EXPERIMENT MANUAL

FUN STEM PROJECTS AND EXPERIMENTS

Pepper Mint

THE DARING IN ESCAPE FROM Hidden Island

THAMES & KOSMOS

Franckh-Kosmos Verlags-GmbH & Co. KG, Pfizerstr. 5-7, 70184 Stuttgart, Germany | +49 (0) 711 2191-0 | www.kosmos.de
Thames & Kosmos, 301 Friendship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com
Thames & Kosmos UK LP, 20 Stone Street, Cranbrook, Kent, TN17 3HE, UK | 01580 713000 | www.thamesandkosmos.co.uk

Safety Information

WARNING! Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard — long wires may become wrapped around the neck. This kit contains a functional sharp needle. Do not injure yourself!

Keep packaging and instructions as they contain important information.

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.

Dear Parents and Adult Supervisors

This STEM experiment kit gives your child a fun way to discover the basic principles of solar energy. This kit includes everything needed for the experiments, except a few common household items. Please help your child obtain these things.

Along with step-by-step instructions, this manual includes a story that unfolds alongside the experiments. The heroine of the story is Pepper Mint — an eleven-year-old girl whose creativity and cleverness help her to find her way through a series of small adventures and to overcome various challenges. Using the character figure and the wooden model of an island, your child can play along with the story.

The Daring Escape from Hidden Island set offers a total of seven exciting experiments. Each experiment adds another element to the island: Sundial, solar wheel, salt crystal farm, solar cell, boat with vibration motor, and lots more.

Every project provides a short explanation of the physics behind it in a fun and engaging way. Along the way, children will learn what sunlight is made up of and how it can be used as an energy source.

Children in this age group are at different stages of development, so you can decide in advance which experiments your child can perform alone and where they will need your help. Please provide them with the help and advice that they need and check the completed assemblies for each experiment.

This kit is not suitable for children under the age of eight. Please keep small children and animals away from the experiments and read through the safety information with your child. Keep the instructions handy for reference at all times.

We hope you enjoy experimenting and playing!

Here's what to do:

1. Read the story or get somebody to read it aloud
2. Carry out the experiments
3. Learn through playing

Kit Contents

Make sure you have all of the components of your kit and check them off:

✔	No.	Description	Quantity	Art.-No.
❍	1	Wooden sheet, natural	1	722067
❍	2	Wooden sheet, printed	1	722068
❍	3	Cardboard sheet, volcano	1	722069
❍	4	Cardboard sheet, island	1	722066
❍	5	Pepper Mint figure	1	722076
❍	6	Wooden stick	1	722070
❍	7	Petri dish	1	722075
❍	8	Needle	1	722071
❍	9	Rivet	1	722072
❍	10	Solar cell with vibration motor, capacitor, and switch	1	722074
❍	11	Sandpaper	1	720574

You will also need:

Ruler, scissors, tap water, drinking water, clock, table salt, craft glue, sticky tape, transparent bowl (ideally made of plastic), glass, teaspoon, stone, plastic wrap, possibly an incandescent halogen lamp, wood glue, sunny place (balcony or windowsill)

Tip!

If you are missing any parts, please contact Thames & Kosmos customer service.

US: techsupport@thamesandkosmos.com
UK: techsupport@thamesandkosmos.co.uk

Table of Contents

Tip! You can find out more background information on pages 16, 22, and 25.

The Hidden Island

Pepper Mint had never been so bored on a beach vacation as she was this summer. She had gone to great lengths to find herself a meaningful activity. It all began with the building of the largest sandcastle that the residents of Misty Bay had ever seen. On the second day of building, Pepper even borrowed a ladder to form the tops of the sandcastle turrets. On the third day, the enormous castle finally collapsed and she had to look for something else to do.

By now Pepper had read all her books and collected pounds of mussels. She had also found out where you could get the best ice cream on the beach promenade and who rode the fastest bicycle. But she was still bored. As Pepper again strolled along the boat jetty with a peppermint ice cream in her hand, a boy with a telescope caught her eye. The boy was looking out toward the open sea, where there was a thick wall of mist on the horizon, even though the sun was shining.

