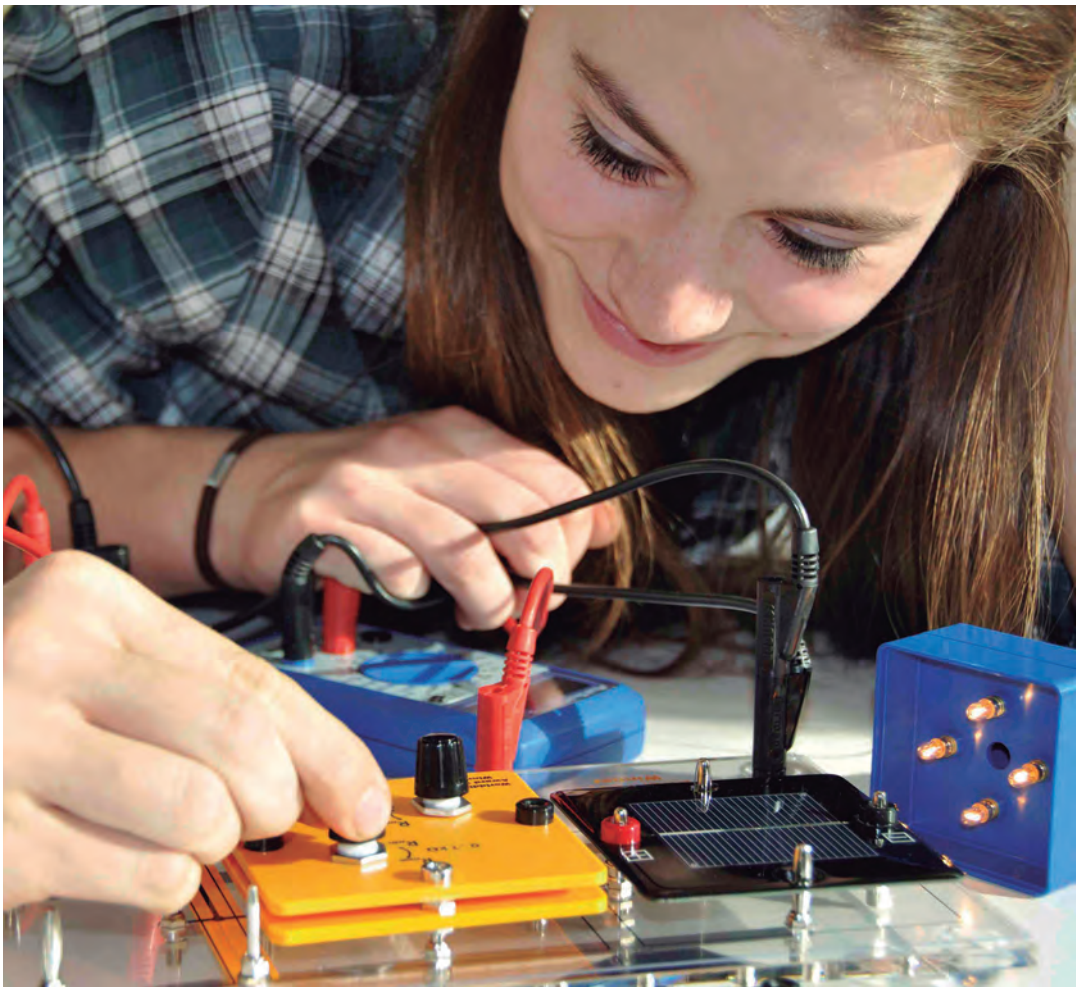
leXsolar-PV Large



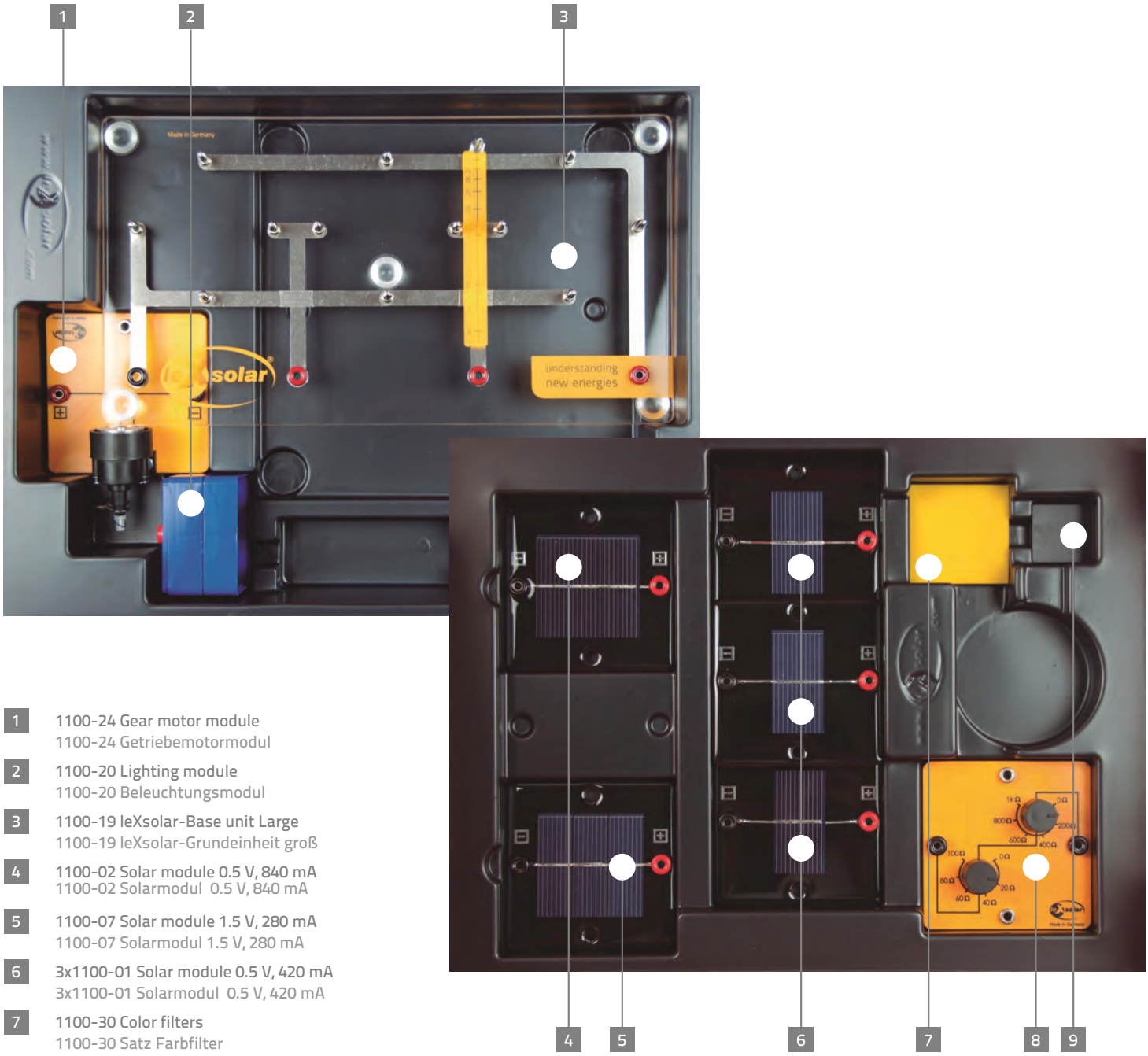
Student's Manual

Layout diagram leXsolar-PV Large

Item-No.1103

Bestückungsplan leXsolar-PV Large

Art.-Nr.1103



1 1100-24 Gear motor module
1100-24 Getriebemotormodul

2 1100-20 Lighting module
1100-20 Beleuchtungsmodul

3 1100-19 leXsolar-Base unit Large
1100-19 leXsolar-Grundeinheit groß

4 1100-02 Solar module 0.5 V, 840 mA
1100-02 Solarmodul 0.5 V, 840 mA

5 1100-07 Solar module 1.5 V, 280 mA
1100-07 Solarmodul 1.5 V, 280 mA

6 3x1100-01 Solar module 0.5 V, 420 mA
3x1100-01 Solarmodul 0.5 V, 420 mA

7 1100-30 Color filters
1100-30 Satz Farbfilter

8 1100-23 Potentiometer module
1100-23 Potentiometermodul

9 1100-29 Solar cell cover set (4 pieces)
1100-29 Satz Abdeckungen f. Solarzelle

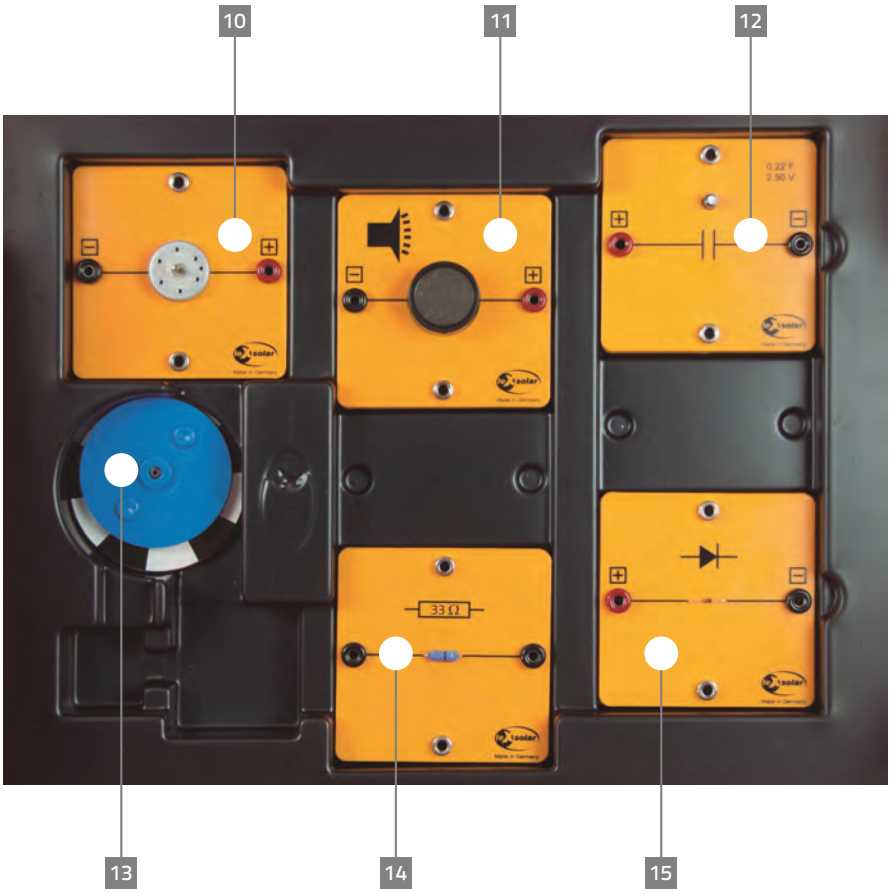
Version number
Versionsnummer

III-01.24_L3-03-129_19.05.2016

CE RoHS2

Layout diagram leXsolar-PV Large
Item-No.1103

Bestückungsplan leXsolar-PV Large
Art.-Nr.1103



10	1100-27 Motor module without gear 1100-27 Motormodul ohne Getriebe	13	1100-28 Color discs - Set 1 1100-28 Farbscheiben-Set I
11	1100-25 Buzzer module 1100-25 Hupenmodul	14	1100-22 Resistor module 1100-22 Widerstandsmodul
12	1400-07 Capacitor module 220 mF, 2.5V 1400-07 Kondensatormodul 220 mF, 2.5V	15	1100-21 Diode module 1100-21 Diodenmodul

