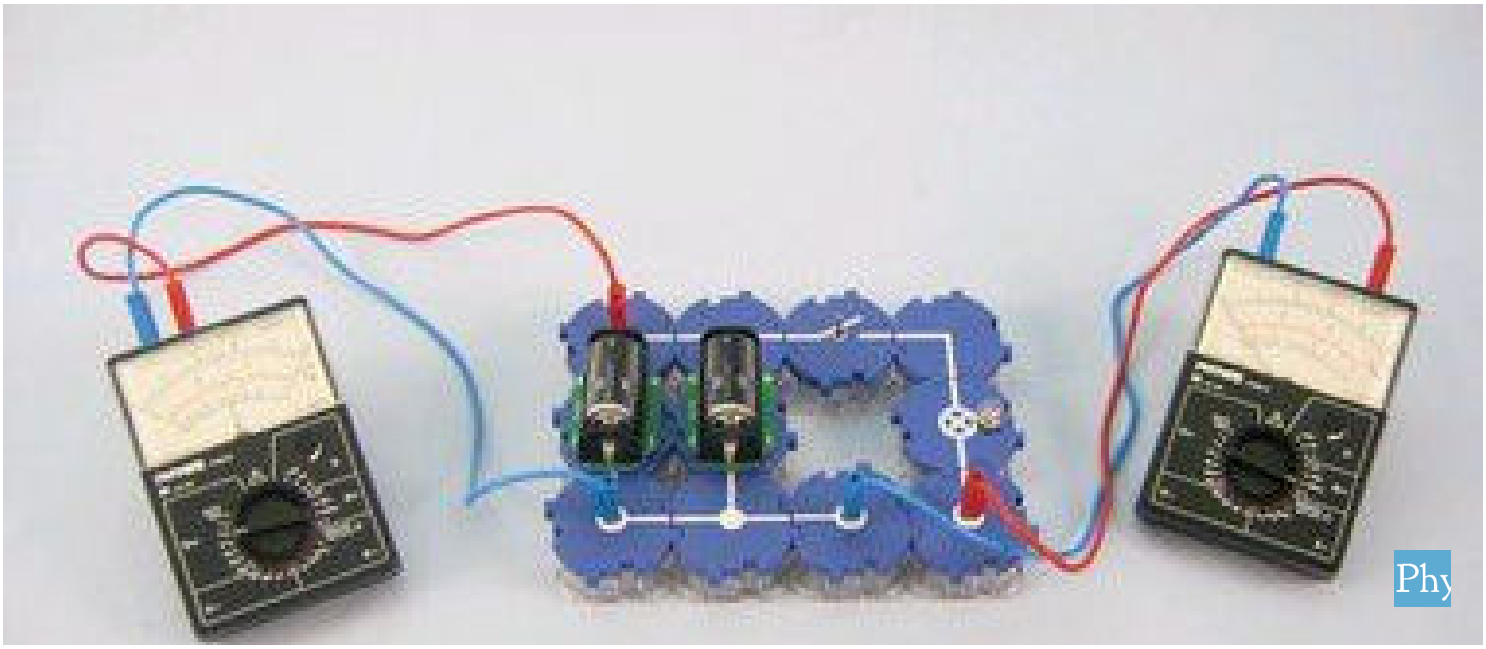
Parallel and series connection of voltage sources



Physics > Electricity & Magnetism > Simple circuits, resistors & capacitors

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

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Teacher information

Application

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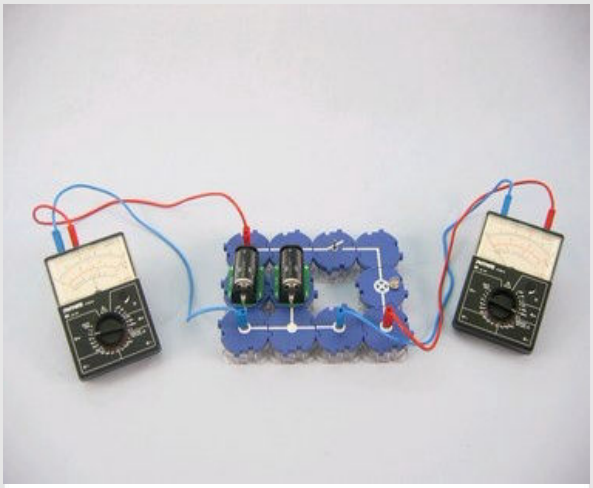

Experiment set-up

In everyday life, it is often the case that several monocells have to be connected together to form batteries to supply power to mobile electrical devices. The application examples are very diverse: drills, flashlights, radios, children's toys and much more.