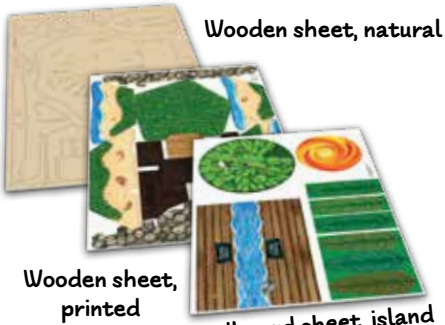
"What are you looking at over there?" asked Pepper.

"The secret Hidden Island," replied the boy, who appeared to not want any distractions from his viewing. Pepper squinted her eyes, trying to see something in the mist. She caught a glimpse of something.

"May I have a look?" Pepper asked excitedly and swapped her ice cream for the boy's telescope. But as much as she tried, she could not find anything in the mist with the telescope. "Are you sure there is an island there?" Pepper finally asked the boy.

"No one really knows for sure," he answered. And just like that, Pepper's beach holiday turned into an adventure ...

YOU WILL NEED ...



You will also need: Sticky tape, or wood glue

HERE'S HOW!

1. Remove the wooden pieces from the two wooden boards and put them together in two steps as shown in the pictures.
2. Now place the grass with the wooden footbridge onto the foundation that you built in step 1.
3. Slide the palm tree roots sideways under the grass plate and begin to attach the side surfaces.

Tip!

If any parts get caught you can use the sandpaper to make the slits wider or the tabs narrower. Never use a lot of force when assembling the pieces!

4. Place the four side panels in their respective places and put the foundation tabs into the slits of the side panels.

5. Now remove the six palm leaves from the cardboard sheet and one by one put them onto the top piece of the palm tree trunk, so that they are fanned out and equally separated from each other. You can recognize the top piece by the round tab that is sticking out.

6. Put the rest of the palm tree pieces together in any order and place the trunk on the palm tree root.

7. Finally, push the marked sides of the beach hut together.

8. Then carefully remove the palm leaf roof from your cardboard sheet, push the two ends together, and attach them with sticky tape. Put the roof on the hut and put the covered hut on the island. Done!

Tip! The Pepper Mint figure can accompany you on all your adventures!

Place your island somewhere where it won't be in the way and where you can play and experiment with it. To make the island even more stable, you can also glue the wood joints with wood glue.

An Unplanned Nap

Pepper spent the rest of the day at the harbor and asked the fishermen about Hidden Island. But all the locals could tell her was a strange story: Only one young fisherman had ever seen the island with his own eyes after he got lost in the mist while out on his boat. But he could not describe the island because as soon as he got back to the mainland, he had forgotten everything about it.

As strange as the story sounded, it certainly intrigued Pepper. She borrowed some maps of Misty Bay and surrounding waters and searched through the old books and newspaper clippings in the library — but to no avail.

As the sun rose the next day, Pepper put on her bathing suit, packed her backpack with water and provisions, and boarded her paddle boat on the beach. By noon, she had almost reached the fog hanging across the water. According to her nautical charts, she was in the middle of the bay and the other side would come into view behind the mist soon.

All of a sudden, the mist spread and swallowed Pepper's boat and all of the sounds nearby. It was so thick that she could not see the beach behind her. Before she knew it, Pepper was struggling to stay awake and eventually fell into a deep sleep.

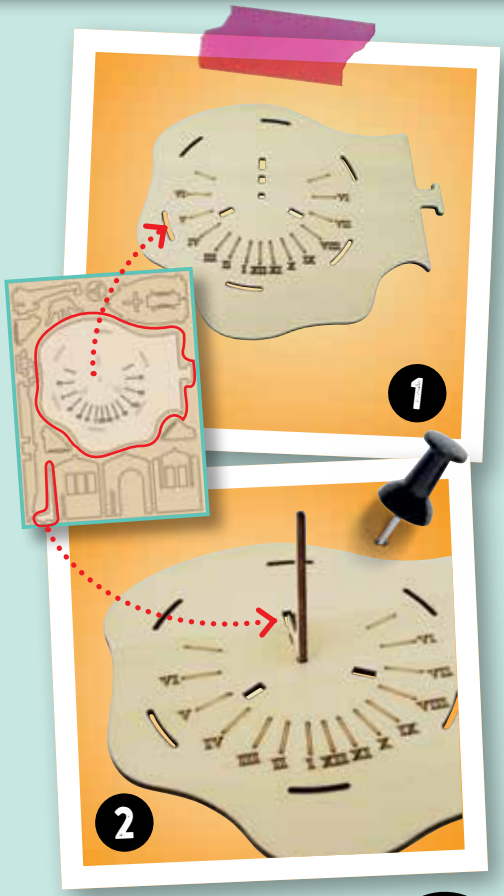
A jolt awoke her from a strange dream. Her paddle boat had been washed up on a beach that looked very different from the bay she had left. Where was she? And how many hours had passed?

