Tasks
Model 6 – Functional model / Solar energy

Construction task Model 6

Build model 6 according to the instructions. Observe the following points:

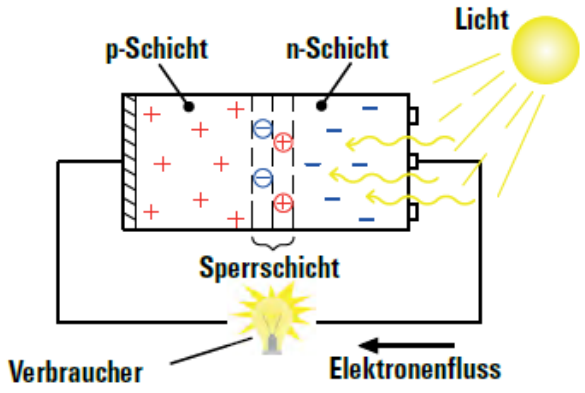
- Use a sufficiently strong artificial light source for your experiments (such as an incandescent bulb or halogen spotlight over 60 watts).
- Always keep a minimum distance away from the light source (depending on the light intensity, at least 30 cm), since the solar modules can become very hot.

Basic solar cell

A solar cell or photovoltaic cell is an electrical component that converts the radiant energy in the light directly into electric energy (direct current). Because we are using sunlight here, this is by definition a renewable energy source. The physical basis of the conversion is the photovoltaic effect.

Most solar cells are made of the semiconductor silicon. The silicon blocks are cut into slices approx. 0.5 millimetres thick. The slices are then contaminated with different foreign atoms, meaning they are purposefully contaminated to cause an imbalance in the silicon structure. This creates two layers, the positive p-layer and the negative n-layer.

To put it simply, the flow of electricity in the solar cell is created when electrons from the negative n-layer move to the positive p-layer after having been excited by the incident light, via the connected device (such as a solar motor, LED). The more light (or energy) hits the cell, the more the electrons move.



p-Schicht	p-layer
n-Schicht	n-layer
Licht	Light

Sperrschicht	Barrier layer
Verbraucher	Device
Elektronenfluss	Flow of electrons

Each solar module consists of two solar cells, connected in parallel. Each cell delivers a voltage of 1 V and a maximum current of 440 mA.

The solar motor has a rated voltage of 2 V, but begins turning at 0.3 V (start-up voltage) (idling, meaning that the shaft of the motor does not have to drive a model).

Topic task

1. Solar technology allows us to use the sun's energy in many different ways. What types of use are there?
2. What type of use did you build the functional model for? What specialist term is used to describe this use?

In general, we can differentiate between direct and indirect sunlight. Direct sunlight strikes the solar module directly, and is the strongest. Indirect or diffuse sunlight is when clouds cover the sun, or if the light is reflected.

The angle of incidence between the sunlight and solar module can also change, depending on the time of day and the season.

Experimental task 1

1. When converting power generation to photovoltaics, researchers ask themselves how they can achieve the best possible efficiency.

   Test structure:

   - Use just one solar module for this experiment
   - Direct a light source towards the solar module
   - Do not change the distance between the light source and solar module
   - The button is closed
   - A geo-triangle can help you determine the angle

   Use the adjusting lever to change the angle of the solar module to the light source, and measure the voltage (V) to find out the angle of incidence for the light at which the solar module delivers the most energy.

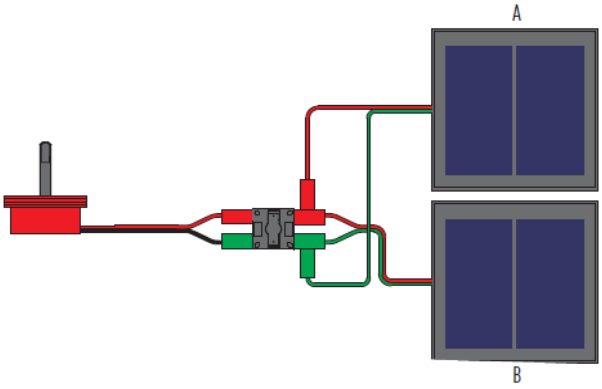
2. Use the adjusting lever to change the angle of the solar module to the light source, and find out from which voltage the motor under load turns the indicator, and how much current is flowing when it does.

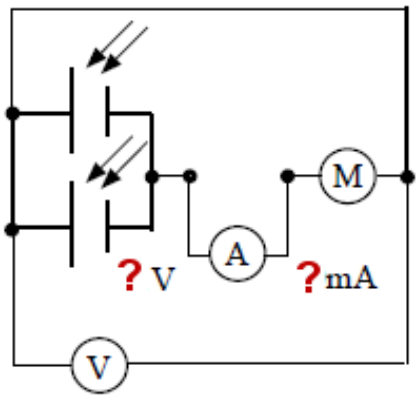
You will find that the motor cannot produce very much force if it is operated with only one solar module.

Additional solar modules can be connected in different ways. The overall effect of doing so will depend on whether they are connected in parallel or in series.