Note: Originally, the term battery was actually used to describe the interconnection of several mono cells. In colloquial language, however, individual mono cells are often referred to as 'battery'.

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Other teacher information (1/3)

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Prior knowledge

The students should already know the structure of a simple circuit with a battery. They should also know terms such as current and voltage and be able to determine these safely.

Scientific principle

With the Kirchhoff rules the circuits can be explained. The node rule says that all currents which enter a node must also flow out again. The mesh rule says that all partial voltages within a mesh add up to zero. From this follows:

Series connection of batteries:

$U_{ges} = \sum_{i=1}^{n} U_i$

Parallel connection of batteries:

$I_{ges} = \sum_{i=1}^{n} I_i$

Other teacher information (2/3)

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Learning objective

Students should learn what difference it makes when two batteries are connected in series or parallel.

Tasks

The students connect two batteries in series and then in parallel and examine how this affects the voltage and current to be measured in the circuit.

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Other teacher information (3/3)

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The bulb 6 V / 0.5 A is recommended for this test because its resistance is relatively small and therefore measurable voltage drops under load can be expected.

The explanation for the fact that the operating voltage (voltage under load) is lower than the open-circuit voltage should only be given once the influence of the internal resistance of a voltage source on its load capacity has been worked out.

The readings obtained by the students can vary relatively widely, as they depend on the condition of the monocells used. The fresher (unused) the monocells are, the lower the effect on the voltage. The monocells can also have an open circuit voltage above 1.5 V, depending on the make. In this case the measuring ranges used may have to be increased.

Safety instructions

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

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Student Information

Motivation

Batteries

Even though more and more ion batteries are being installed in mobile electrical devices, batteries are still very often used. This is the case, for example, with flashlights, children's toys or devices such as wireless headphones or controllers. You have probably changed batteries before. As you know, batteries serve as a power source. You can connect several batteries in different ways: parallel and series connection have different benefits.

In this experiment you will learn about these differences.

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Tasks

What can be achieved by series and parallel connection of voltage sources?

Connect two batteries first in series and then in parallel in a simple circuit with a load and examine how this affects the voltage and current.

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Equipment

Position	Material	Item No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	1
3	T-shaped connector module, SB	05601-03	2
4	Interrupted connector module with sockets, SB	05601-04	2
5	Junction module, SB	05601-10	2
6	Angled connector module with socket, SB	05601-12	2
7	On-off switch module, SB	05602-01	1
8	Socket module for incandescent lamp E10, SB	05604-00	1
9	Battery holder module (C type), SB	05605-00	2
10	Connecting cord, 32 A, 500 mm, red	07361-01	2
11	Connecting cord, 32 A, 500 mm, blue	07361-04	2
12	Battery cell, 1.5 V, baby size, type C	07922-01	2
13	Filament lamps 3.5V/0.2A,E10, 10	06152-03	1
14	Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	2