Pepper Mint and the Sundial

YOU WILL NEED ...

Wooden sheet, natural

You will also need: Clock, balcony, garden, or windowsill



HERE'S HOW!

1. Lay the surface with the sundial in front of you. The symbols on it show Roman numerals, which you can use later to read the time.
2. Put the pointer, also called a style or gnomon, in the pre-punched holes in the surface of the sundial.

WHAT'S HAPPENING?

The Romans used their own system of numbering, which is often used in clocks and watches today:

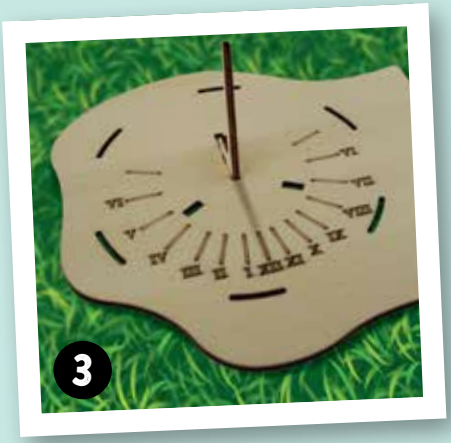
X = 10 V = 5 I = 1 II = 2 III = 3

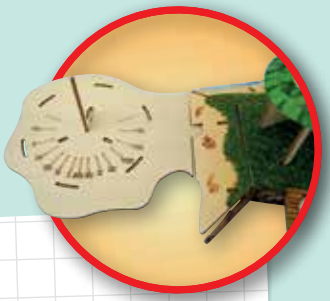
If the symbol I is in front of the symbol for 5 (V) or 10 (X), you have to subtract 1 from them. If for example, I or II or III is after V or X, you have to add 1, 2, or 3 to them. This results in many variations, e.g., II = 2, IV = 4, VIII = 8, and XII = 12.

Can you translate all the symbols on your sundial into our number system? Using a pencil, write them next to the Roman numerals.

❸ Place the sundial horizontally level in a sunny spot. The best spot would be a sunny balcony, somewhere in the yard, or on a windowsill that has direct sunlight. Your sundial should be able to remain there safely.

Take a clock and align the sundial so that at twelve noon the shadow of the pointer is exactly above the XII symbol. Now, if you don't move the sundial you will be able to know the time by the shadow that moves over the wooden board. And you can confirm its accuracy by looking at the sundial at twelve noon the next day.





Tip!

You can connect your finished sundial to your island or use it separately for experiments.

WHAT'S HAPPENING?

The sun moves across the sky during the course of the day, from the east (where it rises) moving across the south to the west (where it sets). It reaches its highest point at noon.

But in reality, it is not the sun that is moving. It is the Earth that is rotating on its axis once every 24 hours, while at the same time orbiting the sun once a year. It only looks as if the sun is moving when viewed from the Earth.

Right at the Top

As crazy as it sounded, Pepper could not have slept more than ten minutes. She was an hour away from the bay and standing on an island surrounded by thick mist, although the sun was shining from the cloudless sky. Pepper turned around in a circle and looked around the island. It was relatively small, surrounded by sand and overshadowed by a high mountain at one end of the island. There were many palm trees, flowers, and some colorful birds. She could not see any people or houses, but the beach was full of flotsam and washed-up objects.

A loud cry made her flinch. Were there any inhabitants on the island who might be hiding? Pepper had to get an overview — and she would have the best and widest view from the top of the mountain.

