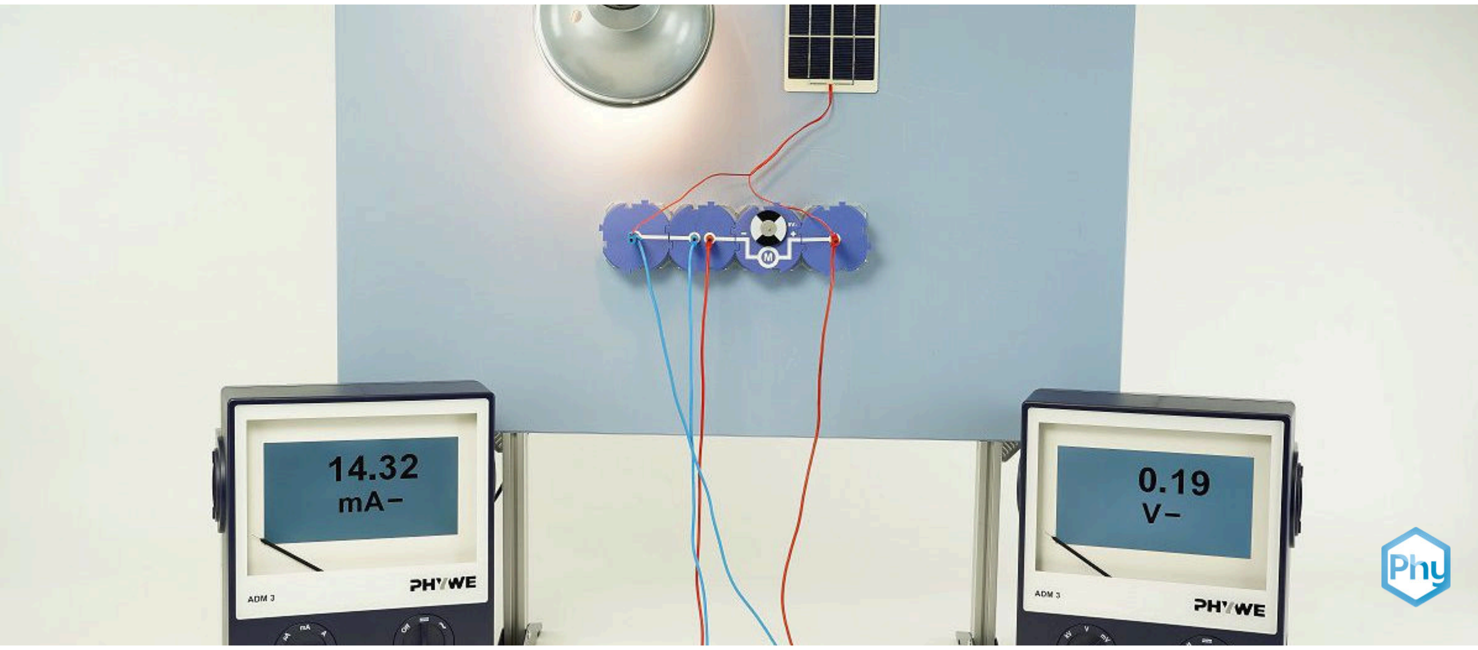
Converting light into motion using a solar cell with ADM3



Physics | Energy | Energy forms, conversion & conservation

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/6167de172d1cf30003518bef

General information

Application

Source photo: wikipedia

Photovoltaic systems can absorb light energy and convert it into electricity. In the summer months, however, photovoltaic systems can heat up considerably, e.g. to 80 °C. If a power loss of about 5 % per 10 °C is calculated, their output in this case would be about 1/4 lower than the rated value at 25 °C. Cooling the system is therefore very important. This is done either by air circulation at the rear or by means of water pipes. The heated water is either used directly (showers, swimming pool), stored (e.g. geothermal storage), or used to air condition rooms with the help of a chiller.

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Other information (1/2)

Previous knowledge

Solar energy can be converted into electrical energy with the help of a solar cell. This is a very important form of energy both in the home and in industry, as it can be easily converted into other forms of energy, such as heat, light or mechanical energy (motion).

Principle

Solar cells convert sunlight into electricity. With high light intensity and long illumination time, solar cells heat up and their performance decreases. This effect can be shown in the second part.

Other information (2/2)

Learning objective

In the experiment, a small electric motor is operated with a solar battery. The experiment consists of two parts. In the first part, electrical power and work are measured simultaneously under different lighting conditions, so that the relationship between the two variables can be demonstrated very clearly and evaluated quantitatively. In the second part, the students should see that the power decreases as the temperature rises.

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Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

For H- and P-phrases please refer to the safety data sheet of the respective chemical.

Theory

The solar cell plays an important role in the development of alternative, non-fossil energy sources. It directly converts light energy into electrical energy.

A solar cell consists of a p-doped and an n-doped layer. When light falls on them, free charge carriers are created, which are forced outwards by the electric field and thus generate a voltage.