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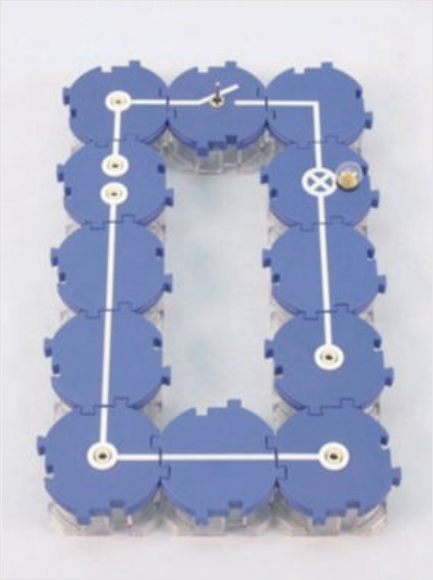
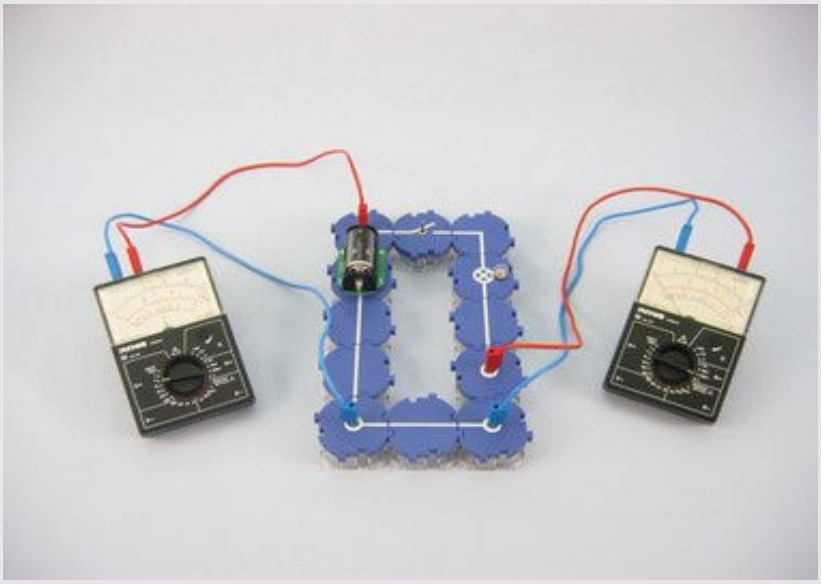
Set-up (1/3)



- First build the circuit for the test according to the adjacent figures.
- The switch should first be open and the 12 V bulb screwed into the lamp socket.

Set-up (2/3)



- Insert the battery in the holder and connect a voltmeter (left) and an ammeter (bottom right) to your circuit.
- Use the measuring ranges 3 V- and 300 mA-.

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Structure (3/3)

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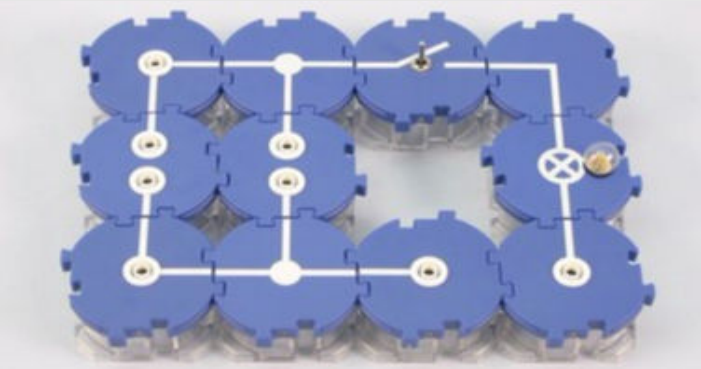
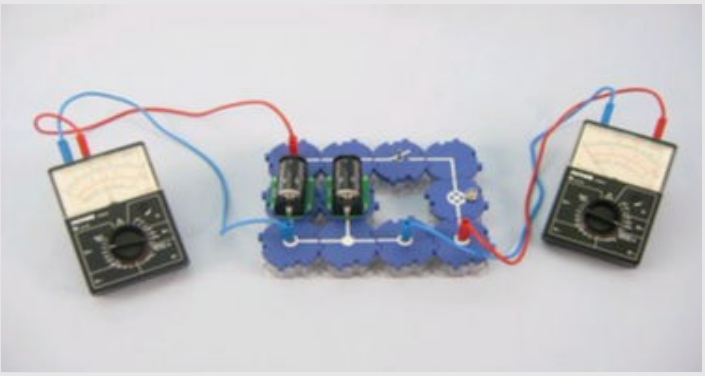
Below you see the experimental setup for the second part of the experiment. Here two batteries are to be connected in parallel. The voltmeter is connected in parallel to the batteries (left) and the ammeter is connected in series again (right).





