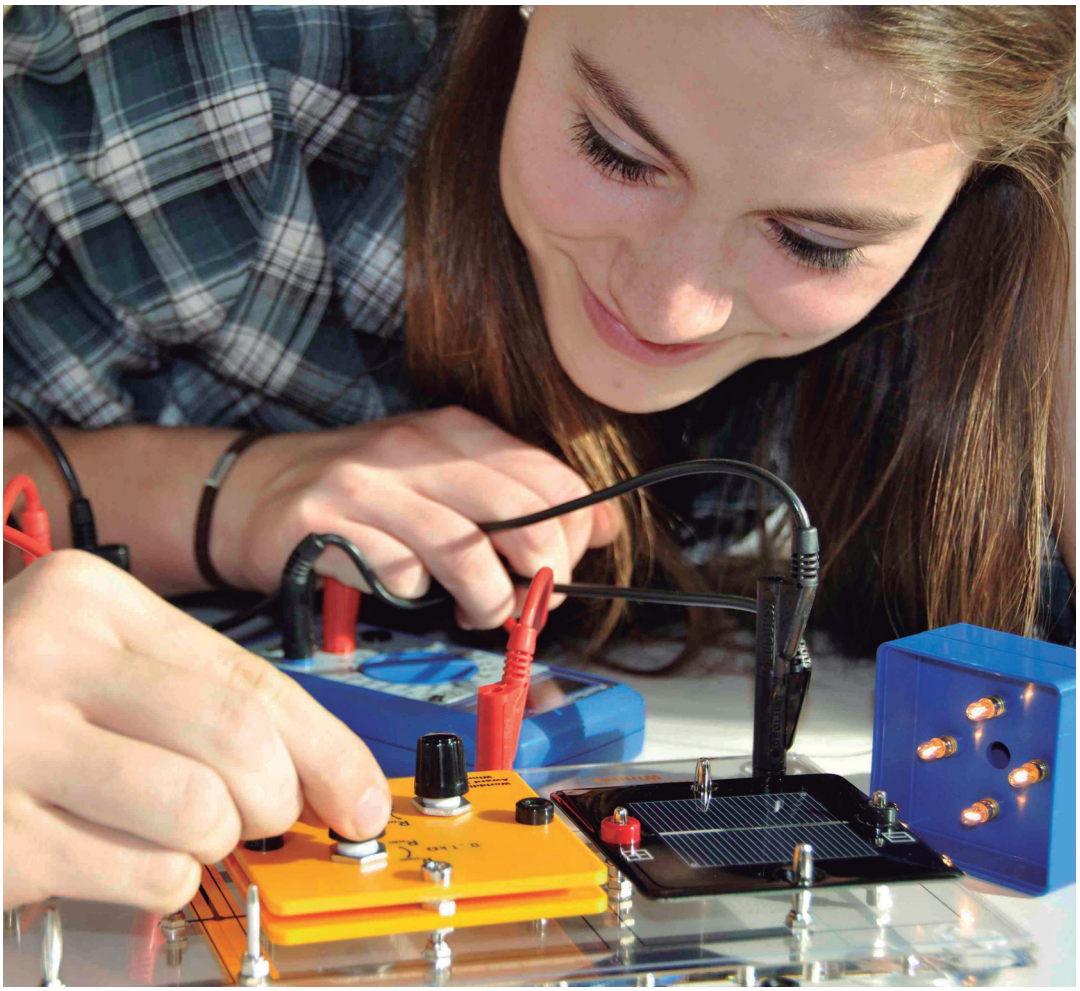
leXsolar-PV Ready-to-go



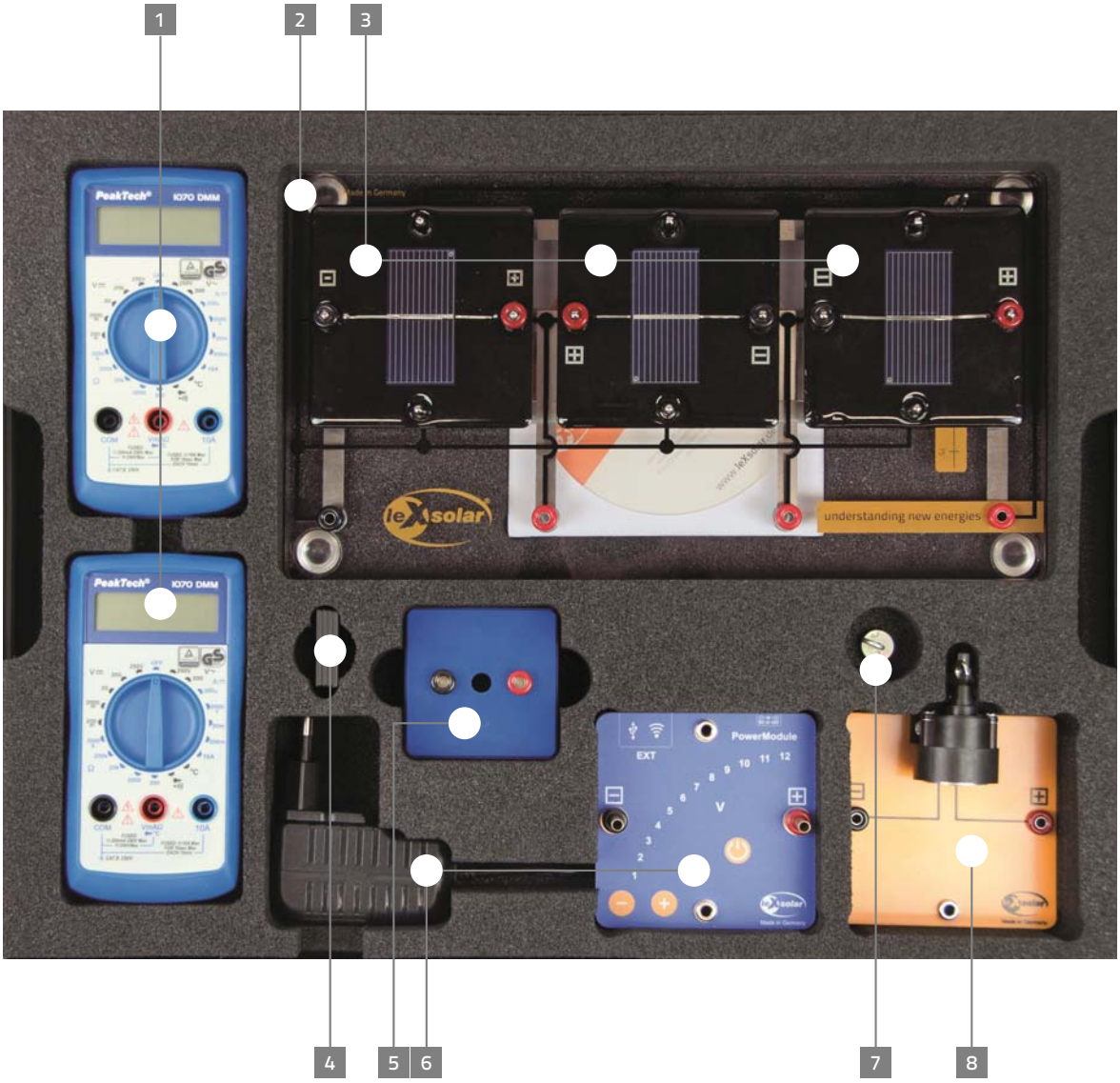
Instructions Manual

Layout diagram leXsolar-PV Ready-to-go

Item-No.1105

Bestückungsplan leXsolar-PV Ready-to-go

Art.-Nr.1105



1	2xL2-06-011 Digital multimeter 2xL2-06-011 Digitalmultimeter	5	1100-20 Lighting module 1100-20 Beleuchtungsmodul
2	1100-19 leXsolar-Base unit 1100-19 leXsolar Grundeinheit groß	6	9105-05 PowerModul with power supply 9105-05 PowerModul mit Stromversorgungsgerät
3	3x1100-01 Solar module 0.5 V, 420 mA 3x1100-01 Solarmodul 0.5 V, 420 mA	7	L2-05-024 Hook weight 20g L2-05-024 Hakengewicht 20g
4	1100-29 Solar cell cover set 1100-29 Satz Abdeckung f. Solarzelle	8	1100-24 Gear motor module 1100-24 Getriebemotormodul

