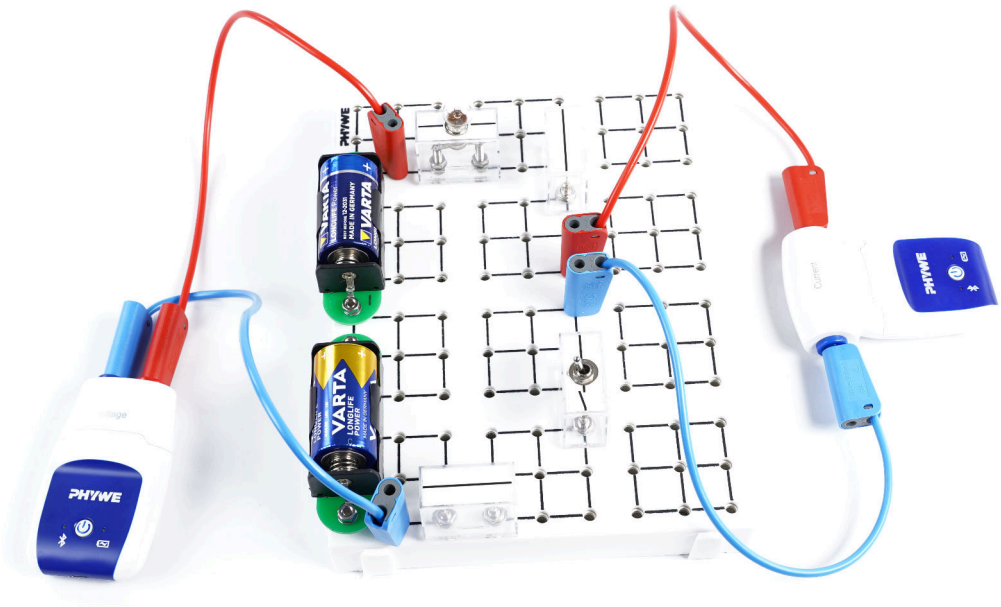
Series and parallel connection of sources of voltage with Cobra SMARTsense



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

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

This content can also be found online at:

https://www.curriculab.de/c/696a57b3d1d683000254b491

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Teacher information

Application

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In everyday life, power sources are often connected in parallel or in series: The most well-known example is probably the remote control. Because the voltage or current of a single battery would not be sufficient, several batteries are used. Depending on whether these are connected in series or parallel, either the current or the voltage can be varied.

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Other teacher information (1/3)

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Prior knowledge

Pupils should be able to independently construct a simple circuit with the help of a circuit diagram. They should also know how to measure electrical current and voltage.

Principle

Kirchhoff's rules can be used to explain the circuit. The node rule states that all currents that flow into a node must also flow out again. The mesh rule states that all voltages in a mesh must add up to zero. This means that the voltages of two batteries in a series circuit add up, while the currents of two batteries in a parallel circuit add up.

Other teacher information (2/3)

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Learning objective

The students should learn what happens when two batteries are connected in parallel or in series.

Tasks

The students first build a series circuit with two batteries and then measure the voltage and current. They then build a parallel circuit and measure the voltage and current for this.

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Other teacher information (3/3)

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The light bulb $6\ \mathrm{V}\ /\ 0.5\ \mathrm{A}$ 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 considerably 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. Depending on the make, the mono cells can also have an open-circuit voltage above $1{,}5\ \mathrm{V}$ own.

Safety instructions

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The general instructions for safe experimentation in science lessons apply.

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Student information

Motivation

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In everyday life, power sources are often connected in parallel or in series: The most well-known example is probably the remote control. Because the voltage or current of a single battery would not be sufficient, several batteries are used. Depending on whether these are connected in series or parallel, the current or voltage can be varied.

In this experiment, you will learn how to connect several voltage sources correctly to achieve the desired effect.

