Electricity: Voltage experiments

These three subexperiments on electricity based on Experimento | 10+ are designed to encourage learning through research in science class in the lower grades. The materials are editable and can be adapted individually to the learning group or supplemented with other interesting content from the media portal of the Siemens Stiftung (https://medienportal.siemens-stiftung.org).

The subexperiments are:

1. Is a solar cell a voltage source?
2. Can wind generate voltage?
3. We create our own voltage source

1 Relevance to the curriculum

Topics related to electricity (current, voltage, electrical circuit) are found in nearly all curricula worldwide. These experiments deal with the following topics:

- Working with electricity
- Electric voltage and current
- Plan and build circuits and simple models of devices
- Electric circuit; voltage sources
- Voltage, unit of measurement: 1 V; current, unit of measurement: 1 A; Alessandro Volta, André Marie Ampère
- Measuring using a voltmeter and ammeter in various circuits (parallel and series connections); circuit diagrams

Repeat, practice, apply, reinforce

- Practice ways of thinking and working: experiment, measure
- Become familiar with terms and graphic symbols: voltage, current, resistance; units of measurement: 1 V, 1 A, 1 Ω; voltage source, voltmeter, ammeter
- Know the effects of electric power

2 General information

2.1 Structure of the worksheets

The experiments supplement the lesson, but are not sufficient on their own for working through the learning content. Each experiment has a worksheet that includes a list of the required apparatus and materials, illustrated instructions for preparing and conducting the experiment, and various assignments that can be completed.
The assignments are suggestions that can always be scaled down or expanded as needed.
Note that in the list of apparatus and materials, items printed in *italics* must be provided separately. These items are not included in the photo.

2.2 Safety information

Observe hazard labeling and the information on safety and disposal, which are found in the teacher instructions for Experimento | 10+: A3 Lemon batteries and other batteries and in Experimento | 10+: A5 Properties of solar cells.

You can always use newspaper as a work surface. However, this is not necessary if the tables can be wiped. In experiment 3 the students work with citric acid. If necessary, hand out plastic bowls. The students can place used materials, such as nails, in these bowls.
Make sure that the alligator-clip connections do not come into contact with each other, or else a short circuit will occur. Because the voltage immediately drops, the experiment will no longer work in this case. However, there is no danger to people.
Before Experimento | 10+ is started, explain how the digital multimeter works. A short basic course on measurements and connections is provided in Experimento | 10+ as an introduction.
If the materials are used as described in the teacher instructions and the experimentation instructions, they pose no hazards.

2.3 Cleaning information

The liquids can be poured down the sink; be sure to rinse the containers thoroughly. Please point out to your students that all objects that become dirty during the experiment must be clean and dry before being returned to the experimentation kit.

3 Information on the subexperiments

3.1 Subexperiment 1: Is a solar cell a voltage source?

3.1.1 Information for teachers

The effect of a solar cell is tested in this experiment. Only the phenomenon is covered; the no-load voltage and load voltage of a solar cell are deliberately not covered. The reason why the solar cell even supplies a voltage should not be explained in this grade. Additional experiments and the theoretical background to solar cells are found in Experimento | 10+: A5 Properties of solar cells.
Series connections, the measurement of voltages, and the drawing of simple circuit diagrams are also covered in the course of the experiment. The terms and the circuit diagrams should therefore have already been covered as a topic in class.

3.1.2 Skills

The students will …

- know that solar cells can supply voltage depending on the illuminance.
- be able to build a circuit from a solar cell and a motor with a propeller.
- know the graphic symbols for solar cell, motor, and voltmeter.
- know the principle of the series connection and be able to apply it practically.

3.1.3 Variation, additional tasks

- Open-ended task: Light up an LED using solar cells.
- Try to light up an LED using several solar cells connected in series.
- Regarding assignment 4: Complete phrases can be removed for faster learners.
- Regarding assignment 7: The graphic symbols can be arranged for the slow learners to then draw in the cables.
- From Experimento | 10 + A5 Properties of solar cells: How does shade or the distance from the light source affect the solar cell?
- From Experimento | 10 + A5 Properties of solar cells: How do solar cells connected in series or in parallel behave?

3.1.4 Answer

Assignment 1
Hold the solar cell under various light sources.
What do you observe? Fill in the table.

Light source	Observation
Classroom lighting	Propeller rotates/does not rotate.
Window light	Propeller rotates/rotates faster/rotates a little.
Cell phone flashlight	…
Candle light	…

Assignment 2
Use the digital multimeter to measure the voltage generated by the solar cell.
Hold the solar cell under various light sources.

