leXsolar-NewEnergy Ready-to-go

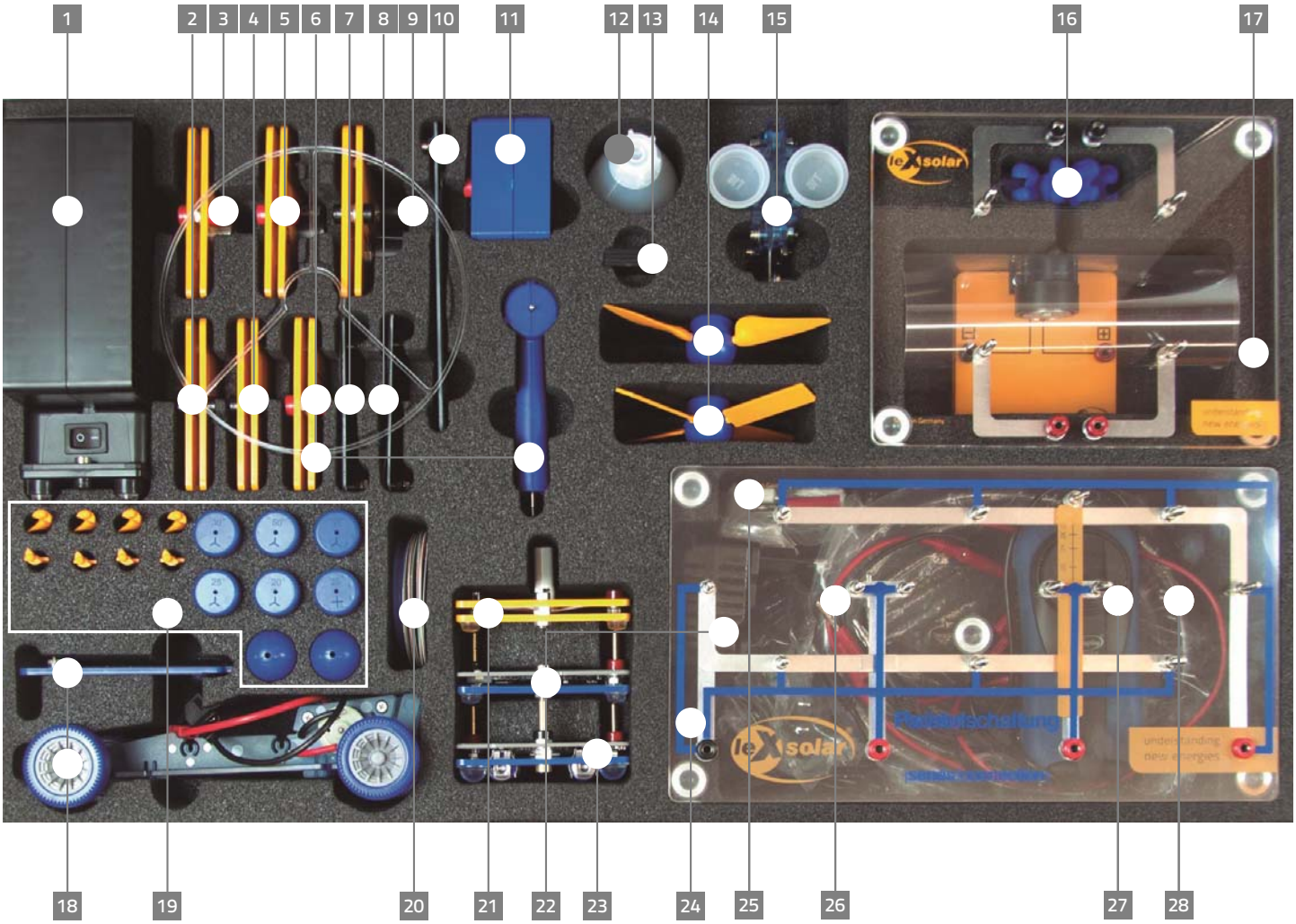
Instructions manual

Layout diagram leXsolar-NewEnergy Ready-to-go

Item-No.2003

Bestückungsplan leXsolar-NewEnergy Ready-to-go

Art.-Nr.2003



1 1400-19 leXsolar-Wind machine
1400-19 leXsolar-Winderzeuger

2 1400-08 LED-module 2mA, red
1400-08 LED-Modul 2mA, rot

3 1100-27 Motor module without gear
1100-27 Motormodul ohne Getriebe

4 1100-26 Light bulb module
1100-26 Glühlampenmodul

5 1100-25 Buzzer module
1100-25 Hupenmodul

6 1400-22 Wind turbine module
1400-22 Windturbinenmodul

7 1100-02 Solar module 0.5 V, 840 mA
1100-02 Solarmodul 0.5 V, 840 mA

Version number
Versionsnummer

III-01.24_L3-03-259_23.03.2016

CE RoHS2

8 1100-07 Solar module 1.5 V, 280 mA
1100-07 Solarmodul 1.5 V, 280 mA

9 1100-23 Potentiometer module
1100-23 Potentiometermodul

10 1100-31 Solar module 2.5 V, 420 mA
1100-31 Solarmodul 2.5 V, 420 mA

11 1100-20 Lighting module
1100-20 Beleuchtungsmodul

12 1800-15 Distilled water (100 ml)
1800-15 Destilliertes Wasser (100 ml)

13 1100-29 Solar cell cover set
1100-29 Satz mit Abdeckung f. Solarzelle

14 1400-21 Wind rotor set (assemblied)
1400-21 Windrotoren (montierter Satz)

