

# Connection of Daniell cells in series and parallel with Cobra SMARTsense



The students have a rough understanding of how a galvanic cell works. In this experiment, the students learn how to increase the efficiency of such a galvanic cell.

Chemistry	Physical chemistry	Electrochemistry	Galvanic elements, fuel cells
 Difficulty level medium	 Group size 2	 Preparation time 10 minutes	 Execution time 20 minutes

This content can also be found online at:



<https://www.curriculab.de/c/68ca906ca59c3600023a357b>

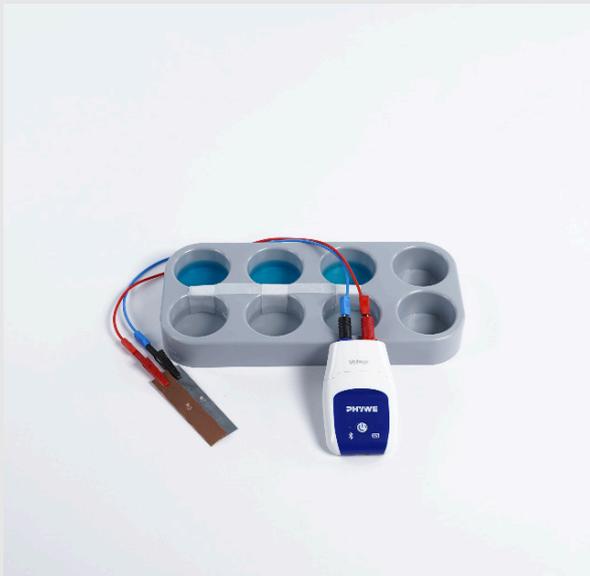
PHYWE

## Teacher information



## Application

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Two electrodes in a salt solution represent the simplest basic form of a battery. In principle, this structure is a **electrical source** through which voltage is generated.

The discovery and further development of so-called galvanic elements, better known as batteries, was a significant advance, as they enable the mobile power supply of a wide variety of devices. However, a galvanic element can only provide a small amount of voltage, so it is important to maximise efficiency by **Series or parallel connection** of several galvanic elements.

Such series circuits have practical applications in portable radios and torches, for example.

## Other teacher information (1/4)

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### Prior knowledge



Students should have worked with galvanic elements (Daniell element) in theory and practice. Students can draw parallels between series and parallel connections and Kirchhoff's node and mesh rules.

### Principle



The voltage can be increased by connecting several galvanic cells in series, e.g. Daniell elements.

## Other teacher information (2/4)

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### Learning objective



The students have a basic understanding of how a galvanic cell works. In this experiment, the students learn how to increase the efficiency of such a galvanic cell by connecting it in series. The aim is to recognise the relationship between the number of galvanic cells connected in series and the resulting voltage.

### Tasks



The pupils are asked to construct a total of three Daniell elements. They then connect first two, then three of these cells in series and measure the respective total voltage with a voltmeter. Then they connect two of the galvanic elements in parallel and compare the measured voltages with the series connection.

## Other teacher information (3/4)

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A galvanic element consists of two half cells, in this case a copper sulphate solution with a copper electrode and a zinc sulphate solution with a zinc electrode. The zinc electrode acts as the anode, at which **Electron emission** the **Oxidation** takes place. The copper electrode acts as a cathode, at which **Electron uptake** the **Reduction** takes place.

The voltage can be increased by connecting several galvanic cells in series, e.g. Daniell elements. The increased voltage corresponds to the sum of the voltages of the individual elements (**Kirchhoff's mesh rule**). When connected in parallel, there is no increase in voltage, but there is an increase in current (**Kirchhoff's knot rule**). The electrolyte solutions of the half-cells are separated by a filter paper strip (salt bridge), which enables a flow of electrons while simultaneously preventing diffusion of the electrolyte solutions.

## Other teacher information (4/4)

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**The solutions can be produced for everyone to save chemicals!**

- **Copper sulphate solution (0, 1 mol/l):** Add 12, 5 g Copper sulphate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Zinc sulphate solution (0, 1 mol/l):** Add 14, 4 g Zinc sulphate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Potassium nitrate (1 mol/l):** Add 50, 5 g Potassium nitrate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.