Light source	Voltage (volts)
Classroom lighting	approx. 0.5 V
Window light	approx. 1 – 1.5 V
Cell phone flashlight	approx. 0.8 – 1.5 V
Candle light	0.1 – 0.4 V

Assignment 4
Hold the solar cells under various light sources.
Note your observations using the speech bubbles as an aid.

Example: I hold the solar cell under the classroom light. I see that the propeller rotates slightly. I measure a voltage of 0.43 volts.

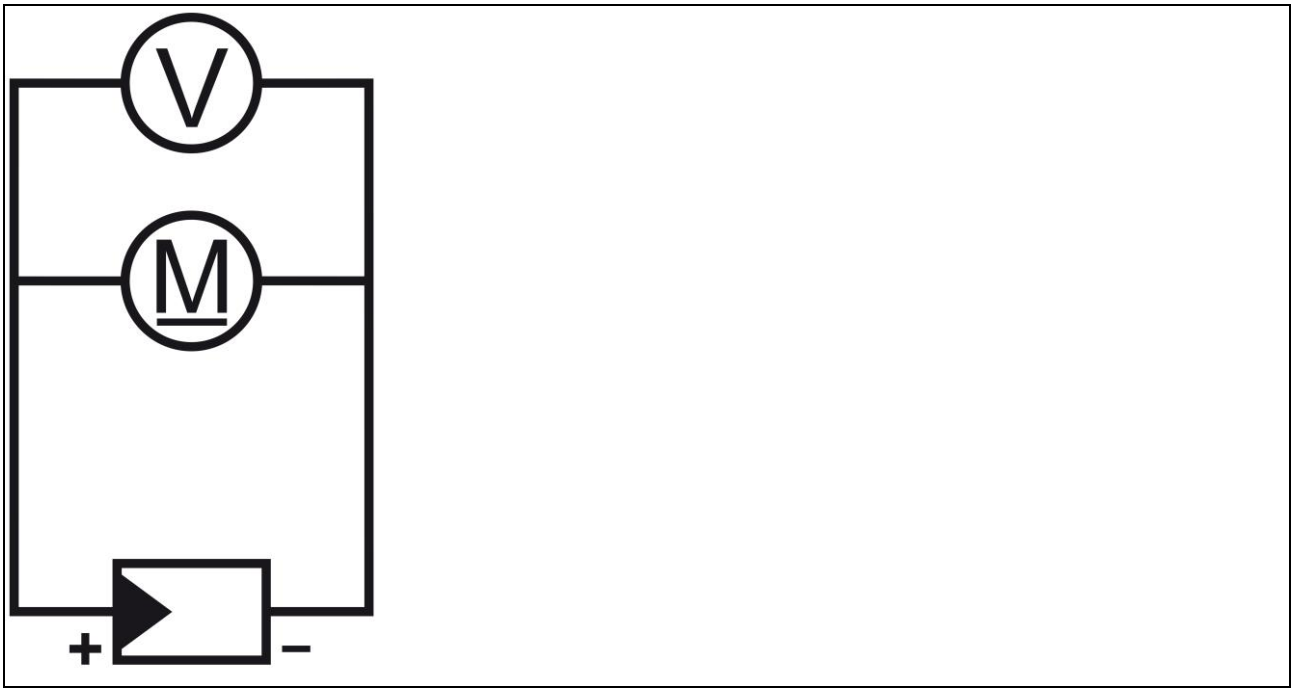
Assignment 5
Fill in the missing words using the following words:
light, solar cell, increases, electricity

Electricity flows in an electrical circuit if sufficient voltage is present.
If sufficient light strikes a solar cell, voltage is produced.
The more light that strikes a solar cell, the more voltage it delivers.
If solar cells are connected in series, the voltage increases.
Solar plants consist of many solar cells and can deliver great amounts of electricity.

Assignment 6
Find the error in the photo. Explain why you therefore cannot conduct the experiment.

Explanation: The series connection between the solar cells is missing. The circuit is interrupted; electricity cannot flow.

Assignment 7
Draw the electrical circuit from assignment 2. Use the graphic symbols.



Subexperiment 2: Can wind generate voltage?

3.1.5 Information for teachers

In this experiment, a motor (used a as generator) produces a voltage with the aid of a propeller. Merely the phenomenon is covered here as well. The functioning of a generator (magnetism/induction) should not be explained in this grade. The conductivity property of the LED (conducting direction/blocking direction) is also not covered. The two electronic parts merely serve as an illustration of how wind can generate electricity.
Series and parallel connections, the measurement of voltages, and the drawing of simple circuit diagrams are covered in the course of the experiment. The terms and the circuit diagrams should therefore have already been covered as a topic in class.
The determination of the voltage in assignments 1, 2, and 3 depends on how strongly, weakly, short, long, or evenly the students blow. The digital multimeter displays the values for only a very short time. Therefore the results for the minimum voltage will vary rather greatly.