15 L2-06-067 Reversible Fuel cell
L2-06-067 Reversible Brennstoffzelle

16 1900-01 Water wheel module
1900-01 Wasserradmodul

17 1602-01 leXsolar-Base unit small
1602-01 leXsolar-Grundeinheit Small

18 1801-02 Electric model car
1801-02 Elektro-Modellfahrzeug

19 1400-12 leXsolar-Wind rotor set
1400-12 leXsolar-Windrotoren

20 1100-28 Color discs - Set 1
1100-28 Farbscheiben - Set 1

21 1600-02 Capacitor module 5.0F/5.4V
1600-02 Kondensatormodul 5.0F/5.4V

22 9100-05 PowerModule
9100-05 PowerModul

23 9100-03 AV-Module
9100-03 AV-Modul

24 1100-19 leXsolar-Base unit Large
1100-19 leXsolar-Grundeinheit groß

25 2xL2-06-033 Short-circuit plug
2xL2-06-033 Kurzschlussstecker

26 L2-06-012/013 Test lead 25 cm. black/red
L2-06-012/013 Messleitung 25 cm. schw./rot
L2-06-014/015 Test lead 50 cm. black/red
L2-06-014/015 Messleitung 50 cm. schw./rot

27 1602-02 Hand generator
1602-02 Handgeneratormodul

28 L2-02-051 Silicone tube 12 mm
L2-02-051 Silikonschlauch innen 12mm

leXsolar – NewEnergy Ready-to-go
Student`s manual

Experiments – Primary level

Experiments – Secondary level

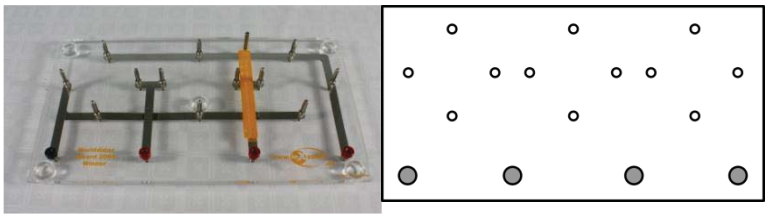
Description of the experimental components
leXsolar-NewEnergy Ready-to-go

In the following schedule every component of the leXsolar- NewEnergy Ready-to-go case is listed. For every component there is the name with article number, a picture, the pictogram for the circuit diagram and operating instructions. With the aid of the article number it is possible to reorder a specific component.

Base unit Small 1602-01

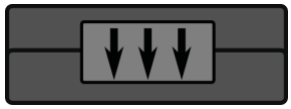
The base unit is a breadboard where 2 components can be plugged in. The current flows along the wires on the bottom side. To connect the components on the base unit with other components, there are 4 terminals on two opposite sides. The terminals can also be connected by short-circuit-plugs.

Base unit 1100-19



The base unit is a breadboard where up to 3 components can be plugged in a series and parallel connection. The current flows along the wires on the bottom side. To connect the components on the base unit with other components, there are 4 terminals at the lower end.
The printed circuit diagram show the connections in a series and parallel connection. To change between series and parallel connection, the modules have to be turned by 90°.

Wind machine 1400-19



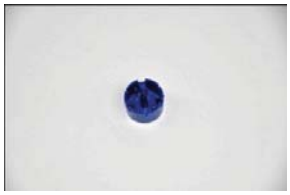
The wind machine is used to control the wind conditions during an experiment with the wind turbine. For those experiments the wind machine has to be connected to the PowerModule (voltage source). For this the negative (positive) pole of the PowerModule has to be connected to the black (red) connection. Towards the connections there is also a seperate on/off-switch. The wind direction is marked with arrows on the upside. The use of the wind machine is only permitted with the PowerModule or a stabilized voltage source. Furthermore, the wind machine has to be protected from intense hits. Otherwise, the rotor blade within the device could break. Misuse leads to termination of warranty.

Specifications:

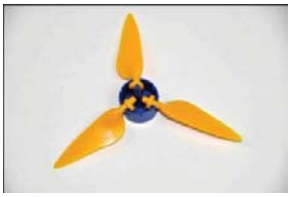
- Maximum voltage: 12V DC (stabilized)
- Wind speed: 0 – 7m/s

Wind rotors 1400-12

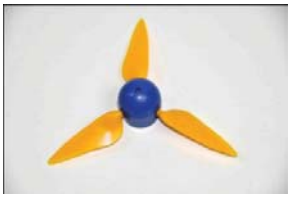
With the available components, rotors with 2, 3 or 4 blades and with a flat or an optimized profile can be created. There is a hub for 4 blades with a pitch angle of 25° and hubs for 3 blades with pitch angles of 20°, 25°, 30°, 50° and 90°.



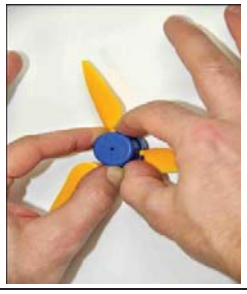
First, a hub with the desired rotor blade pitch and the number of blades should be selected. (The hubs are labeled on the back.) The Two-blade rotor and the Four-blade rotor can both be constructed with the Four-blade hub.



After that, the rotor blades are installed. During the insertion of the blades, make sure that they are installed with the rounded side up.

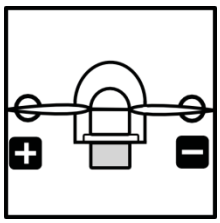


After installation of the rotor blades, the hub-cap will be mounted and lightly pressed against the hub.



To replace the blades, a small nose is located at head of the hub. If the nose is pressed lightly on a hard surface, the hub-cap can be removed easily.

Wind turbine module 1400-22

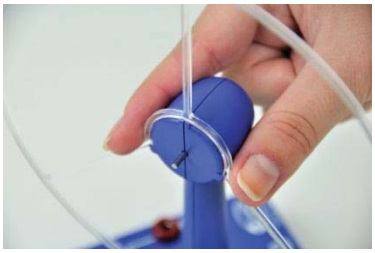


At first the blue wind turbine has to be plugged into the module. The rotor has to be racked at the generator shaft to get a model of a wind turbine. The rotor must not touch the casing to avoid friction, which would considerably impede its rotation. The generator produces a direct current, with its polarity marked on the module. Additionally an angle scale is printed on the module, so it is possible to adjust a certain wind angle.

It is not allowed to touch the rotor during movement due to risk of injury. The rotor may only be touched, when it does not turn!

