explanation

The spiral will soon start to turn. The cause is the warm air rising up from the flame or heater. This stream of air sets the spiral in motion, showing that warm air rises. Cold air, meanwhile, flows downward.

Hot air balloons make use of the pressure of warm air pushing upward. Large gas flames are used to heat the air inside the balloon casing, which makes the balloon rise.

The air inside a hot air balloon is heated with large burners in order to make it rise.

EXP. 29

Invisible rays

Does heat only flow through solid and liquid materials?

You will need

Candle, hot plate or oven, cardboard, plate, pot lid made of metal

Experiment

1. Light the candle and carefully move your hand toward the flame. You will feel warmth coming from the flame.
2. With your other hand, hold the piece of cardboard, then the plate, and then the lid between the flame and your hand. Do you still feel the warmth?

Explanation

Hot objects emit radiation, a sort of invisible light. If this heat radiation hits the skin in sufficient strength, we feel it as warmth. But almost all materials can hold back this radiation — they absorb it and, in time, will become warm themselves.

This heat radiation, by the way, doesn't just penetrate the air — it can even move through the airless vacuum of space. If this were not the case, then we wouldn't feel the heat radiated from the sun.

Energy Saving Tip

Instead of placing hot foods in the refrigerator, first let them cool down to room temperature.

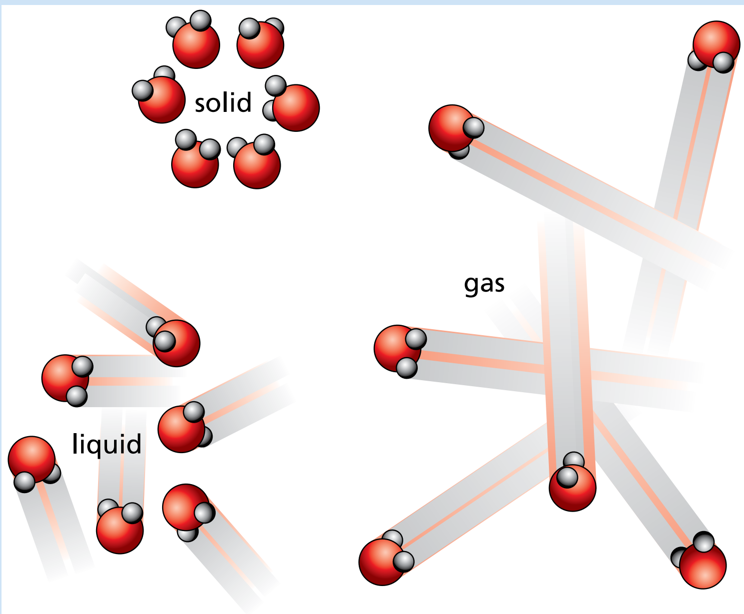
KEYWORD

Heat

Heat is a form of energy — like mechanical work or electricity. So these forms of energy can also be converted into heat, and vice-versa. If heat is transferred to an object, its temperature rises. The amount of temperature rise depends on, among other things, the quantity of heat: Twice the amount of heat causes twice the increase in temperature. The size of the temperature jump from a given amount of heat depends on the material. Some materials (for example, water) need a lot of heat for a given increase in temperature, while others need less.

When something is heated, changes take place on an atomic and molecular level. If, for example, you heat a material such as water, the molecules move back and forth faster and faster as the energy level increases. Because they need more space when they do that, materials expand when heated — a property put to good use in a thermometer. The dancing molecules bump into others and thus transfer energy to them. Also, the forces of attraction between the molecules become weaker and weaker as the energy rises. That is how more and more molecules can leave the liquid and disappear into the air, as the water turns from a liquid into a gas and evaporates.

In a solid object, unlike a liquid or gas, the particles have a fixed position because they exert strong forces of mutual attraction.



The sun as heat dispenser

The sun is constantly sending out large quantities of heat radiation. We can and should make use of this free energy, rather than burning scarce supplies of coal or petroleum. For example, we can use it to make hot water.

EXP. 30 Garden hose as water heater

2 Hrs.

It is not hard at all to capture solar energy and use it to heat water. Even a garden hose will work.

You will need
Thermometer, *garden hose, pencil, note pad*

Experiment
1. Attach a garden hose to the faucet and open the faucet fully for about a minute. Then measure the temperature of the water coming out of the hose. Note the temperature.
2. Turn off the faucet again and let the hose sit in the sun for one or two hours.
3. Open the faucet a little bit and immediately measure the temperature of the water flowing out of the hose. It will have risen noticeably.

Rooftop solar cells for producing electricity and solar collector for heating water

Explanation
The garden hose absorbs the sun's radiation and warms up. It transfers the heat to the water, albeit rather slowly due to the thickness of the plastic. The solar collectors that you see on top of a lot of roofs work in a similar manner, heating up the water as it flows through thin black tubes.

EXP. 31 Black or white?

1 Hr.

In Experiment 12, you saw that black materials absorb heat particularly well. Does that play a role when heating water as well?

You will need
Thermometer, black paper, *white paper, two glass plates or bowls, plastic wrap*

Experiment
1. Fill both plates or bowls with equal quantities of water. Cover both containers with plastic wrap.
2. Set one on white paper in the full sun, and the other next to it on black paper.
3. After an hour, measure the water temperature in both containers.

Explanation
The water on the dark paper has become decidedly warmer, because the black color absorbed the sun's heat better than the white color and transferred it to the water through the glass.

EXP. 32 Hot air in a black bottle

If black absorbs a lot of heat, the black bottle must be a good heat collector.

You will need
Power House, black bottle, thermometer, *pencil, note pad*

Experiment
1. Set the empty, open black bottle in the compartment on the roof. Hold the thermometer by the display body at the top and measure the air temperature inside the bottle (leave the thermometer sensor inside the bottle for about a minute to give it time to absorb the air temperature).
2. Now set the house outside in the full sunshine, so the sun's rays hit the bottle.
3. After 10, 20, and 30 minutes, once again measure the air temperature in the bottle's interior and note it down.

Explanation
The black plastic really soaks up the sun's rays, so even after just a few minutes the temperature inside the bottle increases to almost 40 degrees Celsius.

EXP. 34

Heating water in the solarium

2 Hrs.

You can also make hot water with the help of solar power inside your Power House — in the solarium annex.

You will need

Power House, black bottle, thermometer, *pencil, paper, water*

Experiment

1. Fill the black bottle up to the top with tap water. Immerse the thermometer in the water, and after about three minutes read and note down the temperature.
2. Empty out the contents of the bottle into the basin-like depression of the annex floor. Place the transparent pane over the solarium.
3. Set the Power House in the full sun, with the solarium annex pointing toward the sun. After about an hour, measure the water temperature again and note it down.

Explanation

The sun has already warmed the water in the basin by several degrees Celsius, even though the background isn't black.

EXP. 33

Hot water in the black bottle

30 Mins

Can you heat water inside the black bottle as well?

You will need

Power House, black bottle, thermometer, *pencil, note pad, water*

Experiment

1. Fill the black bottle with tap water, measure its temperature, and note this down.
2. Place the black bottle in the roof compartment again and set the house in the full sun again.
3. After 10, 20 and 30 minutes, measure the water temperature inside the bottle. Note the values and compare them against those from the last experiment.

Explanation

Here, too, the black plastic absorbs the sun's rays and heats up the water. However, the water temperature rises a lot more slowly than the temperature of the air in the last experiment, since a lot more material has to be heated: about 100 grams of water compared to less than one gram of air.

Energy Saving Tip

Lowering room temperature by 1 °C saves about 6 percent in heat energy. Bedrooms and storage rooms, in particular, can easily be cooler.

EXP. 35 Twice the amount of water = half the rise in temperature

1 Hr.

Does the increase in temperature depend on the amount of water?

You will need

Power House, black bottle, thermometer, *water*

Experiment

1. Repeat the last experiment, but this time pour twice the quantity of water (two full bottles) into the basin.
2. Let the sun shine on the annex for the same amount of time, and then measure the water temperature. How high has it risen this time?

Explanation

Every hour, the sun radiates a certain amount of energy into the annex. The amount of water of each full bottle is therefore warmed a certain amount. If you pour in twice the quantity of water, the same quantity of heat is spread out across the greater amount of water, so the temperature only increases half as much. If you want to heat a material to a certain temperature, you therefore have to add heat energy in proportion to the quantity of material.

EXP. 36 Water against sand

1 Hr.

Does the type of material also play a role in the speed that the temperature rises when you heat something?

You will need

Thermometer, *two deep dark-colored plates, sand or dry soil, water*

Experiment

1. Fill a plate about 2 cm deep with water, and fill the other equally high with sand or dry soil. Place both in a dark room for one hour, so that they have the same temperature. Measure the temperature of the water and note it down.

Black beach — you'll burn your feet here in the summer.

2. Set both plates in the full sun for two hours. Measure the temperature of the water and the top layer of sand.

Explanation

Given the same amount of added heat energy, you can heat the sand to a considerably higher temperature than the water. That has to do with the fact that water has a particularly high "heat capacity": It can absorb and store a lot of heat energy without changing its temperature very much. The heat storage ability of sand or soil, on the other hand, is much lower. You may have experienced how the sand on a beach may be scorching hot at mid-day while the water is hardly warmer than before. In this instance as well, it is their variable heat capacity that is responsible.

EXP. 37 Solar pond in miniature

1 Hr.

A solar pond is something you can use to capture a lot of the sun's heat. In Israel, India, and the USA, these kinds of facilities have existed for several years.

You will need

Thermometer, *dark plastic bowl, table salt, wooden spoon, spoon, measuring cup, pencil, note pad, water*

Experiment

1. Pour about 3 cm of water into the dark plastic bowl and dissolve as much table salt in it as possible. One liter of water will dissolve about 330 grams of salt. You will probably have to stir again and again for several hours until everything is dissolved. At the end, you will want to be sure that a little undissolved salt remains on the bottom — the solution should contain as much salt as can possibly dissolve in it.
2. Set the bowl in the full sun and measure the temperature of the solution after three hours. Note this down.
3. Fill a measuring cup with tap water. Since drinking water from the tap is lighter than the concentrated salt solution, it can float on top of the salt water and form its own layer there. You must work skillfully to be sure that the liquids mix as little as possible: Hold a soup spoon right at the surface of the solution, and let the water run gently off it. The spoon will help ensure a gentle flow. Do not move the bowl!
4. Once again, let the bowl stand in the full sun for about three hours and again measure the temperature of the salt solution. It will be several degrees warmer than it was before you covered it with a layer of fresh water.

Explanation

A normal fresh-water pond will not heat up very much in the sun, because some of the

water on the surface will evaporate and carry away a lot of heat. With a solar pond, on the other hand, the salt solution is always noticeably heavier than the fresh water, and it therefore stays on the bottom. The fresh water layer acts as a sort of one-way valve, as it lets the sun's rays penetrate down to the salt solution while holding back the heat radiating away from the solution. In this way, the temperature of the salt solution increases. In large solar ponds, the temperature can reach 90 degrees Celsius. In those ponds, there are pipes laid in the salt solution that carry off heat to heat and evaporate a liquid. The steam in turn drives turbines that produce electricity.

Solar pond in Pyramid Hill, Victoria, Australia (RMIT University/Pyramid Salt) (Illus. Enersalt Pty Ltd, Bridgewater, Australia)

Energy Saving Tip
Close the blinds at night, since they also help retain heat.

KEYWORD

Solar collector

Solar collectors collect the sun's heat and use it to heat water to around 40 to 80 degrees Celsius. Modern collectors for houses are made of black metal surfaces with tubes, enclosed in a glass-covered box. The black color comes from a special coating that absorbs a lot of heat radiation. The glass and other features prevent the heat from being radiated off again.

The heat energy is then transferred to a transport liquid (usually water) flowing through the pipes, which carries the heat to a water-filled storage tank, which in turn supplies the home's hot water taps or heating system. The liquid circulates through the tank and solar collector (often driven by a solar-powered pump), so that the water is heated over and over again as long as the sun is shining. As the solar radiation gets weaker, an automatic mechanism stops the circulation process in order to prevent heat losses.

Solar collectors capture the sun's radiation and convert it into heat for heating a home or hot water.

There's something in the air

Inside a house — and outside it too — it's important to feel as comfortable as possible. Whether or not you feel comfortable has a lot to do with temperature and humidity. If the air is too low in moisture, it will dry your eyes, nose, and throat. But muggy, damp, and warm air of the kind you get in a greenhouse is also unpleasant. So it is important to study the relationship between temperature and humidity.

EXP. 38 Drops disappear into nothing

2 Hrs.

A rain puddle will quickly disappear when the sun starts to shine again — even when the water was on the pavement and couldn't seep away into the ground. What's going on here?

You will need

Solarium annex cover, *note pad, pencil, water*

Experiment

1. Lay the annex cover flat on a table outside, but in the shade. Place a few drops of water on it and note the time.
2. About every half hour, take a look and make a note of when the last drops have disappeared.
3. Repeat the experiment, but this time with the cover in the full sun. How long does it take now for all the water to disappear?

Explanation

The water disappears — it "evaporates" into the air. The only thing that might be left behind is a slight ring of calcium that was dissolved in the tap water.

EXP. 39 How fast does water evaporate?

1 Hr.

You will probably have noticed that the smaller drops disappear faster than the bigger ones. Does the speed of evaporation depend on the size of their surface area?

You will need

Black bottle, *plate, jar*

Experiment

1. Fill the black bottle with tap water and pour it out over the plate. Fill it again and pour the water into the jar.
2. Set both containers next to each other in a quiet spot and take a look from time to time. Where does the water first evaporate completely?

Explanation

Both containers have the same amount of water, but the plate offers a much larger surface area to the air. That is where it evaporates faster. This is also an indication that the water is disappearing into the air.

EXP. 40 On the trail of the evaporated water

1 Hr.

Can water simply disappear into the air? Maybe it is still there, but just invisible. If it is evaporated by heat, maybe you can get it back by using cold.

You will need

2 jars with lids, two paper towels, fork, water

Experiment

1. Dunk both paper towel sheets in water and lay one sheet over the bottom of each of the jars. Screw the lids onto both jars and let them stand for at least an hour in a warm spot.
2. Fish out the two sheets with the fork and put the lids back on quickly. The two jars are now filled with damp air.
3. Place one jar in the refrigerator, and leave the other where it was. After an hour, compare the appearance of the two jars.

Explanation

Countless tiny droplets have accumulated on the inside wall of the cooled jar. The water in these droplets comes from the damp air inside the glass. The process by which moisture in the air turns to liquid through cooling is known as "condensation." On warm days, humidity in the air will even condense on cool drink bottles.

EXP. 41 By a hair

You can't see water that has evaporated into the air. But you can measure how humid the air is — with the help of a hair!

