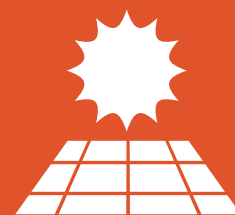
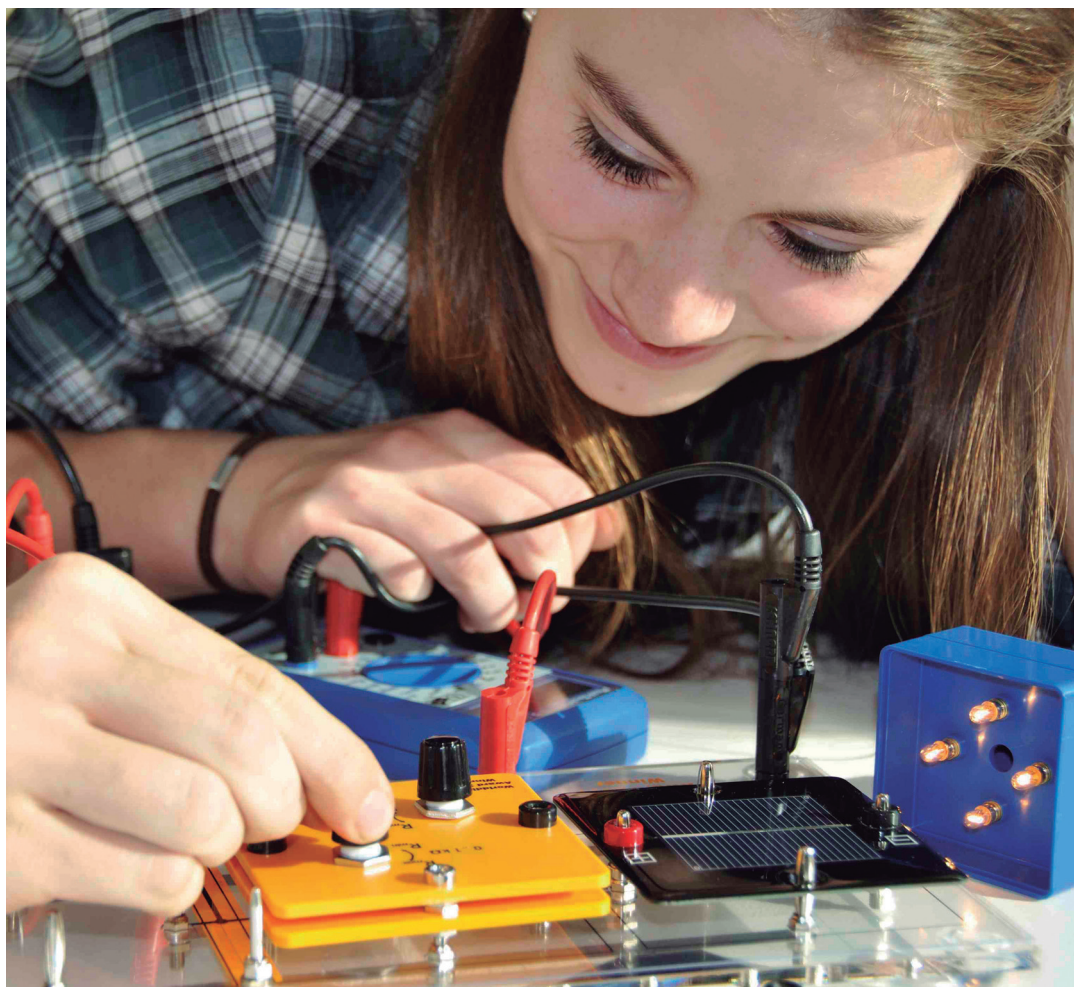