Handling of the fingerguard of the wind turbine 1400-22

As you can see in the picture, the wind turbine has three small retainer to fix the fingerguard.

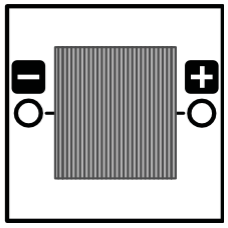


The fingerguard will be attached at the top of the wind turbine and pressed firmly at the lower retainers.

Afterwards, the wind rotor will be fixed at the wind turbine.

Advice: The fingerguard protects the finger against touching the rotor at the side. Do not touch the rotor from the front side because of injury risk!

Solar cell 1100-02 0,5V 840 mA

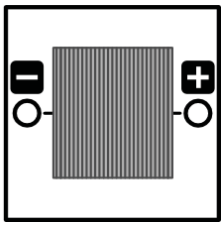


The specifications about open circuit voltage and short circuit current can be found on the back surface.

Specifications:

Material: polycristalline silicon
Open circuit voltage: 0,5V
Short circuit current: 840mA
Maximum power: 0,4Wp

Solar module 1100-07 1,5V 280 mA

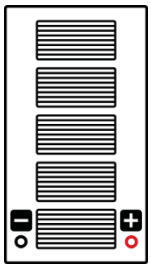


This solar module is a serial connection of three solar cells. The specifications about open circuit voltage and short circuit current can be found on the back surface.

Specifications:

Material: polycristalline silicon
Open circuit voltage: 1,5V
Short circuit current: 280mA
Maximum power: 0,13Wp

Solar module, large 1100-31 2,5V 420 mA



This solar module is a serial connection of five solar cells.

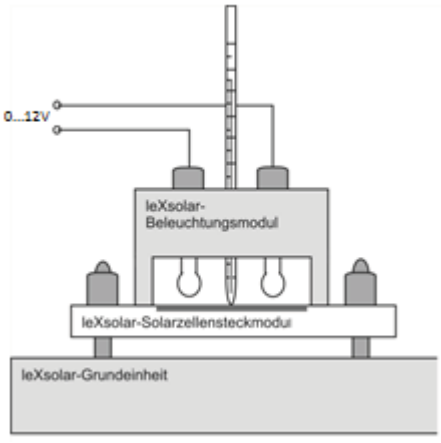
Specifications:

Material: polycristalline silicon
Open circuit voltage: 2,5V
Short circuit current: 420mA
Maximum power: 1Wp

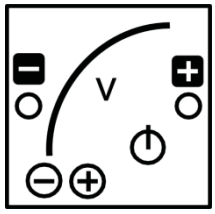
Solar cell cover set 1100-29

Lighting module (1100-20)

The lighting module is operated with the PowerModule. There are 4 light bulbs inside the lighting module. They can or cannot contribute to the lighting by screw or unscrew. It is not recommandable to change the illuminance by changing the voltage since the spectrum of the light will change, which leads to measuring errors. The lighting module has to be setted on the solar cell (see figure). Take care that the lighting should lie only as long as necessarry on the solar cell because of the heat built-up of the solar cell due to heat radiation. Between both connections there is a hole for the laboratory thermometer to measure the temperatur of the solar cell.



PowerModule 9100-05

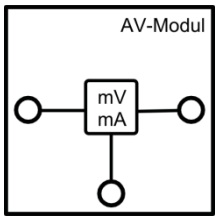


The PowerModule is a compact and intuitively usable voltage source. First, the attached power adapter has to be connected to a power outlet and to the top right input jack. The voltage can be chosen with the „+“- and „-“ -buttons and will be displayed by LEDs. When the desired voltage is chosen, the voltage will be applied by using the yellow on/off- button. In case of a short circuit or currents greater than 2 A the PowerModule will switch off immediately.

Specifications:

- Output voltage: 0-12 V
- Output power: max. 24 W
- Adjustable in 0.5 V steps
- Overcurrent detection >2 A and automatic shutoff
- Input voltage: 110-230 V, 50-60 Hz (with enclosed power adapter)

AV-Module 9100-03



The AV-Module is a combined voltage and current meter. It holds 3 buttons, whose features are described in the display respectively. By pushing a random button the module will switch on. In the disabled state the display shows the leXsolar emblem. When the display does not show anything or the word „Bat“ is shown, it is necessary to change the batteries in the back (2 x AA batteries 1.2 to 1.5V; Take care of the polarity marked on the bottom of the battery case! Do not touch the button while inserting the batteries).
With the top right button the measuring mode can be switched between voltage mode, current mode or combined voltage-current mode. Both measurement mode and required cable connection will be indicated by the circuit symbols on the display. Take care that in voltage mode no current is applied to the right jack. In the combined mode the voltage can be measured with the right jack as well as with the left one. The influence of the internal resistance of the current measurement is compensated internally. The measured values are signed. When the positive pole is connected to a red jack and the negative pole is connected to the black jack, the value of the voltage will be positive. When current is applied from the left to the right, the current value will be positive, as well. The other way around, the algebraic sign changes.

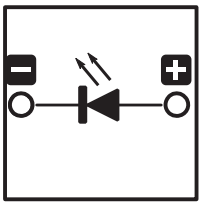
After 30 min without pushing a button or after 10 min of measuring a constant value, the module will switch off automatically. It can measure voltages up to 12 V and currents up to 2 A. In case of exceeding one of the values, the module interrupts the current flow and shows “overcurrent“ or “overvoltage”. This error message can be confirmed by touching a button. The module will resumes measuring, when the values attain acceptable values.