3.1.6 Skills

The students will …

- recognize the wind turbine as a voltage source.
- know that the amount of voltage is related to the “wind power” used.
- be able to theoretically and practically explain the terms series and parallel connection.
- become familiar with the LED as a light source.

3.1.7 Variation, additional tasks

- Free formulations can be expected in assignment 1.
- Other LEDs or lamps can be used for experimentation in assignment 3.
- A simple circuit diagram of a parallel connection can also serve as a guide in assignment 4.

3.1.8 Answer

Assignment 1
Blow using different levels of force. What do you notice?

If I blow on the propeller with a short, light breath, then the LED lights up only briefly or not at all.

If I blow hard on the propeller, then the LED lights up bright and strong.

Assignment 2
Use the digital multimeter to measure the voltage. Determine the voltage and enter it in the table.

Minimum voltage necessary to light the LED:	approx. 0.9 volts
Maximum voltage the propeller can generate:	approx. 1.84 volts

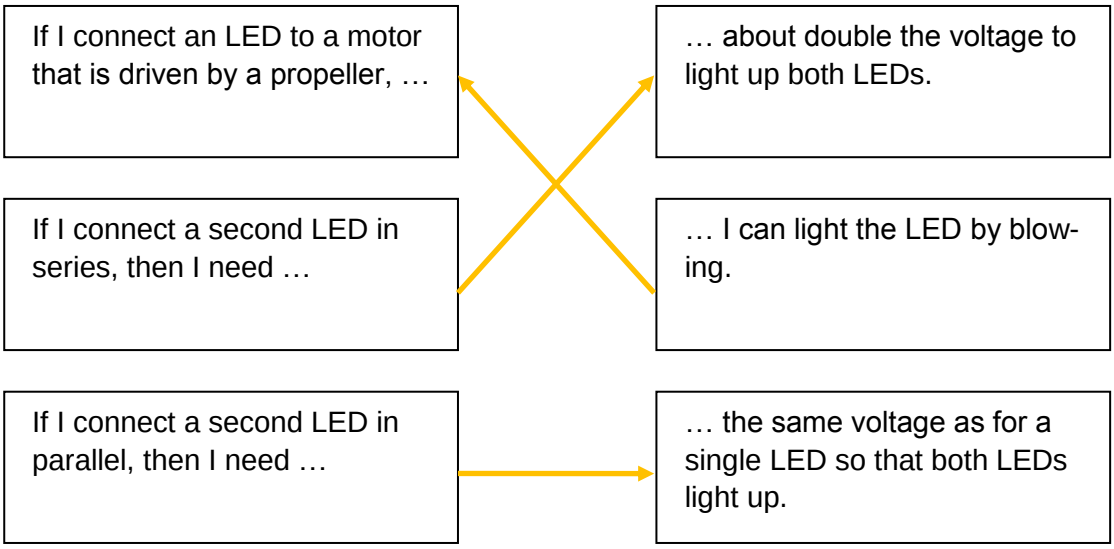
Assignment 3
Connect another LED in series.
Determine the voltage and enter it in the table.

Minimum voltage necessary to light both LEDs:	approx. 1.6 volts
Maximum voltage the propeller can generate:	approx. 1.84 volts

