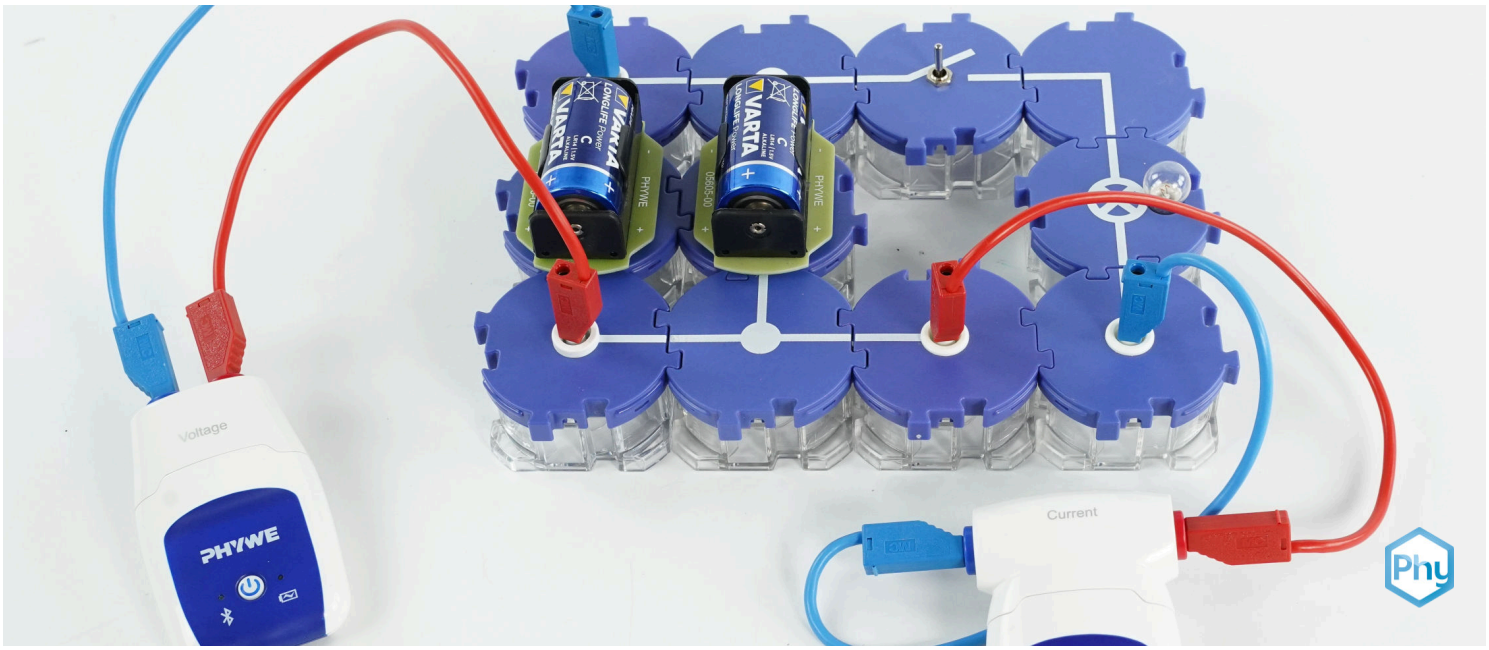
Parallel and series connection of voltage sources



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

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

This content can also be found online at:

https://www.curriculab.de/c/67ff7e3373636c000272b30d

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Teacher information

Application

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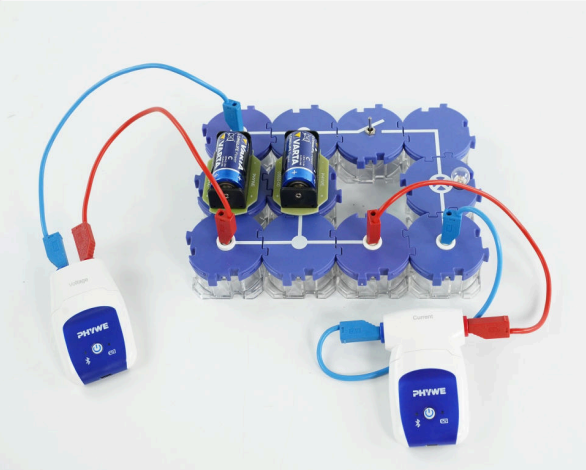

Experimental setup

In everyday life, it is often the case that several mono cells have to be connected together to form batteries to power mobile electrical devices. There are many examples of applications: drills, torches, radios, children's toys and much more.