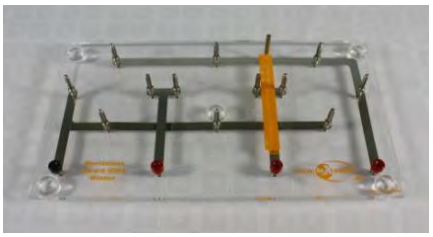
leXsolar - PV Large

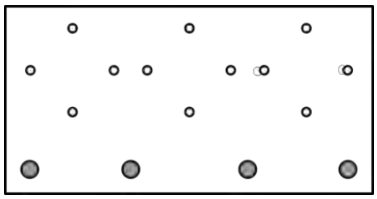
Instructions manual

Chapter 1: Description of the experimental components of leXsolar - PV Large

In the following schedule every component of the leXsolar-PV Ready-to-go 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.

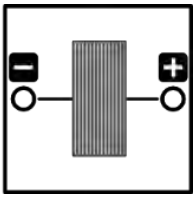
Base unit 1100-19





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 diagrams show the connections in a series and parallel connection. To change between series and parallel connection, the modules have to be turned by 90°.
To the right of the center, there is the shadow bar with angle scale. This shadow bar can be used to align pluged-in solar modules in a certain angle to a light source. The light should be small and be at a big distance to the base unit in order to create a well-defined shadow.

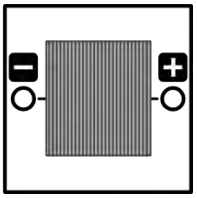
Solar module 1100-01 0,5V 420 mA



Specifications:

Material: polycristalline silicon
Open circuit voltage: 0,5V
Short circuit current: 420mA
Maximum power: 0,2Wp

Solar module 1100-02 0,5V 840 mA

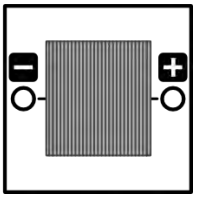


The specifications about open circuit voltage and short circuit current can be found on the back surface.

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



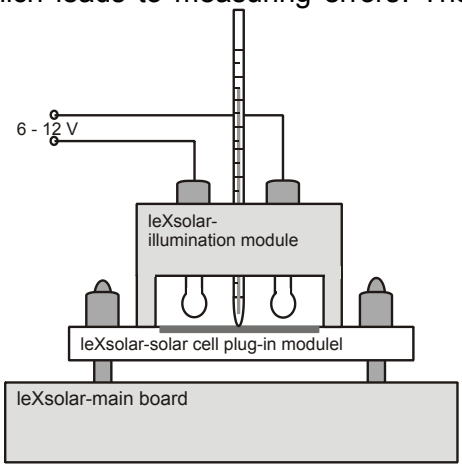