When using this approach variable, a 600 ml beaker can be used. You can find this in the PHYWE webshop.

## Safety instructions

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- The general instructions for safe experimentation in science lessons apply to this experiment.
- All persons in the room must wear safety goggles during the experiment!
- For H and P phrases, please refer to the safety data sheet of the respective chemical.

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## Student information

## Motivation

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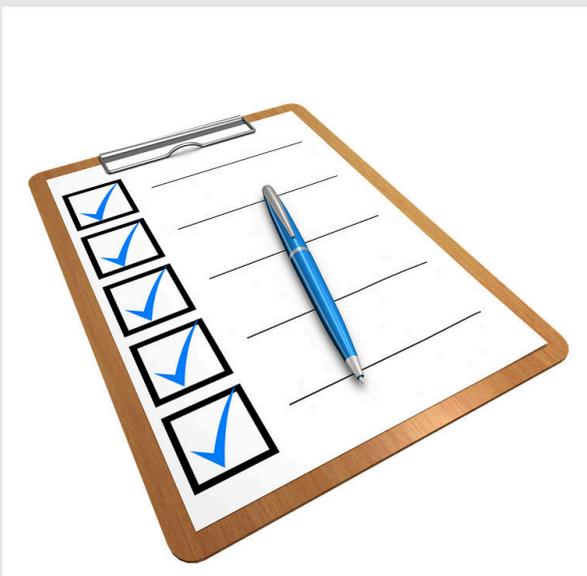


Mobile energy sources are an essential component of modern technology, for example in smartphones, medical devices and portable electronics. The basis of many of these applications is the galvanic cell, whose voltage is characterised by **Series connection** can be increased in a targeted manner.

This experiment investigates how the electrical voltage is affected by the **Combination of several galvanic elements** can be changed. The knowledge gained is central to understanding electrochemical energy storage and its technical utilisation.

## Tasks

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How does the connection of several galvanic elements influence the voltage?

1. Build three Daniell elements.
2. First connect two, then all three elements in series and measure the total voltage of the circuit.
3. Connect two of the Daniell elements in parallel and compare the measured voltage with the values of the series connection.

## Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage $\pm 30$ V (Bluetooth + USB)	12901-01	1
2	Connecting cord, 2 mm-plug, 5A, 500 mm, red	07356-01	1
3	Connecting cord, 2 mm-plug, 5A, 500 mm, blue	07356-04	1
4	Reducing plug 4mm/2mm socket, 2	11620-27	1
5	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	3
6	Copper strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-10	3
7	Beaker, Borosilicate, tall form, 50 ml	46025-00	3
8	Dropping bottle, plastic, 50ml	33920-00	1
9	Block with 8 holes, d = 40 mm	37682-00	1
10	Coverage f.cell-meas.bloc, 8 piec.	37683-00	1
11	Connecting cord, 2 mm-plug, 5A, 25 cm, red	07355-01	2
12	Zinc strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-20	3
13	Water, demineralized, pure, 10000 ml	CHE-882041145	1
14	Potassium nitrate 250 g	30106-25	1
15	Chromatographic paper 100 stripes	32972-00	1
16	Protecting glasses, clear glass	39316-00	1

## Additional material

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Position	Equipment	Article no.	Quantity
1	Tweezers	64610-01	1

## Preparation

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- **Copper sulphate solution (0,1 mol/l):** Add 1,25 g Copper sulphate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.
- **Zinc sulphate solution (0,1 mol/l):** Add 1,44 g Zinc sulphate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.
- **Potassium nitrate (1 mol/l):** Add 5,05 g Potassium nitrate to 25 ml distilled water. Mix well and fill up to 50 ml with distilled water.

## Setup (1/4)

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To measure with the **Cobra SMARTsense** sensors, the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the respective app store (QR codes below). Please check that **Bluetooth is enabled** on your device (smartphone, tablet, desktop PC) before starting the app.



iOS



Android



Windows

## Setup (2/4)

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Moisten three salt bridges one after the other in the potassium nitrate solution using tweezers and place them as a bridge between the measuring cells in the measuring cell block (see figure).