Remark: Originally, the term battery actually only referred to the interconnection of several mono cells. Colloquially, however, individual mono cells are often referred to as 'batteries'.

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Other teacher information (1/3)

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Prior knowledge

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

Principle

Kirchhoff's rules can be used to explain the circuits. The node rule states that all currents flowing into a node must also flow out again. The mesh rule states that all partial voltages within a mesh add up to zero. This results in

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

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

Tasks

The students connect two batteries in series and then in parallel and investigate 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 6 V / 0.5 A incandescent lamp is recommended for this experiment because its resistance is relatively low and therefore measurable voltage drops can be expected under load.

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 measured values obtained by the students can vary relatively widely as they depend on the condition of the mono cells used. The fresher (unused) the mono cells are, the lower the load on the voltage will be. Depending on the make, the mono cells can also have an open-circuit voltage of over 1.5 V. 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

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Batteries

Even though ion rechargeable batteries are increasingly being used in mobile electrical devices, batteries are still very often used. This is the case, for example, with torches, children's toys or devices such as wireless headphones or controllers. You have probably replaced batteries before. As you know, batteries serve as a power source. Several batteries can be connected in different ways: parallel and series connection have different uses.

In this experiment you will learn about these differences.

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Tasks

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What can be achieved by connecting voltage sources in series and parallel?

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

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
2	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-01	1
3	Straight connector module, SB	05601-01	4
4	Angled connector module, SB	05601-02	1
5	T-shaped connector module, SB	05601-03	2
6	Interrupted connector module with sockets, SB	05601-04	2
7	Junction module, SB	05601-10	2
8	Angled connector module with socket, SB	05601-12	2
9	On-off switch module, SB	05602-01	1
10	Socket module for incandescent lamp E10, SB	05604-00	1
11	Battery holder module (C type), SB	05605-00	2
12	Connecting cord, 32 A, 500 mm, red	07361-01	2
13	Connecting cord, 32 A, 500 mm, blue	07361-04	2
14	Battery Type C 1.5 V - Pack of 2 pieces	07400-00	2
15	Filament lamps 3.5V/0.2A,E10, 10	06152-03	1
16	PHYWE Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	2

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Structure (1/4)

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The Cobra SMARTsense and the measureAPP are required to measure the current. The app can be downloaded free of charge from the App Store - see below for QR codes. Check whether Bluetooth is activated on your device (tablet, smartphone).

measureAPP for Android operating systems

measureAPP for iOS operating systems

measureAPP for tablets / PCs with Windows 10

Structure (2/4)

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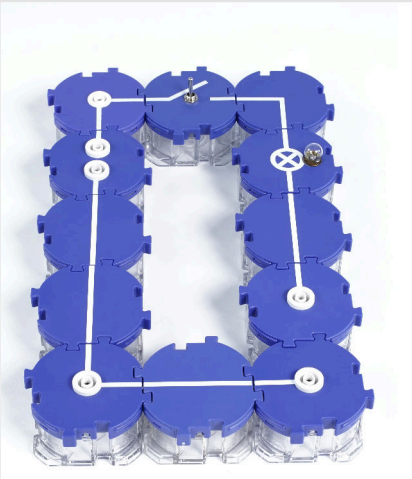

- First set up the circuit for the experiment as shown in the diagrams opposite.
- The switch should first be open and the 12 V bulb screwed into the bulb holder.

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Structure (3/4)