You will need
"Hygrometer" die-cut parts, *fastening clip, a long hair (light, fair hair works best), tape, pen, penny*

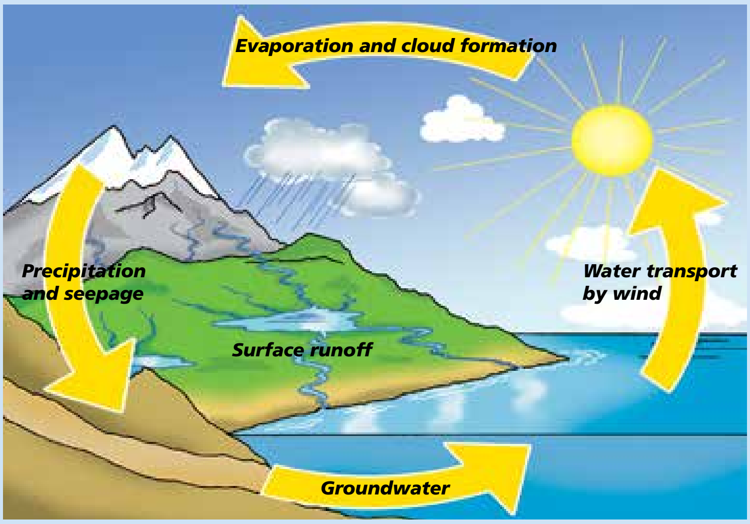
Experiment
1. Remove the "hygrometer" (which means air humidity gauge) pieces from the die-cut sheet and push out the pre-cut sections. Fold in the sides and tape the base section together. Tape a penny to the shaded circle on the red pointer.
2. Insert the hair through the small hole in the pointer, pull it through the slit and tie a knot on the other side.
3. Use the fastening clip to secure the pointer to the hole in the housing. Be sure that the pointer can move easily. Now guide the hair through the upper hole and tie it so that it is nice and taut. To keep the knots from loosening, you can also attach some tape over them.

KEYWORD

Water cycle

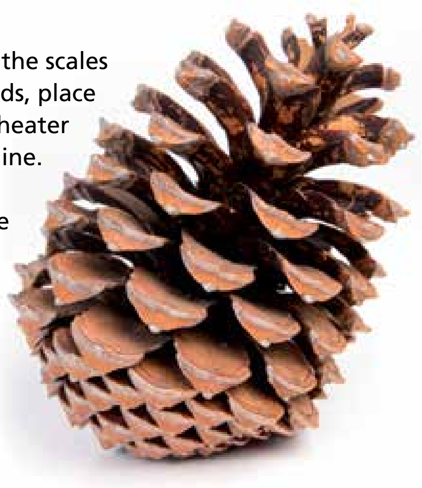
The water on Earth is always in motion. The heat of the sun produces huge quantities of water vapor from the oceans and seas, and a lot is also released from the ground, lakes, and plants. A large part of it rises up and gets into cooler layers of the air. Once there, the humidity condenses into fine drops of water or ice crystals. Clouds form and release the water again as rain or snow. Most of the precipitation falls into the ocean, but some clouds are pushed by the wind over solid land, so it rains and snows there too. Some of the water seeps into the ground and forms groundwater that feeds springs and wells. Some of it runs through rivulets, streams, and rivers back into the ocean, thus completing the water cycle. It is only by being supplied with fresh water that plants and animals are able to live on dry land.

Diagram of the water cycle



Explanation
A hair will react to the level of humidity in the air: In humid air, it will stretch, and in dry air it will contract. The hygrometer makes use of that property to indicate atmospheric humidity.

Additional Experiment:
In the woods, look for a fallen cone from a fir tree, spruce, or pine. Place it in the jar with the damp air from Experiment 40 and observe how it changes. A conifer cone will close its scales if the air is damp, because damp air indicates that it will rain soon, which might harm the seeds beneath the scales if the scales were open. Afterwards, place the cone on a warm heater or in the warm sunshine. Then it will open up again, since when the weather is nice the wind is supposed to blow out the seeds and carry them far away.



KEYWORD

Relative humidity

Air can absorb water vapor, but not in unlimited quantities. The amount of water that can be absorbed in one cubic meter (1000 liters) of air depends on the temperature: The warmer it is, the more water vapor the air can absorb. At 10 degrees Celsius, for example, it can hold just under 10 grams of water, at 30 °C it can hold about 30 grams and at 70 °C about 200 grams. That is why one normally talks about "relative humidity" (RH). This is the relationship between the maximum and the actual quantity of water contained in the air at a given temperature. For example, 50% RH means that the air contains half as much water as possible.

If the temperature in a given place is increased without water vapor being added, the relative humidity will therefore drop. It rises, by contrast, when the temperature drops. If it exceeds the maximum value of 100 percent, the water separates from the air in the form of droplets. That happens, for example, when warm, moist air rises up and gets into cooler layers of air, forming clouds. And when air that has absorbed a lot of moisture during the day cools off in the evening or night, fog or dew will form.

Dew drops on blades of grass

EXP. 42 Tropical air in the Power House

In the last few experiments, water seemed to disappear when it evaporated. Now you can use the hygrometer to test whether it is still there.

You will need

Power House, disk, hygrometer, *paper towels, water*

Experiment

1. Cover the floor of your Power House with damp paper towels. Close all doors and windows except for the large window.
2. Place the black disk on the damp paper near the wall of the annex and set the hygrometer as vertically as possible on top of it — the pointer has to be able to move freely. The disk prevents the cardboard from getting wet. Then put on the roof. Set the house in a warm place and watch the pointer through the window.

Explanation

After a few minutes, the pointer will start to move in the "humid" direction, indicating rising humidity. This humidity, of course, comes from the water evaporating from the paper towels.

EXP. 43 Fogged-up window

1 Hr.

In winter, windows can fog up from time to time, particularly when it is very cold. Why do they do that?

You will need

Power House, *paper towels, transparent plastic wrap, scissors, tape, water, cold room*

Experiment

1. Cut a piece of plastic wrap and secure it with tape over the outside of the large window opening, pulling it nice and smooth. Close all other doors and windows.

2. Remove the roof, cover the floor of your Power House with damp paper towels, and then put the roof back on.
3. Set the house in a warm room or on the heater for an hour and then in a very cold room — or outside if it's winter. After a few minutes, what do you notice on the inside surface of the plastic wrap?

Explanation

The moisture from the warm room air has precipitated on the cold window. And if the outer walls of your house are not well insulated against heat loss, moisture can also precipitate on or in the wall and cause all kinds of damage, such as mold or mildew.

EXP. 44 Insulated window for a clear view

1 Hr.

Fogged-up windows can be annoying, as you probably know from when the windows fog up in the car. But modern house windows hardly fog up at all. How do they avoid it?

You will need

Power House, *paper towels, transparent plastic wrap, scissors, tape, water, cold room*

Experiment

1. Repeat the last experiment, with one difference: Place one piece of plastic wrap over the inside wall of the large window opening in addition to placing a piece over the outside.
2. Wait a few minutes in the cold again. This time, the inside of the plastic wrap hardly fogs up.

Explanation

The double film works like a simple insulated window, since the air enclosed between the two pieces of plastic wrap does not let the heat escape so freely to the outside. The inside piece does not cool down as fast, so it fogs up less. Today's insulated windows are made of special panes of glass enclosing an inside space filled with water-free gases that conduct heat poorly; they are often also coated with special sun-protective layers.

Energy Saving Tip

Heaters must be free and unobstructed, without being covered by curtains or blocked by furniture. Also, they should not gurgle.

The cushion of air between the panes ensures better blockage of heat and sound than a single glass pane.

Water, salt, and rain

For us, it goes without saying that you only need to turn on the tap to get drinking water. This water usually comes from underground wells. Will it ever run out?

EXP. 45 Rain measurements

The underground reservoirs are constantly refilled by rainwater seepage. How much actually comes down in a strong rainstorm?

You will need

Glass with vertical sides (!), ruler, paper, pencil, tape, scissors

Experiment

1. Cut a white paper strip about 2 cm in width and 10 cm in length. Use the pencil to draw a millimeter scale on it like the one on your ruler.
2. Tape the scale to the outside of your glass. The zero point should be at the level of the inner floor of the glass. Protect the paper from water by covering it with transparent tape.
3. Set the glass someplace outside. Keep it from falling over by placing three stones against it. After it has rained, see how many millimeters of rain have fallen by reading the height of the water level on the scale.

Explanation

The rainwater collects in the glass and the scale shows you its quantity. One millimeter of rain corresponds to one liter of rainwater across an area of one square meter. After a strong thunderstorm, the water level in the glass can easily stand above 30 millimeters. That equals the contents of three large household buckets emptied out over an area of 1 square meter.

EXP. 46 Drinking water from salt water

3 Hrs.

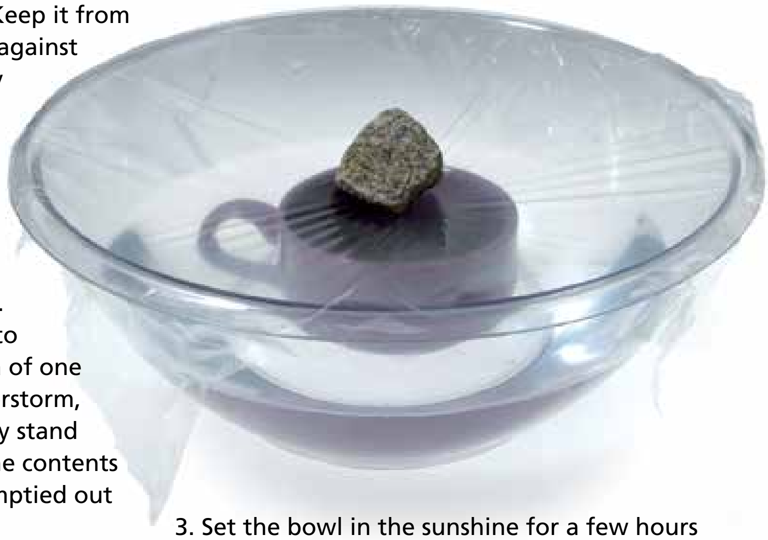
Drinking water is often in short supply, particularly in hot regions where there are long dry periods with no rain. Wouldn't it be great to be able to obtain drinking water from the abundant supplies of salty water from the ocean?

You will need

Plastic bowl, salt, cup, plastic wrap, small stone, teaspoon, water

Experiment

1. First make your seawater. Sprinkle one teaspoon of salt into a cup of water. Stir well until all the salt is dissolved. Pour the "seawater" into a plastic bowl. The liquid should only be a few millimeters deep.
2. Set the cup in the center of the bowl. Cover the bowl with plastic wrap. Place a small stone on the plastic wrap precisely above the cup, so it pushes down on the plastic wrap there.



3. Set the bowl in the sunshine for a few hours on a warm day. Droplets will form on the underside of the plastic wrap and drip into the cup. If that doesn't happen, moisten a paper towel and place it on the plastic wrap.
4. Check to see whether the water that has dripped into the cup tastes salty.

Explanation

The evaporated water condenses due to the cool outside air against the plastic wrap, and then it collects in the cup. The salt cannot evaporate and remains in the plastic bowl. Similar arrangements are used to obtain drinking water from actual seawater, although such facilities require large areas of land for the evaporation process. That is why other techniques are used these days.

EXP. 47 Salt pond in the Power House

Seawater is available in huge quantities in coastal areas. If the water can be separated so effectively from the salt, might it not also be possible to obtain salt as a raw material?

You will need

Power House, black paper, *plastic wrap, salt, teaspoon, glass, water*

Experiment

1. Make some artificial seawater by dissolving two teaspoons of salt in a glass of water while stirring.
2. Cover the floor of the solarium annex with black paper. Then spread out a piece of plastic wrap over the paper and pull it upward a few centimeters at the edges, so it forms a watertight basin.

3. Fill the floor of this basin with several millimeters of your "seawater." Don't let the black paper get wet!
4. Set the Power House in a warm spot for a few days with its solarium uncovered — in the sun if possible, but protected from the rain. Start by replenishing any evaporated water with your "seawater." Finally, let all the water in the basin evaporate.
5. Test the flavor of the white crusts that have formed on the plastic wrap.

Explanation

The heat makes the water evaporate. The salt, however, can't simply disappear into the air. It remains behind, accumulates, and forms white crusts when all the water has evaporated. Salt evaporation ponds work according to the same principle. They are large ponds used for obtaining salt from seawater with the help of the sun's warmth. They can be found in warm and sunny regions having little summer rain.

EXP. 48 Mini-wastewater treatment plant for the Power House

We humans produce huge amounts of wastewater, dirtied with all sorts of substances. It is a tedious job to make it clean again. But a Power House will naturally need a small wastewater treatment plant.

You will need

4 empty yogurt containers, scissors, sand, cotton wool, activated charcoal (aquarium supply store or drug store), soil, cocoa powder

Experiment

1. Use the scissors to puncture small holes in the bottom of two of the yogurt containers. Be careful not to injure yourself! Also, don't damage the table surface!
2. Cover the bottoms of the punctured containers with some cotton wool and pour about 2 cm of clean, washed sand into one of them. In the second container, also pour a thin layer of sand and then a layer of activated charcoal on top of that. The third container without holes will remain empty.
3. Stack the three containers one inside the other — the one without holes on the bottom.
4. Prepare some dirty water by mixing some water with soil and a pinch of cocoa in the fourth container. Pour the dirty water into the top yogurt container, being careful not to let it overflow. Wait for it to flow completely through to the bottom. Keep pouring from time to time from the top as necessary.
5. Check the color of the water that has flowed through. It is almost completely clear again.

Do not drink this water under any circumstances! It may look clean, but it still contains a lot of bacteria and other pollutants that your plant cannot completely filter out.

Explanation

The sand and cotton wool filter out the larger particles from this filthy broth, and the activated charcoal removes the finer components, such as the cocoa. The porous charcoal grains have an unbelievably large inner surface area — just the quantity in your mini-facility corresponds to the surface area of a football field! — to which a lot of pollutants remain stuck. Every city these days has treatment plants like this, as do a lot of towns and large factories.

Modern treatment plant

EXP. 49 Why you get cold when your skin is wet

30Min

A warm bath in clean water is a lot better than a filthy broth. But even with a warm bath, you can get cold. Think of how it feels: You get out of the tub or the swimming pool and you get goose bumps — even on a warm day. Why does that happen?

You will need
Thermometer, *paper towels, note pad, pencil*

Experiment
1. Let the thermometer sit for a few minutes in the shade, read the temperature, and note it down.
2. Wrap a paper towel around the thermometer sensor and moisten it.
3. Take some temperature readings over the next 30 minutes. The temperature will gradually drop. Make a note of the lowest reading. If the paper dries off too soon, moisten it again.

Explanation
The water on the paper evaporates. To do that, it needs a lot of heat, which it takes from the surroundings — in this case, primarily from the thermometer. Result: It cools off. Water on your skin will also evaporate in the air and cool off your skin in the process, so you feel cold.

EXP. 50 Shivering in the wind

30Min

It is especially easy to get a chill when you step out of the swimming pool on a windy day, even though the wind presents no problems if your skin is dry. What causes that?

You will need
Thermometer, *paper towels, note pad, pencil, tape*

Experiment
1. Repeat the previous experiment, but this time move the thermometer with the damp paper to and fro. That replicates a flow of air, i.e. wind.
2. Again, keep your eye on the temperature.

Explanation
Now, the temperature drops by several degrees more than in the last experiment. That is because in the last experiment, as the water evaporated the water vapor collected around the paper and prevented further evaporation. In this experiment, however, the wind blows it away, so the water evaporates faster and carries heat away more quickly — so the temperature drops more.

EXP. 51 Air conditioner for the Power House

30Min

The effect that you discovered in the last experiment can be used to construct an air conditioning system for your Power House. On hot days, it will cool the inside of the house to a more pleasant temperature.

You will need
Power House, thermometer, dowel, *cup, paper towel, hair dryer on cold air setting, scissors, pencil, note pad*

Experiment
1. Set a cup in front of the open door of the Power House and place the dowel so that it crosses through the house to the opposite window.

Good Advice

Normally, the holes in the roof should be just large enough for the thermometer to be in the right position and just the sensor projects into the house. With the upper hole, it helps if you insert the thermometer at a slant, rather than straight down. If it still slips through (maybe because the holes have been widened through repeated use), try wrapping a little tape around the section just above the sensor.