Specifications:

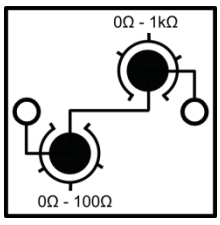
Voltage metering:
- range: 0...12 V
- accuracy: 1 mV
- automatic shutoff in case of overvoltage >12 V

Current metering:
- range: 0...2 A
- accuracy: 0,1 mA (0...199 mA) and 1mA (200 mA...1 A)
- automatic shutoff in case of overcurrent >2 A
- internal resistance <0,5 Ohm (0...200 mA); <0,2 Ohm (200 mA...2 A)

LED-Module 1400-08

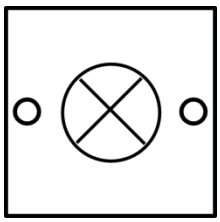


Potentiometer module 1100-61



The potentiometer module holds a 0-10-Ω-potentiometer and a 0-100-Ω-potentiometer. Both are serially conneted, so that the potentiometer can attain resistances between 0 Ω bis 110 Ω. The measuring error amounts to 0.5 Ω for the small resistor and 5 Ω at other one.

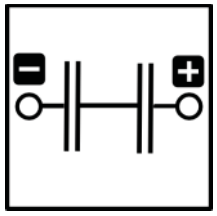
Light bulb module 1100-26



Specifications:

Light bulb P_{typ} = 200 mW (at 3.5 V)
Fuses work up to maximum voltage of 6 V

Capacitor module 1600-02

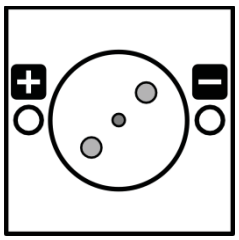


The capacitor module consists of 2 series-connected capacitors. The maximum voltage of the capacitor amounts to 5.4 V. Charging voltages for the capacitor should not exceed 5 V. It is possible to short-circuit the capacitor to discharge, because there are fuses to avoid damages. For quick charging, it is also possible to connect the capacitor directly to a power supply. The voltage source should be switched on at a voltage of 0.5 V and can be increased by 0.5 V every 10 s. The capacitor should be charged with the final voltage for 30 s.

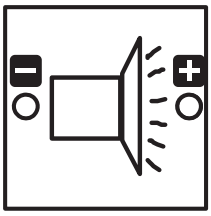
Specifications:

Capacitance: 5 F
Maximum voltage: 5,4 V

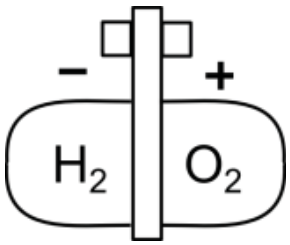
Motor module (1100-27) with color discs set 1 (1100-28)



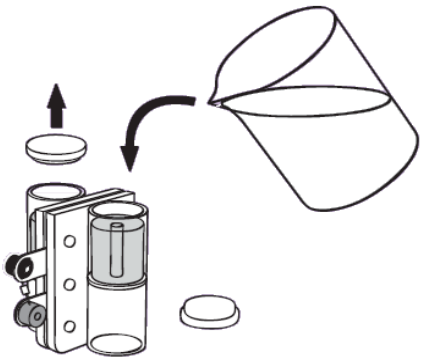
Buzzer module 1100-25



Reversible fuel cell L2-06-067 with distilled water 1800-15



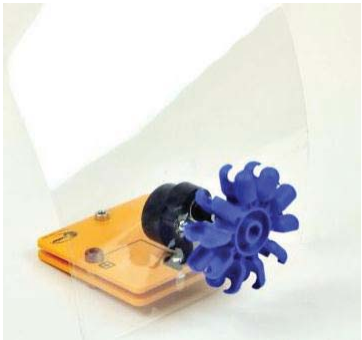
The reversible fuel cell consists of an electrolyzer and a fuel cell. To fill the reversible fuel cell you should proceed in the following way:



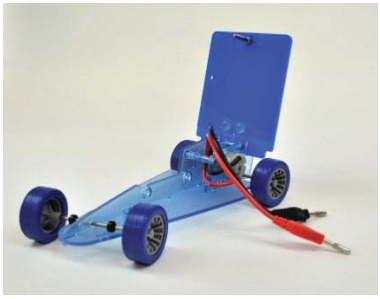
1. Fill the rev. fuel cell with distilled water as shown in the alongside figure.
2. Fill both storage cylinders up to the top of the tubules, which are inside the cylinders.
3. Knock the rev. fuel cell slightly on the table.
4. Continue filling in water until it flows through the tubules.
5. Close the storage cylinders with the plugs and turn over the rev. fuel cell. (the plugs must be on the bottom)

To charge the reversible fuel cell the applied voltage should not exceed 1.5 V. Otherwise the resulting current could exceed 1 A, which would damage the fuel cell.

Water wheel module 1900-01



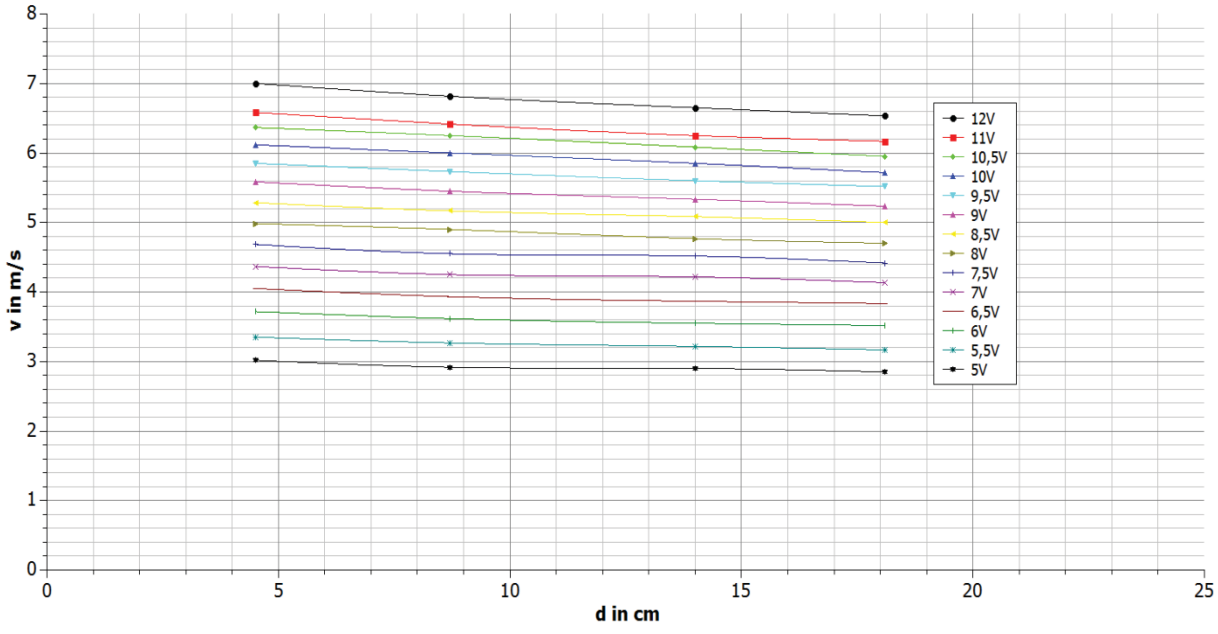
Electric model car with battery adapter 1801-02