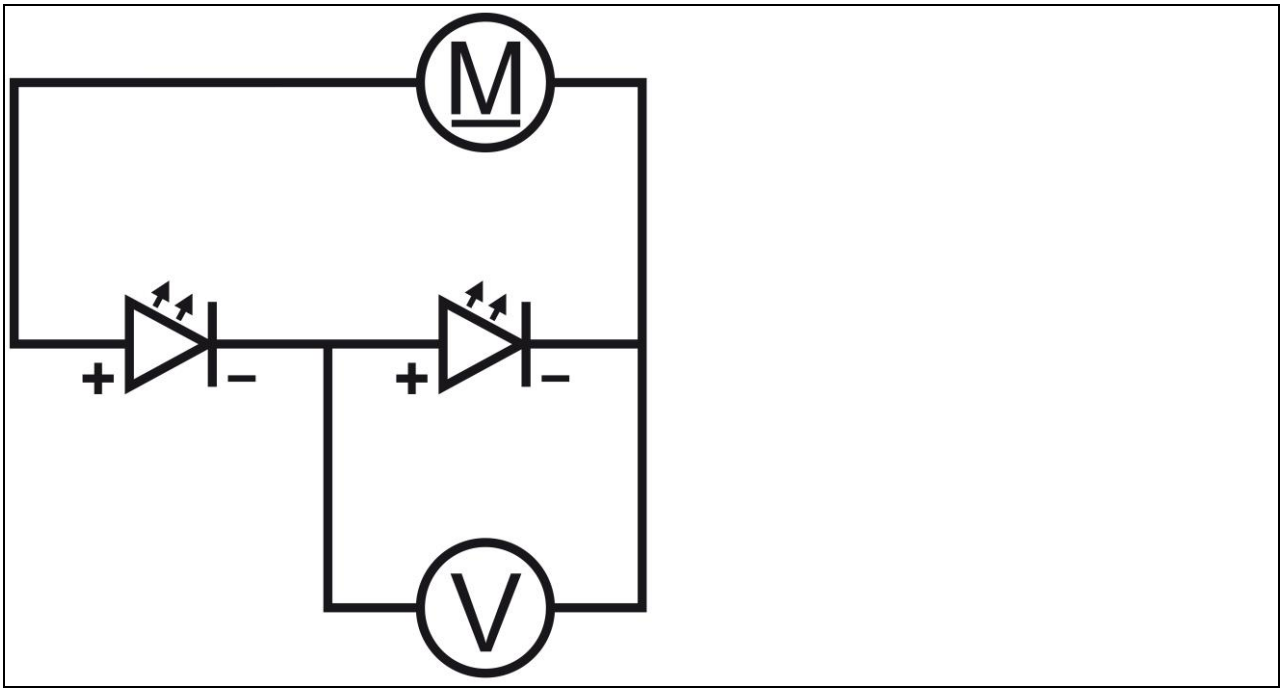
Assignment 4
Connect the two LEDs in parallel.
Determine the voltage and enter it in the table.

Minimum voltage necessary to light both LEDs:	approx. 0.9 volts
Maximum voltage the propeller can generate:	approx. 1.84 volts

Assignment 5
Complete the sentences so they make sense. Draw arrows to match the sentences.



Assignment 6
Draw the simple electrical circuit from assignment 1 with an additional LED connected in series as in assignment 3. Use the graphic symbols.



3.2 Subexperiment 3: We create our own voltage source

3.2.1 Information for teachers

This experiment shows that a simple “battery” made from two different metal pins and an electrolyte (conductive liquid) can serve as a voltage source. The chemical processes are not covered here; the phenomenon is merely observed and evaluated. More precise background information and additional, more detailed experiments can be read in Experimento | 10+: A3 Lemon batteries and other batteries.
The nails in the liquid must not come into contact with each other for the experiment to work.
Attention: Before the students handle the materials in this experiment, point out how they should safely handle acids (safety instructions).

3.2.2 Skills

The students will …

- be able to make a simple voltage source (battery) from copper, zinc, and citric acid.
- know how to measure voltages using a multimeter.
- be able to safely handle citric acid.
- be able to build simple circuits on their own.

3.2.3 Variation, additional tasks

- Open-ended task: Build a voltage source. To do so, use other materials, for example, other metal pins or liquids.
- Conduct the experiment with salt water and soda water. What do you notice?

- From Experimento I 10+: A3 Lemon batteries and other batteries: What happens if you use tap water?
- From Experimento | 10+: A3 Lemon batteries and other batteries: What happens if you dissolve copper sulfate in the water? Can the battery support a load?

3.2.4 Answer

Assignment 1
What will happen if you hold both nails in the liquid?
Write down your guess.

The propeller rotates briefly, but then quickly stops rotating.

Assignment 2
Measure the voltage generated by the zinc-copper battery.

The zinc-copper battery generates a voltage of 0.6 – 1.0 volts.

Assignment 3
How does the voltage change if you connect the motor with the propeller to the electrical circuit?

The voltage drops relatively quickly from the starting value (approx. 0.6 – 1.0 V) to 0.00 V. The battery no longer provides voltage.

Assignment 4
Read the following text and mark the correct answers with an X.

An electrical voltage is produced by a chemical process between the metals and the citric acid solution.
This voltage can be used to
- ☒ drive a load, e.g., a motor with a propeller.
- ☐ drive a solar cell.

This home-made battery
- ☒ produces useful voltage for only a very short time.
- ☐ can be used for a very long time.

For this reason, the battery we built
- ☐ is good to use.
- ☒ is of little use.

Without a load (motor), the battery maintains
- ☐ the voltage only for a short time.
- ☒ the voltage.

Batteries drain if you connect loads. Without loads, batteries maintain their voltage for a long time.