This solar module is a serial connection of three solar cells.

Specifications:

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

Lighting module (1100-20) with PowerModule (2105-00)

The lighting module is operated with the PowerModule or any other variable power supply (0…12V). 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). Tale care that the lighting should lie 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. 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.

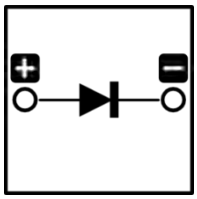


Specifications:

Lighting modules
Operating voltage: 0-12V
Maximum power: 4W
Maximum illuminance: 200W/m^2
Aperture of the light source: 6x6cm

PowerModule
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)

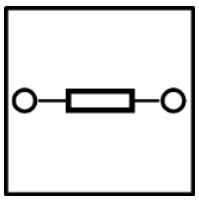
Diode module 1100-21



Specifications:

Schottky diode
$U_{forward}$ = 0.33 V
Maximum current: 200 mA (500 mA Peak <1 s)

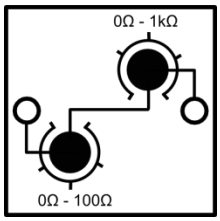
Resistor module 1100-22



Specifications:

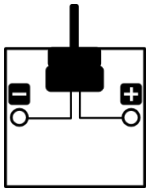
Maximum power: 2W

Potentiometer module 1100-23



The potentiometer module holds a 0-100-Ω-potentiometer and a 0-1-kΩ-potentiometer. Both are serially conneted, so that the potentiometer can attain resistances between 0 Ω bis 1100 Ω. The measuring error amounts to 5 Ω for the small resistor and 20 Ω at other one. The maximum current amounts to 190 mA.