Experimental task 2

1. Now, connect the second solar module in parallel with the first module. The button is not shown on the image.





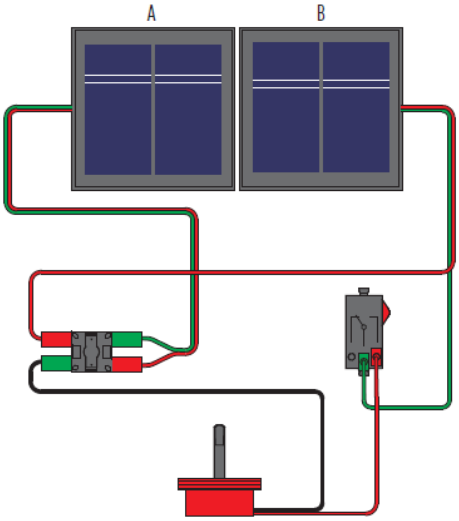
Measurement setup

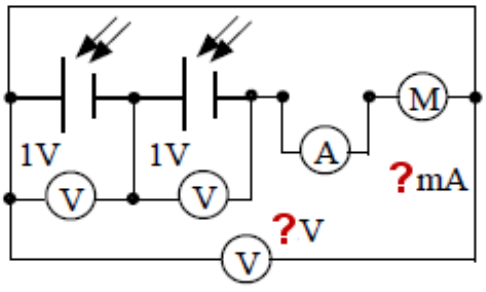
What happens to the voltage (V) and amperage (A) when both modules are connected in parallel?

2. Reduce the distance to the light source first with one module and then with two modules connected in parallel. Find out which motor variant (under load) can make the indicator move first.
3. In your observation, does the change affect the speed or torque of the motor?

Experimental task 3

1. Now, connect the second solar module in series with the first module.





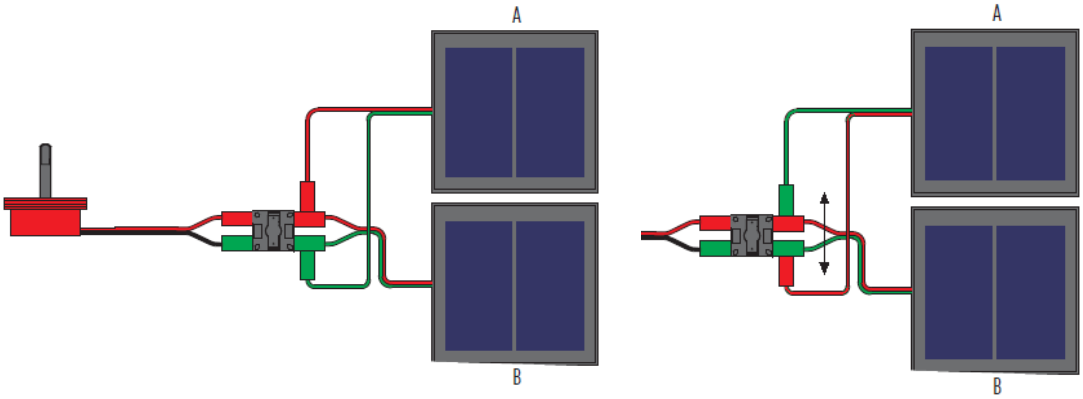
Measurement setup

What happens to the voltage (V) and amperage (A) when both modules are connected in series?

2. Compare the rotational speed of the indicator between parallel and series connection with the same distance from the light source. What can you conclude from this?
3. Cover one solar module with a piece of paper or with your hand while the run indicator is turning. Do so both with the modules connected in parallel and with them connected in series. What can you observe while *shadowing the modules*?
4. Under what lighting circumstances is a parallel connection better than a series connection for your fischertechnik models?

Experimental task 4

1. Now you are an expert in wiring solar modules. There is a third option for connecting the modules to one another. This is called antiparallel wiring. To do so, change the wiring used in parallel connection by exchanging the red and green plugs on the second solar module.



What effect does antiparallel wiring have when you shadow the individual modules?

2. What is the electrical component that triggers the same effect called?

Solar vehicle construction task

To test out the different types of wiring, you can build the solar vehicle model for the following experiments.

Experimental task 5

What type of wiring did you choose, and why?

Storage of electrical energy - Goldcap

Unfortunately, our solar vehicle stops working as soon as they are away from the light source or in a shadow.

However, we can use an energy storage device to convert our solar car to an electric vehicle and operate it independently of the sun's energy.

The **Goldcap** contained in the building set is one such energy storage option. It consists of two pieces of activated carbon that are separated from one another by only a thin layer of insulation. The Goldcap stands out for its extremely high capacity. The capacitor you are using has a capacity of 10 F (Farad).

You can use the Goldcap like a small battery. The advantage it has over a battery is that you can charge the Goldcap very quickly; it cannot be overloaded, and does not undergo deep discharge.

Note:

The Goldcap may never be connected to a voltage greater than 2.3 V; otherwise, it may explode! Never connect the Goldcap to a normal 9 V fischertechnik power supply.

When mounting the plug on the Goldcap, you must ensure the plug's polarity is correct (connect the red plug to the plus terminal).

Goldcap solar filling station construction task

Before we can use the Goldcap, it needs to be charged up. To do so, we will use the Goldcap filling station model from the building instructions.

- Note that the red plug on the Goldcap (+) must be connected to the red plug on the solar module.
- Ensure the light source is the correct distance from the solar module, so that the solar module does not become overheated or damaged.
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Experimental task 6

1. Measure the voltage on the Goldcap while charging. What is the maximum amount the Goldcap can be charged using the solar module?
2. What happens if the solar module is covered by a shadow during the charging process?
3. What trick can you use to check the charge level of the Goldcap even without a measurement device?
4. What would be an alternative way to charge the Goldcap, besides solar power?

Electric vehicle construction task

After charging, connect the Goldcap to the vehicle motor instead of the solar cells. See the Electric vehicle building instructions.

Experimental task 7

1. How can you optimise your electric vehicle so it will drive farther?

Optional:

- Use the Goldcap with other fischertechnik models.
- You can test out different experimental setups with model 6.
    a. Solar module → Goldcap → Motor
    b. Solar module → Fuel cell → Voltage converter → Motor