The strenuous climb lasted two full hours and meant that Pepper used up half of her water supply. At the top, she was positively astonished. Pepper was not standing on the summit of a mountain, but on the edge of a volcanic cone! A warm stream of air rose from the bottom of the volcano, making her hair blow around wildly.

"This would be a good place to fly a flag and signal the people back on the shore," thought Pepper. "With any luck, the flag will be visible through the mist and then the Hidden Island will be visible to everyone."

After Pepper had taken another good look around in every direction, she went to work on raising her flag.

Pepper Mint AND THE Solar Wheel

YOU WILL NEED ...

You will also need: Sticky tape, sunlight

HERE'S HOW!

1. Remove the pointer of your sundial and fasten the three supports onto the baseplate.
2. Put the connector disk over the supports.
3. Insert the wooden stick from the top through the middle gap in the disk to the base plate.
4. Carefully remove the cone from the black die-cut sheet and attach the sides together with sticky tape. Place the black cone on the sundial platform. The black tabs then sink into the circular slots located on the surface of the sundial. Using sticky tape, attach the needle with its tip facing up to the top of the wooden stick.

5. Carefully remove the colorful wheel from the cardboard sheet and bend one side of each wing down. Push the rivet up through the hole in the middle of the wheel with the point of the rivet facing upward. Now you can balance the solar wheel on the tip of the needle using the rivet.

6. Set the volcano upright in a sunny place. A sunny spot protected from the wind like a balcony or a windowsill with direct sunlight would be ideal. Your volcano should be able to remain there safely.

   Leave the volcano in direct sunlight for about one hour and observe what happens to the solar wheel.

NOTICE

The use of solar energy by conversion into heat energy (thermal energy) is also called solar thermal energy. This form of energy is considered a renewable energy.

WHAT'S HAPPENING?

The solar wheel heats up in the sunlight. With it, the air in the cone gets warmer and therefore rises. Due to the resulting air flow from bottom to top, the colorful wheel starts to turn (like a wind turbine in the wind). The rivet balanced on the needle tip is quite loose and can easily be moved, so it hardly generates any friction. Therefore, even the smallest movements of air are enough to make the wheel turn.

You have now used the heat of the sun's rays to move a solar wheel. Would this experiment also work with a white cone?

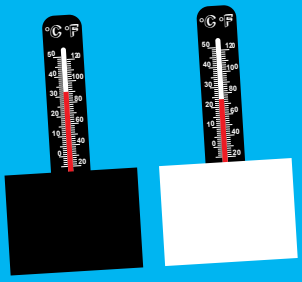
WHAT IS SUNLIGHT MADE UP OF?

The sun is the brightest light source that we can see. It consists mostly of the gases hydrogen and helium, with small amounts of carbon, oxygen, and nitrogen, as well as smaller amounts of various other elements. The burning hydrogen is what creates sunlight.

Traveling as a straight beam, sunlight reaches Earth. But the beam is not white or yellow, as it may appear. Sunlight is actually made of many colors (in fact, all the colors of the rainbow). When this light hits a green tree, most of the light colors are "absorbed" by the leaves, and only the green rays are reflected back. The color of the reflected rays is the color of the object — in this case green. Dark colors absorb more light, while light colors will reflect more.

LIGHT AND WARMTH

Light is also a form of energy (electromagnetic radiation) that can be converted into another form of energy. You have probably noticed on occasion that your body heats up in the sun. Maybe you've noticed that black areas become warmer in the sunlight than white areas. That is because black objects absorb the sun's rays and are warmed up by them. On white objects, on the other hand, most of the sun's rays are reflected (like with a mirror), leaving them relatively cool. So, if you don't want to sweat as much on a hot summer's day, it's best to wear light colored clothing.



ENERGY FORMS AND ENERGY CONSERVATION

Energy is very transformable. You can find it around you in many different forms. In addition to heat or radiant energy, there is, for example, movement or kinetic energy and gravitational potential energy, which (as the name suggests) is characterized by the movement of an object relative to its altitude or elevation.