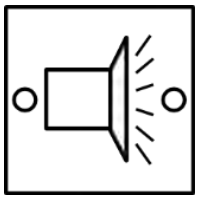
Gear motor module (1100-24) with mit hook weight 20g (L2-05-024)



Specifications:

Starting current: ≅ 20mA
Starting voltage: ≅ 0,35V
Minimum operating current: 10mA
Maximum voltage: 4V

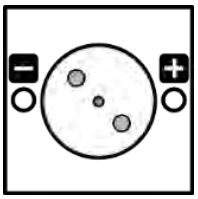
Horn module 1100-25

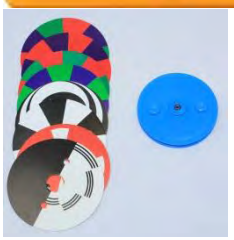


Specifications:

Starting voltage: 0.7V
Starting current: 0.3mA

Motor module without gear (1100-27) with color disks– Set 1 (1100-28)

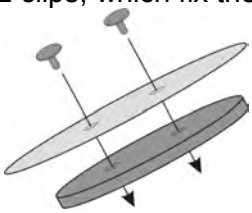




Specifications:

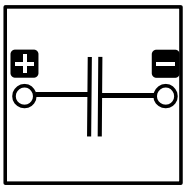
Starting current: 20mA
Starting voltage: 0.35V

The color disks are: red-green-blue, red-blue, red-green, green-blue und 3 black-white color disks. The color disks are fix at the motor module by use of the plastic disk. The plastic disk holds 2 clips, which fix the disk at the plastic disk (see figure).



In the center of the plastic disk is a hole, which will be placed on the pin of the motor.

Capacitor module 1400-07



The capacitor module has a capacity of 220 mF and is able to apply a maximum voltage of 2.5 V. Do not apply a higher voltage than 2.5 V during charging. If you want to discharge the capacitor quickly, it can be short-circuit since there are fuses inside the module which avoid high currents. To charge the capacitor quickly, it is possible to connect it directly with the PowerModule. Power on the PowerModule at a voltage of 0.5 V and increase the voltage by 0.5 V every 10 s. Charge the capacitor at the end voltage for 30 s.

Specifications:
Capacity: 220 mF
Voltage: 2,5 V

Solar cell cover set 1100-29

Specifications:

Size: 3x3cm

Color filters 1100-30

1. Understanding the leXsolar base unit

Task

Examine the different circuits to learn more about the base unit.

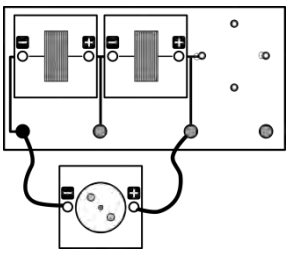
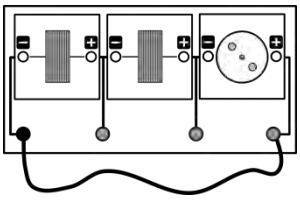
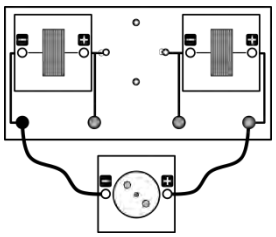
Required devices

- leXsolar base unit
- 3 small solar cells
- leXsolar-motor
- 3 cables

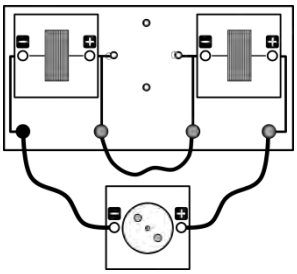
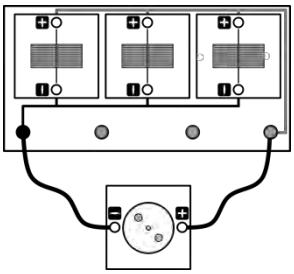
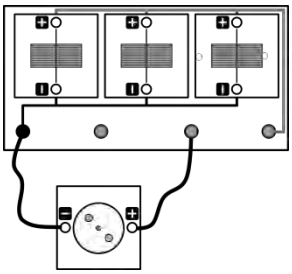
Procedure:

1. Set up the circuits 1 – 6 and check each time, if the motor rotates.
2. Examine the base unit for each circuit and draw the circuit diagram. Decide, whether it is a series or parallel connection.
3. Describe the energy conversions and the physical processes during the experiment with circuit 1.

Evaluation

Circuit 1	Circuit 2	Circuit 3
		
Does the motor rotate? ☐ yes ☐ no	Does the motor rotate? ☐ yes ☐ no	Does the motor rotate? ☐ yes ☐ no
It is a: ☐ series connection ☐ parallel connection	It is a: ☐ series connection ☐ parallel connection	It is a: ☐ series connection ☐ parallel connection

1. Understanding the leXsolar base unit

Circuit 4	Circuit 5	Circuit 6
		
Does the motor rotate? ☐ yes ☐ no	Does the motor rotate? ☐ yes ☐ no	Does the motor rotate? ☐ yes ☐ no
It is a: ☐ series connection ☐ parallel connection	It is a: ☐ series connection ☐ parallel connection	It is a: ☐ series connection ☐ parallel connection

3.

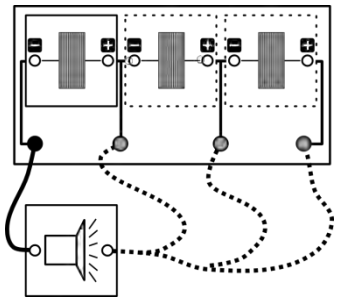
11. Behavior of voltage and current in series and parallel connections of solar cells

11.1 Behavior of voltage and current in series and parallel connections of solar cells (qualitative)

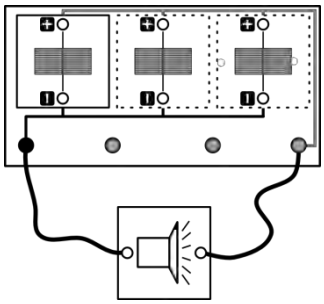
Task

Examine the behavior of a horn depending of different series and parallel connections and draw conclusions about voltage and current.