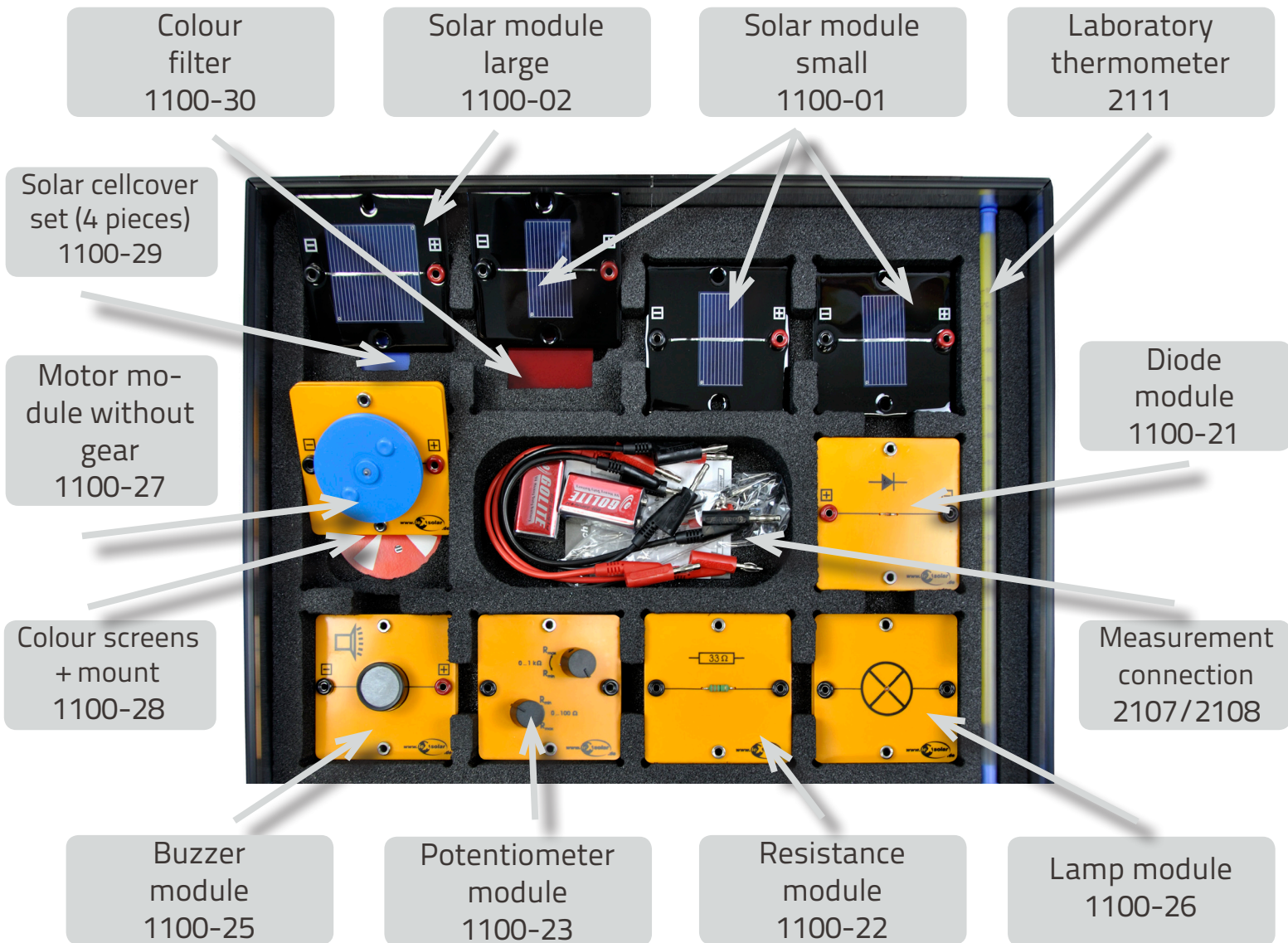