2. Cut a few pieces of paper towel about the size of a postcard, dip them in water, and hang them over the dowel.
3. Put on the roof and insert the thermometer into the hole near the peak. Read the temperature and note it down.
4. Use the hair dryer to blow cold air through the house for a few seconds, repeating this

every few minutes for about half an hour. Keep your eye on the thermometer as you do this.
5. Lift off the roof and touch the moist paper. It feels really cold, much colder than at the start of the experiment.

Explanation

The temperature in the house gradually drops by a few degrees because the damp paper absorbs heat. The moist air is blown out of the house by the hair dryer. This is a very low-effort cooling technique. In the Far East, unglazed clay jugs are used to cool water: Some evaporates through the porous clay wall, cooling the contents.

Energy Saving Tip
Fresh air is healthy! But you only need to open the window for five minutes in order to freshen the air in a room.

KEYWORD

Air conditioning

The small air conditioning systems found in some apartments or cars work similarly to a refrigerator. They operate by the principle that gases heat up when they are compressed, and absorb heat when they expand again. So in an air conditioning system, special gases operate in a cycle. In one location, the gas is compressed by use of a pump (compressor) and turned to liquid in the process. The released heat is guided to the outside by cooling fins and blowers. The liquid then flows into the interior part of the system, where it can expand and turn to gas again. The heat absorbed in this process is taken from the room air, which causes the cooling effect. Then, the gas flows back to the compressor.

Air conditioning systems of this type use a lot of energy. So-called adiabatic systems, which simply evaporate water and use this for their cooling effect, are much more environmentally friendly. This is the effect that you saw in Experiment 51.

Air conditioning system atop a large office building.

Light and heat from the sun

Heating water is nice enough. But the sun's light can be used to do other things as well. First, though, you have to learn a little about the behavior of light.

EXP. 52 A star made of light

A candle's flame illuminates, which is to say it emits light. What happens to the light it sends out?

An adult should be present for this experiment!

You will need

"Light path" die-cut piece, tealight candle, matches, white paper, tape

Experiment

1. Remove the "light path" piece from the die-cut sheet. Bend it together into a circle and secure it with some tape.
2. Place the circle on a sheet of white paper in a darkened room. Set a tealight candle in the center and light it. What do you see?

Explanation

A ray of light streams through each one of the slits. It runs perfectly straight. So light spreads out equally in all directions. As the rays of light get farther from their source, they diverge farther and farther from each other.

EXP. 53 Do the sun's rays also diverge?

Strange: Objects in sunlight cast sharp shadows. How can that be, if rays of light move apart from one another as soon as they leave their source?

You will need

"Light path" die-cut piece, roof piece, *white paper, lamp*

Experiment

1. Remove the tape and pull the strip apart again. Tape it to the roof of your experimental house and observe the patterns that the sun makes as it shines through it.
2. Unlike the candle in the previous experiment, the sun is very far away from the "comb." Use a desk lamp or flashlight to experiment with the way that the distance between the light source and the "comb" can affect the shadows.

Explanation

Rather than diverging, the rays of the sun run parallel — that is, they always keep the same distance from one another. That is due to the unbelievably huge distance of the sun from Earth. That becomes clear in the second pat of the experiment: The greater the distance between the "comb" and the light source, the less the rays diverge.

Appearances are deceiving: The sun's rays only seem to diverge. In reality, they run parallel.

EXP. 54 Why it gets cold in winter

If you want to save energy with your Power House and, more importantly, in an actual building, the outside temperature will have an important role to play. In the winter, you will need a lot more heat than in summer, because it is cold. But why is it cold, actually?

You will need

Flashlight, yarn or string, tape, scissors, graph paper, colored marker

Experiment

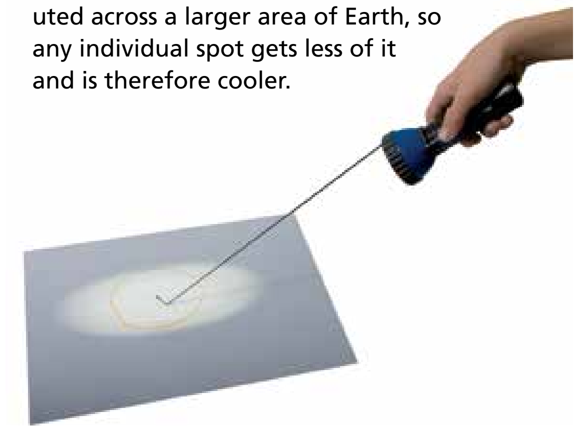
1. Cut off a piece of yarn about 30 cm in length. Tape one end to the center of a sheet of graph paper, and tie the other end to the flashlight.
2. Shine the light straight down on the paper from above with the yarn pulled taut, and use the marker to draw a line around the spot of light.

3. Now shine the light at an angle from the side from the same distance, and mark the bright spot again.
4. Count the squares inside the two outlined areas and compare.

Explanation

When you shine the light at a slant, the bright spot is much larger, but also less bright. That is due to the fact that the quantity of light from the flashlight now has to be distributed across a much larger surface area. Any single individual square, then, gets less light.

It's similar with sunshine. In the winter, when the sun stands closer to the horizon than in winter, its light and warmth are distributed across a larger area of Earth, so any individual spot gets less of it and is therefore cooler.



EXP. 55 Light rays take a detour

Normally, as Experiment 52 showed, light rays will stubbornly run straight ahead and won't turn any corners. There are a few tricks, though…

You will need

Solarium annex cover, *aluminum foil, white paper*

Experiment

1. Look at the transparent annex cover at a slant. It is reflective. So you will see things, for example, that are behind you and to the side.
2. If you hold the paper and cover sheet in the sun as shown in the illustration, you can create a bright spot on the paper or on a shaded wall.
3. Bend the edges of the sheet slightly toward the sun. How do the shape and size of the spot change?
4. Now bend the edges of the sheet away from the sun. What effect does that have on the spot?
5. Place smooth aluminum foil behind the sheet, with the shiny side toward the sheet, and repeat the experiments. Now the spot is somewhat brighter.

Explanation

Smooth surfaces reflect light rays — in other words, they change the direction of movement of the rays. That fact lets you use the sheet to look around corners, for example, or to direct the sunlight onto a shaded wall. It works even better with the shiny aluminum foil, which reflects more light — the cover, after all, lets most of the light through. Mirrors work best of all. With a smooth sheet, incoming parallel light rays keep traveling in parallel manner after being reflected, just in a different direction. But if you bend the sheet, you also change the manner in which the rays of light are reflected back. As shown in the illustration, you can use this technique to concentrate the rays on one spot or to pull them apart.

EXP. 56 Diffuse lighting

A good mirror is pretty expensive. Why not try it with a piece of paper?

You will need

Black paper, *white paper*

Experiment

1. Hold the white sheet of paper in the full sun a few centimeters away from a shaded wall. The wall close to the paper will appear brighter, but only slightly so. You won't see a clearly bright spot.
2. Repeat the experiment with the black paper. Now the wall doesn't look any brighter at all.

Explanation

The black paper swallows up almost all the light and therefore doesn't light up the wall at all. The white paper, on the other hand, reflects back almost all the light that hits it — which is why it looks bright white to us. But it scatters the light: The originally parallel rays are steered in all directions by the rough paper surface.

EXP. 57 Can heat be reflected?

If the aluminum foil redirects the sun's light, can it do that with heat as well?

You will need

Thermometer, solarium annex cover, *aluminum foil, tape*

Experiment

1. Set the solarium cover on the table and lay a piece of aluminum foil on top of it, with the dull side toward the cover. Smooth out the foil and secure it to the cover with tape. Now the shiny side is nice and flat and can easily be used as a mirror.
2. Hold the thermometer in a shady location for a few minutes in order to measure the air temperature, and make a mental note of it.
3. Then use the aluminum foil to direct sunlight onto the sensor of the thermometer — but don't let direct sunlight hit it. After a few minutes, take a reading of the temperature.

Explanation

Even reflected sunlight can increase the thermometer temperature quite a bit. Apparently, then, the heat of the sun is reflected too.

EXP. 58 Focused heat rays

In Experiment 55, you saw how to focus rays of light by using a certain shape of mirror. Maybe you can do that with heat rays too.

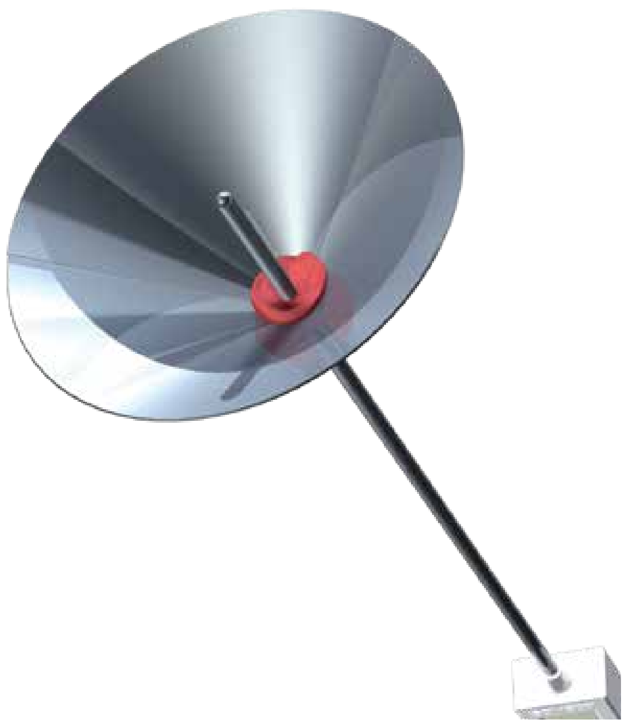
You will need

Thermometer, small concave mirror from the cutout sheet, *aluminum foil, scissors, glue*

Experiment

1. Cut out the small concave mirror from the cutout sheet and glue aluminum foil to its back, shiny side down. The foil should be as smooth as possible.
2. Pull the ends over one another to form a cone-shaped structure with the aluminum foil on the inside, and secure it with glue.

3. Hold the concave mirror in the sun and use your hand or a small piece of paper to determine where most of the reflected rays meet. That will be the brightest spot, and you will even be able to feel a little warmth with your hand.
4. Push the thermometer into the concave mirror from below so that as many reflected rays as possible hit the thermometer sensor, but as little direct sunlight as possible. As you do this,



hold the thermometer body at the top. Watch the temperature. Within a few minutes, it will start to rise.

Explanation

The aluminum foil concentrates the captured solar energy onto one small area, which therefore becomes hotter. Even though the concave mirror is small and doesn't have a particularly shiny surface, the effect is quite noticeable.

EXP. 59

The bigger, the hotter

The little mirror in the previous experiment managed to produce quite a noticeable increase in temperature. Will the effect be even more noticeable with a bigger and better mirror?

You will need

Thermometer, large concave mirror from the cutout sheet, *scissors, aluminum foil, glue*

Experiment

1. Cut out the large concave mirror from the sheet and glue aluminum foil to its back, shiny side out. The foil should be as smooth as possible. Glue the ends over one another as in the previous experiment.
2. Point the concentrated rays at the sensor of the thermometer, and watch the temperature. It will rise quickly and dramatically.

Be careful not to let the temperature rise above 100 degrees Celsius, or the thermometer could get damaged.

Explanation

With its large surface area, this mirror captures a lot more sunlight than the small one.

Be careful when experimenting with the concave mirror and the sun!
Never look directly into the sun, or you could suffer eye damage.
Always store the concave mirror with its foil side down, and never leave it unattended. Do not leave any ground lenses, such as magnifying lenses or eyeglasses, lying near it. It could cause a fire!

Energy Saving Tip

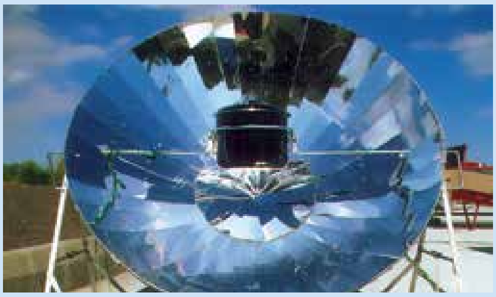
Don't let water run unnecessarily (while brushing your teeth, for example).

KEYWORD

Concave mirror

This is the name for a mirror that has an inward-curving surface rather than a flat one. Incoming parallel rays of light are not reflected back as a bundle of parallel rays, but are concentrated together in a tight spot. If the concave mirror forms a hemisphere, it creates a shape known as catacaustic, with the rays failing to meet exactly at one point. It is only with a so-called parabolic mirror that they do that, as shown in cross-section in the drawing. The larger the mirror, the more of the sun's rays it can capture and the hotter it will get at this "focal point."

In the Pyrenees Mountains in southern France, there is a giant solar oven with a concave mirror as tall as a house that is capable of generating temperatures of 3600 degrees Celsius. It has 63 secondary tracking mirrors that reflect the sun's light into the large concave mirror.



Instead of round mirrors, large solar power plants usually have parabolic mirrors in the shape of a channel or "trough." These mirrors have a focal line rather than a focal point, along which pipes carry a special liquid that is heated by the sun and that transports the heat to electricity generators.

Parabolic trough power plant in the California desert

EXP. 60 Solar trap cone

It is not at all easy to produce the right shape of concave mirror. But you can do it in a different way — with a sort of cone.

You will need

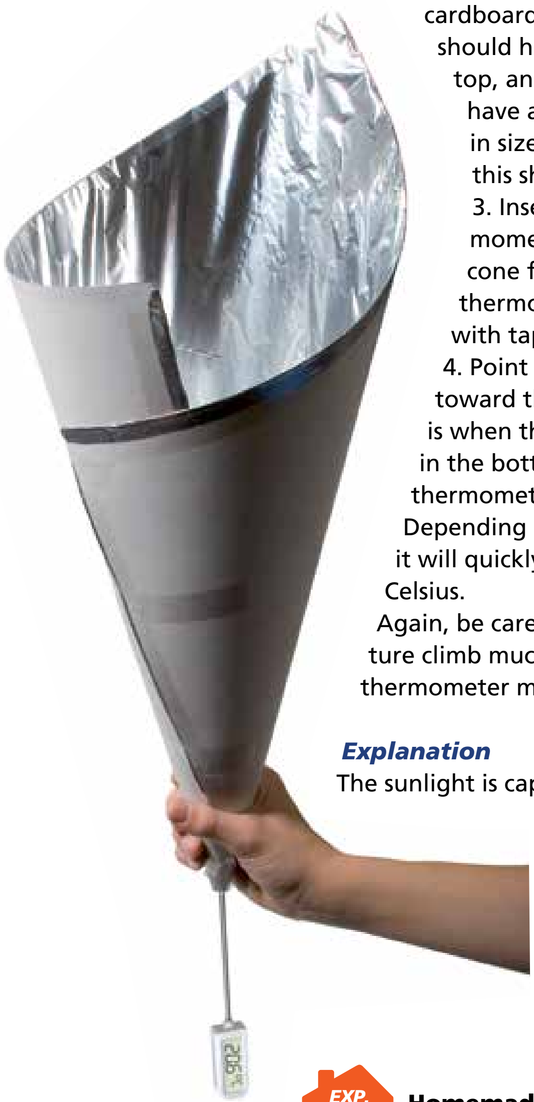
Thermometer, *cardboard, aluminum foil, glue, scissors, tape*

Experiment

1. Cut a more or less square piece of cardboard about 40 by 40 cm in size. Glue aluminum foil over the entire surface, with the shiny side up. It should be as smooth as possible.
2. Once the glue has dried, roll the cardboard up to form a cone. It should have a large opening at the top, and at the bottom it should have a small hole just about 1 cm in size. Use tape to secure it in this shape.
3. Insert the sensor of the thermometer about 3 cm into the cone from the bottom. Hold the thermometer in place or secure it with tape so it can't slip out.
4. Point the opening of the cone toward the sun. The best position is when the light appears brightest in the bottom opening. Watch the thermometer reading.