Setup



Circuit 1



Circuit 2

Required devices

- leXsolar-base unit
- 3 small solar cells
- horn module
- Cable

Procedure

1. Set up a series connected circuit (circuit 1). First use one, then two, then three solar cells. Do not forget to plug in the cable in right red jack. Color the respective squares in the table.
2. Now set up a parallel connected circuit (circuit 2). Take care, that the illuminance conditions are the same.

Evaluation

	Series connection	Parallel connection
One solar cell	No < faint sound < loud	no < faint sound < loud
Two solar cells		
Three solar cells		

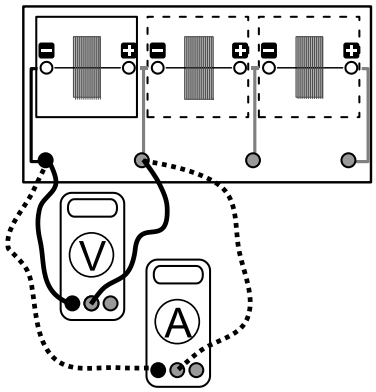
Draw conclusions about the voltage and current.

11.2 Behavior of voltage and current in series and parallel connections of solar cells (quantitative)

Task

Examine the behavior of total voltage and total current in series and parallel connections.

Setup



Required devices

- leXsolar-base unit
- 3 small solar cells
- 1 voltmeter
- 1 amperemeter
- Cable

Primary notes

In this experiment only short-circuit currents and open-circuit voltages are measured. These cannot be measured simultaneously.

Procedure

1. Set up the experiment according to the circuit diagram.
2. Measure the current and voltage of one solar cell (see circuit diagram)!
3. Modify the circuit so that two resp. three solar cells are connected in series. Again, measure the current and voltage.
4. Carry out analogous measurements for parallel-connected solar cells. In order to do this, develop a new circuit diagram in accordance with the diagram of the base unit.
5. Note the measured values in the table.

Evaluation

1. Draw the n-I-diagram (*n*... number of solar cells) for series- and parallel-connected cells. Draw both graphs into one diagram!
2. Draw the n-V-diagram for series- and parallel-connected cells. Draw both graphs into one diagram!
3. Phrase a rule for the total current and total voltage with series- resp. parallel-connected cells.

11.2 Behavior of voltage and current in series and parallel connections of solar cells (quantitative)

Measured values

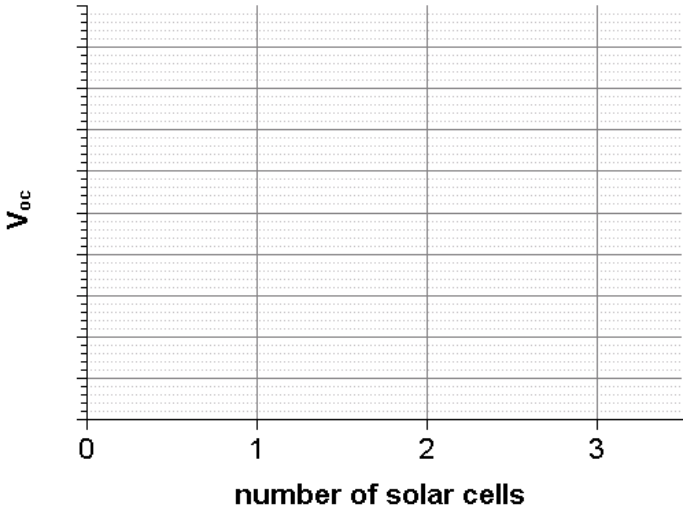
Series connection:

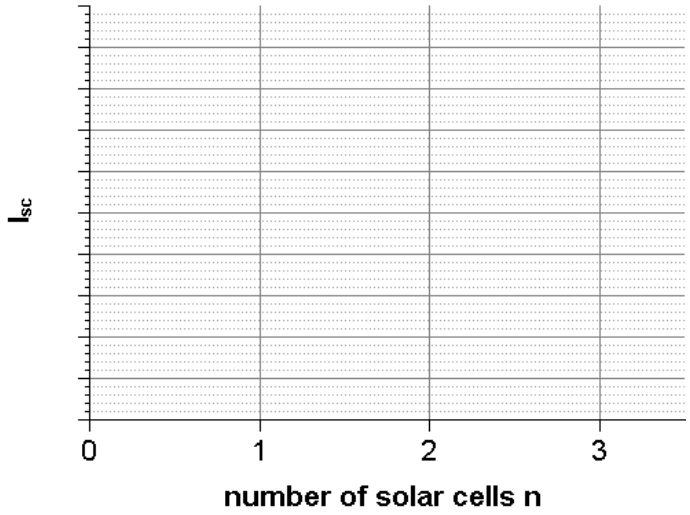
	one solar cell	two solar cells	three solar cells
V_{OC} (V)			
I_{SC} (mA)			

Parallelschaltung:

	one solar cell	two solar cells	three solar cells
V_{OC} (V)			
I_{SC} (mA)			

Diagrams





Evaluation

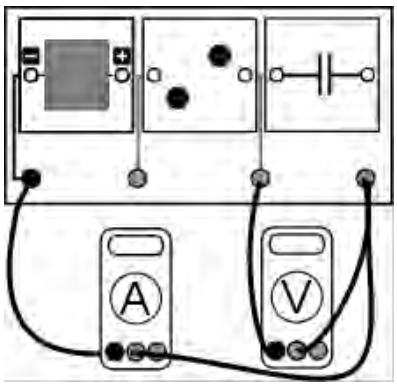
	Behavior of	
	Voltage	Current
Series connection		
Parallel connection		

14.1 Characteristic graphs of a capacitor charged by a solar cell

Task

Examine the charge process of a capacitor.

