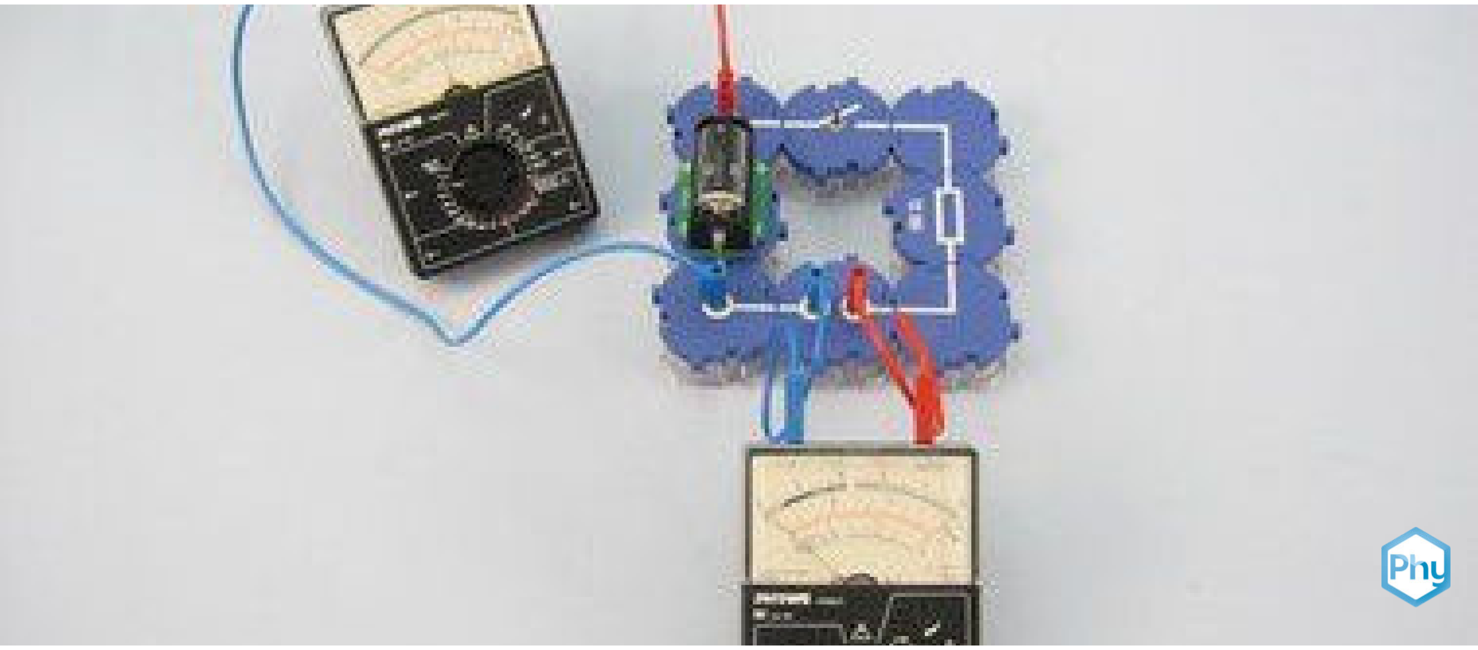
The internal resistance of a voltage source



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:

http://localhost:1337/c/630cf25c70919e00038fa0ee

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Teacher information

Application

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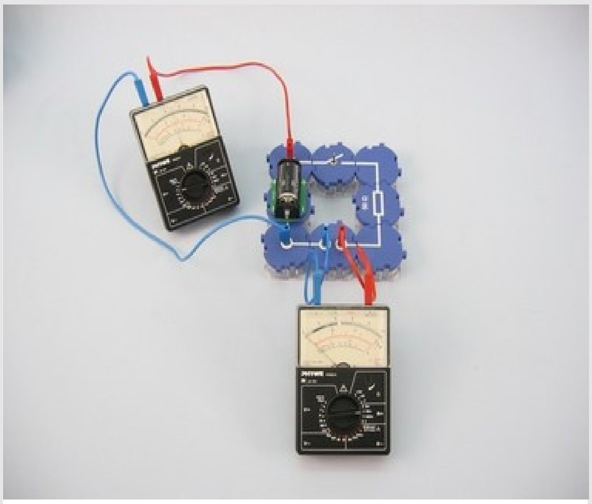

Experimental setup

Every electrical measuring device and every voltage source has an internal resistance. Due to this internal resistance, the terminal voltage of a loaded voltage source deviates from the original voltage in the unloaded case. However, so that this does not have to be considered with every use, power supply units are voltage-stabilised. Commercially available dry batteries or mono cells, on the other hand, are not, so that they cannot be used in circuits that are sensitive to voltage fluctuations.