Depending on how strong the sun is, it will quickly climb above 70 degrees Celsius.

Again, be careful not to let the temperature climb much above 100 degrees, or the thermometer might get damaged.



Explanation

The sunlight is captured by the cone, reflected back and forth between the walls, and concentrated near the tip. Larger "solar traps" of this type can easily reach 130 to 150 degrees Celsius.

EXP. 61 Homemade greenhouse gas

The gas carbon dioxide — which is what bubbles so nicely in sparkling water or soda — has a bad reputation: It accumulates in the atmosphere and causes the planet to heat up. In this experiment and the following one, you will get to know a little about the gas and its properties.

You will need

Baking soda (supermarket), vinegar, glass, tealight candle, match

Experiment

1. Place one full teaspoon of the white baking soda in the glass and pour some vinegar over it. The powder will foam up, releasing countless gas bubbles.
2. Hold a burning match in the glass from above. It will quickly go out.
3. Place the tealight candle on the table and light it. Then carefully empty the invisible contents of the glass over it — but not the liquid at the bottom! The flame will go out right away.

Explanation

The baking soda powder releases large quantities of carbon dioxide gas when it comes into contact with the vinegar. The gas is non-toxic and non-combustible, and it will put out a flame. That is why it is used in many fire extinguishers. In nature, it plays an important role: Animals exhale it, and plants absorb it from the air and use it as a crucial raw material.

EXP. 62 Carbon dioxide turns up the heat

How does non-toxic carbon dioxide gas heat up Earth? That is what this rather elaborate experiment will show you.

You will need

Thermometer, black paper, drinking straw, *bucket, baking soda, tablespoon, vinegar, large glass, balloon, empty plastic water bottle, kitchen funnel, desk lamp, pencil, paper*

Experiment

1. First of all, you will have to produce a large quantity of carbon dioxide. Fill the plastic bottle a quarter of the way with vinegar. Use the funnel to pour one tablespoon of baking soda into the balloon, and fit its neck over the bottle opening, with the balloon itself hanging down, so no baking soda gets into the bottle yet.
2. Now, lift the balloon so that the baking soda falls into the bottle. The carbon dioxide that is produced will inflate the balloon. Leave the balloon on the bottle for now.
3. Lay the black paper over the bottom of the bucket. Set the thermometer at a slant in the bucket, positioned so that you can read the display.
4. Let the lamp shine into the bucket from above — it represents the sun. The air in the bucket will warm up, and the thermometer will be able to read the temperature quickly. Note this temperature.
5. Remove the balloon from the bottle, but without letting the carbon dioxide escape from it. Push the drinking straw into the neck of the balloon, pinch the rubber tightly around it, and hold the other end of the straw in the bucket, as close as possible to the bottom.
6. Then let the carbon dioxide escape through the straw. It is heavier than air and will gradually fill the bucket, even though you can't see it. You can use a burning match to check whether it is full: Carbon dioxide will make the flame go out. Make as little movement as possible, or it might blow the carbon dioxide out of the bucket. Watch the temperature. Within a few minutes, it will have climbed by a few degrees Celsius.

Explanation

The energy radiating from the lamp into the bucket heats up the paper to a certain temperature. The temperature it reaches depends on, among other things, how quickly the heat escapes into the air again. But carbon dioxide does not let heat escape as easily as air. If you replace the air in the container with carbon dioxide, the temperature therefore increases.

Energy Saving Tip

Old rolled-up hand towels or a store-bought "draft guard" can help with drafty gaps under the front door.

KEYWORD

CO_2 as greenhouse gas

Earth's atmosphere is in a state of balance: The amount of heat radiated out is equal to the amount that is absorbed by Earth. That balance left Earth with an average temperature of about 15 degrees Celsius during recent centuries. There were, however, periods (the Ice Ages) during which the temperature dropped considerably lower. For a few decades, humans have been disturbing this balance. We have been burning immense quantities of oil and coal and destroying huge areas of forest through cutting and burning. These burning practices produce the gas carbon dioxide, more and more of which accumulates in the atmosphere. True, it isn't toxic, but it has the property of blocking the flow of heat from Earth's surface into space — you learned about its poor heat-conducting qualities in Experiment 62. The result is that Earth is getting hotter and hotter. In the 20th century alone, it has become warmer by 0.74 degrees Celsius on average. This is known as the greenhouse effect, and carbon dioxide is therefore known as a greenhouse gas. 0.74 degrees may not sound like much, but as carbon dioxide emissions rise, Earth's climate zones could shift and local climates could change so much that it causes agriculture to suffer and droughts, torrential rains, floods, and storms to increase.

Exhaust gases from a car tailpipe.

Electricity from solar energy

There are many ways of generating electricity from solar energy. The most elegant ways — even if not currently the cheapest ones — involve solar cells, which have no moving parts. Let's see what your solar cell can do for the Power House.

EXP. 63

Generating electricity on the roof

You can find blue-shimmering solar cells on many roofs these days, and your Power House roof can hold one too. First, you will have to install it.

You will need

Solar cell, Power House, 2 contact clips

Experiment

1. Insert both contact clips into the slits on the roof of the house. Push them far enough in so that the smooth upper side closes off the four holes flat against the roof.
2. Insert the solar cell terminals into the two lower holes of the contact clips. The LEDs or motor will be connected to the two top holes in the following experiments.

Explanation

The amount of electricity that a solar cell supplies will depend on its orientation and angle. It works best when the sun's rays hit the solar cell pretty much vertically. That is one reason they are usually mounted on roofs, which offer a suitable orientation in addition to a large surface area.

EXP. 64

Solar current powers the motor

The installed solar cell will soon show you what it can do.

You will need

Power House with installed solar cell, motor, propeller

Experiment

1. Open the section of the roof without the solar cell. Guide the red and black connecting wires from below through the holes in the roof and insert them into the upper holes of the contact clips on the solar cell.
2. Guide the other ends from inside through the holes above the front door.
3. On the outside, connect the wires to the motor wires and insert the propeller onto the motor shaft.
4. Illuminate the solar cell with sunlight. The motor will turn.

Explanation

An illuminated solar cell acts like a battery: It supplies electricity.

EXP. 65 **Does it also work without sun?**
The sun doesn't always shine. Will the solar cell also work with other light sources?

You will need

Power House with installed solar cell and motor from Experiment 64, various lights and *lamps*

Experiment

1. Try various light sources, such as a desk lamp, a flashlight, a fluorescent lamp, a car headlight. Does the motor run with all of them?

Explanation

The motor will almost always run — even if you might sometimes have to give it a push. Bright halogen lights work the best. Fluorescent lights and energy-efficient bulbs are the only things that usually won't work. They spread out their light over a large area, so the solar cell gets too little of it.

Energy Saving Tip
Replace standard light bulbs with energy-efficient ones; they save a lot of electricity.

KEYWORD

Electrical current

Regardless of how accustomed to it we may be, a lot of people still think of electricity as very mysterious. For one thing, it's invisible. We can only see its effects, such as a spinning motor. As its name indicates, electrical current consists of a flow — a flow of the tiniest particles, electrons, through wires. These particles are even much smaller than atoms.

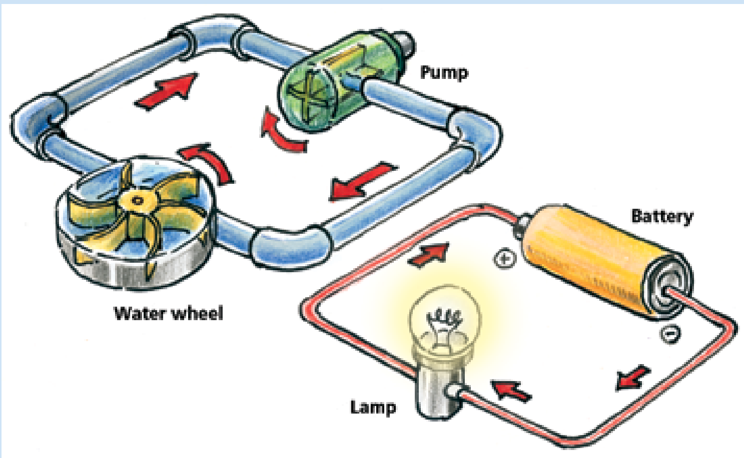
What happens in this sort of electrical circuit? Imagine a water-filled pipe that forms a closed circle. A pump is installed in one part of the circle. If you turn the pump, it sets water into motion, which then moves through the circle. In another location, there is a small water wheel, which is made to rotate by the water and in turn drives a small propeller, for example.

In this model of an electrical circuit, the pump corresponds to your solar cell or a battery, which pushes electrons along. The electrons flow in the wires, which correspond to the pipes. And the water wheel would be an motor or lamp, for example.

Of course, more or fewer electrons might flow through the wires per second, and the current could be more or less strong. A strong current can accomplish more. The "current strength" is therefore an important unit of measure in electronics.

Another important thing is the force with which a solar cell, for example, pushes the electron current through the wires. This force is known as electrical voltage — corresponding to the water pressure in a water circuit. It is measured with a unit called a volt. Your solar cell supplies about 3 volts, a penlight battery 1.5 volts, a car battery 12 volts, and the wall outlet (deadly dangerous!) supplies 120 volts.

Water circuit and electrical circuit



EXP. 66 Without interruption

Why is it that a solar cell, the motor, a battery, and all other electrical components always have two connection terminals?

You will need

Power House with installed solar cell and motor, *lamp*

Experiment

1. Let the motor run under a light again. Pull each of the wires, one after the other, from the contact clips, or remove one of the two wire connections from the motor. The motor will stop right away.
2. Restore all the connections and note the direction of rotation. Then switch the wire connections to the motor. Now the motor will rotate in the opposite direction.

Explanation

Electrical current always runs in a circle — that is, in an electrical circuit. When you illuminate the solar cell, it basically pushes electrons out of one of the two terminals. They flow through the wires to one terminal of the motor, then back out through the other terminal, and then they flow back to the solar cell again: the circuit is closed. If the circuit is interrupted or broken at any location, then the flow of electrons will immediately stop, since the solar cell can no longer emit any electrons due to the fact that no more are coming in. That stops the motor too. The fact that the current really does flow through the wires like a current of water is demonstrated by the reversal of the motor rotation when your switch the terminals. Now, the current flows through the motor in the opposite direction — and the motor therefore turns in the other direction as well.

Humans are good electrical conductors as well, and we should therefore protect ourselves from contact with electrical current.

EXP. 67 Conductor and non-conductor

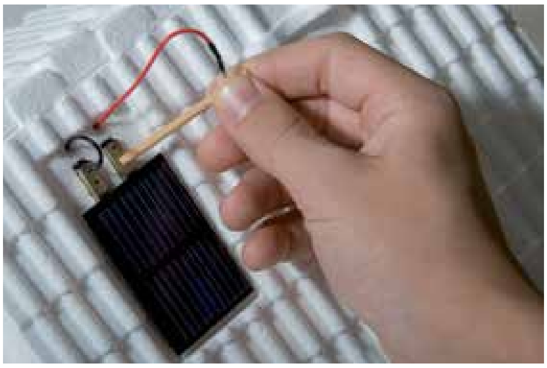
In your experiment, electrical current runs through wires, which are made of copper encased in plastic. Will other materials besides copper also conduct electricity?

You will need

Power House with installed solar cell and motor, small dowel, *objects made of various materials, lamp*

Experiment

Pull one of the wires from the contact clip and hold objects made of other materials in such a way that they touch the contact clip and wire at the same time. Try it with metal or plastic spoons, for example, or with the small dowel, a metal nail, a coin, your fingers, paper, glass, aluminum foil. Does the motor run?



Explanation

All metals will conduct electricity. That is why they are known as "conductors." Materials such as plastic, wood, paper, glass, cardboard, and air, on the other hand, will not conduct electricity and are therefore known as "non-conductors." Of course, even non-conductors do contain electrons. But they are so hard to move that the electrical power of a solar cell or battery is not enough to make them flow.

Direct contact between electrical conductors and your fingers is only OK here because the solar cell's power is so weak. Never try something like this with a wall outlet!

EXP. 68 Red light from the LED

So-called light-emitting diodes, or LEDs for short, are a modern form of light producer. You will find one in your experiment kit — look for the small red plastic device with two terminal wires.

You will need

Power House with installed solar cell and wires, 2 contact clips, LED, *black paper, tape, scissors, lamp*

Experiment

1. Insert the two contact clips into the slots

designed for them above the door, and the two wires into the upper holes.
2. Bend the LED wires so that each one of them fits into one of the lower holes of the contact clips, and insert the LED there.
3. Illuminate the solar cell with a bright lamp or sunlight. Shade the LED with your hand to be sure that it's lighting up. If it doesn't, remove it from the contact clips and reinsert it with its terminals reversed. It should light up now.
4. Even if the LED did light up at first, try reversing the terminals. Now it won't light up anymore. It only works in one direction.
5. It is hard to see the LED light up in bright light. So cut a piece of black paper about 4 by 4 cm in size, roll it into a tube, and fix it with a piece of tape. Bend the LED slightly upward and stick the paper roll over it. Now you should be able to see how brightly it lights up even in sunlight.

Explanation

An LED is a kind of valve for electrical current: It only lets the electricity run through it in one direction. And it only produces light when the electricity flows. If it is connected the wrong way around, it will remain dark. LEDs have a few important advantages over conventional light bulbs: They use much less electricity for the same amount of brightness, and have a much greater life span.

KEYWORD

Light-emitting diode

Light-emitting diodes, or LEDs, are modern electronic components. They are made from a tiny crystal embedded in a transparent plastic casing. If electricity flows through an LED, a portion of the energy is converted into visible light. By selecting a certain kind of crystal material or through certain additives, one can also select the color of the light. In any case, LEDs work like an electrical valve: They only let current flow through in one direction.

Today, there are LEDs in many different colors, as well as white ones and ones in invisible infrared and ultraviolet wavelengths. LEDs have developed countless applications, such as in electronic device displays, for emitting signals in TV remote controls, in numerous electronic devices such as scanners and printers, for emitting light through fiber-optic cables, in medicine, in colored advertising displays, and most recently as economical and long-lasting light sources in car tail lights, flashlights, and street lighting.

LEDs as display lights in electronic devices

Never connect the LED directly to a battery! The sensitive component would immediately be destroyed.

EXP. 69 Clouds in front of the sun

The sun isn't always shining in a cloudless sky. What happens to the solar cell electricity supplier when it is partially shaded?

You will need

Power House with installed solar cell and LED with paper tube, solarium cover, *paper*

Experiment

1. Position the Power House so that the solar cell gets full sunlight, and note the brightness of the LED. Now partially shade the solar cell with your hand, and watch the LED as you do this.

2. Observe the effect of clouds as they move in front of the sun. How is the LED output on a rainy day? And how does it drop off as evening approaches?
3. Cover the solar cell with light paper, the transparent solarium cover, plastic wrap and other things, and observe whether they have an effect on the LED brightness.

Explanation

Partial shade quickly reduces the solar cell's electricity production, and the LED turns noticeably darker. The sun will also supply much less light as it goes down. Even the clear solarium cover reduces its performance, although you have to look closely and move the cover quickly back and forth in order to see the effect.

On a dreary day, the engine may not run at all. An overcast day, after all, can be a lot darker than a sunny day. Our eyes deceive us quite a bit when we try to judge the intensity of light: A sunny day is actually about 250 times as bright as a dreary winter day!

EXP. 70 Thrifty motor

The LED seems to need quite a bit of electricity. Is the motor more economical?