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Tasks

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1. First set up a simple circuit with a battery and measure the voltage and current
2. Extend this circuit to a series connection of two batteries and measure the voltage and current again
3. Now build a parallel circuit from two batteries and measure the voltage and current.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-02	1
2	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-02	1
3	Plug-in board, for 4 mm plugs	06033-00	1
4	on-off switch, G1	39139-00	1
5	Wire building block, housing G1	39120-00	4
6	Lampholder E10, case G1	17049-00	1
7	Battery holder	39115-01	2
8	Connecting cord,19 A,25cm, red	07313-01	2
9	Connecting cord,19 A,25cm, blue	07313-04	2
10	Battery Type C 1.5 V - Pack of 2 pieces	07400-00	2
11	Filament lamp 6 V/3 W, E10, 10 pcs.	35673-03	1
12	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Setup I (1/3)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check whether your device (smartphone, tablet, desktop PC) is running **Bluetooth activated** is.

iOS

Android

Windows

Setup I (2/3)

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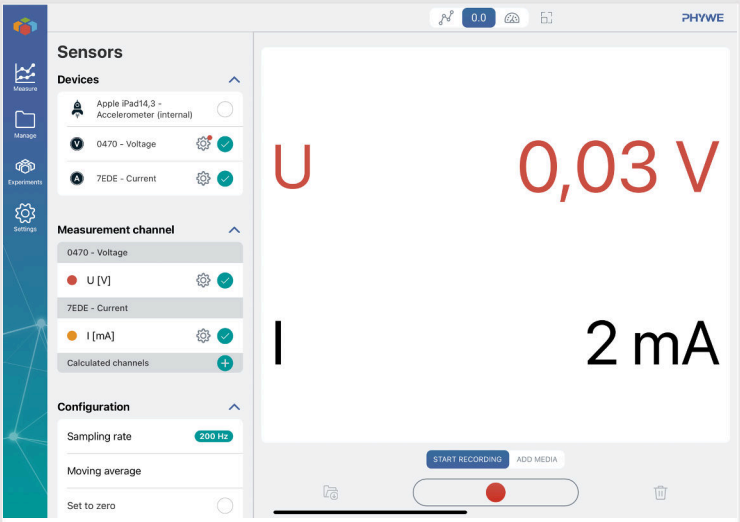

Example screenshot

- Start the two Cobra SMARTsense sensors by pressing the on/off button for three seconds. Open the measureAPP. Connect to the two sensors by clicking on the name. Finally, switch to the view in which the measurement results are displayed as numbers. You do this by clicking on "0.0" in the upper part of the app.
- You will see small fluctuations in the measured values, even when no current is applied. This is due to the noise of the sensors, which can be neglected in this experiment.

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Setup I (3/3)

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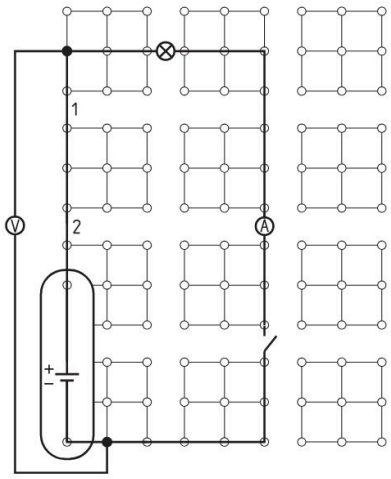

Circuit diagram of the first test setup

- Set up the experiment as shown in the circuit diagram on the left. If you are unsure how the whole thing looks when assembled, you can press the blue button. A picture of the assembled circuit will then appear.
- Leave the switch open for the time being.

Procedure I

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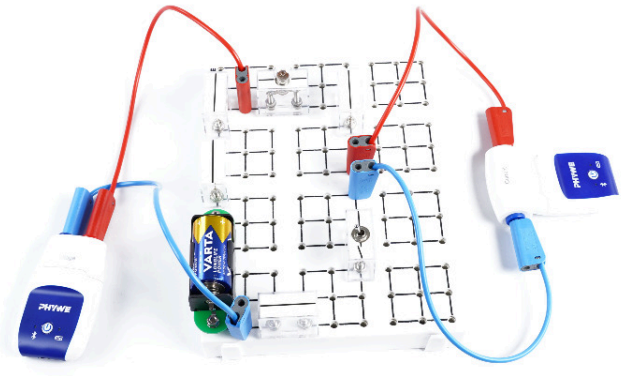

- Measure the voltage at the battery with the switch open U_L. This voltage is also called open-circuit voltage. Note the voltage in Table 1.
- Now close the switch. Observe the light bulb and note the measured voltage U_B (load voltage) and the measured current I in table 1.