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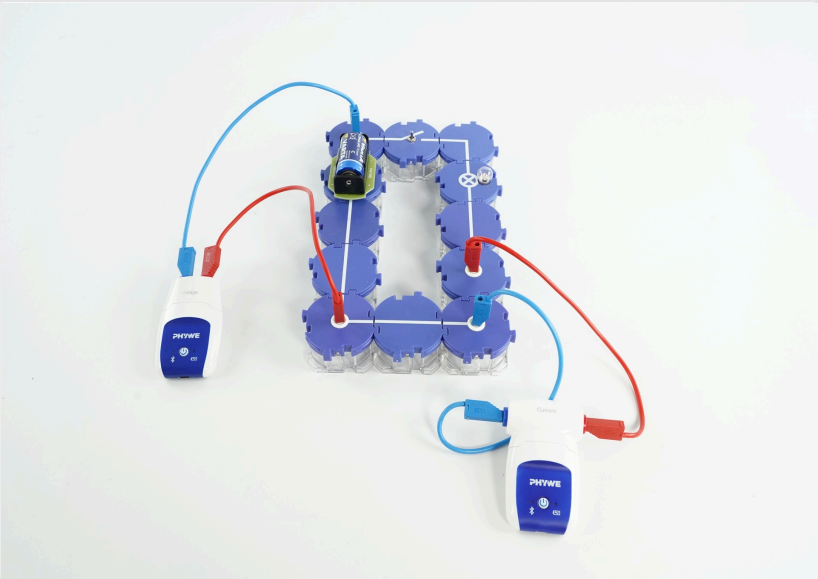

- Build the circuit as shown in the diagram.
- Insert the battery in the holder and connect the 'Voltage sensor - Voltage' (left) and the 'Current sensor - Current' (bottom right) to your circuit.
- Note that a voltage sensor is always connected in parallel and the current measurement is always connected in series.

Structure (4/4)

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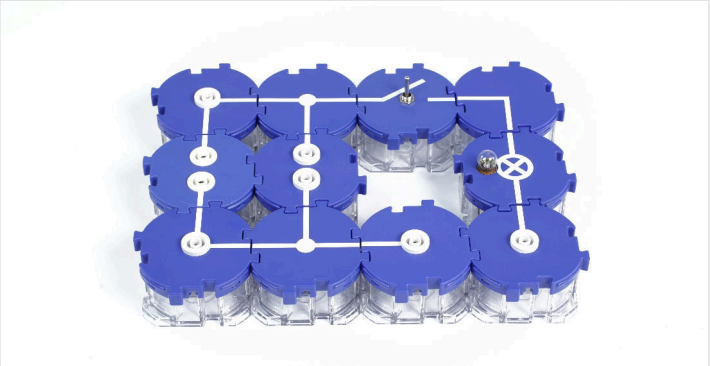
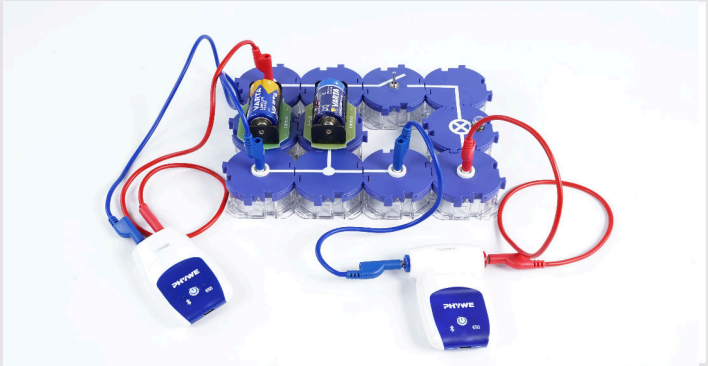
Below you can see the test setup for the 2nd part of the experiment. Here, two batteries are to be connected in parallel. The voltmeter (Voltage) is then also connected in parallel to the batteries (left) and the ammeter (Current) is again connected in series (right).





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Procedure (1/6)

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Voltage sensor

- Switch on the currently used SMARTsense sensors and make sure that the end device can connect to Bluetooth devices.
- Open the PHYWE measureApp and select the sensors used "Voltage".
- Select the sampling rate of your choice. The higher it is, the more accurate the measurement will be.

Procedure (2/6)

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Current sensor

Switch on your Cobra SMARTsense-Current by pressing and holding the button on the sensor for 3 seconds.

Open the measure app on your tablet or smartphone.

Select the sensor "SMARTsense-Current" and set "Repeat measurement".

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Procedure (3/6)

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- Switch on both SMARTsense sensors by pressing and holding the power button and ensure that the tablet can connect to Bluetooth devices.
- Open the PHYWE measure app and select the sensors "Voltage" and "Current" as shown in the picture.
- The measurement can be saved after each of the following measurements. The measurement can be opened again at any time under "My measurements" for further analysis.