You will need

Power House with installed solar cell, motor, and propeller

Experiment

1. Pull the wires from the contact clips above the door and reconnect the motor.
2. Position the Power House so that the solar cell gets full sunlight. The motor will turn quickly — which tells you that the electrical connections are working. Partially shade the solar cell with your hand. You will have to cover it almost completely before the motor slows down enough to notice.
3. Now let only reflected light from a bright wall or a piece of white paper hit the solar cell. The motor will still run pretty well.
4. Turn the Power House so that the solar cell is just pointing to blue sky rather than the sun. Shade it from any direct solar rays. If it's a sunny day, the motor will still run, even if noticeably more slowly.

Explanation

The motor does indeed need a lot less electric current than the LED. Even if it is shaded, it still runs pretty well.

EXP. 71 It works when it's doubled too

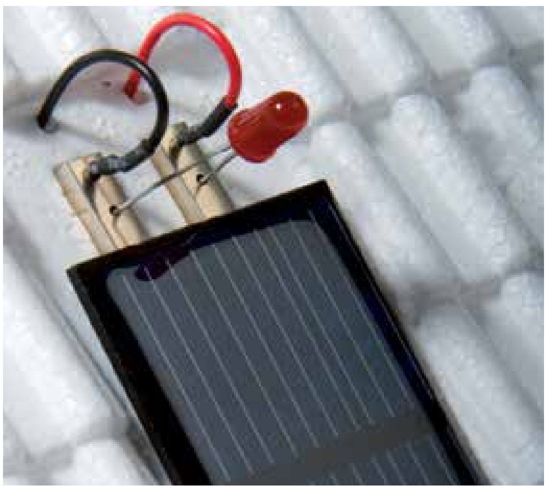
If the motor really does use so little electricity, might the current be enough for both light and motion?

You will need

Power House with installed solar cell, LED with paper tube, motor with propeller

Experiment

1. Augment the setup for experiment 70 by inserting the LED in the solar cell's contact clips. Mount the paper tube and make sure the LED is inserted correctly, in the correct direction.



2. Position the Power House so that sunshine hits its solar cell. The LED lights up and the motor runs.
3. Partially shade the solar cell. The LED gets darker or goes out, while the motor keeps running at first.
4. Try testing other light sources as well. Depending on the brightness, both LED and motor will run, or just the motor.

Explanation

The quality of the solar cell in the kit is so high that it can produce enough electricity for both the motor and the LED if the lighting is good. In some of the following experiments, you will also be operating both the LED and motor at the same time. For these experiments, always connect the LED to the solar cell contact clips, not above the door.

EXP. 72 Following the sun's path

In the experiments with the LED, you saw that the solar cell responds sensitively to light intensity. What happens if it isn't pointed directly at the sun?

You will need

Power House with installed solar cell and LED with paper tube

Experiment

From Experiment 9, you know the path that the sun traces across the sky, where it rises where you live, where it stands at noon, and where it sets. Turn the Power House so that the solar cell is oriented toward all these points along the sun's path, one after the other. As you do this, watch the brightness of the LED.

Explanation

The solar cell supplies the most electricity when it is pointing directly at the sun. But since the sun moves during the day, the output of a fixed solar cell will also change over the course of the day. That is why there are solar power facilities in which the cells follow the path of the sun. They are, however, quite a bit more expensive. Fixed solar cells should ideally be pointed toward the south.

EXP. 73 The angle of elevation is important too

The path of the sun across the sky is not a straight one, but a curved one. It therefore doesn't just change direction, it changes its height above the horizon as well. What is the effect of this on the solar cell?

You will need

Power House with installed solar cell and LED with paper tube

Experiment

Repeat the previous experiment, except this time try adjusting the solar cell to the height of the sun above the horizon by adjusting the tilt of the house. Again, watch the brightness of the LED as you do this.

Explanation

The height of the sun above the horizon also has a clear effect on the performance of the solar cell. Fixed cells are therefore generally set at an angle that yields good results most months of the year — as is the case with your Power House too. The optimal angle is about a 30°–45° deviation from the horizontal.

> ***Energy Saving Tip***
> When you buy new appliances to replace old ones, get the most efficient ones you can. Pay attention to the energy label — it shows how efficient an appliance is.

Solar plant with tracking

EXP. 74 Reflected sunlight

Of course, it would also be possible to keep the solar cell fixed in place and to reflect the sunlight onto it. Then, you would just have to track the sun's movement with the mirror. Would that work?

You will need

Power House with installed solar cell, LED and motor, solarium annex cover, *mirror, aluminum foil, tape*

Experiment

1. Place the Power House in a shady location outside, and use the mirror to direct sunlight onto the solar cell. The LED lights up, and the motor runs, even if the light is somewhat weak.
2. Try using the shiny side of the aluminum foil as a mirror. Press the foil onto the solarium annex cover, smooth it out as much as possible, and attach it with tape. Now, the motor should at least run.

Explanation

With a good mirror, judging by the illumination of the LED, the solar cell's performance is almost as good as when the sun hits it directly. The aluminum foil, on the other hand, does not work as a very good mirror in this respect.

EXP. 75 Concentrated by concave mirror

A concave mirror will concentrate the light differently than a regular mirror. Try it.

You will need

Power House with installed solar cell, LED and motor, concave mirror from Experiments 58 and 59.

Experiment

1. Take the concave mirror from Experiments 58 and 59.
2. Place the Power House in the shade and direct the rays concentrated by the concave mirror onto the solar cell, in such a way that the brightest spot hits the cell. Pay attention to the brightness of the LED.

Explanation

Thanks to its ability to focus the rays, a large enough concave mirror will enable good performance, which you can see by looking at the LED. The motor will run in any case.

EXP. 76 The closer the brighter

When you supply the solar cell with sunshine, it makes no difference whether the cell is close to the ground or in the sixth floor of an apartment building. But if you use a lamp as a light source, its distance makes a big difference. Why? And exactly how great an effect does distance have?

You will need

Power House with installed solar cell, LED with paper tube, motor, black paper, *yardstick or ruler, lamp, pencil, paper, tape*

Experiment

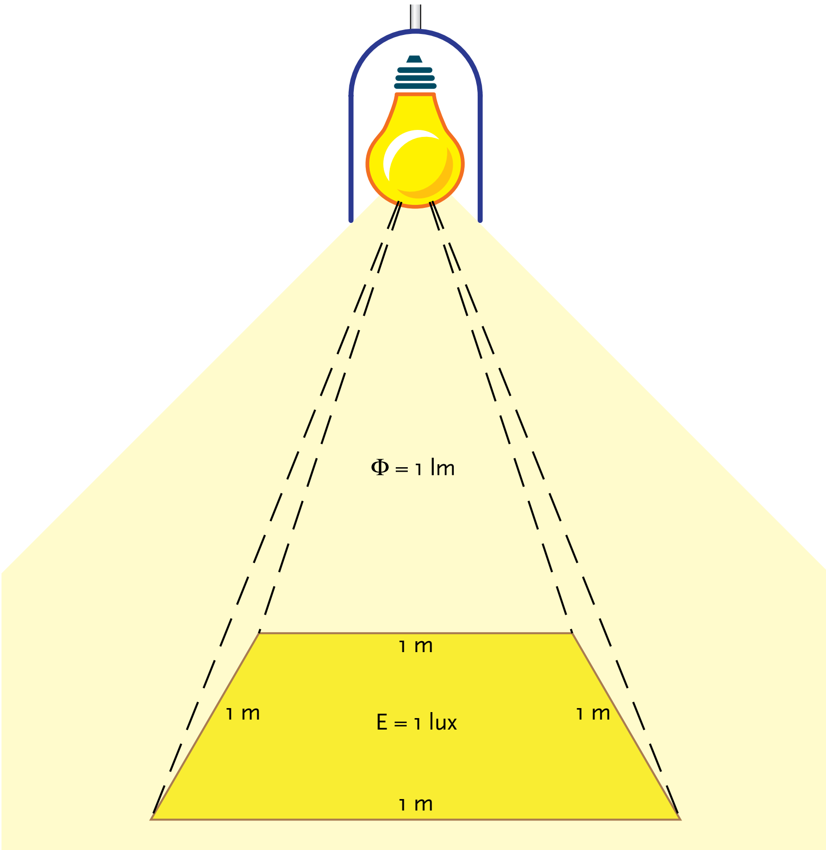
1. Cover exactly half of the solar cell with the black paper. Point the lamp — a bright desk lamp, for example — in such a way that it emits light horizontally.
2. Move the lamp close enough to the solar cell for the LED to light up, and then increase the distance until the LED just goes out. Measure the distance between the lamp and the solar cell.
3. Remove the covering from the solar cell, repeat the experiment, and measure the distance again. Write down both measurements.
4. Repeat both experiments, but this time in each case note the distance at which the motor just stops running.

Explanation

First, the experiment clearly shows that the light intensity drops with the distance of the lamp: Even when you increase the distance just a little, the LED goes out, and a few centimeters farther away the electricity that is produced is not even enough for the motor.

As your measurements showed you, however, the light intensity does not drop in direct proportion to distance. You first measured the distance corresponding to a given light intensity — the distance, in other words, at which the LED goes out. Then you removed the covering from the solar cell. That has the same effect as doubling the brightness of the lamp. And yet, the LED does not go out at twice the distance from the lamp, but at about one and a half times the distance. You get the same result with the motor part of the experiment.

In fact, the drop in light intensity is the square of the distance. If you double the distance, the intensity doesn't drop to half, it drops to a quarter, and if you triple the distance the intensity drops to one ninth, and so on. That is why you shouldn't install streetlights, house lights, or reading lights too far away from the area to be illuminated.



EXP. 77 **Color-changing red cabbage juice**

Let's take a little detour into a fascinating area of research: electrochemistry. An electrical current can also work like a chemist, doing astounding things in the process.

You will need

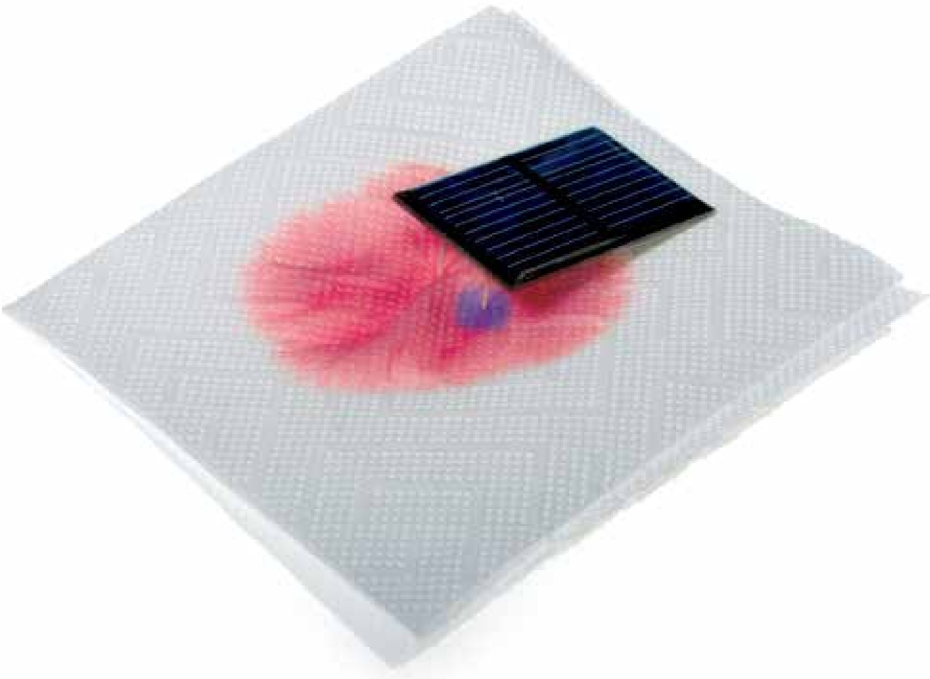
Solar cell, solarium cover, paper towel, *table salt, red cabbage juice, glass*

Experiment

1. Add about one tablespoon of red cabbage juice (which you can get by boiling red cabbage in water) to the glass, and dissolve about three pinches of salt in it.
2. Soak a paper towel in this red solution and spread it over the solarium cover.
3. Press both solar cell terminals against the paper towel and hold it in the full sun for a few minutes. Then remove the solar cell and look at the paper towel. At one terminal (the negative pole –), the red color has changed: There, the paper is now blue, or it may have turned yellow.

Explanation

A chemist calls table salt sodium chloride, because it consists of a chemical compound of sodium and chloride. The electricity produced by the solar cell dissolves this compound. In the process, there is a substance produced at one terminal that turns the red cabbage juice blue. Also, a small quantity of chlorine gas is released, which combines with the red cabbage juice and bleaches it — hence the yellow color. You can also play this kind of color game with other dyes from flowers or fruits — although not with all. For example, try blueberry or cherry juice, always with a little table salt dissolved in it.



Energy Saving Tip
Turn off appliances if you're not using them — they use a lot of power unnecessarily in stand-by mode.

Energy from the wind

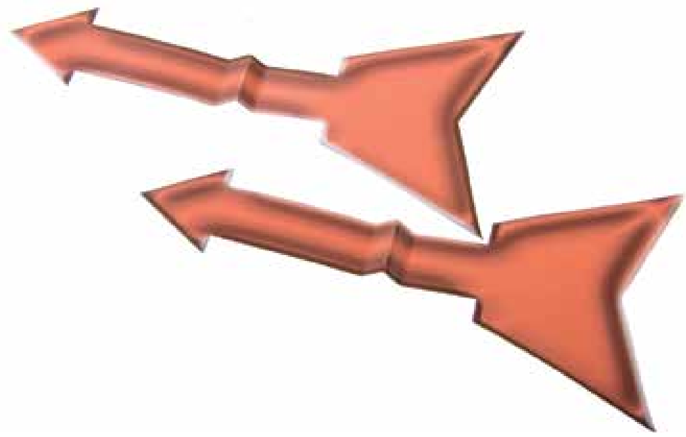
Wind has once again become a very popular renewable energy source. Wind power makes use of the flow of air to drive large wind turbines that generate electricity as they turn. Your Power House can also be equipped with a wind power station.

EXP. 78 Weather vane shows the wind direction

The wind can exert quite a lot of force: It can rip roofs off of houses and blow trees around. A weather vane, on the other hand, is one of the most harmless things that the wind can move.

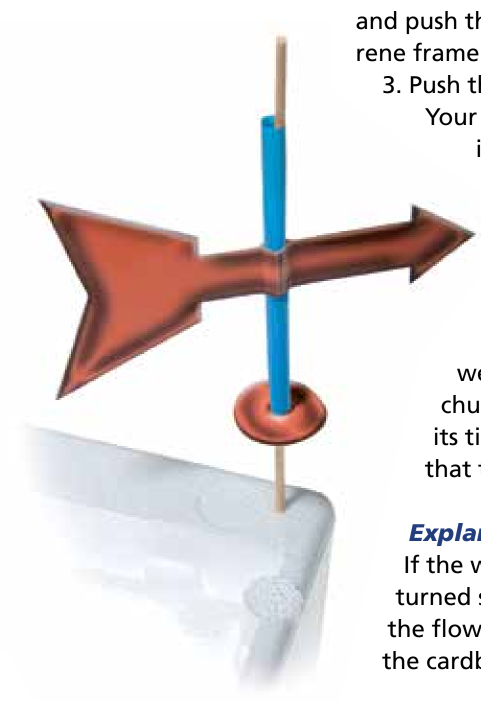
You will need

"Wind vane" die-cut parts, long pointed wooden stick, polystyrene frame, straight drinking straw, *glue, hair dryer*



Experiment

1. Remove the wind vane parts from the die-cut sheet, bend the arrow as shown in the illustration, and glue it to the straw.
2. Insert the disk on the wooden stick and push the dowel into the polystyrene frame.
3. Push the straw over the dowel. Your vane can now turn freely in the wind.
4. Blow on the wind vane with the hair dryer. It always turns with its point aimed precisely toward the dryer. A wind vane or weathercock mounted on a church steeple will also point its tip or beak in the direction that the wind is coming from.