## Setup (3/4)

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Fill the measuring cells with the corresponding metal salt solutions (see illustration).

Place a measuring cell cover on each measuring cell.

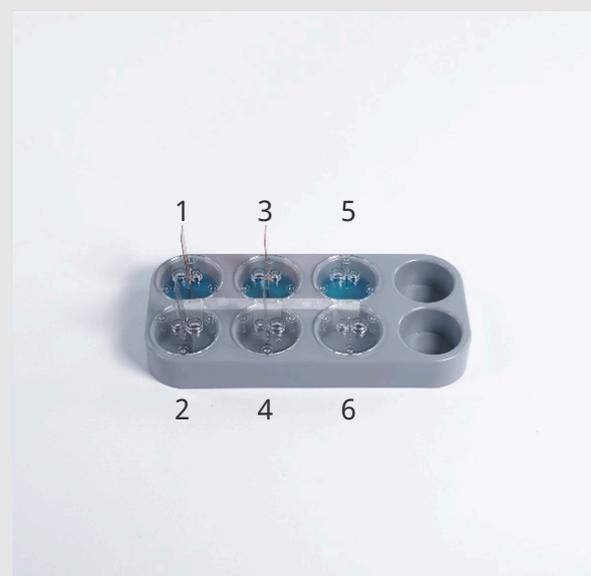


## Structure (4/4)

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Take a look at the electrodes: If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.

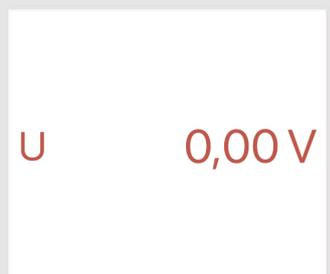
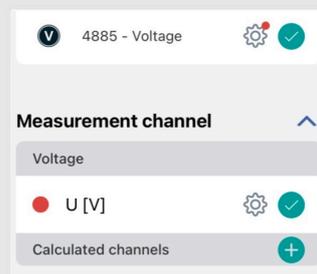
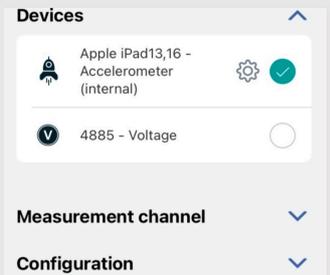
Then insert the copper electrodes into measuring cells 1,3,5 and the zinc electrodes into measuring cells 2,4,6.



## Procedure (1/5)

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- Start the measureAPP on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping  next to the description of the sensor in the measureAPP.
- Set the measured value display by tapping **0.0** above the diagram.



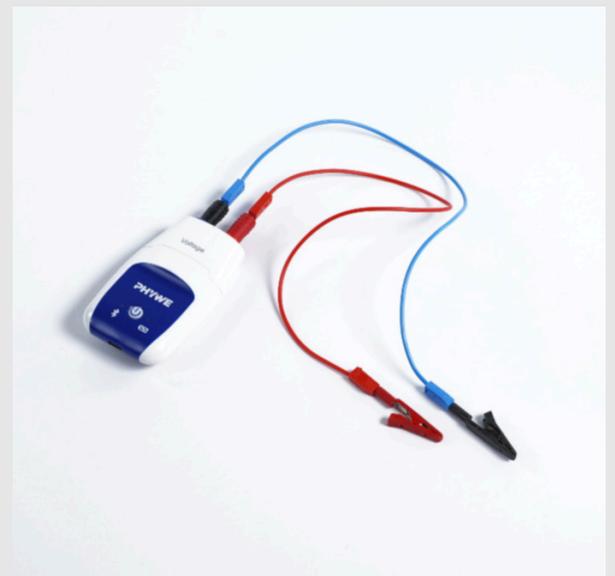
## Procedure (2/5)

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*Note the colour of the connections below: blue (zinc, negative pole) always to blue (black) and red (copper, positive pole) always to red!*

Connect the cables to the Cobra SMARTsense Voltage Sensor using a reducing plug.

In the next step (see next slide), the crocodile clips are connected to the metal electrodes (copper and zinc sheet).