Version number
Versionsnummer

L3-03-130_30.05.2016

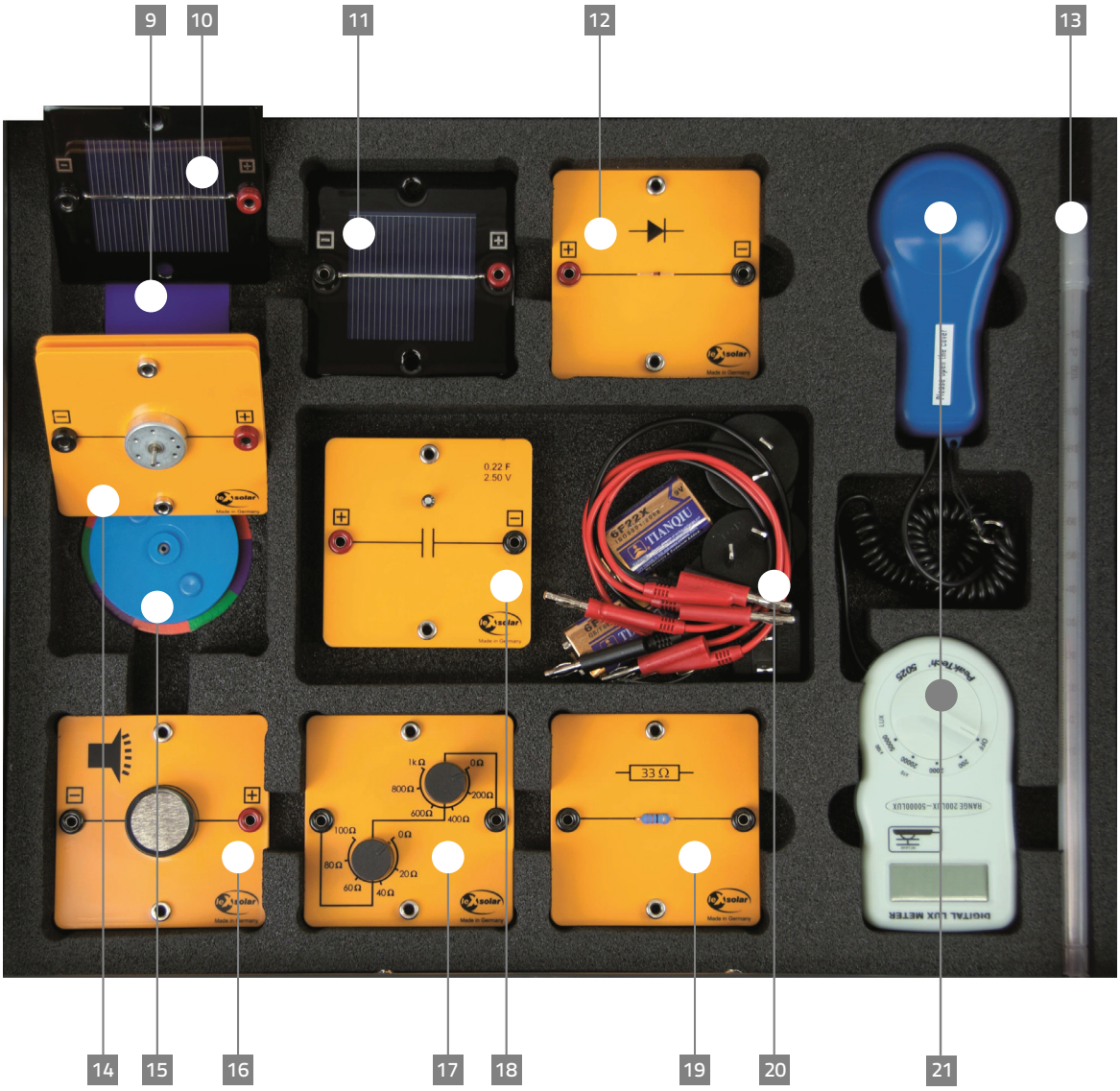
CE RoHS2

Layout diagram leXsolar-PV Ready-to-go

Item-No.1105

Bestückungsplan leXsolar-PV Ready-to-go

Art.-Nr.1105



9 1100-30 Color filters
1100-30 Satz Farbfilter

10 1100-02 Solar module 1.5 V, 280 mA
1100-02 Solarmodul 1.5 V, 280 mA

11 1100-07 Solar module 0.5 V, 840 mA
1100-07 Solarmodul 0.5 V, 840 mA

12 1100-21 Diode module
1100-21 Diodenmodul

13 L2-06-016 Laboratory thermometer
L2-06-016 Laborthermometer

14 1100-27 Motor module
1100-27 Motormodul

15 1100-28 Color discs with mount-Set I
1100-28 Farbscheiben-Set I

16 1100-25 Buzzer module
1100-25 Hupenmodul

17 1100-23 Potentiometer module
1100-23 Potentiometermodul

18 1400-07 Capacitor module 220 mF, 2.5 V
1400-07 Kondensatormodul 220 mF, 2.5 V

19 1100-22 Resistor module
1100-22 Widerstandsmodul

20 L2-06-012 Test lead 25 cm, black
L2-06-012 Messleitung 25 cm, schwarz
L2-06-013 Test lead 25 cm, red
L2-06-013 Messleitung 25 cm, rot
2xL2-06-014 Test lead 50 cm, black
2xL2-06-014 Messleitung 50 cm, schwarz
2xL2-06-015 Test lead 50 cm, red
2xL2-06-015 Messleitung 50 cm, rot