Procedure (4/6)

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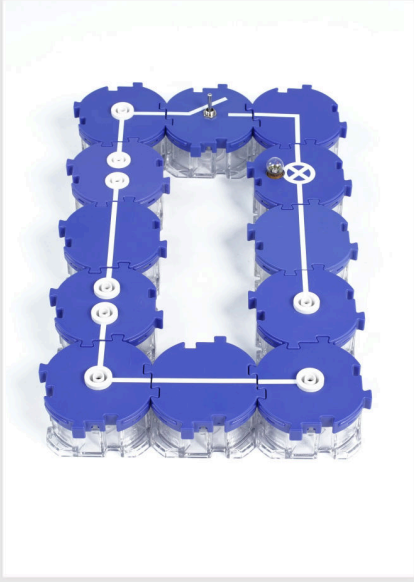

- Measure the so-called open-circuit voltage with the switch open U_L and note the measured value in the log.
- Close the switch and measure both the current I as well as the tension under load U_B. Observe the brightness of the light bulb. Note down the measured values.
- Open the switch and connect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

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Procedure (5/6)

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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 to each other.
- As before, first measure the open-circuit voltage U_L and after closing the switch U_B and I under load.
- Observe the brightness of the light bulb again.
- Open the switch.
- Note all your measurement results in the log.

Procedure (6/6)

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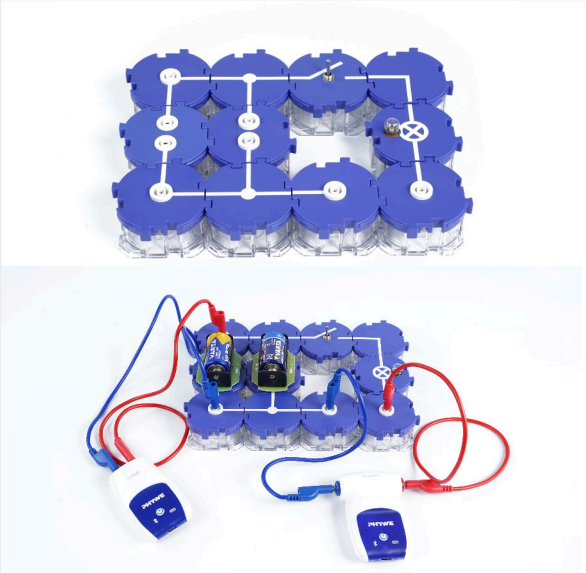

- Now build the parallel circuit according to this diagram
- As before, measure the open-circuit voltage with the switch open U_L and then, with the switch closed, the voltage U_B and amperage I under load while you observe the bulb.
- Open the switch.
- Note your measured values again in the log.

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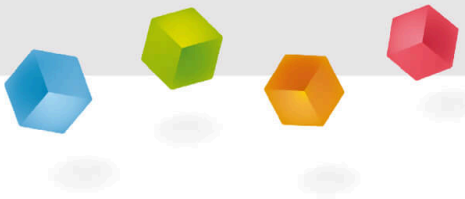

Report

Table 1

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

	idle		under load	
	U_L in V	U_B in V	I in mA	Lamp brightness
1 Battery				
2 batteries (+ to -)				
2 batteries (+ to +)				

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Table 2

PHYWE

Enter your measured values and observations for the 2nd part of the experiment (parallel circuit)!

	idle		under load	
	U_L in V	U_B in V	I in mA	Lamp brightness
2 Batteries				

Task 1

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Insert the words in the correct places.

The _____ of _____ achieves an _____ in _____ if the correct _____ is observed.

- voltage sources
- increase
- series connection
- polarity
- voltage

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?

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

Check

Task 3

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Which statement is true?

- ○ The tension increases under load.
- ○ The voltage remains the same under load.
- ○ The voltage drops under load.

Check

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Task 4

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Insert the words in the correct places.

The _____ of _____ enables higher _____ to be achieved. In addition, the _____ of the voltage sources drops less with the same _____.

- current levels
- parallel connection
- operating voltage
- voltage sources
- load

Check

Slide	Score / Total
Slide 24: Voltage change with series connection	0/5
Slide 25: Equation of the voltage in series connection	0/1
Slide 26: Change in voltage under load	0/1
Slide 27: Voltage change with parallel connection	0/5

Total amount 0 / 12

Solutions Repeat Export text

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