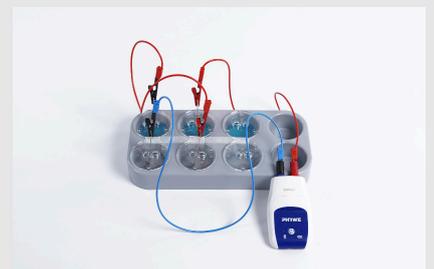
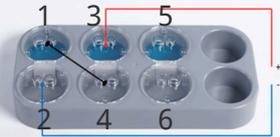


## Realisation (3/5)

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### Series connection (1/2)

Then connect the copper electrode of half cell 1 to the zinc electrode of half cell 4 using a short connecting lead (Fig. above) and then measure the voltage between the zinc electrode 2 and the copper electrode 3.

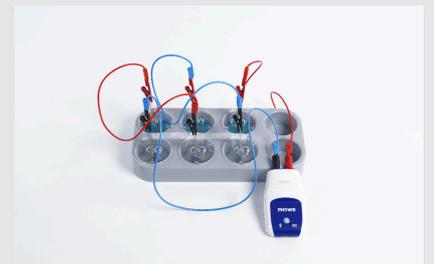
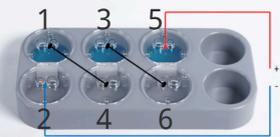


## Procedure (4/5)

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### Series connection (2/2)

Now also connect the copper electrode 3 to the zinc electrode 6 via a short connecting lead (see fig. above) and then measure the voltage between the zinc electrode 2 and the copper electrode 5.



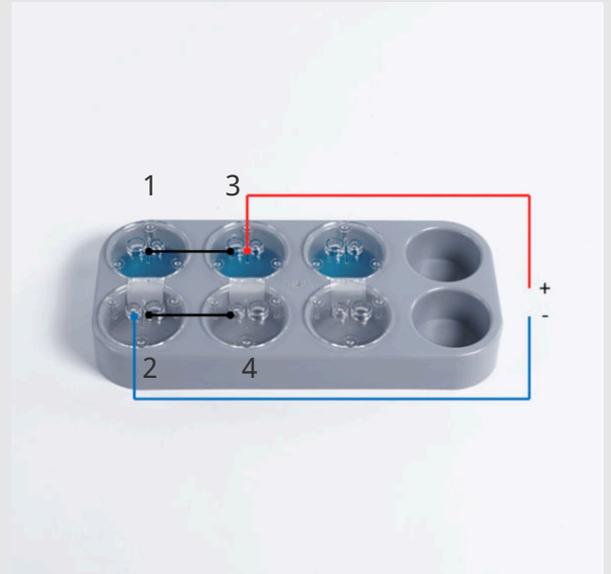
## Procedure (5/5)

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### Parallel connection

Connect the copper electrodes 1 and 3 (fig. right) and the zinc electrodes 2 and 4 using short connecting leads. Then measure the voltage between electrodes 2 and 3 (or between 1 and 4).

How does the electrical voltage in a parallel circuit differ from that in a series circuit?



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## Report



## Task 1

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What could be observed with a series connection of the galvanic elements?

- When connected in series, it was observed that the current was increased.
- In the series connection, it was observed that the increased voltage corresponds to the product of the individual elements.
- None of the answers are correct.
- In the series connection, it was observed that the increased voltage corresponds to the sum of the individual elements.

✓ Check

## Task 2

PHYWE

What could be observed with a parallel connection of the galvanic elements?

- The same effect was observed with the parallel connection as with the series connection.
- A reduction in current intensity was observed in the parallel connection.
- An increase in the current strength was observed in the parallel connection.
- No current could be measured in the parallel connection.

✓ Check

## Task 3

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Which KIRCHHOFF rule is used for parallel connection?

- The KIRCHHOFF mesh rule. This states that the increased stress corresponds to the sum of the stresses of the individual elements.
- KIRCHHOFF's node rule. This states that there is no increase in voltage but an increase in current.
- KIRCHHOFF's rule does not apply.

✓ Check

Slide	Score/Total
Slide 24: Series connection	0/1
Slide 25: Parallel connection	0/1
Slide 26: KIRCHHOFF's rule	0/1

Total amount  0/3

👁 Solutions

🔄 Repeat