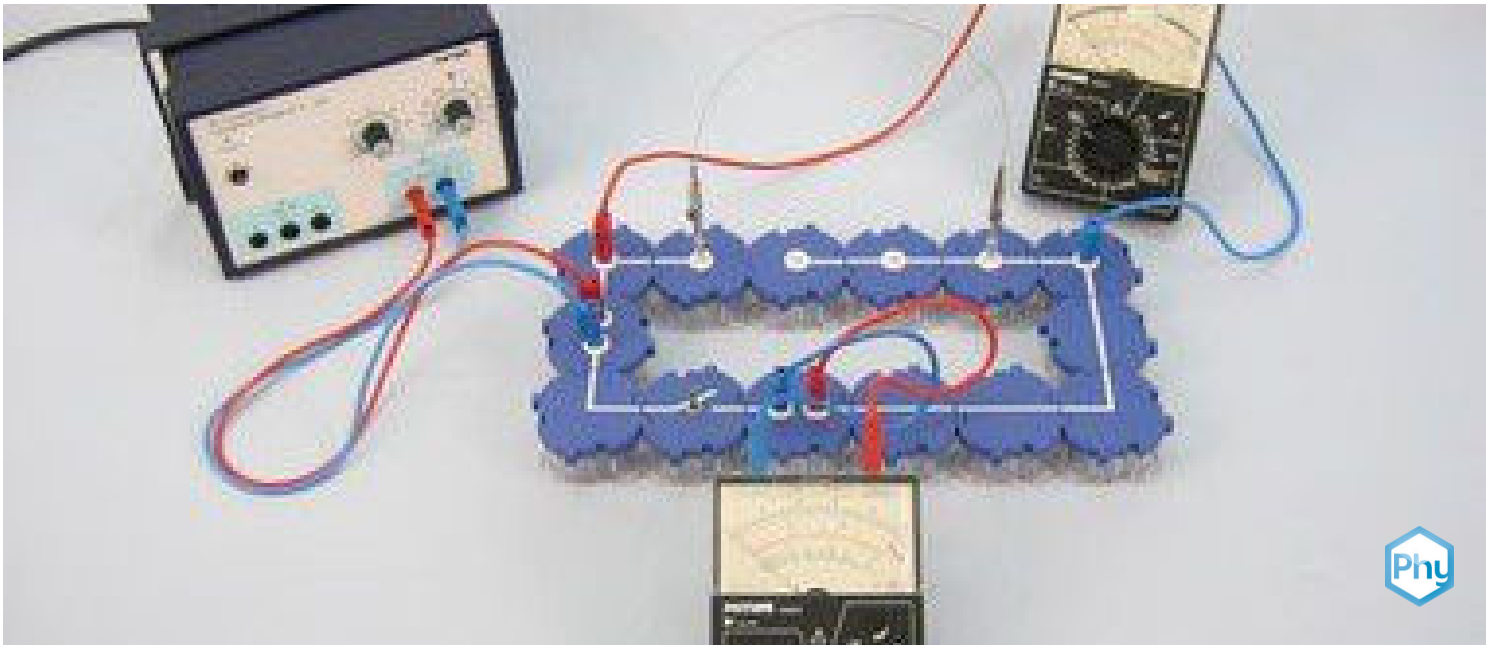
The resistivity of wires



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/6307b99b0454360003d3658f

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Teacher information

Application

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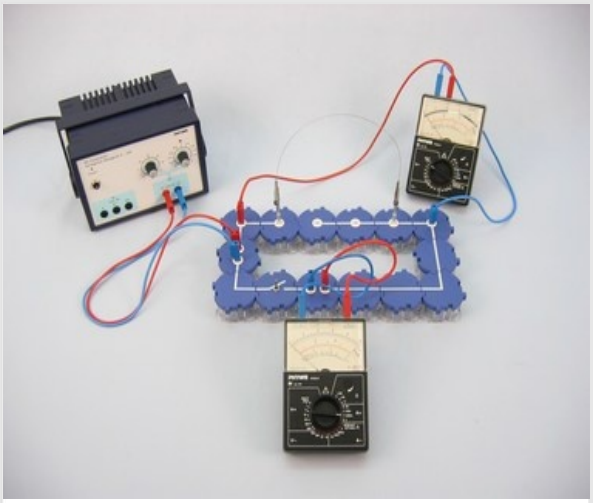

Experimental setup

All electrical devices usually have to be charged with a cable or are connected to the mains via a cable. However, they have different requirements for current and voltage values, which are regulated by resistors that also exist in cables, so that the electrical devices are not damaged. The following applies here:

$$R = \rho \cdot (L/A)$$

With the length L , the cross-sectional area A , and the material-dependent specific resistance ρ. The specific resistance ρ that some common materials have, is experimentally investigated in this experiment.

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Other teacher information (1/3)

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Prior knowledge

The students should be able to construct a simple electric circuit. They should be familiar with the principles of current and voltage. Ideally, the concept of resistivity should already have been dealt with theoretically in relation to the cross-section and length of a wire.

Principle

The electrical resistance of a material depends on its shape (length and cross-section) but also on its material-specific resistance. The latter is much lower for metals than for other materials, whereby the specific resistance also differs significantly between different metals.

Other teacher information (2/3)

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Learning objective

Based on the experimentally determined relationships $R \propto l$ for constant ρ and A, and $R \propto 1/A$ for constant ρ and l, the specific resistance was introduced as a material "constant" via $R \propto l/A$ and the equation $R = \rho \cdot l/A$. With the help of this equation, the students are to experimentally determine the quantity ρ for common conductor materials.