An important principle in physics is the preservation of energy. That means that energy can neither be created nor destroyed. But you can transform one energy form into other forms of energy. For example when you drop a ball from a height of one meter, you convert potential energy into kinetic energy.

SOLAR UPDRAFT POWER PLANT

What you have built using your solar thermal wheel is basically, on a small scale, the same as what is used in large solar updraft power plants. However, instead of a nice wheel, in power plants huge turbines are driven, which then convert that movement into electricity.

SOLAR SYSTEM

We live on a relatively small, blue planet called Earth. It revolves around a huge star that we have named the Sun. This forms the center of our solar system. In its journey around the sun, Earth is not alone. Seven other planets also orbit the sun in differently sized, elliptical orbits. Some of them, like Earth, have one or more moons orbiting them. In order to better remember the names and especially the order of the planets, there is a practical mnemonic you can use: "My very educated mother just served us nachos." [Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune]

Fresh Water

The colorful flag twirled around in the updraft from the volcanic cone and was visible from all sides of the island — hopefully also through the mist.

As she descended from the top of the volcanic cone, it started to get dark and Pepper had to accept that she would be spending the night on the island. She quickly collected some pieces of driftwood and fallen palm leaves and built a small shelter for the night. After that, Pepper made a campfire and ate the food that she had brought. Funnily enough, she did not feel afraid. The monotonous buzzing and chirping on the island made her rather sleepy. Soon the loudest sound on the island was Pepper's own ear-splitting snoring — which is still a well-kept secret!

The next morning, Pepper woke up and emptied her water bottle, leaving just one last sip. It was time to leave the island and tell the others about her adventure! Her parents would be really worried about her by now.

Pepper climbed into her paddle boat and steered it toward the middle of the mist. This time, she was determined to stay awake for the ten minutes she would need to cross the mist. But even the first breath from within the mist made her very tired and made her fall asleep again a short time later. She woke up only as the waves washed the boat back to Hidden Island's shore. But Pepper wouldn't give up that easily! That afternoon she was going to try again.

But before that there was a much more urgent problem to solve: She needed fresh drinking water!

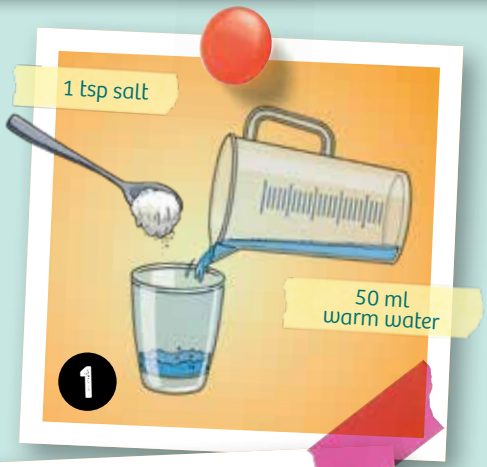
Pepper Mint AND THE Salt Crystals

YOU WILL NEED ...

Petri dish

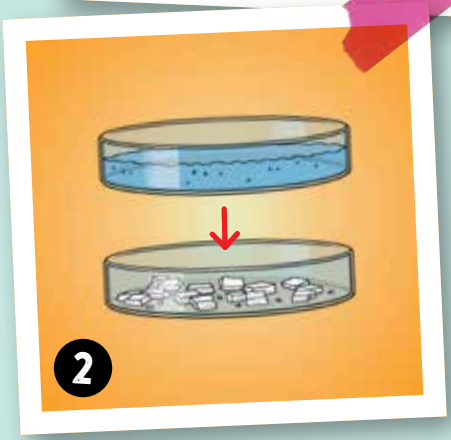
You will also need:

- *Measuring cup*
- *Warm tap water*
- *A teaspoon*
- *Table salt*
- *Glass*
- *Sun light or warmth*



HERE'S HOW!

1. Mix one teaspoon of table salt with 50 ml of warm water. Stir with the teaspoon until the salt has completely dissolved in the water.
2. Using the teaspoon, put some of the salt water in a petri dish until it is about half full.
3. Place the petri dish on the grass and wait until the next day. Did you discover anything? Add some more salt water if necessary.



WHAT'S HAPPENING?