Explanation

If the wind vane starts by being turned sideways to the wind, the flow of air pushes against the cardboard on the shaft. The pressure makes it rotate until it has the smallest possible surface area turned toward the wind. Then the tip is pointing in the direction from which the wind is coming.

EXP. 79 "Winding up" a load

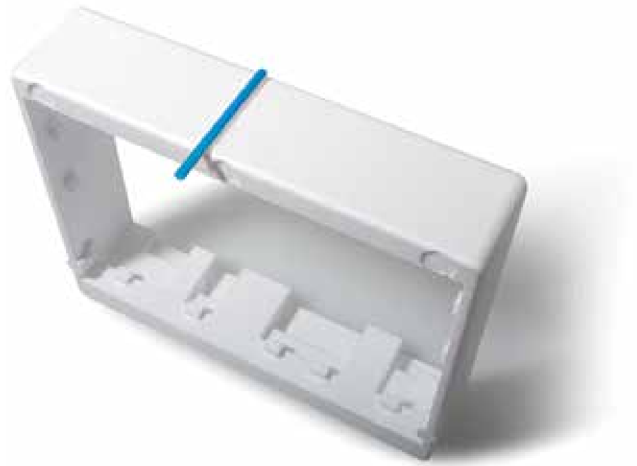
Turning a wind vane is not exactly something you'd call a lot of work. Can the wind also perform "real" work, such as lifting a weight?

You will need

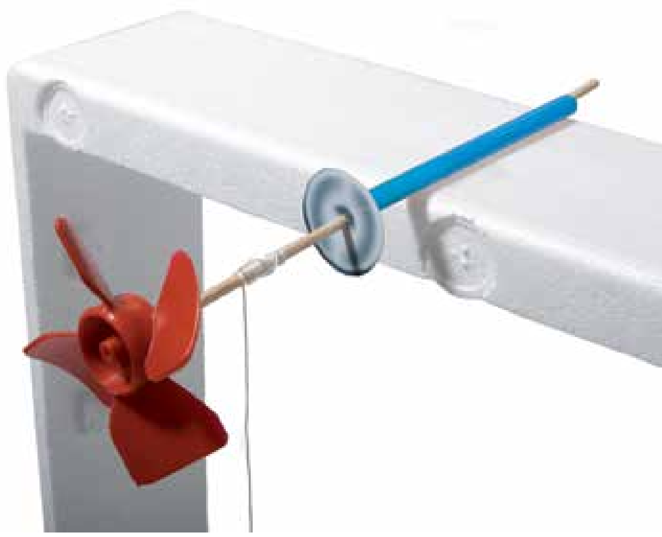
Black bottle with cap, thin pointed wooden stick, propeller, thin dowel, polystyrene frame, straight drinking straw, round "vane" disk from *die-cut sheet, string, tape, measuring cup, hair dryer*

Experiment

1. Set the polystyrene frame at the edge of a table, with the long edge with the broken-off polystyrene connectors (to which the house parts were attached) toward the bottom, so it sits at a slight tilt. Tape the drinking straw crossways across the top frame section.



2. Remove the "wind vane" disk from the die-cut sheet and push it onto the long wooden stick. Mount the propeller over the stick's pointed tip.



3. Tape some string between the propeller and disk. Then push the stick into the straw.
4. Tie the other end of the string to the black bottle. Blow on the propeller with your mouth or the hair dryer. The propeller will turn, winding up the string in the process and pulling the bottle upward. If the flow of air stops, the bottle drops down again and rotates the shaft and the propeller.
5. Gradually fill the bottle with water from the measuring cup to determine the exact performance limits of your windmill. It's a good idea to screw on the cap when you do this.

Explanation

The shaft and string convert the rotational movement into upward movement. Your windmill is quite a nice little machine: It transforms one form of energy — namely, the bodily force of your lungs — into another — the potential energy of the lifted object. Stop blowing, and the windmill converts this potential energy back into a movement of the shaft, the propeller — and the air. The rotating propeller, after all, produces an air current.

Energy Saving Tip

Taking a shower instead of a bath saves a lot of hot water, and thus a lot of heat energy as well.

For this experiment to work properly, it is important for the polystyrene frame to be tilted back a little.

Helicopter rescue of injured person with cable winch.

KEYWORD

Wind power plants

Humans have been using the power of the wind for thousand of years, for such things as grinding grain or pumping water. Large-scale production of electricity from wind has only been pursued for a few years — but it holds a lot of promise for the future.

A wind energy device is basically pretty simple to build, and is quite similar to the setup on your Power House: A (typically three-bladed) propeller drives an electric generator via a gearbox, and the generator produces electricity. The generator housing is rotatable, and the propeller blades are adjustable. This way, the device can adapt to any wind direction and strength. Of course, the propeller and tower have to be able to withstand powerful forces.

In addition to wind power plants on land, more and more wind farms with lots of wind turbines are being planned and built off the coast on the open sea, where the wind blows more evenly and strongly. Then, the electricity can be taken back to solid land through underwater cables.

Wind turbines in a wind farm

EXP. 80

A wind power plant for your house

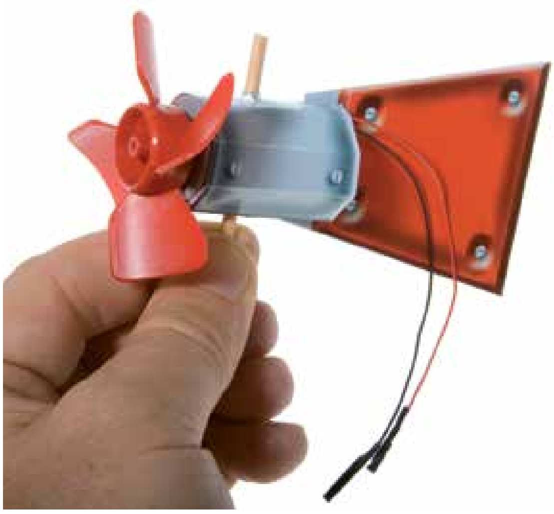
It would sure be nice to use the power of the wind to produce electricity. Let's assemble a wind power plant for your Power House.

You will need

Power House, motor, connecting wires, "motor bracket" and "steering vane" die-cut parts, long dowel, short dowel, propeller, *glue*

Experiment

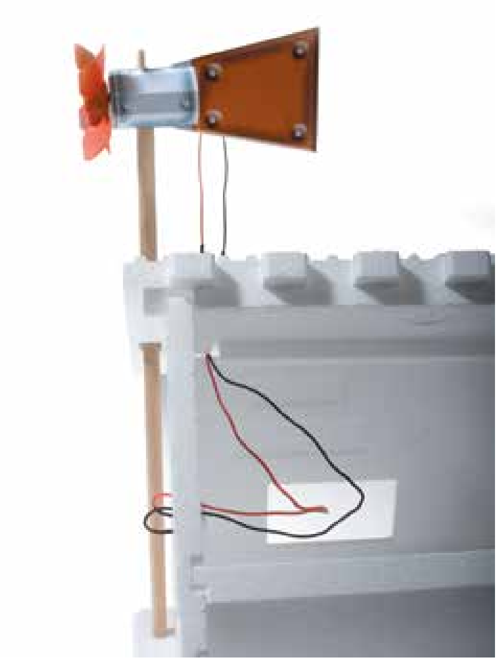
1. Remove the "motor bracket" and "steering vane" pieces from the die-cut sheet. Roll the "motor bracket" piece to form a tube. Its diameter has to be just big enough to let the motor fit snugly inside it and the short dowel pass through the holes. Once you have done that, secure the tube with glue.
2. Push the motor into the bracket, but with the shaft still protruding out. Guide the wires out of the holes in the back, being careful that they don't get stuck or damaged. Push the red propeller onto the motor shaft.
3. Fold the steering vane and glue it together. Then, insert the shorter end into the motor bracket slit from behind.



4. Insert the long dowel through the large opening at the side of the roof and into the hole in the base platform. The hole in the dowel must be pointing up. Now insert the short dowel with motor, propeller, and steering vane into that hole.
5. Guide the motor wires through the roof hole into the house. Open the other half of the roof and connect the motor wires to the connecting wires leading from the contacts to the inside of the house via the opening above the door.

Explanation

The motor won't be operating as an motor — that is, converting electricity into movement — in the following experiments, but doing just the opposite: It will be working as a "generator," or electricity-producer, by converting movement (of the propeller) into electrical current. This is also what large wind power plants do.



Wind makes light

EXP. 81

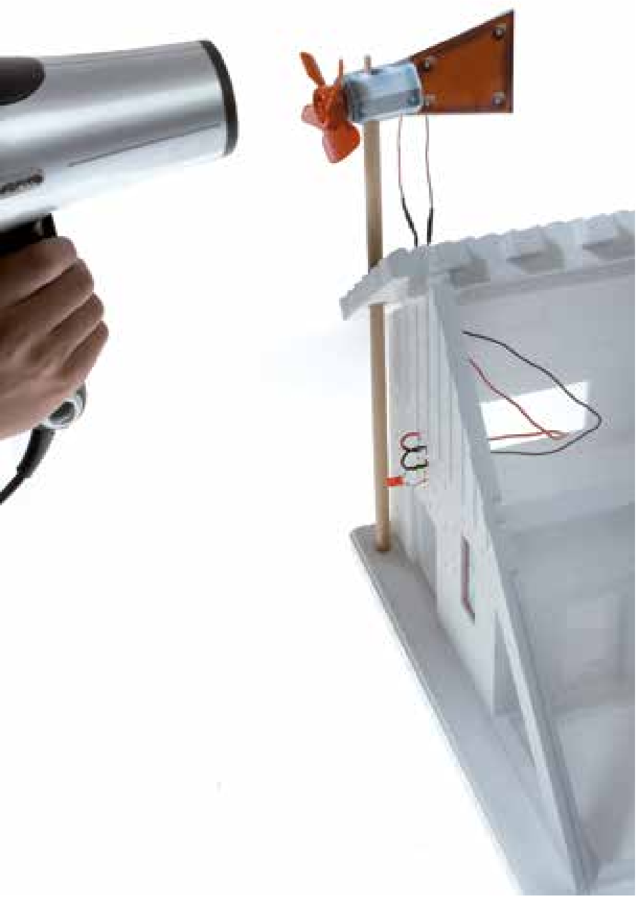
You can test out the wind power plant right away. Will it be able to make the LED light up?

You will need

Power House with wind power plant, LED, *hair dryer*

Experiment

1. Insert the LED into the contact clips above the door, to make a connection to the motor terminals.
2. Make the propeller spin quickly by blowing a strong stream of air against it with the hair dryer. If the LED doesn't light up, insert it the other way around in the contact clips. Now it should light up if the propeller is turning fast.



Explanation

The motor works as a generator and produced electricity when the propeller turns the shaft. If the rotation speed is fast enough, there will be enough current to make the LED light up.

Wind at your back

EXP. 82

Will the motor also generate electricity when the wind blows the propeller from behind?

You will need

Power House with wind power plant, propeller, LED, *hair dryer*

Experiment

1. Blow on the propeller from the front with the hair dryer. The LED should light up.
2. Now blow from behind, holding the steering vane in place so it doesn't turn. The propeller spins almost as fast, but in reverse. The LED doesn't light up. Now reverse the position of the LED in the contact clips and aim the hair dryer at the propeller from the rear again. This time, the LED lights up.
3. Carefully remove the propeller from the motor shaft and mount it the other way around. Blow from the rear: Now the LED won't light up.
4. Blow on the propeller from the front: Now the LED lights up.

For the following experiments, make note of the direction in which the motor has to turn in order for the LED to light up — for example, in a clockwise or counter-clockwise direction from a front perspective.

Explanation

When it works as a generator, the motor acts like a battery: When electricity is generated, the electrons flow out from one terminal and into the other. If the rotational direction of the motor changes, the current direction also changes. Since the LED only lights up when the current is flowing in the right direction, it will refuse to do its job after you switch the direction of rotation — until it is likewise switched around, or until the prior rotational direction of the motor is restored by turning the propeller around.

Energy Saving Tip

You can significantly reduce your water consumption by using a water-saving shower head.

EXP. 83 Homemade wind turbine

The red propeller works pretty well. But it can't be adjusted. For your experiments, you will have to build your own experimental wind turbine.

You will need

Power House with wind power plant, "small fan blade" die-cut parts, 4 short wooden sticks, disk, *ruler, tape*

Experiment

1. Use the ruler to determine the center of the disk as precisely as possible, and make a small hole there with the thin wooden stick. It should be just big enough to let you fit the disk onto the motor shaft.
2. Remove the four "small fan blade" cardboard parts from the die-cut sheet, and tape them to the four small wooden sticks at an equal distance from their ends. This will give you your small fan blades (rotor blades).
3. Insert the four wooden sticks into the disk at right angles to one another, as shown in the illustration. The portion inserted into the disk should not be too long — the stick should not reach the center point where the motor shaft will be.
4. Push the disk with its pre-punched hole onto the motor shaft. Be sure that it can spin freely.

Explanation

This wind turbine naturally won't look as elegant as the red propeller. But on the other hand, you will be able to use it to perform interesting experiments to determine the best shape for a wind turbine to have.

EXP. 84 At the right angle

The angle of the rotor blade plays a very important role. You can easily change the angle by turning the small thin wooden sticks, which will let you find out the best setting.

You will need

Power House with wind power plant, wind turbine from previous experiment, LED, *hair dryer*

Experiment

1. First, adjust all four rotor blades so that the stream of air strikes flat against their surface. Blow with the dryer (set to "cold") or your mouth against the wind turbine. It will hardly budge.
2. Adjust the angle of the surface of each of the four rotor blades. This is also known as the "angle of attack." Change the angle in several steps from 0° (full surface flat against the wind) to 90° (edge-on against the wind), checking the rotation speed each time. Always keep the dryer the same distance from the wind turbine, about 10 cm.

3. Repeat the experiment, but this time shift the rotor blades in the opposite direction. The wind turbine will turn in the air current, but the other way around now.
4. Set the blades in the best position, with the turbine spinning in the right direction (see Experiment 82). If the dryer is blowing at full blast and the LED above the door is connected properly, it should light up.

Explanation

As you increase the angle, you will notice a steady increase in the rotation speed, followed by a drop back to zero. The wind turbine turns fastest when the rotor blades are angled about 30°.

EXP. 85 Will fewer blades work too?

Large wind turbine blades are not made of cardboard, but of special, extremely resistant plastics, and they can therefore be quite expensive. Do you absolutely have to have four of them?