The electric model car can be used with the reversible fuel cell or the capacitor module. The fuel cell can be plugged directly in the car. The capacitor can be plugged with the adapter in the car. The car will move when both cables are connected with the voltage source. There will be a short circuit when the wires are held during the short circuit.

Hand generator 1602-02

Wind speed at constant voltage at the wind machine depending on the distance

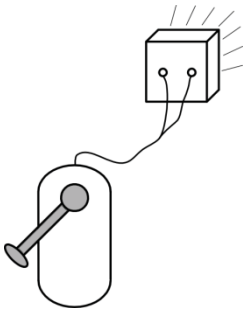


1. From muscular strength to current...to light

Task

Generate current by turning the crank of the hand generator and make the lighting module shine.

Setup



Required devices

- Hand generator
- Lighting module

How to do

Plug both plugs of the hand generator in the lighting module.

Crank the hand generator strongly. What do you see?

Try to turn the crank now very slowly. What do you observe?

Allow your classmate to touch one of the light bulbs carefully for some time while you are cranking rapidly. What can he sense?

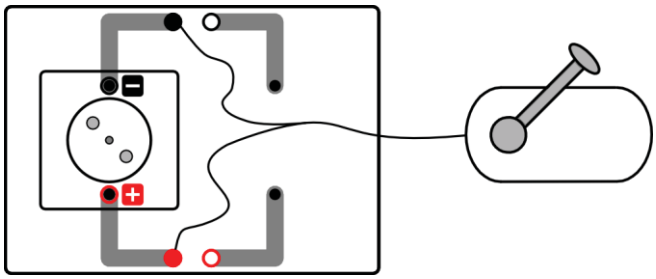
Which energy conversions did you observe in this experiment?

2. From muscular strength to current...to motion

Task

Generate current by turning the crank of the hand generator and drive a motor

Setup



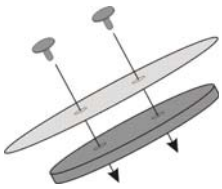
Required devices

- Base Unit
- Hand generator
- Lighting module

How to do

Assemble the experiment as seen in the picture above. Take care to get the correct polarity (red cable into the red socket, black cable into the black socket).

Lift the blue disk carefully from the motor module and loosen the small clips. Fix the red and blue cardboard disk onto the blue rotation disk and put it back on the motor.



Crank the hand generator rapidly! What do you observe?

Try to turn the crank now very slowly. What do you observe this time?

Interchange the cables of the hand generator – that means red cable to black socket and vice versa. Crank slowly. What happens?

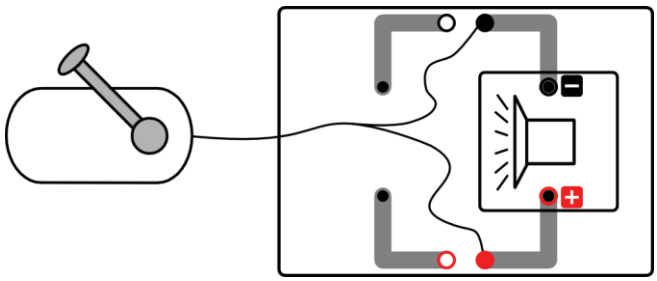
Which energy conversions took part in this experiment?

3. From muscular strength to current...to Noise

Task

Generate current by turning the crank of the hand generator to stimulate the buzzer to make a noise.

Setup



Required devices

- Base Unit
- Hand generator
- Buzzer module

How to do

Assemble the experiment as seen in the picture above. Take care to get the correct polarity (red cable into the red socket, black cable into the black socket).

Crank the hand generator rapidly! What do you observe?

Try to turn the crank now very slowly. What do you observe this time?

Interchange the cables of the hand generator – that means red cable to black socket and vice versa. Crank slowly. What happens? Can you explain your observation?

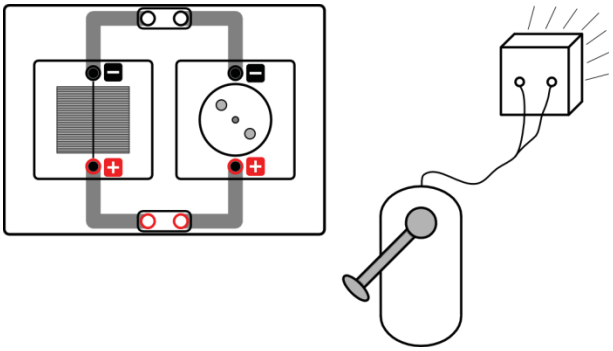
Which energy conversions took part in this experiment?

4. The solar cell drives a motor

Task

Assemble the solar cell and the motor so that the motor rotates when light shines on the solar cell.

Setup



Required devices

- Base Unit
- Solar *cell,* 0.5V
- Motor module
- Short-circuit plugs

If there is no sunshine you will also need:

- Hand generator
- Lighting module

How to do

Expose the solar cell to sunlight. If the sun is not shining, then point the lighting module toward the cell and turn the crank rapidly or expose the solar cell to the light from a lamp.