Salt dissolves better in warm water than in cold water. The saltwater in your petri dish evaporates and the salt remains in the form of small crystals. In coastal regions, salt is extracted by separating seawater from the sea in small pools and allowing it to be heated up by the sun. When the water evaporates, the sea salt is left behind. In that way, you can get about 23 kilograms of salt from 1,000 liters of seawater.

Pepper Mint AND THE Salt Water Filter

You will also need:

- *Large bowl (made of plastic)*
- *Warm tap water*
- *Table salt*
- *A teaspoon*
- *Plastic wrap*
- *Glass*
- *Stone*

HERE'S HOW!

1. Dissolve three teaspoons of table salt in 200 ml of warm water. Then pour the salt water into the plastic bowl until the bottom is covered by about 2 cm of water.
2. Put a glass in the middle of the bowl. It should be stable and not floating in the water.
3. Seal the opening of the bowl with plastic wrap and place a stone or another heavy object in the middle of the film so that the film curves downwards over the glass.
4. Choose a warm, sunny, and sheltered place, e.g., on the windowsill. Leave the bowl there for one day. The next day, take the glass out of the bowl and look at how much water has collected in the glass and how much is left in the bowl? Can you see the salt crystals?

WHAT'S HAPPENING?

The water evaporates as it heats up, rises to the top, and sticks to the plastic wrap. There it cools down and liquefies again. The salt is left in the bowl. If enough water accumulates in one place, it runs down the film and drips into the glass below it at the lowest point, in the middle of the film. The water gathered in the glass is called fresh water, it is free from salt due to the evaporation process.

Tip! If the sun is not shining, you can speed up the experiment a little by placing the bowl in a warm room or near a heater.

Plan B

The second attempt to not fall asleep in the mist had failed. Pepper woke up in her paddle boat shortly before sunset on the beach of Hidden Island again. She had to admit that she would not make it through the mist like that. Pepper needed a new plan!

All night, she sat in her shelter and thought until she came up with two different solutions: She could either stop breathing in the mist (with perhaps very negative consequences for her health) or she would have to increase the speed of her boat to get through the mist as fast as possible. That would work best with an engine.

The next morning she drank her filtered drinking water and went to the coast in search of useful flotsam. From a distance, she had seen some old boats and wreckage, which she searched for engines. It quickly became apparent that finding an old boat engine with a propeller to attach to her boat would not be a problem. Unfortunately, she would need fuel to get the engine running, and this is something she could not find. Pepper became disheartened and was thinking about going back to Plan A (not breathing) when she noticed something shiny in the sand: a solar cell was right next to her feet ...

"That's it!" shouted Pepper excitedly. She could start the boat engine with the energy from the solar cell and leave the misty island that day. Pepper got to work immediately.

YOU WILL NEED ...

Solar cell with capacitor, switch, and vibration motor

HERE'S HOW!

1. Look closely at the solar cell. It is connected to a circuit board by two cables. On the board is a vibration motor, a capacitor, and a switch.
2. Slide the switch to the charging position, which is on the left, and put the solar cell in the light. Let it charge for 15 minutes. If the sun is not shining, you can also use an incandescent light bulb or a halogen bulb in a lamp to charge it. Most LED flashlights are not powerful enough to power the solar cell.
3. Slide the switch to the output position, which is on the right. What happens?

GOOD TO KNOW

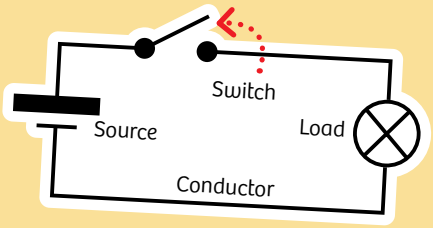
Sunlight is also an energy that you can turn into electricity and movement. You can store, convert, but not destroy energy. That is called energy conservation.

WHAT'S HAPPENING?

As soon as you slide the switch to the output position, the vibration motor is supplied with the energy that is stored in the capacitor and it begins to turn. The imbalance of the rotating asymmetrical motor axis makes it feel like the entire board is vibrating. You have collected energy from sunlight, stored it in the capacitor for a short time, and converted it into kinetic energy using the vibration motor. The next page explains the components and function of your solar cell in more detail.