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Setup II

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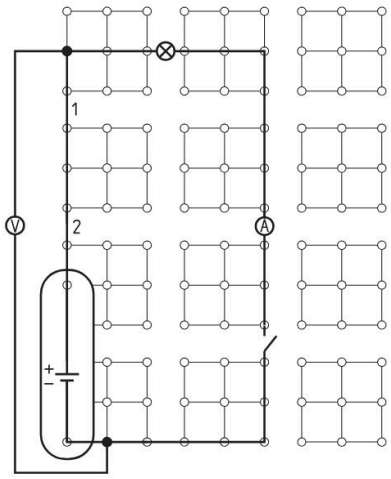

Inserting a second battery

- Open the switch.
- Now remove the cable modules labelled 1 and 2 in the diagram. Insert another battery in their place, making sure that the negative terminal of the new battery is connected to the positive terminal of the old one.
- Again, you can see a photo of this by pressing the blue button.

Procedure II (1/2)

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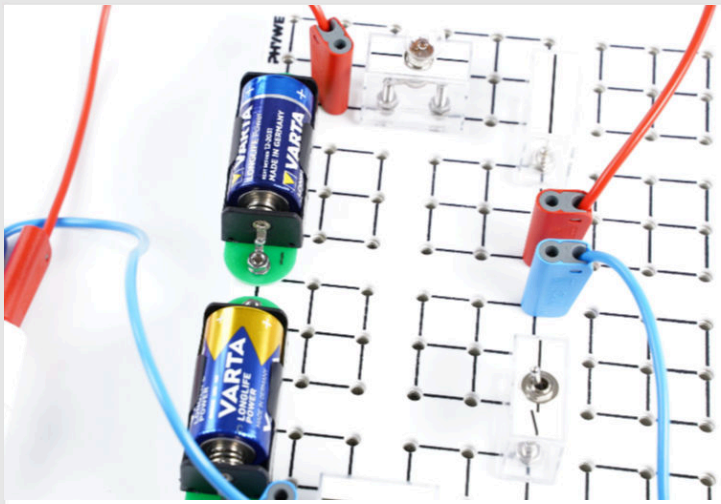

Inserting a second battery

- Measure the open-circuit voltage of the two batteries together again with the switch open. Make a note of your measurement in Table 1.
- Close the switch and measure the load voltage and the current. Observe the light bulb. Make a note of your measurements and observations in Table 1.

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Procedure II (2/2)

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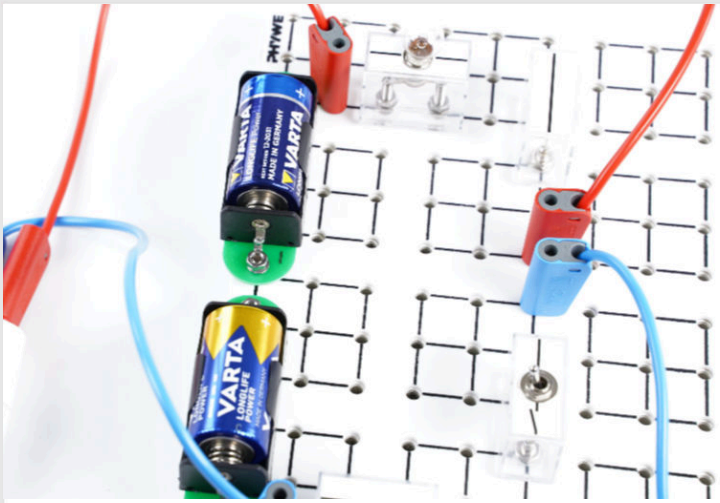

Inserting a second battery

- Open the switch.
- Turn one of the two batteries round once so that the positive terminal of one battery is also connected to the positive terminal of the other battery.
- Now repeat the measurements from the previous steps: Measure the open-circuit voltage and the load voltage and record both in Table 1. Observe the light bulb and record your observations in Table 1.
- Now open the switch again.