What do you observe?

Move the main board slowly away from the light or ask a classmate to lift the lighting module slowly.
What do you observe?

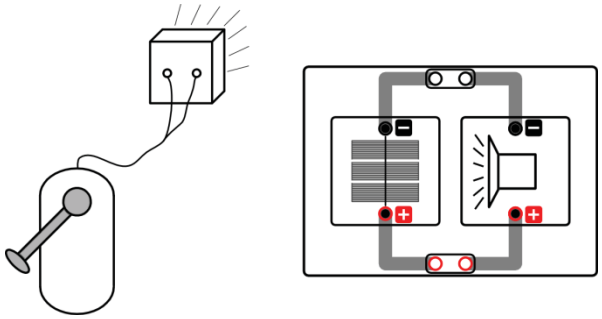
Explain your observation!

5. The solar module powers a buzzer

Task

Assemble the solar module and the buzzer so that the buzzer makes a noise when light shines on the solar module.

Setup



Required devices

- Base Unit
- Solar *module,* 1.5V
- Buzzer module
- Short-circuit plugs

If there is no sunshine you will also need:

- Hand generator
- Lighting module

How to do

Expose the solar cell to sunlight. If the sun is not shining, then point the lighting module toward the cell and turn the crank rapidly or expose the solar cell to the light from a lamp.

What do you observe?

Move the main board slowly away from the light or ask a classmate to lift the lighting module slowly.
What do you observe?

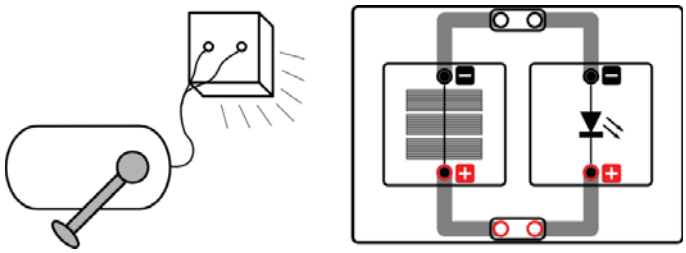
Explain your observation!

6. The solar module powers a LED

Task

Assemble the solar module and the LED so that the LED lights when sunlight shines on the solar module.

Setup



Required devices

- Base Unit
- Solar *module,* 1.5V
- LED module
- Short-circuit plugs

If there is no sunshine you will also need:

- Hand generator
- Lighting module

How to do

Expose the solar cell to sunlight. If the sun is not shining, then point the lighting module toward the cell and turn the crank rapidly or expose the solar cell to the light from a lamp.

What do you observe?

Move the main board slowly away from the light or ask a classmate to lift the lighting module slowly.
What do you observe?

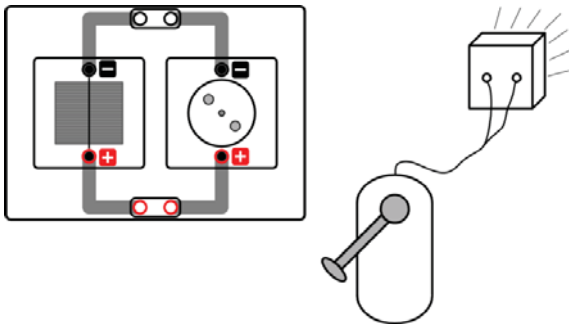
Explain your observation!

7. The larger the solar cell, the ...?

Task

Find out how the motor works with a smaller or larger solar cell.

Setup



Required devices

- Base Unit
- Solar *cell,* 0.5V
- Motor module with color disk
- Short-circuit plugs
- Cover plates

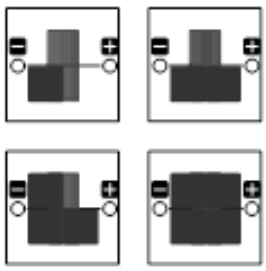
If there is no sunshine you will also need:

- Hand generator
- Lighting module

How to do

Expose the solar cell to sunlight. If the sun is not shining, then point the lighting module toward the cell and turn the crank rapidly or expose the solar cell to the light from a lamp.

You can change the active surface area of the solar cell by shading parts of it. Repeat the same experiment using no cover plate, one cover plate, two cover plates, three or four cover plates. Stop the motor each time between experiments and note in which situation the motor is rotating the fastest, the second fastest and so on.



Solar cell scaled down through covering:	*Ranking of rotation speed (1 fastest … 5 slowest):*
• Solar cell without cover	
• One quarter of the solar cell covered	
• Half of the solar cell covered	
• Three quarter of the solar cell covered	
• Solar cell completely covered	

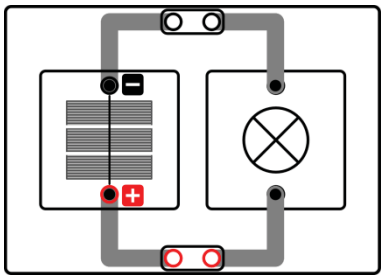
The larger the area of the solar cell, the _____the color disk rotates!

8. The solar module powers a LED

Task

From which direction does light need to reach the solar cell to make it work the best?

Setup



Required devices

- Base Unit
- Solar *module,* 1.5V
- Light bulb module
- Short-circuit plugs

This experiment has to be carried out in direct sunlight!

How to do

Hold the main board into the sunlight. The solar cell should be perpendicular to the direction of the incoming light. (You can determine that, for example, when the Short-circuit plugs do not throw any shadows.)

Tilt the main board slowly away from the direction of the light and observe the brightness of the lamp.

What do you observe?

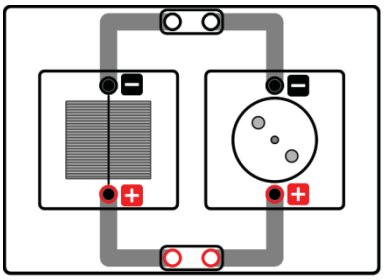
What does your observation mean for the performance of the solar cells on roofs during the day?