CIRCUITS AND ELECTRICAL COMPONENTS

Electrical current is made up of moving electrons. These are tiny particles that flow through the circuit and electrical components. A circuit consists of an energy source (in this case, the solar cell), a conductor (cables and wires), and an electrical load (vibration motor). In your circuit, a switch controls if the circuit is closed, which is a prerequisite for the electrons to flow. Your solar cell generates electricity by converting energy (solar energy into electrical energy) and in this way triggers the movement of the electrons. In the vibration motor this current is then consumed, meaning that the electrical energy is converted into mechanical energy: The axis of the motor turns. With the help of the capacitor, you can store the electrical energy for a while. In this way, you could operate your engine for a short time at night.



SOLAR CELL

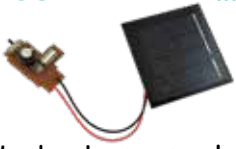
A large portion of solar cells consists of a chemical element called silicon, which is very common on Earth. When the rays of the sun shine on the processed silicon in these cells, the unimaginably small elements inside them begin to react with each other. The resulting free electrons begin to flow in one direction. This generates electricity that can be tapped and used. The stronger the sun shines, the more productive the solar cell. Accordingly, it has no, or at least very little, output at night or in heavy cloud cover — whenever there is no light hitting it.

RENEWABLE ENERGY

You may have heard that our fossil fuels (coal, oil, and others) will not be able to be used as energy sources for too much longer. We are therefore looking for alternatives that will ideally never run out and are therefore called renewable energies. Renewable energy sources include, among other things, wind power, hydropower, and solar power.

Pepper Mint AND THE Vibration Boat

YOU WILL NEED ...



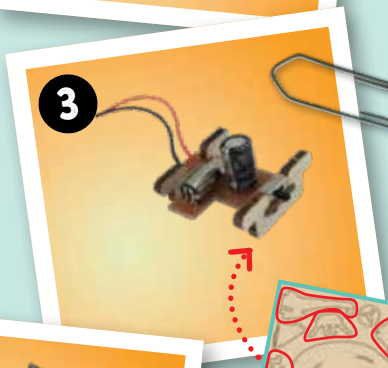
Solar cell with vibration motor, capacitor, and switch

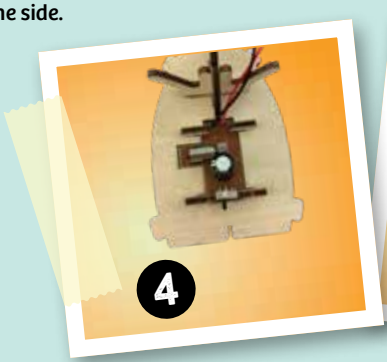
Wooden sheet, natural

Cardboard sheet, island

HERE'S HOW!

1. Put your solar cell in charging mode. Then charge your solar cell in the sunlight or under an incandescent light bulb / halogen bulb for about 15 minutes.
2. Put the deck of your boat together as shown in the pictures.
3. Slide the two U-shaped pieces, which you carefully remove from the wooden sheet, onto the circuit board from the left and right sides.
4. Insert the circuit board into the deck. The switch points outward, toward the back.
5. Slide the solar cell into the holder from the side.





6 Carefully remove the two sides of the boat from the cardboard sheet and clip them on both sides around the deck.

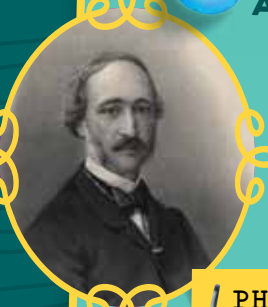
Place your boat on a flat surface and switch the charged solar cell to the output mode.

WHAT'S HAPPENING?

As soon as you flip the switch, the whole boat vibrates for about 90 seconds. Due to the shape of the side panels, it does not just remain where it is, but moves around. Just try it and see what happens to the boat if you keep your solar cell in the light for a very short time or let the boat run while in direct sunlight. Can you configure the boat to get it to move forward, backward, and sideways?

Tip! Set the feet toward the back so that your boat vibrates forward.

Now your Hidden Island is fully equipped! Have fun experimenting and playing!