21 L2-06-034 Luxmeter
L2-06-034 Luxmeter

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leXsolar-PV Ready-to-go

Student`s Manual

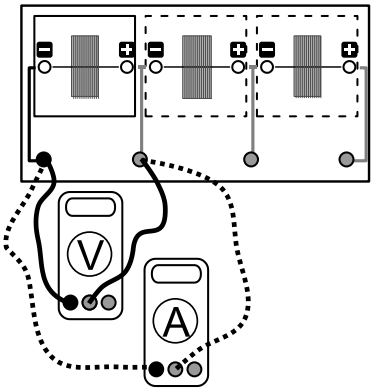
Content

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

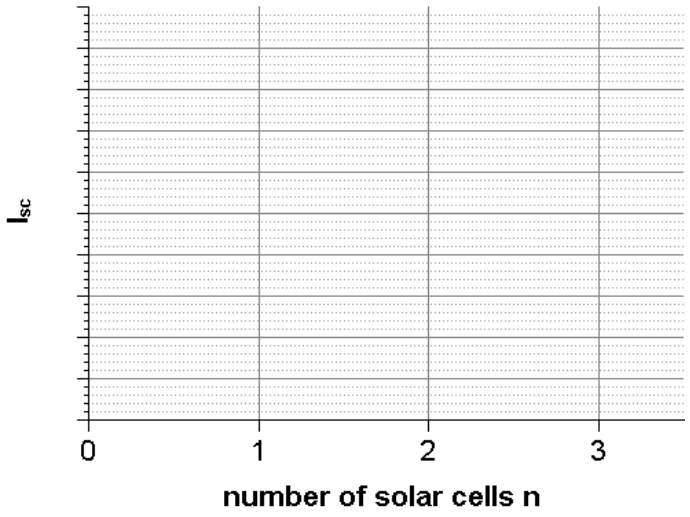
Series connection:

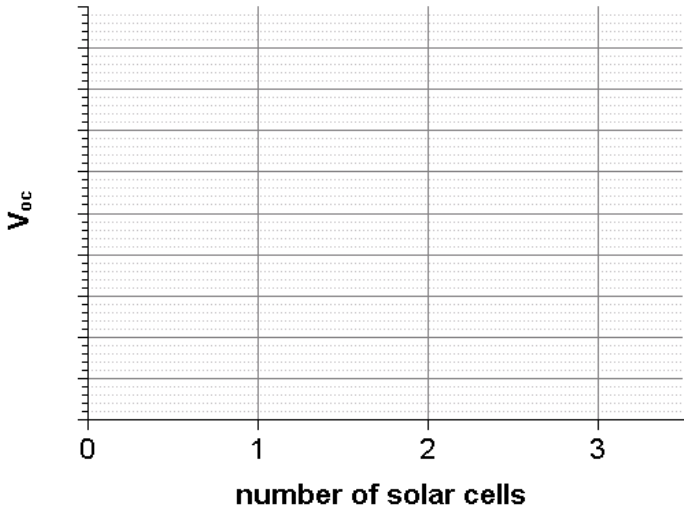
	one solar cell	two solar cells	three solar cells
V_{oc} (V)			
I_{sc} (mA)			

Parallel connection:

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

Diagrams





Evaluation

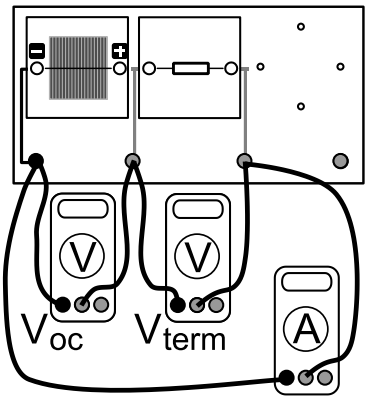
	voltage	current
series connection		
parallel connection		

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!