leXsolar-PV Ready-to-go



Instructions Manual

Layout diagram leXsolar-PV Ready-to-go



This layout diagram is valid for the lower tray of the suitcase. The layout diagram of the upper tray you can find on the back inside cover.



leXsolar-PV Ready-to-go

Student`s Manual

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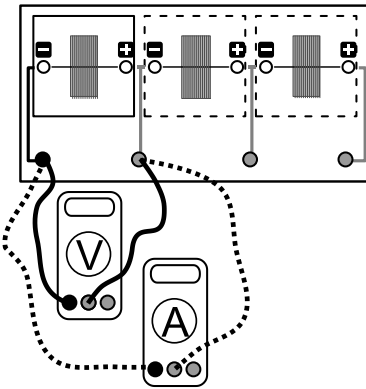


1. Series and parallel connection of solar cells

Task

Determine the behavior of the total voltage and the total amperage of series- and parallel- connected solar cells!

Setup



Required devices

- base unit
- 3 small solar cells
- voltmeter
- amperemeter

Preparation

In this experiment only short-circuit currents and open-circuit voltages are measured. These cannot be measured simultaneously; in order to measure the open-circuit voltage the circuit must be broken. Set up the experiment according to the circuit diagram!

Execution

1. Measure the current and voltage of one solar cell (see circuit diagram)!
2. Modify the circuit so that two resp. three solar cells are connected in series. Again, measure the current and voltage!
3. 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.
4. Record the measured data in a table!

Evaluation

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



1. Series and parallel connection of solar cells

Measured values

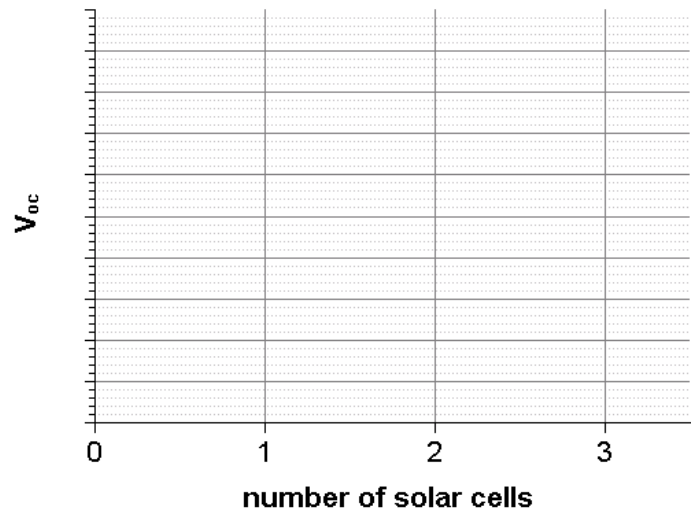
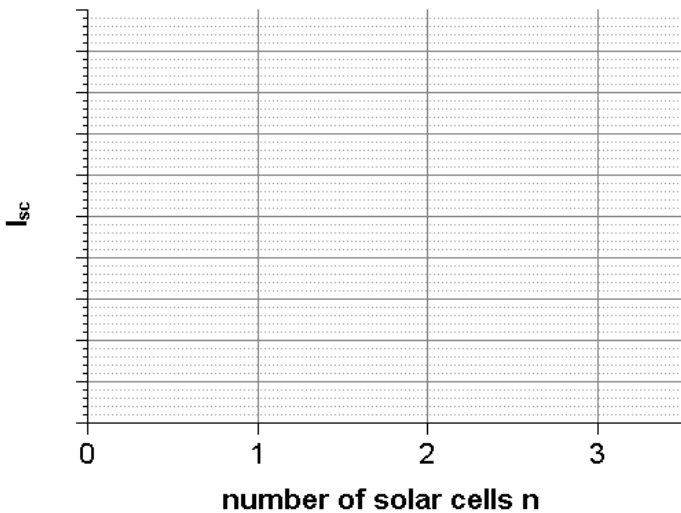
Series connection:

	one solar cell	two solar cells	three solar cells
V_{oc} (V)			
I_{sc} (mA)			

Parallel connection:

	one solar cell	two solar cells	three solar cells
V_{oc} (V)			
I_{sc} (mA)			

Diagrams



Evaluation

	voltage	current
series connection		
parallel connection		

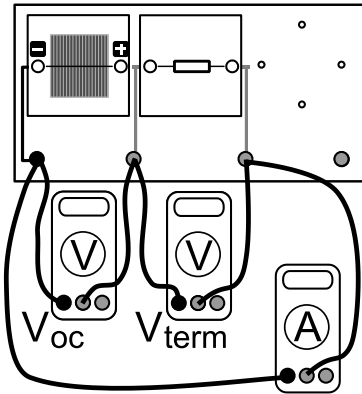


6. Dependence of the internal resistance on the illumination intensity

Task

Determine the internal resistance R_i of a solar cell and the dependence on the illumination level E !