ALEXANDRE EDMOND BECQUEREL

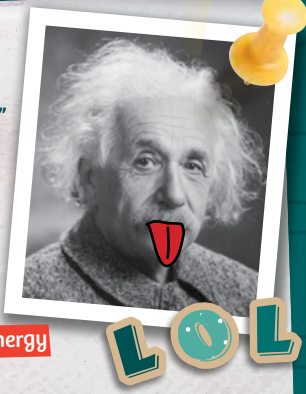
- Was born in Paris, France in 1820
- Many in his family were also physicists, for example his father, son, and grandson
- Discovered the photovoltaic effect on which today's solar cells are based

PHOTOVOLTAIC EFFECT

Light can be directly converted into electrical energy!

ALBERT EINSTEIN

- Once said: "I have no special talent. I am only passionately curious."
- Was born in Ulm in the 19th century
- Had a crazy hair style and hated socks
- Got a Nobel Prize in physics for the photoelectric effect (look for it on the Internet!), but secretly wanted it for his Theory of Relativity — from which we have one of the best-known formulas: $E = mc^2$
- He contributed a lot to our understanding of the conservation of energy



ENERGY CONSERVATION

Energy can neither be destroyed nor created. When we talk about "consuming" energy, we mean that the form of energy changes. For example, a light bulb converts electrical energy into light and heat.

Did you know?

Have you ever wondered why so many famous physicists of the past were men, and only a few were women? It was because of the strict rules of society back then. Fortunately, things have changed a lot in the last few decades. Now you can study whatever you choose ...

Believe in yourself!

Kosmos Quality and Safety

More than one hundred years of expertise in publishing science experiment kits stand behind every product that bears the Kosmos name. Kosmos experiment kits are designed by an experienced team of specialists and tested with the utmost care during development and production. With regard to product safety, these experiment kits follow European and US safety standards, as well as our own refined proprietary safety guidelines. By working closely with our manufacturing partners and safety testing labs, we are able to control all stages of production. While the majority of our products are made in Germany, all of our products, regardless of origin, follow the same rigid quality standards.

Project Management: Swetlana Maier
Technical Product Development: Dominik Ulrich
Background text and editing: Anna Nolde
Product design: Manuel Aydt, crosscreative, Pforzheim
Design concept for instructions and packaging: Love Pavlov, Stuttgart; in medias res, Nürnberg
Layout for instructions and packaging: Mariela Schwerdt, Stuttgart
Illustrations for instructions and packaging: Tanja Donner, Riedlingen
Photos of models and parts: Michael Flaig, ProStudios, Stuttgart
Cover image rendering: Liwia Ostrowska, Hamburg
Instruction photos: photobalance gemeinfrei (Sonnensystem, © Wikipedia); Gradt (Windrad, © Fotolia); photobalance (Petrischale, © Adobe Stock); gemeinfrei (Sonnensystem, Becquerel; beide © Wikipedia); Georg Slickers (Siliziumzelle, © Wikipedia); Orren Jack Turner (Einstein, © Wikipedia) askaja (all paper clips); Jamie Duplass (all adhesive tape); picsfive (all push pins, all previous © Fotolia.com); Mr. Twister (wood textures), Digiselector (design elements; all previous © Shutterstock.com)

The publisher has made every effort to locate the holders of image rights for all of the photos used. If in any individual cases any holders of image rights have not been acknowledged, they are asked to provide evidence to the publisher of their image rights so that they may be paid an image fee in line with the industry standard.

1st English Edition © 2019 Thames & Kosmos, LLC, Providence, RI, U.S.A.
® Thames & Kosmos is a registered trademark of Thames & Kosmos, LLC.
Editing: Ed Gartin and Ted McGuire; Additional Graphics and Layout: Dan Freitas

Distributed in North America by Thames & Kosmos, LLC. Providence, RI 02903
Phone: 800-587-2872; Web: www.thamesandkosmos.com

Distributed in United Kingdom by Thames & Kosmos UK LP. Cranbrook, Kent TN17 3HE
Phone: 01580 713000; Web: www.thamesandkosmos.co.uk

We reserve the right to make technical changes.

Printed in China

626039-03-270319