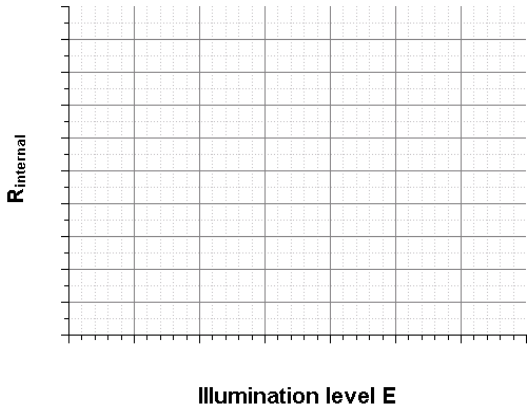
6. Dependence of the internal resistance on the illumination intensity

Measured values

	1 lamp	2 lamps	3 lamps	4 lamps
Illumination level E (W/m²)				
V_{oc} (V)				
$V_{terminal}$ (V)				
I (mA)				
$R_{internal}$ (Ω)				

Circuit diagram

Diagrams



Evaluation

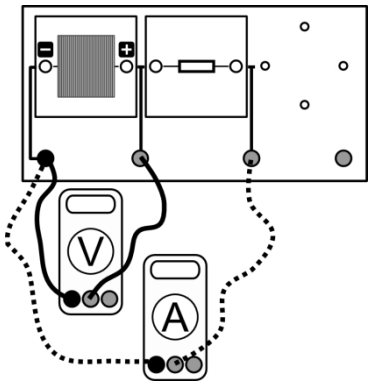
Explanation for the behavior:

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.

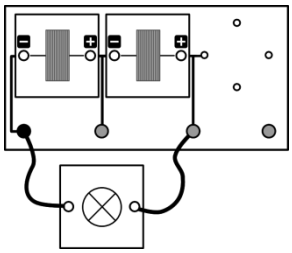
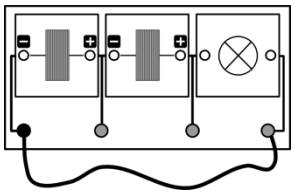
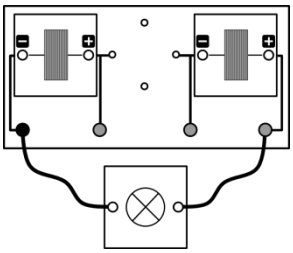
Required devices

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

Execution

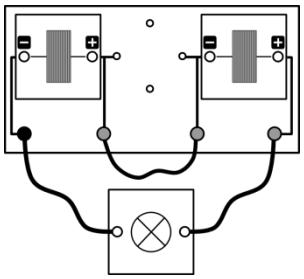
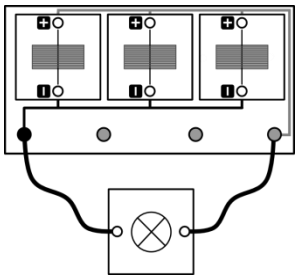
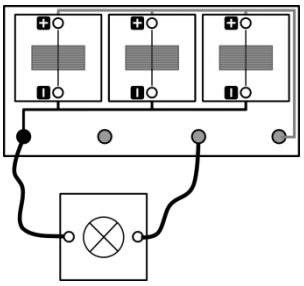
Set up the circuits 1, 2 and 3 one after the other and check whether the lamps go on. Fill in the tables.

Evaluation

Circuit 1	Circuit 2	Circuit 3
		
Does the lamp light? ☐ yes ☐ no	Does the lamp light? ☐ yes ☐ no	Does the lamp light? ☐ yes ☐ no
It is a: ☐ Series connection ☐ Parallel connection	It is a: ☐ Series connection ☐ Parallel connection	It is a: ☐ Series connection ☐ Parallel connection

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:

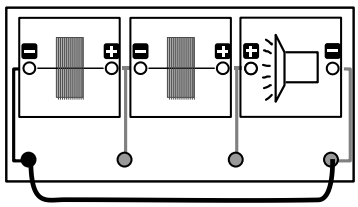
Evaluation

Circuit 4	Circuit 5	Circuit 6
		
Does the lamp light? ☐ yes ☐ no	Does the lamp light? ☐ yes ☐ no	Does the lamp light? ☐ yes ☐ no
It is a: ☐ Series connection ☐ Parallel connection	It is a: ☐ Series connection ☐ Parallel connection	It is a: ☐ Series connection ☐ Parallel connection

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?

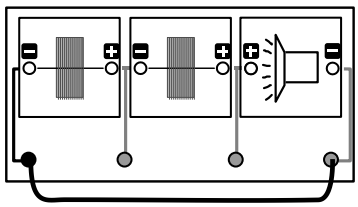
Now cover a part of both solar cells (e.g. one half) with your hand. What happens?

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.

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