Setup



Required devices

- 1 base unit
- 1 large solar cell
- 1 potentiometer
- 1 capacitor
- 1 voltmeter
- 1 amperemeter
- 1 stopwatch
- 1 lamp with table clamp

Execution

1. Set up the experiment according to the circuit diagram! Make sure that the capacitor is discharged. The potentiometer should have a resistance of 100Ω.
2. Close the circuit with the amperemeter and start the time measurement. Note every 5 seconds the voltage and the current values.

Evaluation

1. Draw the V-t and the I-t curves into one diagram.
2. Describe the behavior of voltage during the experiment. Explain the behavior.
3. Describe the behavior of current during the experiment. Explain the behavior.

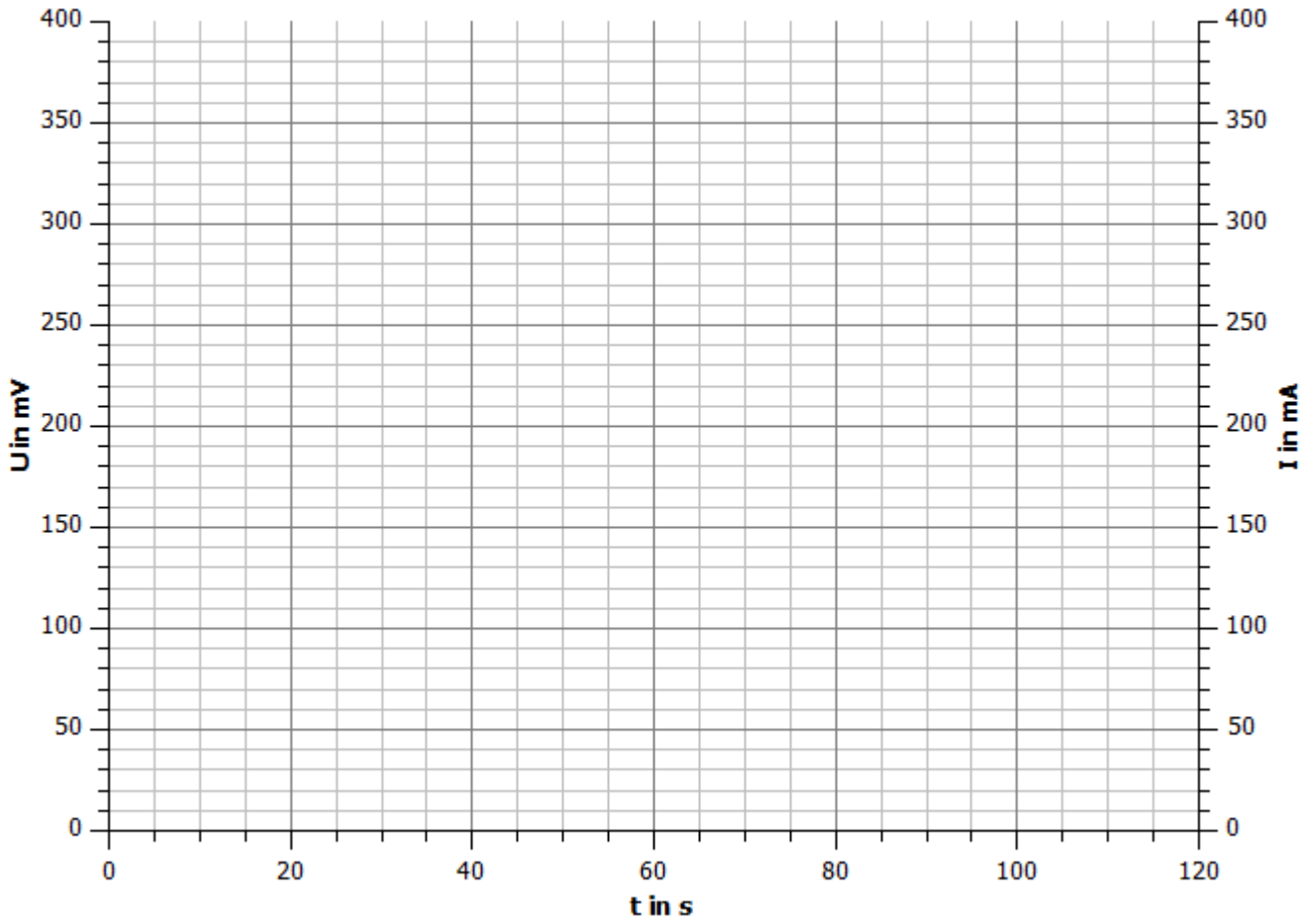
Measured values

time in s	0	5	10	15	20	25	30	35	40	45	50
V in mV											
I in mA											

time in s	55	60	65	70	75	80	85	90	95	100
V in mV										
I in mA										

14.1 Characteristic graphs of a capacitor charged by a solar cell

Diagram



Evaluation

2.