In this experiment, the internal resistance is investigated using a dry battery.

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Other teacher information (1/4)

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Prior knowledge

Students should be able to construct a simple electric circuit. In addition, they should have an understanding of the concepts of voltage, current and resistance.

Principle

A commercially available dry cell or mono cell is well suited for investigating the internal resistance of voltage sources. Its internal resistance is large enough to be easily measurable and it is easily replaceable if it is carelessly destroyed by prolonged overloading. The power supply unit is not suitable for investigating the internal resistance because it is voltage-stabilised.

Other teacher information (2/4)

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Learning objective

With the help of this experiment, the students should learn that voltage sources have an internal resistance.

Tasks

Do voltage sources also have a resistance?

Install resistors of different sizes in an electric circuit and investigate by measuring the current strength I and the clamping voltage U_C of the voltage source its internal resistance R_i.

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Other teacher information (3/4)

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Notes on structure and implementation

The measurements during the short circuit require special attention, because if the switch-on time is too long, the measured voltage can drop very sharply and the battery can become unusable. If at least two students are experimenting together, the measured values for U_C and I can be read simultaneously to minimise the duration of the short circuit. Otherwise, the student should short circuit and read one of the values at a time.

Other teacher information (4/4)

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Further remarks

If necessary, an experimental group could also use a "used" battery to investigate how it behaves in the case of $I = 0$ or in the event of a short circuit or even at low load. The short-circuit current strength and thus the internal resistance depends strongly on the battery's state of charge. Therefore, the measurement results of the individual experiment groups will also be different. A battery (voltage source) is of high quality if its short-circuit current strength is particularly high and thus its internal resistance is particularly low. It is recommended that, if necessary, only one experiment group investigates the short-circuit case and reports its results to the other groups. In this way, the reduction in quality of the other batteries can be avoided. Switching to the measuring range $1\,V$ for the measurement of U_C during a short circuit was deliberately not suggested because this measuring range is not sufficient when the switch is opened!

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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

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Motivation

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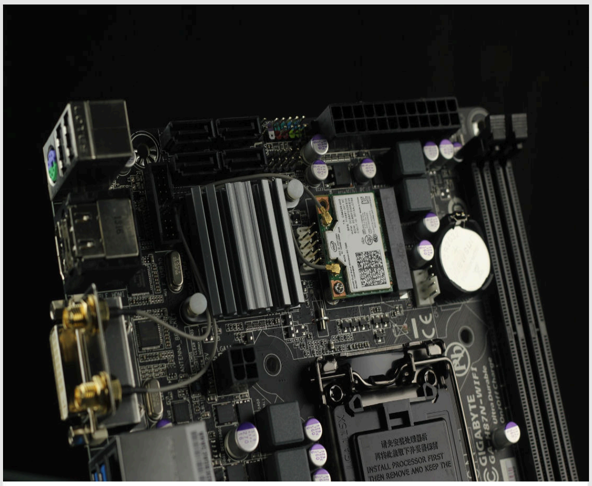

Motherboard with processor - example of a sensitive circuit

Voltage sources and measuring devices have an internal resistance that ensures that the voltage source has a different voltage when a component is connected, for example, than when this component is not connected. These voltage fluctuations can cause damage to sensitive circuits such as processors.

It is therefore important to know these voltage fluctuations caused by the internal resistance in order to enable suitable stabilisation.

In this experiment, you examine the internal resistance of a dry cell battery.

Tasks

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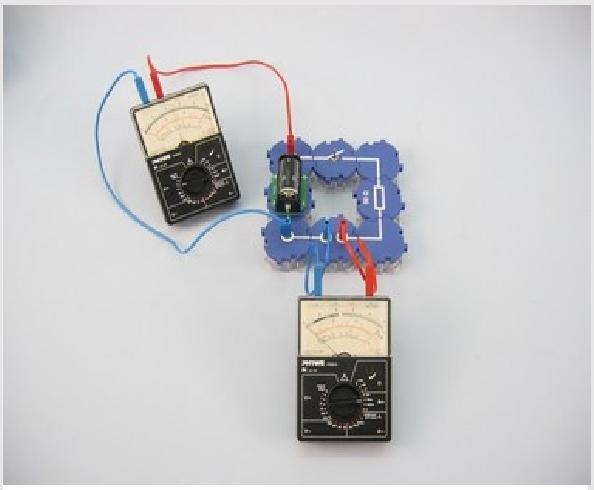

Experimental setup

Do voltage sources also have a resistance?