You will need

Power House with wind power plant, wind turbine from previous experiments, LED, hair dryer

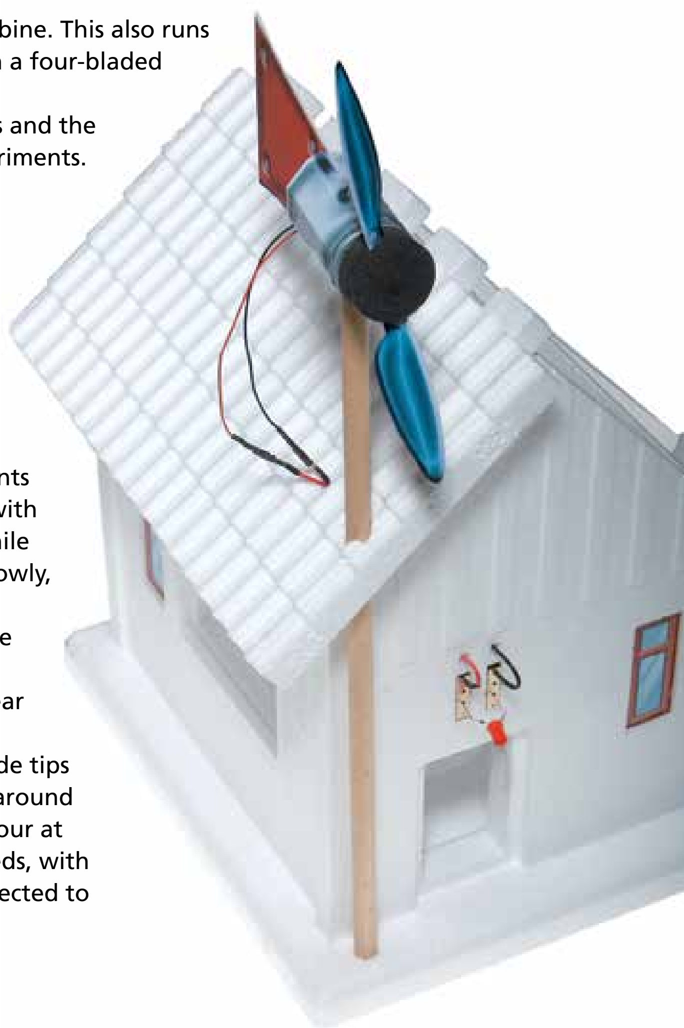
Experiment

1. Set the rotor blades to the best possible angle, and check whether the LED lights up in the hair dryer stream.
2. Pull out one of the rotor blades and check the rotation speed now attained. It is less than in the last experiment, and is hardly enough for the LED.
3. Remove another rotor blade, resulting in a two-bladed wind turbine. This also runs well, but slower than a four-bladed one.

Save the rotor blades and the disk for further experiments.

Explanation

The more blades the wind turbine has, the better it can make use of the wind's energy at low wind speeds. There are reasons, though, why large power plants have wind turbines with just three blades. While they do turn more slowly, they can create high rotation speeds at the electricity generator with the help of a gear transmission system. And even so, the blade tips will reach speeds of around 300 kilometers per hour at normal rotation speeds, with the rotor blades subjected to enormous forces.



The generator, installed in the wind turbine housing, converts rotational movement into flowing current.

Energy Saving Tip
Halogen bulbs devour electricity — use them as little as possible.

EXP. 86 Load lifter in a homemade assembly

Modern wind energy plants are unbelievably large. Their rotor blades can be up to 60 meters long and are therefore very expensive. What advantage do large rotor blades have over small ones? As in Experiment 79, here you will be judging the performance of a windmill by how well it can lift a load. A hair dryer won't be a strong enough wind source for the large rotor blades that you will need for this. You will need to use either actual wind outside or a table or pedestal fan.

You will need

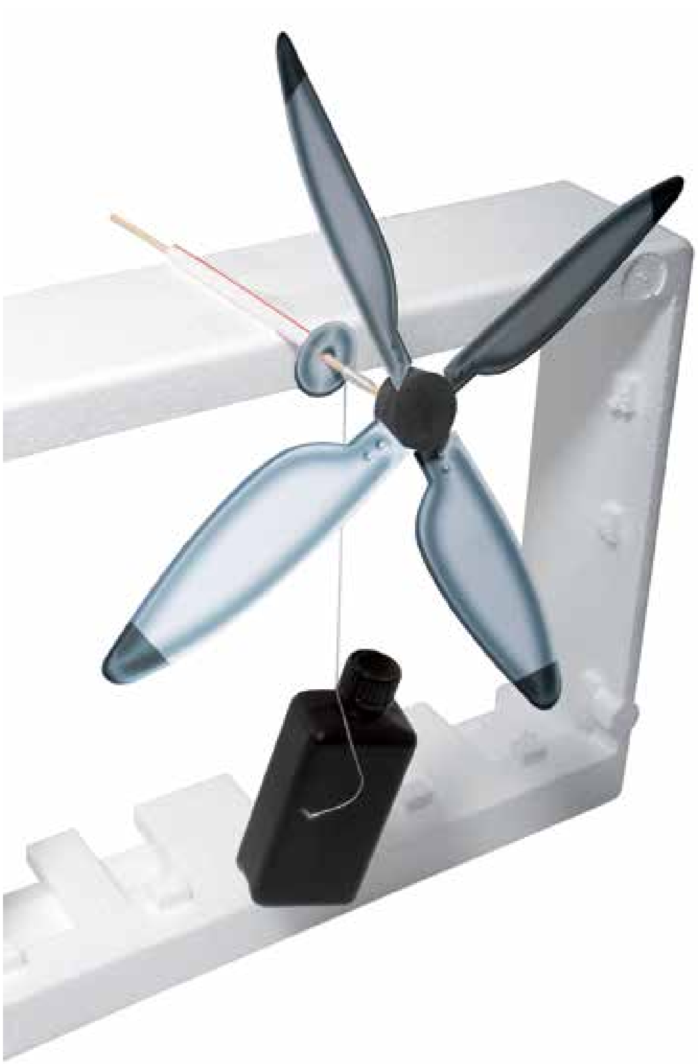
Rotor blades from Experiment 83, "large fan blade" die-cut parts, 4 short wooden sticks, long wooden stick, straight drinking straw, polystyrene frame, black bottle with cap, *tape, string, measuring cup, possibly a table fan*

Experiment

1. First, assemble the setup as in Experiment 79 and use the air current of a fan to determine its lifting power on the bottle partially filled with water. It will be less than when you blow with the hair dryer, since fans usually emit a slower air stream.
2. Remove the "large fan blade" cardboard pieces from the die-cut sheet, and tape each one onto a short wooden stick. Remove the short rotor blades from the disk and replace them with the long ones. Push them in firmly so they don't slip out. Adjust the cardboard pieces to the optimal angle.
3. Measure the lifting power of the device in the air stream of a fan, as in step 1. This rotor will turn considerably more slowly than the small one, but develops considerably more lifting force in compensation.

Explanation

The larger rotor covers a much larger area than the small one, so it can take up a lot more energy from the flow of air. In addition, the leverage of the long rotor blades is greater than that of the small ones.



Current flow experiments with the propeller

Wind power plants are constructed in such a way that they use air current to their best possible advantage in obtaining energy. In order to make the equipment more efficient, you have to know a thing or two about air currents and their properties. The following experiments will give you some initial insight into this interesting field.

EXP. 87 Solar-powered blower

If the sun is shining in the summer time, it can get pretty warm. How would you like a small fan to cool you off — solar-powered, of course?

You will need

Solar cell, motor, motor bracket from the die-cut sheet, red propeller, 2 contact clips

Experiment

1. Mount the red propeller on the motor shaft and secure the motor in its bracket. Connect the wires and insert their free ends into the solar cell contact clips.
2. Illuminate the solar cell with sunlight or bright lamp light. The motor runs, and the propeller sends out a stream of air. If it doesn't, remove the propeller from the shaft and mount it the other way around.

Explanation

Just as an air current can rotate a propeller, the motor-driven propeller can also produce an air current.

EXP. 88 Wind direction indicator

Weak air currents can be difficult to see. A simple flow indicator can help.

You will need

Long wooden stick, *yarn or tissue paper, glue, scissors*

Experiment

1. Cut a few pieces of yarn or strips of thin tissue paper that are about 2 cm long. Glue some of these strands with one end near the tip of the thin wooden stick. The other end must hang freely off the stick.
2. When the glue is dry, hold the strands on the thin wooden stick in the air stream of your propeller, or simply blow on them. Their movement indicates that the air is flowing and the direction in which the air is flowing.

Explanation

This model is similar to wind direction indicators found on masts at airports and bridges that are in the form of long, tubular bags. These “wind bags” show pilots or drivers the strength and direction of the wind.

EXP. 89 Mini Solar Boat

The air flow generated by the solar-powered propeller is strong enough to move a little boat around in the water. The best part is that it uses no fuel.

You will need

Solar cell, motor, motor bracket from the die-cut sheet, red propeller, long wooden stick, *small plastic container, tape*

Experiment

1. Put the long, thin wooden stick through the motor mount and fasten it with tape it.
2. Tape the thin wooden stick to the inside wall of a small plastic bowl, or put it in a suitable piece of polystyrene foam. The bowl or foam will serve as the boat hull, and must float upright in water. The motor must sit so that the propeller can rotate freely.
3. Connect the solar cell with the motor connection cables. Place the solar cell in the bowl so that it is exposed to full sun.
4. Set the bowl in the water and distribute the weight so that your boat sits reasonably level in the water. Position the propeller so that it emits its air power to the rear of the boat. Now you can put your solar boat in a pool, pond, or other enclosed body of water.

Explanation

The current of air created by the propeller pushes the boat forward. The energy needed by the motor is provided entirely by the sun.

Energy Saving Tip
Always turn off the lights when leaving an unoccupied room.

Note! If the electronic components get wet, let them dry before you use them again.

KEYWORD

Solar boats and hovercraft

Your solar boat has some very big friends. Solar-powered boats can be found on rivers and bays around the world, mostly for transporting tourists on scenic excursions. They have lots of solar cells that convert solar energy into electricity, which can in turn be stored in rechargeable batteries and used to power the boat. However, these boats use ordinary ship propellers as their means of propulsion.

But there are also vehicles that are driven by air propellers the way your boat is. These are known as hovercraft. They can move over flat land and water, gliding on a cushion of air produced beneath the vehicle by powerful engines and propellers. A rubber apron around the vehicle prevents the air from flowing outward too rapidly. Powerful propellers are used for horizontal movement, as with your boat. These vehicles consume a lot more energy, however, than solar cells can provide.

Solar-powered passenger ferry. Photo: www.kopf-solarschiff.de

EXP. 90 Solar boat with self-assembled impeller

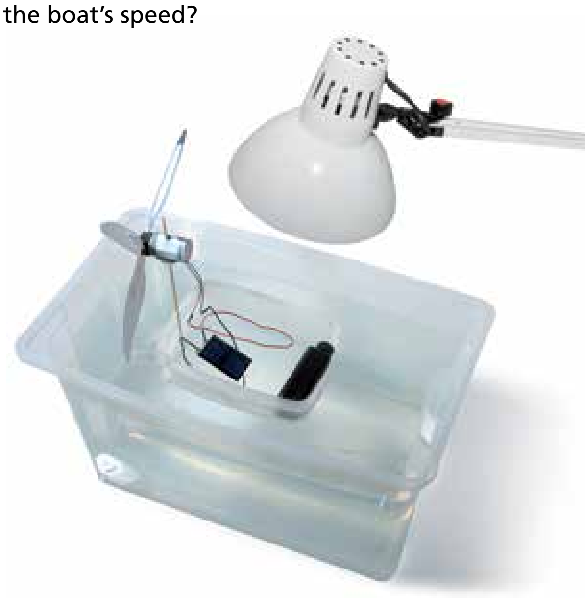
You can test and compare the ability of various propeller shapes to drive your solar boat.

You will need

Solar boat with motor and solar cell from Experiment 89, disk, rotor blades from Experiment 84

Experiment

1. Equip the solar boat with your previously-assembled wind turbine and let it run. How does its speed compare to that of the solar boat with the red propeller?
2. Adjust the angle of the blades as in Experiment 84, and find out the angle that lets the boat go the fastest. Here, too, it will probably be an angle of about 30°.
3. Change the number of rotor blades as in Experiment 85. What effect does that have on the boat's speed?



Explanation

Just as with your wind turbine, a four-bladed propeller with the blades set at an angle of about 30° will be optimal. Admittedly, the red propeller works even better. The reason is its special rotor blade shape, which resembles that of an airplane propeller. This shape "shovels the wind" very effectively. The large wind turbines at wind power plants also have specially-shaped rotor blades adjusted to wind and rotation speeds.

EXP. 91 Airflow resistance

Sometimes, the wind can blow very hard and develop into a storm or even a hurricane. Winds like these can exert enormous forces on objects. So it would be good to know which shapes are safest and which ones are most threatened by a storm.

You will need

3 "air drag" strips from the cutout sheet, round "wind vane" disk from the die-cut sheet, bendable drinking straw, motor with bracket, red propeller, solar cell, contact clips, roof section for solar cell, Power House base platform, connection wires, long wooden stick, *tape, lamp*

Experiment

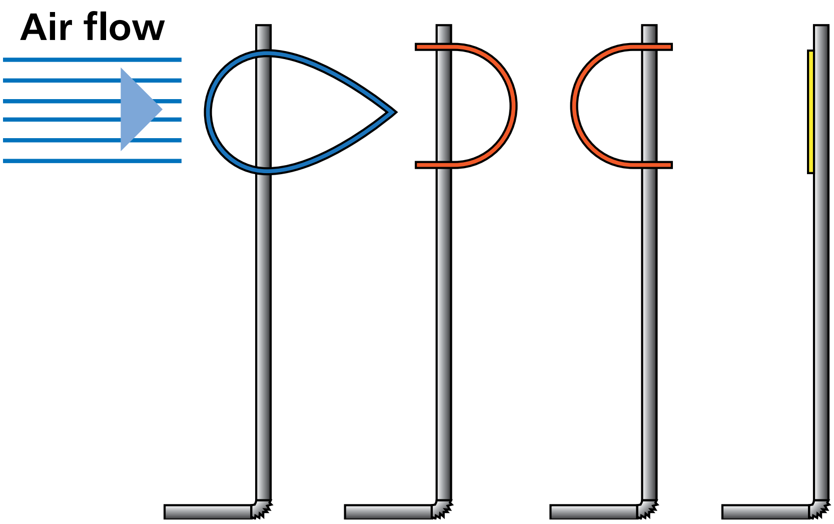
1. Install the solar cell with the contact clips in the roof section of the Power House, and place this flat against the base platform.
2. Push the round, gray wind vane cardboard disk onto the long wooden stick and push the motor with its bracket on top of it. The disk will keep the motor from slipping down. Insert the wooden stick into the base platform.
3. Use the connection wires to connect the motor to the solar cell, and check whether the propeller blows a stream of air when it runs off the solar cell. If not, switch the wires in the contact clips.
4. Cut the three strips out of the cutout sheet and carve a small cross into the marked locations with a knife or scissors (place a kitchen cutting board beneath it for support). That is where the strips will be inserted onto the straw. Have an adult help you with this part!
5. Tape the straw about 10 cm away from the wooden stick with its short section against the base platform, with the long section freely moveable thanks to the bendable joint.
6. Tape the blue strip together at the taping surface, forming a teardrop-shaped loop.
7. Tape the yellow strip to the straw in such a way that the propeller's air stream blows frontally against it. Take note of the way the straw leans.
8. Remove the strip, straighten the straw again, and push the two other strips onto the straw, one after the other. Test which shape results in the most resistance to the stream of air — that is, which causes the greatest deflection, or movement, of the straw. Which is the most streamlined, showing the lowest deflection?

> ***Energy Saving Tip***
> When you heat water in a pot, put the lid on: Evaporated water takes away a lot of heat energy.

Low air resistance and good lift with an airplane wing

Explanation

The teardrop-shaped piece is the most streamlined. The wind exerts a lot of force, on the other hand, on a flat or rectangular surface — these parts have a particularly high wind resistance.



Tricks that plants use

Using the energy of the sun — it's no recent invention, let alone a human invention. Green plants have been doing it for billions of years. That is reason enough to study plants a little more closely.