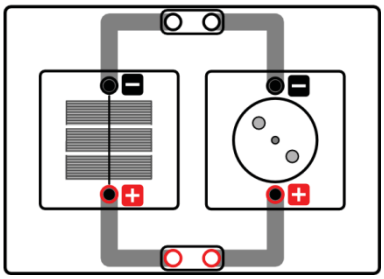
9. From the solar cell to the solar module

Task

Compare a solar cell to a solar module (three solar cells connected).

Setup





Required devices

- Base Unit
- Solar *cell,* 0.5V
- Solar *module,* 1.5V
- Light bulb module
- Motor module
- Buzzer module
- LED module
- Short-circuit plugs

This experiment should be carried out in direct sunlight!

How to do

In this experiment all four consumer modules (motor, light bulb, buzzer, LED) are powered once by a solar cell and once by a solar module.

First set up the experiment with the motor module and characterize the behavior of the module when it is connected to the solar cell, respectively to the solar module. Repeat the experiment for the other consumers (light bulb, buzzer, LED).

	with solar cell	**with solar module**
Motor	_____	_____
Buzzer	_____	_____
Light bulb	_____	_____
LED	_____	_____

Some consumers need a minimum voltage to work. What can you conclude from your observations about the difference between solar cell and solar module

_____

_____

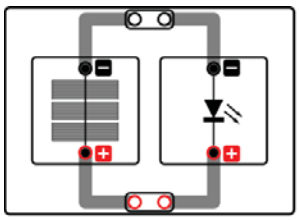
_____

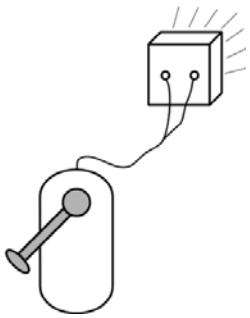
10. Shading of solar modules

Task

What happens if parts of the solar module are shaded?

Setup





Required devices

- Base Unit
- Solar *module,* 1.5V
- LED module
- Short-circuit plugs
- Dark strip of paper/cardboard

If there is no sunshine you will also need:

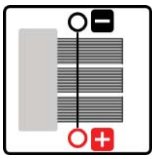
- Hand generator
- Lighting module

How to do

Hold the solar module in the sunlight! If the sun is not shining, then point the lighting module toward the solar module and turn the crank rapidly or expose the solar module to the light of a lamp. What do you observe?

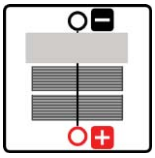
Cover the solar module with two cover plates, as in the picture (right) and illuminate the solar module:

What changes do you observe?



Now cover the solar module with two cover plates like in this picture and illuminate the solar module:

What changes do you observe?



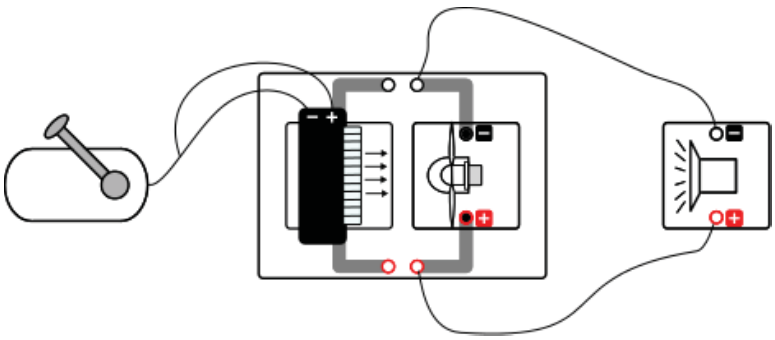
What differences do you observe depending on how you shade the solar module? Can you explain this behavior?

11. The wind turbine powers a buzzer

Task

Assemble the wind turbine and the buzzer so that the buzzer makes a noise when the wind starts to blow.

Setup



Required devices

- Base Unit
- Wind machine
- Wind turbine with optimized profile
- Buzzer module
- Hand generator
- Cables

Warning Risk of injury: Do not touch the rotating rotor!

How to do

Turn the crank rapidly! What happens with the wind turbine module?

What happens with the buzzer?

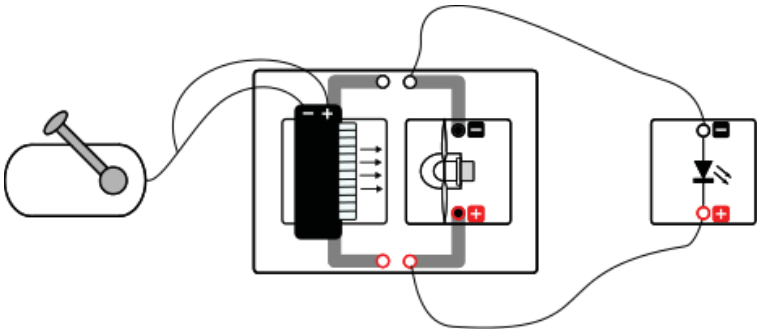
Explain your observation!

12. The wind turbine powers a LED

Task

Assemble the wind turbine and the LED so that the LED lights when the wind starts to blow.

Setup



Required devices

- Base Unit
- Wind machine
- Wind turbine with optimized profile
- LED module
- Hand generator
- Cables

Warning Risk of injury: Do not touch the rotating rotor!

How to do

Turn the crank rapidly! What happens with the wind turbine module?

What happens with the LED?

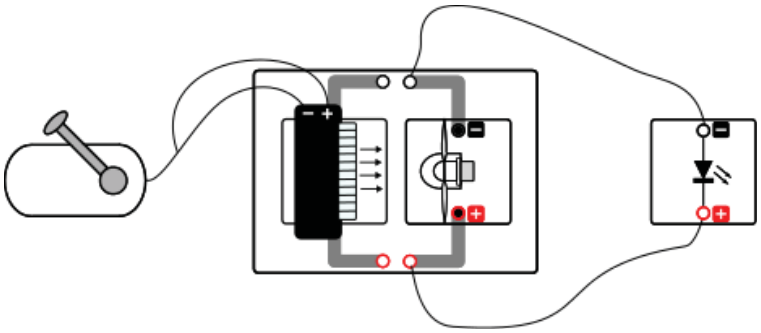
Explain your observation!