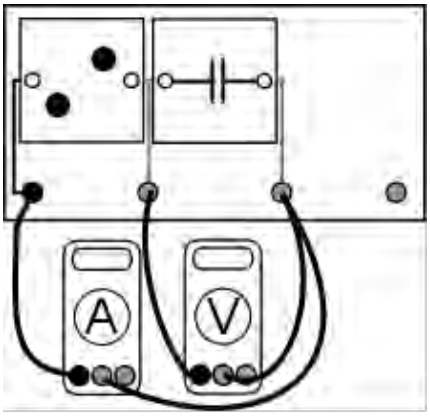
3.

14.2 Discharging process of a capacitor

Task

Examine the discharging process of a capacitor.

Setup



Required devices

- 1 base unit
- 1 potentiometer
- 1 capacitor
- 1 voltmeter
- 1 amperemeter
- 1 stopwatch

Preparation

It is recommendable to do the experiment directly after the experiment 14.1 and to use the same setup, but without the solar module.

It is also possible to use other consumer, like the light bulb or the motor. This would accelerate the experiment.

Execution

1. Set up the experiment according to the circuit diagram! Make sure that the capacitor is fully charged. The potentiometer should have a resistance of 100Ω.
2. Close the circuit with the amperemeter and start the time measurement. Note every 5 seconds the voltage and the current values.

Evaluation

1. Draw the V-t and the I-t curves into one diagram.
2. Describe the behaviors of voltage and current during the experiment. Explain these behaviors.

Measured values

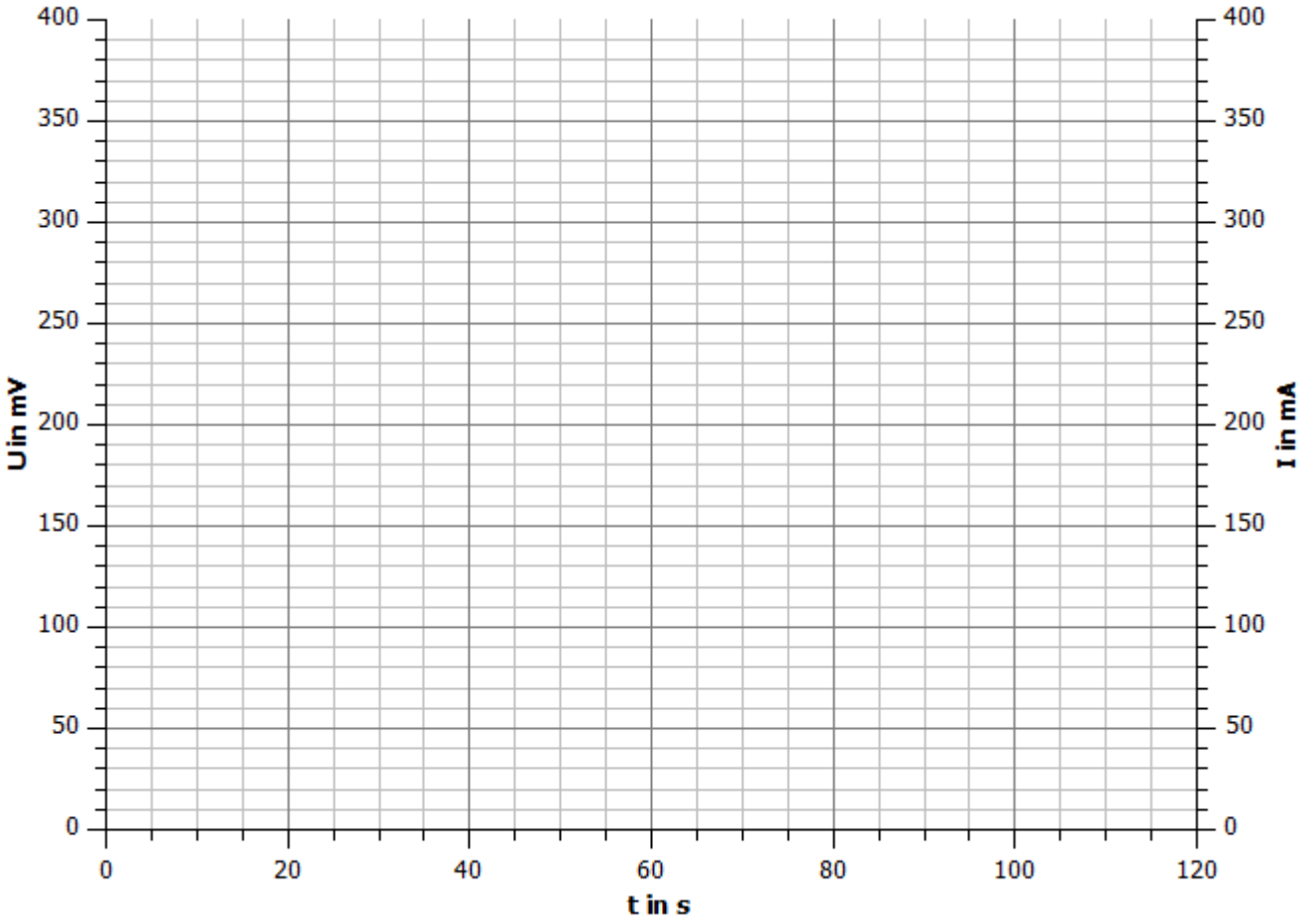
time in s	0	5	10	15	20	25	30	35	40	45	50
V in V											
I in mA											