Procedure (1/3)

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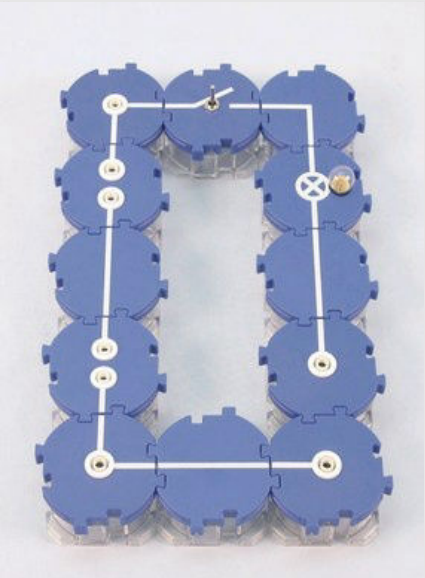

- Measure the so-called open-circuit voltage when the switch is open U_L and note the measured value in the protocol.
- Close the switch and measure both the current I as well as the stress under load U_B. Observe the brightness of the bulb. Note the measured values.
- Open the switch and connect a second battery in series to the first by changing the circuit as shown opposite. The positive pole of the first battery is connected to the negative pole of the second.

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Implementation (2/3)

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- Measure the open circuit voltage again U_L.
- Close the switch and determine U_B and Iwhile you observe the brightness of the light bulb.
- With the switch open, turn one of the two batteries 180° so that either both positive poles or both negative poles are connected.
- Measure again as before first the open circuit voltage U_L and after closing the switch U_B and I under load.
- Again, observe the brightness of the bulb.
- Open the switch.
- Note all your measurement results in the protocol.

Implementation (3/3)

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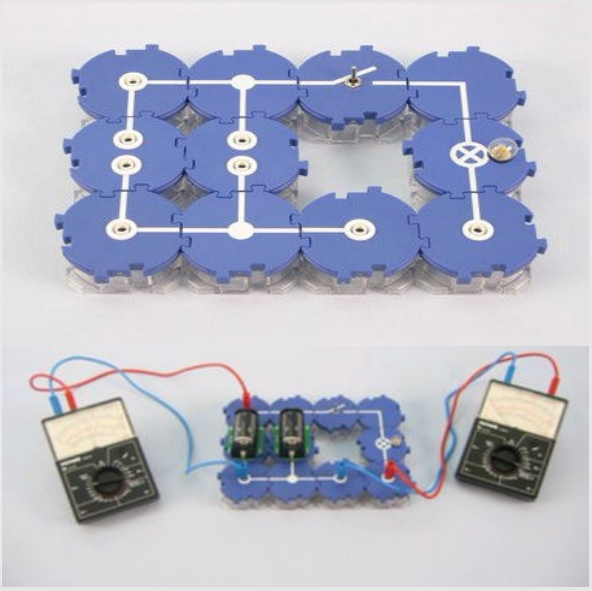

- Now convert to parallel connection.
- Measure the open-circuit voltage as before with the switch open U_L and then, with the switch closed, the voltage U_B and amperage I under load while you watch the light bulb.
- Open the switch.
- Note your measured values in the log again.

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Report

Table 1

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Enter your measured values and observations for the 1st experimental part (series connection)!

	in neutral		under load	
	U_L in V	U_B in V	I in mA	Lamp Brightness
1 battery				
2 batteries (+ on -)				
2 batteries (+ on +)				

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Table 2

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Enter your measured values and observations for the 2nd experimental part (parallel connection)!

	in neutral	under load		
	U_L in V	U_B in V	I in mA	Lamp Brightness
2 batteries				

Task 1

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Paste the words in the right places.

The _____ of _____ will result in an _____ of the _____ if the correct _____ is observed.

series connection
polarity
voltage
voltage sources
increase

Check

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Task 2

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What is the relationship between the total voltage U_G and the tensions U_1 and U_2 of the individual batteries results from the series connection?

- ○ $U_G = U_1 \cdot U_2$
- ○ $U_G = U_1 + U_2$
- ○ $U_G = U_1 - U_2$
- ○ $U_G = U_1 / U_2$

Check

Task 3

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Which statement is true?

- ○ The voltage increases under load.
- ○ The voltage drops under load.
- ○ The voltage remains constant under load.

Check

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Task 4

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Paste the words in the right places.

By _____ of _____ it is possible to achieve higher _____. In addition, the _____ from the voltage sources decreases less for the same _____.

- parallel connection
- load
- currents
- voltage sources
- operating voltage

Check

Slide	Score / Total
Slide 20: Voltage change with series connection	0/5
Slide 21: series voltage equation	0/1
Slide 22: Change in voltage under load	0/1
Slide 23: Voltage change with parallel connection	0/5

Total amount 0 / 12

Solutions | Repeat | Exporting text

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