Setup



Required devices

- base unit
- lighting module
- resistance module
- large solar cell
- amperemeter
- voltmeter
- power supply (6V)

Preparation

Set up the experiment according to the circuit diagram! Use only one of the lamps of the lighting module with 6V at first! The voltmeter to measure V_{oc} and $V_{terminal}$ can be switched during the measurement so that you only need one voltmeter.

Note: See the note at experiment L 4.1 dealing with the variation and the calculation of the illumination level.

Execution

1. Put the lighting module on the solar cell!
2. First measure the open-circuit voltage of the solar cell (while disconnecting the rest of the circuit), then measure the terminal voltage and current under load. Repeat the measurement with 2, 3 and 4 lamps in the lighting module! Record your results in a table!

Note: In order to avoid over-heating of the solar cell, the lighting module should not stay on the solar cell for too long.

Evaluation

1. Sketch the equivalent circuit diagram in which the internal resistance of the solar cell appears! Calculate the internal resistance for each number of lamps!

Note: $V_{oc} = V_{terminal} - I \cdot R_{internal}$

2. Sketch the $R_{internal}$ - E -diagram. What relation can be found?

Additional task:

3. Compare this experiment with experiment L 4.2 and explain the course of the $R_{internal}$ - E -curve!



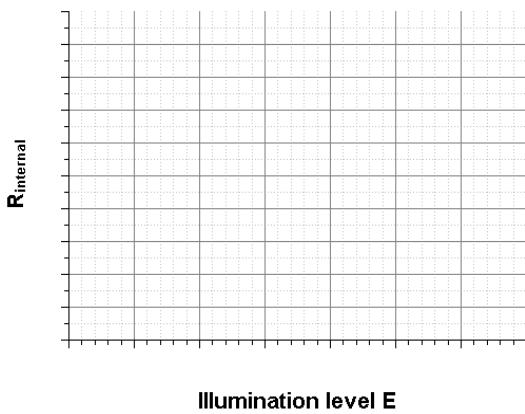
6. Dependence of the internal resistance on the illumination intensity

Measured values

	1 lamp	2 lamps	3 lamps	4 lamps
Illumination level E (W/m^2)				
V_{oc} (V)				
$V_{terminal}$ (V)				
I (mA)				
$R_{internal}$ (Ω)				

Circuit diagram

Diagrams



Evaluation

Explanation for the behavior:

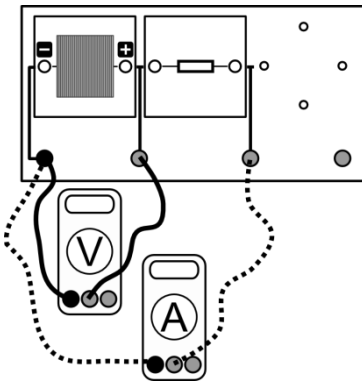


12. Dependence of the solar cell power on the frequency of the incident light

Task

What relation can be found between the power of the solar cell and the frequency of the incident light?

Setup



Required devices

- base unit
- large solar cell
- amperemeter
- voltmeter
- resistance module
- several colored glasses
- lighting module
- power supply (6V)

Preparation

1. The table given below lists the spectral range which is transmitted by each of the color filters. Use the values to calculate the energies of the transmitted photons!
2. In which spectral range do you expect the maximum power when assuming that all three filters transmit approximately the same number of photons (which holds true for the given filters)?

Execution

1. Set up the experiment according to the circuit diagram!
2. Place the lighting module on the solar cell and connect it to the power supply!
3. Cover the solar cell with the different color filters and measure the open-circuit voltage and short-circuit currents for each color! List the data in a table!