14.2. Discharging process of a capacitor

Measured values

time in s	55	60	65	70	75	80	85	90	95	100
V in V										
I in mA										

Diagram



Evaluation

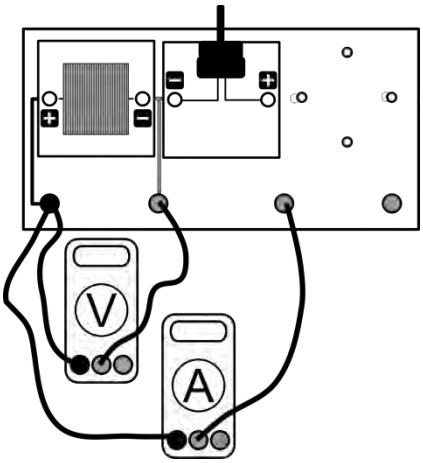
2.

15.1 Determination of efficiency of some energy conversions

Task

Determine the efficiency of conversion from electric to mechanic energy.

Setup



Required devices

- leXsolar-base unit
- leXsolar-lightning module
- gear motor module
- 1 large solar module (1,5 V)
- 1 PowerModule (12V)
- 1 weight 20g
- 1 amperemeter
- 1 voltmeter
- Stopwatch, ruler
- cables
- string

Procedure

1. Set up the experiment according to the sketch and place the base unit to the edge of the table so that the weight hangs freely at approximately 45 cm on a piece of string! Lay the lightning module on solar module and apply a voltage of 12 V with the PowerModule.
2. Switch on the PowerModule and measure the time it takes for the motor to wind up a marked length of string! At the same time, measure the current and voltage of the solar cell.
3. Modify the circuit so that the current and voltage are measured at the PowerModule. Select the measuring range of 10 A at the amperemeter. Repeat the experiment. Note the measured values in the table.

Evaluation

Calculate the total efficiency of the following energy conversions:

a) Electric energy of solar module > potential energy weight
b) Electric energy of PowerModule > radiation energy of light bulbs > electric energy of solar module > potential energy of weight

15.1 Determination of efficiency of some energy conversions

Measured values

- with determination of the power at the motor

h (cm)	height by which the weight was lifted	
t (s)	time it took to reach *h*	
V (V)	voltage of the solar module	
I (mA)	current in the circuit of the solar module	

- with determination of the power at the lamps

h (cm)	height by which the weight was lifted	
t (s)	time it took to reach *h*	
V (V)	voltage drop over the lamps	
I (mA)	current in the circuit of the lamps	

Evaluation

Calculations:

Results: Energy conversion efficiency of the electric energy of the solar cell to potential energy of the weight amounts to: _____.

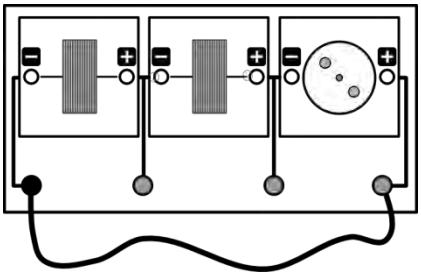
Energy conversion efficiency of the electric energy of the power supply to potential energy of the weight amounts to: _____.

15.2 Rotational direction and speed of a motor

Task

Examine the rotational direction and speed of a motor.

Setup



Required devices

- leXsolar-base unit
- 2 small solar cells
- 1 motor module
- 1 cable
- lamp with table clamp

Procedure

1. Set up a series connection out of the two solar cells and the motor.
2. Hold the base unit to the light source until the motor starts rotating. Note the rotational direction and observe the movement.
3. Change the polarity at the motor by turning the motor module 180° on the base unit. Note again the rotational direction.
4. Remove the cable and observe the movement again.

Evaluation

Rotational direction during the first experiment:

□ clockwise □ anti-clockwise

Rotational direction after changing polarity:

□ clockwise □ anti-clockwise

1. Describe the movement of the disk before and after removing the cable.

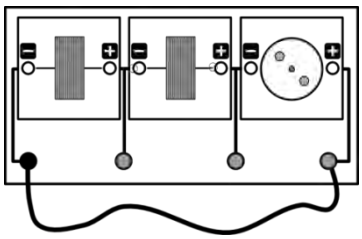
2. Explain the behavior of the rotational direction during different polarities.

15.3 Starting and running current of a motor

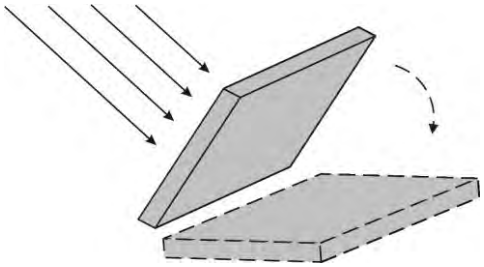
Task

Examine the starting behavior of a motor.

Setup



circuit



Picture 2

Required devices

- leXsolar-base unit
- 2 small solar cells
- Motor
- 1 cable
- lamp with table clamp

Procedure:

1. Set up the experiment according to the circuit diagram.
2. Hold the setup to the light source and wait until the motor starts rotating.
3. Tilt the base unit slowly away from the light source as shown in picture 2 until the motor stops rotating.
4. Now, tilt the base unit slowly towards the light source until start rotating again.

Evaluation

1. Describe the movement of the motor during the experiment.

2. Explain this behavior.

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