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Demo Physics board with stand	02150-00	1
2	PHYWE Demo Multimeter ADM 3: current, voltage, resistance, temperature	13840-00	2
3	Junction, module DB	09401-10	2
4	Motor with indicating disc, 5 V, module DB	09469-00	1
5	Solar battery, with cable, connectorsand magnet pads	06752-23	1
6	Scale for demonstration board	02153-00	1
7	Clamp on holder	02164-00	1
8	Support rod, stainless steel, 750 mm	02033-00	1
9	Ceramic lamp socket E27, with reflector, switch and security plug	06751-01	1
10	Filament lamp, 220V/120W, with reflector	06759-93	1
11	Connecting cord, 32 A, 250 mm, blue	07360-04	1
12	Connecting cord, 32 A, 500 mm, yellow	07361-02	1

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Set-up and procedure

Set-up (1/2)

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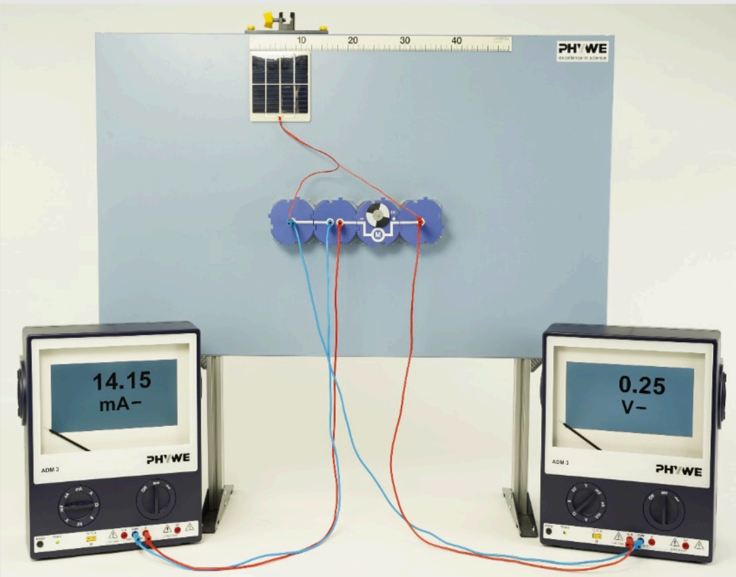

- Set up the circuit according to the illustration.
- Connect the plug of the solar battery in series with the motor.
- To measure the current, connect the left ADM3 in series.

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Set-up (2/2)

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- Above the solar battery on the upper edge of the panel, carefully screw the sleeve to the support.
- Fix the tripod rod of the lamp in it and align the lamp with the solar battery.
- The distance between the center of the solar battery and the front of the lamp should be about 35 cm.
- Place the magnetically adhesive scale vertically on the board so that the zero is at the top edge of the solar battery.

Procedure (1/4)

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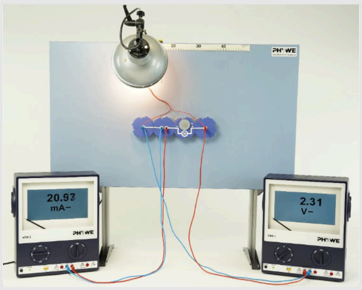

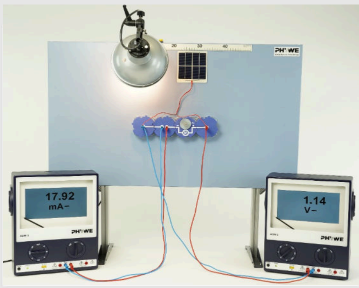

Relationship between performance and work

- Switch on the lamp and the ADM3 multimeter.
- After 1 min, note the voltage and current with the multimeter (distance 35cm).
- Now move the solar battery by 22cm.
- Wait 1 minute and note the voltage and current again.
- Finally, move the solar battery again by 5cm and note the same measurement data after 1 min

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Procedure (2/4)

The qualitative context of performance $P$and work W can already be calculated during the measurement. The following formulas are now to be used to determine a correlation at constant illumination.

$$P = U \cdot I$$

(Power = Voltage · Current)

$$W = P \cdot t$$

(Work = power · Time)

Enter the values in the table:

Position in [cm]	$P\,[mW]$	$W\,[mWmin]$
0		
+ 22		
+ 5		

Procedure (3/4)

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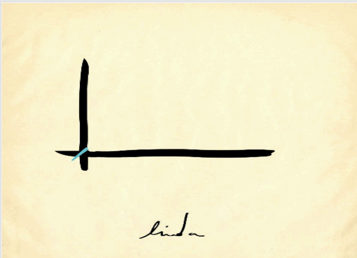

Power of the solar battery during heating

Before this measurement, the solar battery and the wall behind it must be as cold as possible. To cool down to room temperature, wait for about 2 to 5 min after the previous part of the experiment.

Alternatively, a jet of cold air from a cold air blower can be directed onto the surface of the solar battery for approx. 1 to 2 min.

- Shorten the distance between the lamp and the solar battery to 30 cm and align the lamp optimally with the solar battery again.
- Switch on the lamp and enter the voltage and current over 7 minutes in the table on the next page.

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Procedure (4/4)

About the already known formula for the power P can now be taken a connection about the power in relation to time.

$$P = U \cdot I$$

(Power = Voltage · Current)

Enter the values in the table!

$t\,[min]$	$U\,[V]$	$I\,[mA]$	$P\,[mW]$
+ 1			
+ 2			
+ 3			
+ 4			
+ 5			
+ 6			
+ 7			

Evaluation (1/2)

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Test part 1

Relationship between performance and work

Drag the words into the correct boxes!

At constant illumination, the power of the motor is (approximately) ______ and the electrical work increases ______ with time. At lower illumination, the power of the motor becomes ______. The mathematical relationship between work and power holds: ______.

smaller | linearly | constant | $W = P \cdot t$

Check

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Evaluation (2/2)

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Test part 2

Power of the solar battery during heating

If the solar battery is illuminated for a long time with high light intensity,

- the power increases gradually.
- the power remains constant.
- the power output gradually decreases.

Slide	Score / Total
Slide 15: Relationship between performance and work	**0/4**
Slide 16: Relationship during heating	**0/3**

Total score 0 / 7

Show solutions | Repeat | Export text

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