EXP. 92 Growing cress plants in the solarium

7 Days

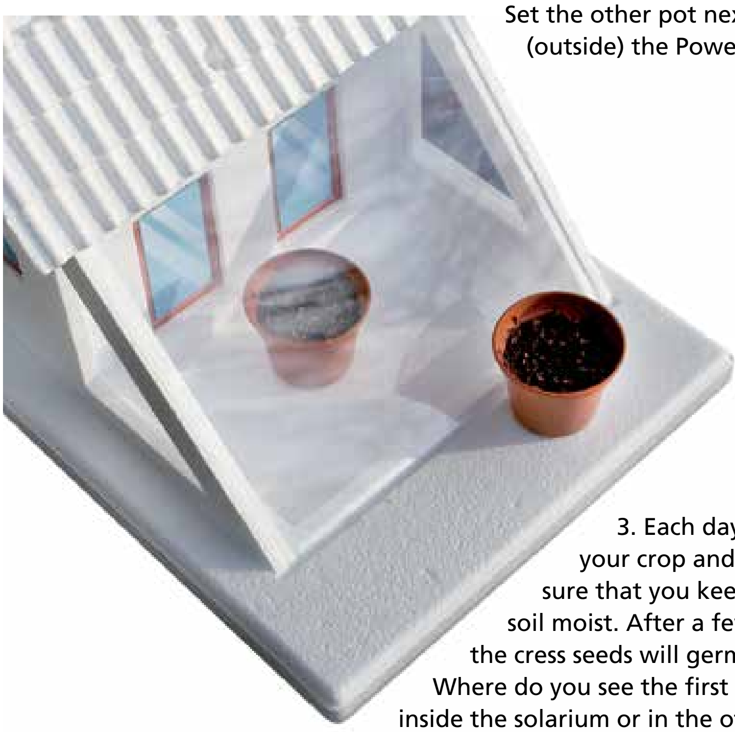
It isn't hard to grow plants. Still, it's best to start with a plant that's really easy to grow, and that will also fit easily into your greenhouse: cress.

You will need

Power House, 2 plastic pots, *cress seeds, soil*

Experiment

1. Fill two pots with potting soil up to about 1 cm below the rim. Sprinkle cress seeds on the soil and press them lightly into the soil. Moisten the soil a little, but don't let it get wet.
2. Place the Power House by the window or outside if the weather is nice. Close the doors and the windows between the house and the solarium annex. Set one pot in the annex, and put on the transparent cover. Set the other pot next to (outside) the Power House.



3. Each day, look at your crop and make sure that you keep the soil moist. After a few days, the cress seeds will germinate. Where do you see the first green — inside the solarium or in the other pot? Let the plants grow a few days and then use them for the next experiment.

Explanation

It's a little miracle of nature: Each of the tiny seeds contains the complete blueprint for a cress plant. In their dry state, they can keep for years, but in an appropriate environment — above all, if it's moist — the seeds will germinate and form a sprout, from which a new plant will grow.

Good Advice

You will be carrying out most of the experiments in the solarium annex of your Power House. To prevent the floor from getting dirty from soil or water, begin by covering it with plastic wrap.

EXP. 93 No life without water

3 Days

In the instructions for the last experiment, you read that the cress seeds always have to be kept moist. Why is that?

You will need

Power House, pot with cress from the previous experiment

Experiment

1. Set both pots in the solarium and remove the cover. Each day, moisten the soil in one of the pots and never let it completely dry out. Don't give any water to the cress in the other pot. After a few days, compare the appearance of the plants.
2. If you want to save the dried-out cress, water it: If you haven't waited too long, it will revive.

Explanation

Water, as the saying goes, is the stuff of life, and now you see why: All living things, plants as well as animals, depend on it. Green plants need it to produce the building blocks for their bodies. If they don't have it, their green chlorophyll disappears, and their leaves turn yellow. Also, they need water to maintain their internal pressure: Too little water makes plants floppy and limp.

Energy Saving Tip

Do not leave empty charging devices and unused adapters plugged into the wall socket — they consume power even when not being used.

Carrot tops form new shoots when placed on a damp surface.

EXP. 94 New growth from carrots

7 Days

If a person loses a fingertip, you obviously can't grow a new person from it. But plants can perform feats like that.

You will need

Power House, pots, *paper towels, carrot tops, potting soil*

Experiment

1. Spread a large sheet of paper towel, folded several times over and thoroughly wetted, on the floor of the solarium annex. From the kitchen, get two carrot tops — the cut-off top part that the stalk came out of. Place the carrot tops cut-side-down on the damp paper.
2. Cover the solarium annex and re-moisten the paper towel at least once a day.

Dolly the cloned sheep, the first mammal without a biological father. (Illus. Wikipedia)

After a few days, tiny roots will form along with new stalks and leaves. Once the new plants are about 2 to 3 cm tall, you can replant them in the pots filled with potting soil.

Explanation

New plants will often grow from cut-off plant sections. This is known as "vegetative reproduction" (i.e., reproduction without seeds), or "cloning." Gardeners often use this kind of propagation with newly-bred plant types, so they can be sure that the young plants have the same properties as the mother plant.

EXP. 95 Seeds won't sprout under water

3 Days

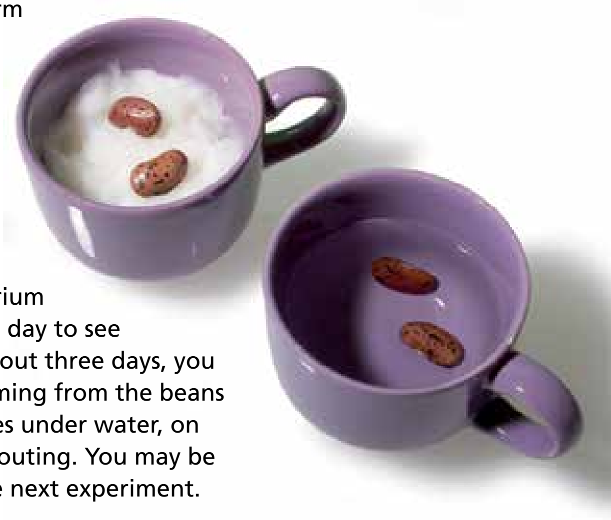
What do beans and other seeds need? Water, and what else?

You will need

Power house, *2 cups, 4 bean seeds, cotton wool*

Experiment

1. Fill one cup with lukewarm water and place all the beans in it overnight.
2. Fill the second cup with well-moistened cotton wool. Place two beans in the moist cotton wool. Leave the other two in the other cup under water.



3. Set both cups in the solarium annex and take a look each day to see what's happening. After about three days, you will see the first sprouts coming from the beans in the cotton wool. The ones under water, on the other hand, are not sprouting. You may be able to use the beans in the next experiment.

Bean sprouts

Explanation
In order to sprout, beans and a lot of other seeds need air in addition to water and light. That is why the beans in the first cup will not sprout.

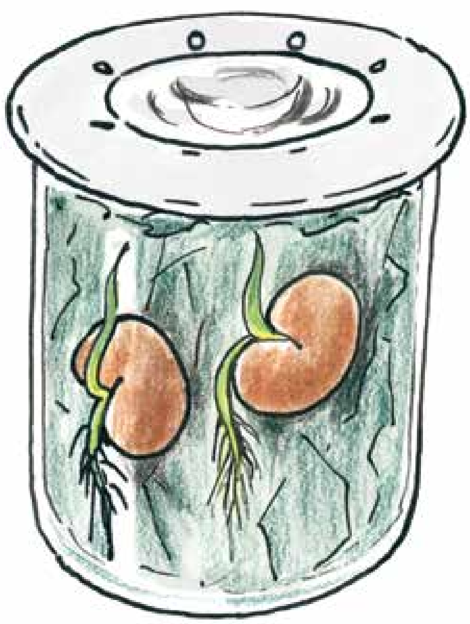
EXP. 96

Bean for bean

7 Days

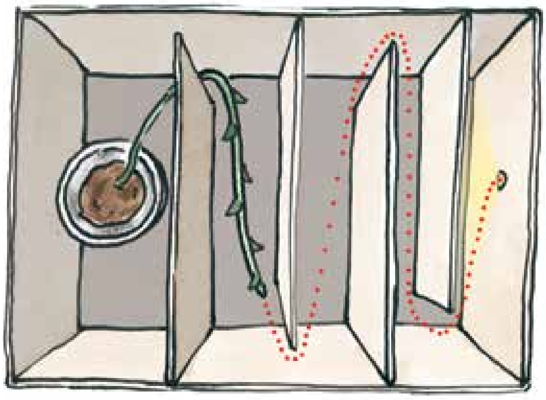
It's actually pretty amazing that a whole new plant will grow out of a seed. Try taking a closer look at what's going on.

You will need
Power House, plastic pots, potting soil, 2 drinking glasses, 6 beans (seeds), cup, cotton wool



Experiment
1. Place six beans overnight in the cup with lukewarm water.
2. Fill the glasses loosely with cotton wool, and moisten it well. Place three beans in each glass, placing them near the wall of the glass. Set both glasses in the solarium annex, shut the doors to the house and set the transparent cover on top. Each day, take a look at your beans and keep the cotton wool nice and moist.
3. After a few days, you will see a little root push out the side of each bean and grow downward. Soon after, another sprout will form, which will push upward and turn into a stalk. Now plant the beans in the soil-filled pots and keep watering them every day. Soon, your bean plants will grow green leaves and quickly grow larger.

Explanation
In addition to a sprout, beans also contain nutrients for the first part of life. That is why the young plants can get by for a while without any soil. Isn't it amazing that the root can sense which way is down? It has a sensory organ for gravity. And isn't it astounding that the sprout "knows" which way to go to reach the light?



A sprout finds a way to the light.

EXP. 97

Oxygen from green plants

4 Hrs.

Without green plants, we would not be able to live. They produce food for plant-eating animals, and for people too. But above all, they produce oxygen, which people and animals need to breathe.

You will need
Large preserving jar, small drinking glass, Elodea (aquatic plants from aquarium supply stores) or a wad of green algae from a pond

Experiment
1. Fill the preserving jar with water. Place the Elodea or algae in it. Immerse the drinking glass, with its opening pointed up, into the preserving jar. Once it has filled with water, turn it upside down in the water, so the opening is pointing down. This technique ensures that no air will get into the glass. Now position it over the plant in the jar.
2. Set the preserving jar in the sunshine. After a few hours, you will see silvery gas bubbles on the plant's leaves, which will rise up and collect in the drinking glass. The bubbles are made of oxygen gas.

Explanation
The green plants use their chlorophyll to capture sunlight, and use its energy to produce nutrients and building materials from the water and from the carbon dioxide in the air. In this chemical process, known as photosynthesis, oxygen is released. The plants release it to the outside, which is particularly easy to see with water plants.

EXP. 98 **Thirsty stalks** — 3 Days
Plants can get pretty thirsty, even if they have lost all their roots.

You will need
Drinking glass or empty yogurt container, cooking oil, cut flower (such as carnation, aster, or freesia), felt tip pen

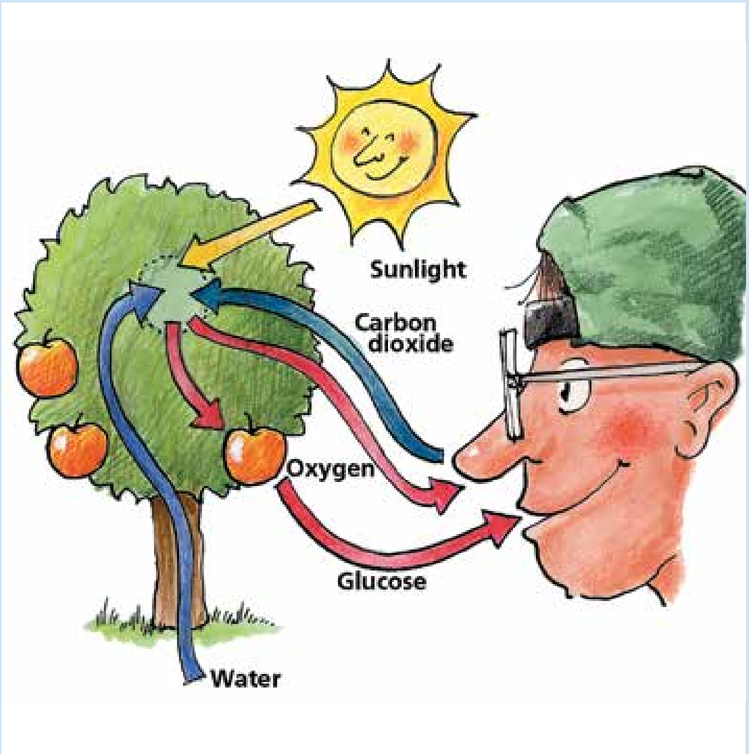
Experiment
1. Fill the drinking glass three quarters of the way with water and put the cut flower in it. Carefully add enough cooking oil to the water to form a layer a few millimeters thick. Don't let the opening at the end of the flower stalk come into contact with the oil.
2. Use the felt tip pen to make a mark on the outside of the glass showing the level of the liquid. Let the glass sit for a few days and then look at the liquid level. It will have dropped quite a bit.

Explanation
Because the oil prevents evaporation, the water can only have disappeared through the flower. In fact, flowers do suck up a lot of water through fine tubes in their stalks.

Energy Saving Tip
Use a dark screen saver on your computer — it saves electricity.

KEYWORD
Photosynthesis

This is the term given to the production of energy-containing materials with the help of energy from sunlight. In addition to green land plants, some algae and bacteria have the ability to do this. Green plants capture light by using their green coloring, known as chlorophyll. Complex chemical reactions are used to transfer this energy to molecules such as carbon dioxide, which they filter out of the air, and water. This multi-step process gives rise to energy-rich substances such as glucose, with oxygen gas emitted into the air as a by-product. Plants use the products of photosynthesis to make all the building materials and nutrients they need, and animals and people live on the energy-rich nutrients that green plants generate. That is why we can consider photosynthesis to be the most important chemical reaction on Earth. Ultimately, we all survive off the sun's energy.



EXP. 99 Plants humidify the air

4 Hrs.

Plants obviously need a lot of water. But what do they do with it?

You will need

Twig with green leaves from a tree or a bush, transparent plastic bag, string, tape

Experiment

1. Stretch the plastic bag over a section of the twig with green leaves and securely close the opening with string. Seal any rips with tape.
2. After a few hours, or after a few days at most, lots of little droplets of water will have accumulated on the inside of the bag.

Explanation

The water must come from the twig, since you closed the opening of the bag. In fact, plants do give off huge quantities of water through their leaves. They need to do that because the negative pressure that thereby arises in their water-conducting capillaries helps them to pull water up from their roots.

KEYWORD

Biomass

Green plants use the sun's energy to create huge quantities of plant mass, which continues to hold a lot of that energy inside it. We use a portion of this so-called biomass as food. But otherwise unusable plant materials, such as straw, wood, or oil, can also be directly used for the production of heat energy, engine fuel, or even electricity. Procedures for doing this are currently being developed in many places. The advantage: Every year, many billions of tons of biomass are regenerated, making it a renewable energy form.

Even fuels such as petroleum, natural gas, and coal once arose from biomass — from the remains of plants or microorganisms.

In a biomass plant, biomass is fermented to produce biogas, which can in turn be used to produce electricity and heat.

EXP. 100 Where the water goes

3 Days

Keeping plants in the house can create a pleasant living environment. They don't just produce oxygen and filter dust out of the air, they also humidify the air.

You will need

Power House, plastic pots, hygrometer from Experiment 41, *cress seeds, potting soil*

Experiment

1. Grow some cress as in Experiment 92. Place the hygrometer in the solarium annex, set the transparent cover on top, close all the house doors and windows, and take a look at the hygrometer reading after a few hours.
2. When the plants are nice and green, set them in the solarium. Watch how the hygrometer reading changes over course of the following hours and days.

Explanation

The hygrometer indicates that the air is getting more humid. That is partly due to the moisture evaporating from the potting soil, but mostly to the water given off into the air by the cress plants.

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