13. Influence of the wind direction

Task

Examine the influence of the wind direction on the power of the wind turbine.

Setup



Required devices

- Base Unit
- Wind machine
- Wind turbine with optimized profile
- LED module
- Hand generator
- Cables

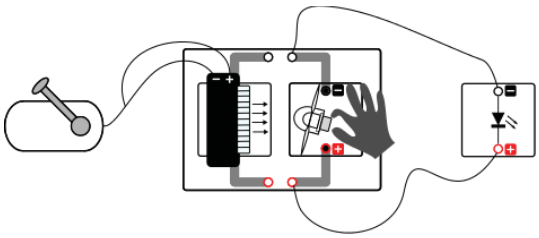
Warning Risk of injury: Do not touch the rotating rotor!

How to do

This experiment should be done in twos. One student turns the crank rapidly during the whole experiment.

Wait, till the LED shines brightly. Now touch the foot of the wind turbine, carefully! Hold your hand flat to avoid injury and obstruction of the air flow.

Turn the wind turbine slowly to the right, as you can see in the picture below. What happens?



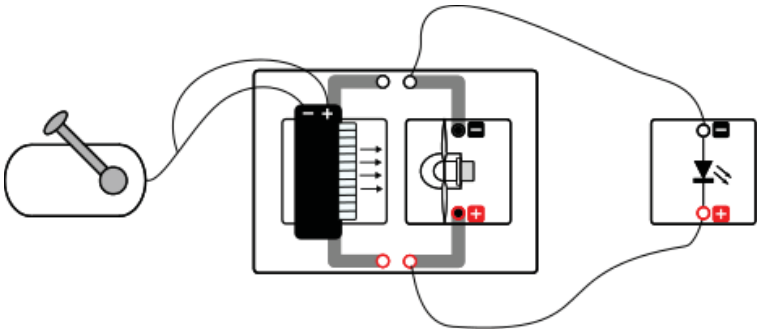
Now change the places and your partner turns the wind turbine to the left. What happens?

14. Influence of the rotor blade shape

Task

Examine the influence of the rotor blade shape on the power of the wind turbine.

Setup



Required devices

- Base Unit
- Wind machine
- Wind turbine with optimized profile and flat profile
- LED module
- Hand generator
- Cables

Warning Risk of injury: Do not touch the rotating rotor!

How to do

First, set up the experiment with the optimized profile.

Turn the crank rapidly! What happens with the wind turbine module?

What happens with the LED?

Now change the rotor to the flat profile and repeat the experiment. What can you observe at the wind turbine and at the LED?

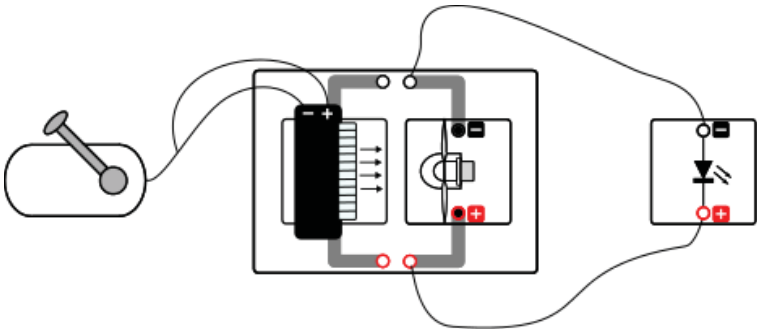
Compare both rotor blade shapes!

15. Influence of the wind speed

Task

Examine the influence of the wind speed on the power of the wind turbine.

Setup



Required devices

- Base Unit
- Wind machine
- Wind turbine with optimized profile
- LED module
- Hand generator
- Cables

Warning Risk of injury: Do not touch the rotating rotor!

How to do

This experiment should be done in twos. One student turns the crank during the whole experiment. In this experiment the crank should be turned with different speeds. Start with the highest speed and observe the LED. Hold your hand behind the wind turbine to feel the wind speed. Now decrease the speed of the crank and observe the LED respectively the wind speed. Now try to fill the table

Speed of the crank	**Wind speed** (1 … high to 4 … low)	**Brightness of the LED** (1 … high to 4 … low)
very fast	_____	_____
fast	_____	_____
middle	_____	_____
slowly	_____	_____

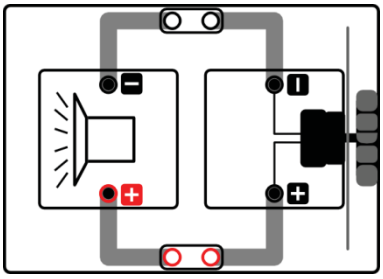
Now change your roles and check your results.

16. The water wheel powers a buzzer

Task

Assemble water wheel module and the buzzer so that the buzzer makes a noise when water is falling on the water wheel.

Setup



Required devices

- Base Unit
- Water wheel module
- Buzzer module
- Tube
- Short-circuit plugs

Additionally needed:
- Two large bowls / boxes
- Water
- Table / chair / higher position

How to do

Set up the circuit like in the picture. Place one bowl of water on the table, the other one is placed on the floor or chair so that you can collect the water with which you will drive the waterwheel.
Now insert the hose with one end in the water and suck the water until the water level in the tube is deeper than the water in the bowl. (Put your finger on the tube so that the water level does not drop again).
Alternatively, you can also put the tube completely into the bowl. Make sure that no air bubbles arise. Now hold your finger on one end of the tube and hold it down to the water wheel. Make sure that the other end of the tube remains in the water.
Hold the base unit with the water wheel over the lower bowl. Now take your finger from the opening of the tube so that the water jet hits the waterwheel.

Note your observations!