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Equipment

Position	Material	Item No.	Quantity
1	Angled connector module, SB	05601-02	2
2	T-shaped connector module, SB	05601-03	2
3	Interrupted connector module with sockets, SB	05601-04	2
4	Angled connector module with socket, SB	05601-12	2
5	On-off switch module, SB	05602-01	1
6	Socket module for incandescent lamp E10, SB	05604-00	2
7	Resistor module 50 Ohm, SB	05612-50	1
8	Connecting cord, 32 A, 250 mm, red	07360-01	1
9	Connecting cord, 32 A, 250 mm, blue	07360-04	1
10	Connecting cord, 32 A, 500 mm, red	07361-01	1
11	Connecting cord, 32 A, 500 mm, blue	07361-04	1
12	Battery Type C 1.5 V - Pack of 2 pieces	07400-00	1
13	Filament lamp 6 V/3 W, E10, 10 pcs.	35673-03	1
14	PHYWE Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	2
15	Straight connector module, SB	05601-01	2
16	Battery holder module (C type), SB	05605-00	1

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Set-up

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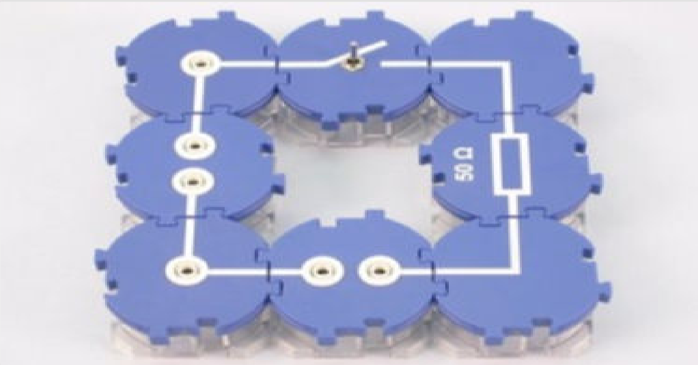
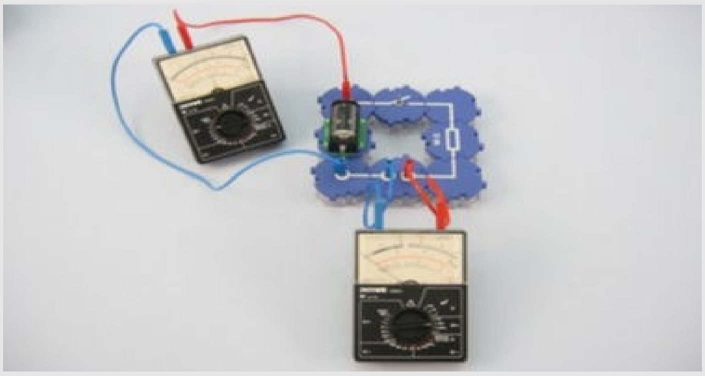
Set up the circuit as shown in the illustration on the left and the illustration on the right. The switch is open at first. The lower meter is switched as an ammeter and the left one as a voltmeter.





Procedure (1/2)

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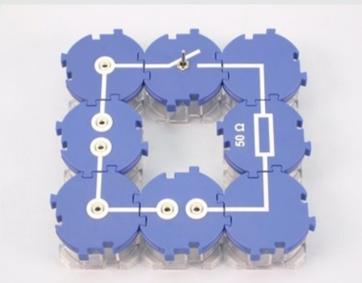

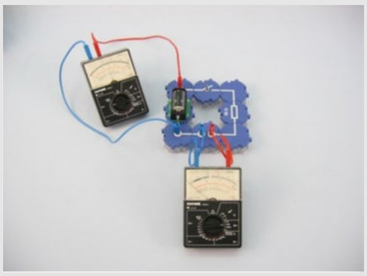

- Select the measuring ranges of the ammeter $3\,V$- and $30\,mA$-.
- Measure the clamping voltage U_C for $I = 0$ i.e. without loading the voltage source. Note your measured values in the table in the report.
- Close the circuit, read the terminal voltage U_C and the current strength I (under load). Note your measurements in the table.
- Break the circuit and install the light bulb in place of the resistor.
- Set the measuring range of the ammeter to $300\,mA$-.
- Close the circuit and read again U_C and I and note down your readings.

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Procedure (2/2)

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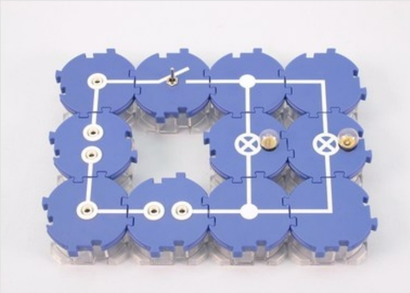
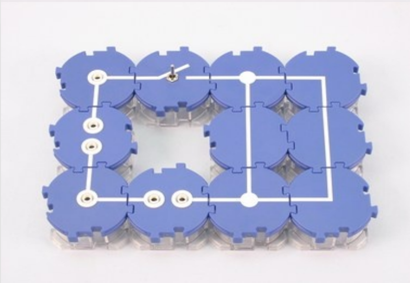
- Open the switch and install 2 bulbs in parallel (fig. above).
- Close the circuit and again read U_C and I and note down your readings.
- Open the switch and replace the bulbs with a line module (fig. below).
- Select the measuring range of the ammeter $3\ A$-.
- Close the switch for a short time (!), measure U_C and I at the short circuit and enter the values in the table in the report.