Evaluation

1. Calculate the power of the solar cell in each of the spectral ranges!
2. At which photon energy do you find the maximum power? Does this result correspond to your expectation?
3. How do you explain this effect?



12. Dependence of the solar cell power on the frequency of the incident light

Measured values

color filter λ	red 650 ... 800 nm	yellow 550 ... 700 nm	blue 400 ... 550 nm
$E_{photons}$ (eV)			
V (V)			
I (mA)			
$P=V \cdot I$ (mW)			

Evaluation

The power of the solar cell is at its maximum when illuminated with photons having an energy hf _____ ... _____ eV.

Reason:



13. Working with the leXsolar plugging module

Task

Get to know the leXsolar plugging module.

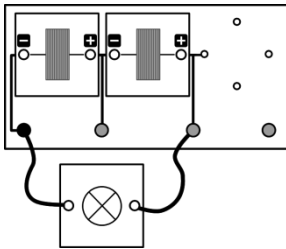
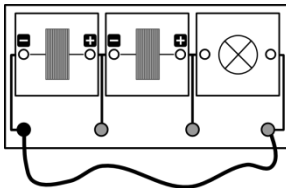
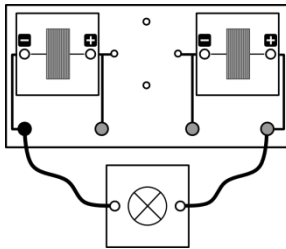
Required devices

- base unit
- 2 small solar cells
- light bulb module

Execution

Set up the circuits 1, 2 and 3 one after the other and check whether the lamps go on. Fill in the tables.

Evaluation

Circuit 1	Circuit 2	Circuit 3
 <p>Does the lamp light?</p> <p><input type="checkbox"/> yes <input type="checkbox"/> no</p>	 <p>Does the lamp light?</p> <p><input type="checkbox"/> yes <input type="checkbox"/> no</p>	 <p>Does the lamp light?</p> <p><input type="checkbox"/> yes <input type="checkbox"/> no</p>
<p>It is a:</p> <p><input type="checkbox"/> Series connection</p> <p><input type="checkbox"/> Parallel connection</p>	<p>It is a:</p> <p><input type="checkbox"/> Series connection</p> <p><input type="checkbox"/> Parallel connection</p>	<p>It is a:</p> <p><input type="checkbox"/> Series connection</p> <p><input type="checkbox"/> Parallel connection</p>

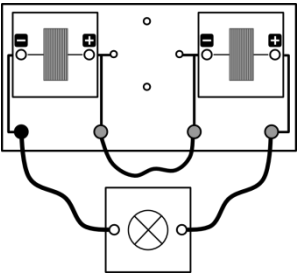
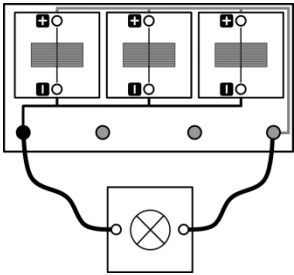
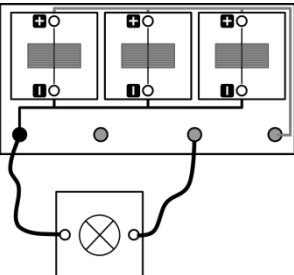
In order to decide whether it is a series or a parallel connection and to understand why the lamp does or does not light, you can draw the circuit diagrams by yourself on the next page:



13. Working with the leXsolar plugging module

Evaluation



Circuit 4	Circuit 5	Circuit 6
 <p data-bbox="129 1128 400 1164">Does the lamp light?</p> <p data-bbox="129 1189 400 1240"> <input type="checkbox"/> yes <input type="checkbox"/> no </p>	 <p data-bbox="512 1128 783 1164">Does the lamp light?</p> <p data-bbox="512 1189 783 1240"> <input type="checkbox"/> yes <input type="checkbox"/> no </p>	 <p data-bbox="892 1128 1163 1164">Does the lamp light?</p> <p data-bbox="892 1189 1163 1240"> <input type="checkbox"/> yes <input type="checkbox"/> no </p>
<p data-bbox="89 1317 177 1350">It is a:</p> <p data-bbox="89 1375 387 1426"> <input type="checkbox"/> Series connection </p> <p data-bbox="89 1458 397 1509"> <input type="checkbox"/> Parallel connection </p>	<p data-bbox="467 1317 555 1350">It is a:</p> <p data-bbox="467 1375 766 1426"> <input type="checkbox"/> Series connection </p> <p data-bbox="467 1458 780 1509"> <input type="checkbox"/> Parallel connection </p>	<p data-bbox="849 1317 936 1350">It is a:</p> <p data-bbox="849 1375 1147 1426"> <input type="checkbox"/> Series connection </p> <p data-bbox="849 1458 1158 1509"> <input type="checkbox"/> Parallel connection </p>

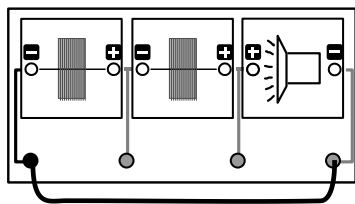
In order to decide whether it is a series or a parallel connection and to understand why the lamp does or does not light, you can draw the circuit diagrams by yourself here:





18.1 Differences in brightness 1

Setup



Required devices

- base unit
- 2 small solar cells
- buzzer module

Execution

Set up a series connection consisting of two solar cells and buzzer module as shown in the circuit diagram above. Go to the wall that is opposite of the window and slowly walk towards the window.

Evaluation

What do you observe?

Now cover a part of both solar cells (e.g. one half) with your hand. What happens?

Now cover a part of both solar cells (e.g. one half) with your hand. What happens?

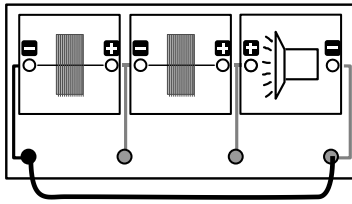
Questions:

1. Why do solar cells on rooftops usually point to the south?
2. Why shouldn't there be a large tree standing in front of the southern side of the roof?



18.2 Differences in brightness 2

Setup



Required devices

- base unit
- 2 small solar cells
- buzzer module

Execution

1. Set up a series connection consisting of the two solar cells and the buzzer module as shown in the above circuit diagram.
2. Bring the solar cell close to a lamp. (Pay attention that the solar cells are illuminated evenly!)
3. Take the solar cells away from the lamp again.

Evaluation

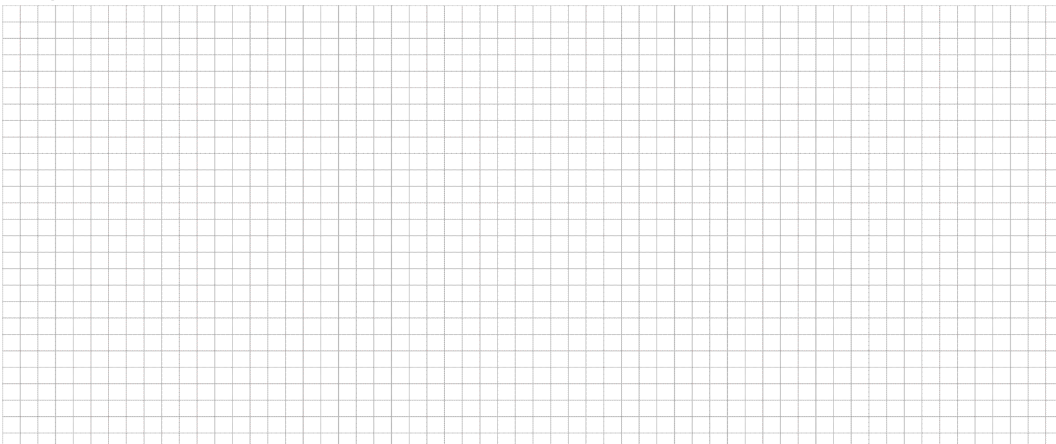
The closer the solar cells are to the lamp, the _____ is the buzzer.