Setup III

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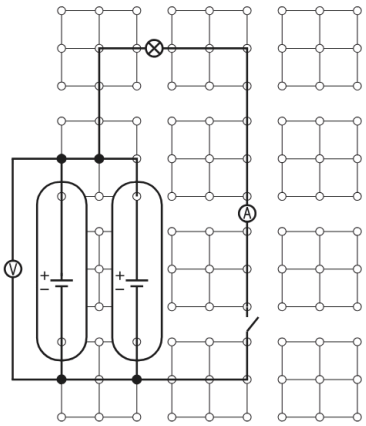

Inserting a second battery

- In the last part of the experiment, the measurements are now to be repeated for two batteries connected in parallel.
- To do this, rebuild the plug-in board as shown in the circuit diagram on the left. You can see a photo of the circuit by clicking on the blue button.

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Procedure III

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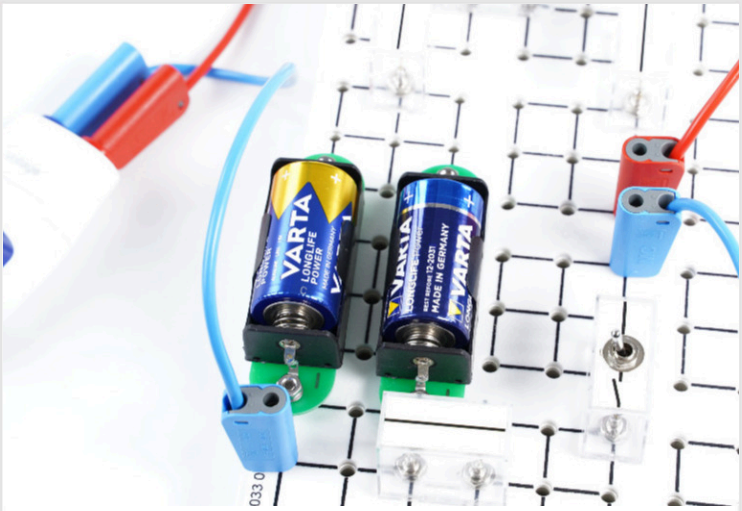

Parallel connection of the batteries

- Now measure the open-circuit voltage again first with the switch open.
- Then measure the operating voltage and current with the switch closed and observe the light bulb.
- Note your measurements and observations in Table 2.
- Then open the switch.

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Report

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Table 1

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Results series connection

	U_L [V]	U_B [V]	I [mA]	Lamp lights up
One cell				
Two cells (+ to -)				
Two cells (+ to +)				

Table 2

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Results parallel connection

	U_L [V]	U_B [V]	I [mA]	Lamp lights up
Two cells				

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Task 1

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What is achieved by connecting voltage sources in series?

- An increase in the amperage
- A reduction in the voltage
- An increase in voltage

Task 2

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Two voltage sources U_1, U_2 are connected in series. What results for the total voltage U_G?

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

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Task 3

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Drag the correct words into the gaps.

There are two ways of connecting two voltage sources in series: Either two equal poles are connected together or two opposite poles are connected together. If the same poles are connected together, the voltages are _____ and cancel each other out. The experiment also showed that the open-circuit voltage differs from the voltage under load. In general, the voltage _____ under load. This can be counteracted as the voltage drop under load is lower when voltage sources are connected in _____.
Not used (in alphabetical order): _____, _____, _____

parallel
rectified
rising
drops
opposed
series

Check

Slide	Score / Total
Slide 23: Series connection	0/1
Slide 24: Total voltage	0/1
Slide 25: Cloze text	0/6

Total amount 0 / 8

Solutions Repeat Export text

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