Hint: The short-circuit current must only flow for a very short time so that the voltage source is not destroyed.





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Report

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Table 1

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Enter your measurements in the table.

Circuit	$I\ [A]$	$U_C\ [V]$
Switch open		
$50\ \Omega$ Resistance		
1 bulb		
2 bulbs		
Short circuit		

Task 1

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How can the relationship between the load I and the clamping voltage U_C be described?

- The clamping tension increases with load, and more so the greater the load.
- The clamping voltage decreases under load, and the greater the load, the more it decreases.
- The load and the clamping voltage are independent of each other.

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Task 2

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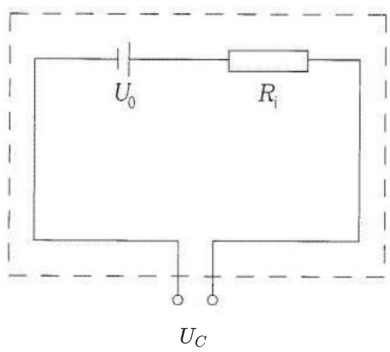
Here you see an equivalent circuit for the voltage source with its internal resistance R_i. The voltage R_i drops across $R_i \cdot I$ under pressure. U_0 is the voltage which the unloaded voltage source (i.e. for $I = 0\,A$) supplies . Formulate the relationship between U_0 and U_C in an equation. (Note: Consider the law of series connection $U_{total} = U_1 + U_2$).



Drag the equations into the correct boxes!

From the equation ______ follows with $U_1 = U_0$ and ______ the context ______

$U_{total} = U_1 + U_2$ | $U_2 = -I \cdot R_i$ | $U_C = U_0 - I \cdot R_i$

Check

Task 3

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Convert the equation found in task 2 to R_i. Which equation is correct?

- ☐ $R_i = I/(U_0 - U_C)$
- ☐ $R_i = U_0/I - U_C/I$
- ☐ $R_i = (U_0 - U_C)/I$
- ☐ $R_i = (U_C - U_0)/I$
- ☐ $R_i = I/(U_C - U_0)$

Check

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Task 4

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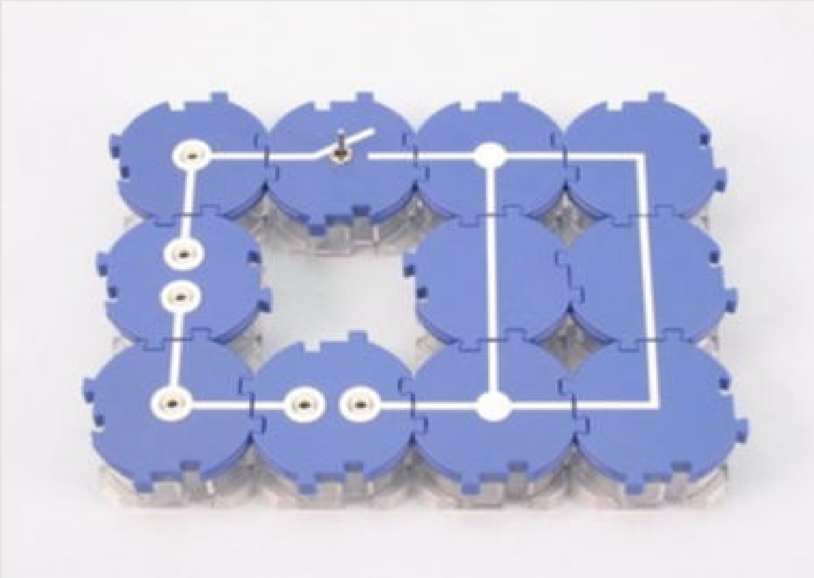
Using the measured values in Table 1, calculate the internal resistance for the case of a short circuit R_i of the voltage source under investigation.

$I\ [A]$	$U_C\ [V]$

$U_0\ [V]\ (I=0)$	$R_i\ [\Omega]$



Slide	Score / Total
Slide 17: Context \(U_{C}\) and \(I\)	0/1
Slide 18: Equation clamping voltage	0/3
Slide 19: Equation \(R_i\)	0/2

Total 0/6

Solutions Repeat Export text

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