Do a similar experiment during sunshine. What do you expect when bringing the solar cells closer to the sun?

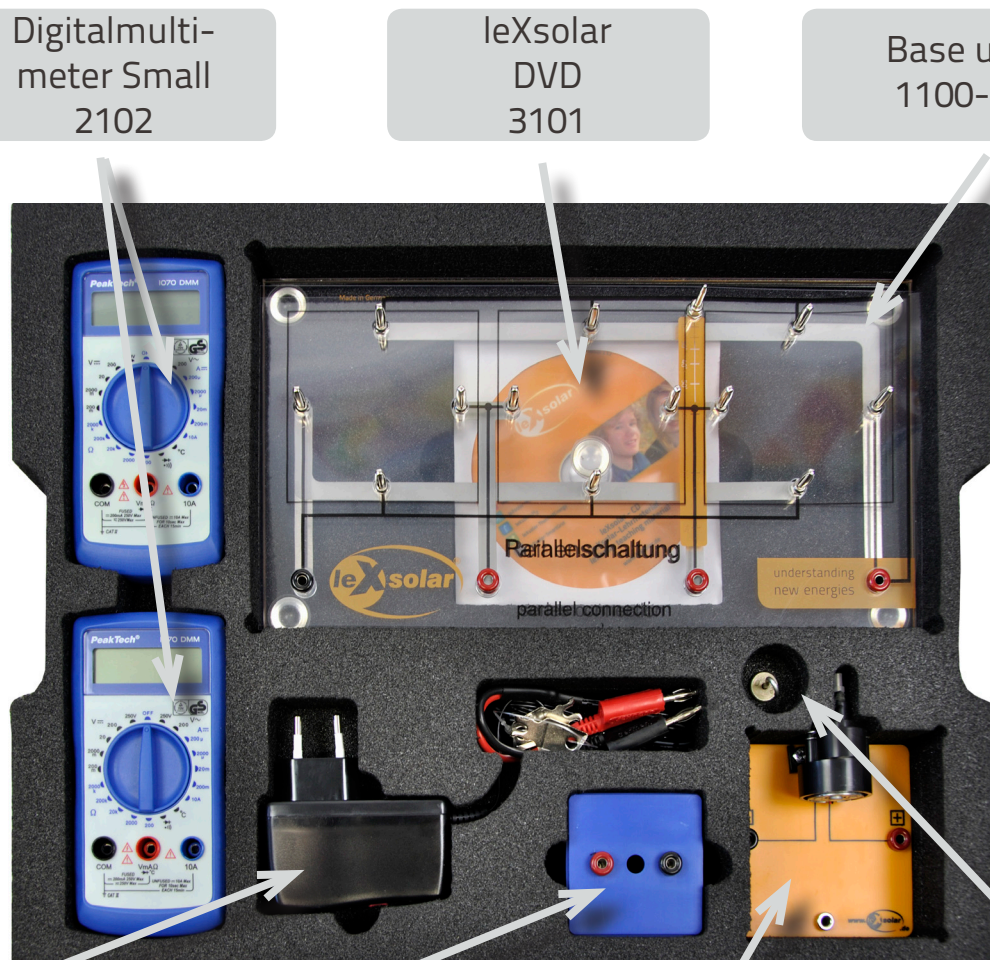
Are your expectations confirmed with the experiment?

How can this be explained through the light-beam-model? Draw a sketch for both experiments.

Note: Notice the distance between the sun and the solar cell in comparison with the distance between the lamp and the solar cell.



Layout diagram leXsolar-PV Ready-to-go



Digitalmulti-
meter Small
2102

leXsolar
DVD
3101

Base unit
1100-19

Power supply
2105

Lighting
module
1100-20

Motor module
with gear
1100-24

weight
for
1100-24



This layout diagram is valid for the upper tray of the suitcase. The layout diagram of the lower tray you can find on the front inside cover.



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