Task

The specific resistance of 3 different materials (copper, iron and constantan) is to be measured in the form of a wire. To do this, the wires are inserted into a circuit and first the voltage is measured at a constant current. Then the length of the clamped wires is recorded in order to calculate the different specific resistances in the evaluation.

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Other teacher information (3/3)

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Notes

In contrast to the determination of ρ for constantan, extra care must be taken when determining ρ for iron and especially for copper; For example, the relative error for the voltage is large when examining the copper wire, and when examining the iron wire, the contacts might not be optimal due to the build-up of rust.

The specification of the direct current strength of $250\,mA$ is therefore necessary so that the wires do not heat up too much and the measuring range for U and I do not have to be changed.

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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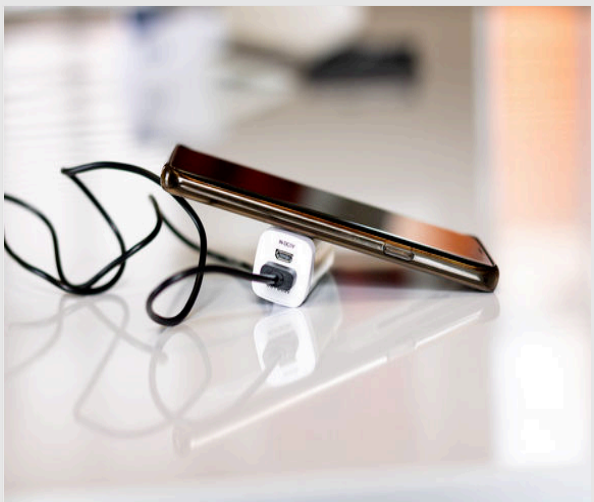

Charging a smartphone

In order to be able to charge your smartphone, a conductive cable is usually used through which the current can flow from the socket into the smartphone to charge the battery. How well the current flows through this conductor depends on various parameters. These include the resistance of the cable. This so-called specific resistance depends on the material. With the right choice of material, the resistance in the cable can be optimised.

In this experiment, you will learn about the specific resistance of some materials.

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Tasks

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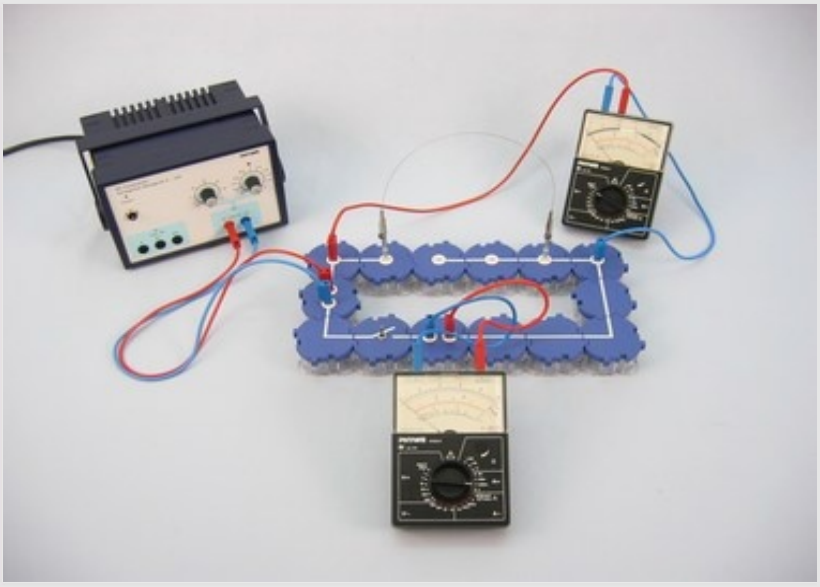
What are the resistivities of some metals?

Determine the resistivity of wires from:

- Copper
- Iron
- Constantan



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Equipment

Position	Material	Item No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	2
3	Interrupted connector module with sockets, SB	05601-04	2
4	Junction module, SB	05601-10	2
5	Straight connector module with socket, SB	05601-11	2
6	Angled connector module with socket, SB	05601-12	2
7	On-off switch module, SB	05602-01	1
8	Alligator clips, bare, 10 pcs	07274-03	1
9	Connecting plug, 2 pcs.	07278-05	1
10	Connecting cord, 32 A, 250 mm, red	07360-01	1
11	Connecting cord, 32 A, 250 mm, blue	07360-04	1
12	Connecting cord, 32 A, 500 mm, red	07361-01	2
13	Connecting cord, 32 A, 500 mm, blue	07361-04	2
14	Copper wire, d = 0.2 mm, l = 100 m	06106-00	1
15	Iron wire, d = 0.2 mm, l = 100 m	06104-00	1
16	Constantan wire, 15.6 Ohm/m, d = 0.2 mm, l = 100 m	06100-00	1
17	PHYWE Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	2
18	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Equipment

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Position	Equipment	Quantity
1	Ruler (approx. 30 cm)	1

Set-up

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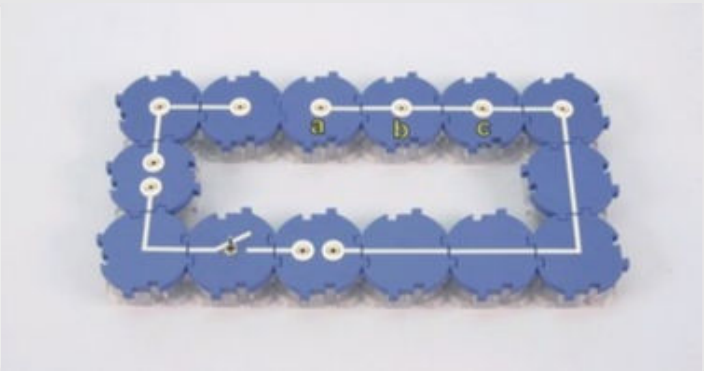
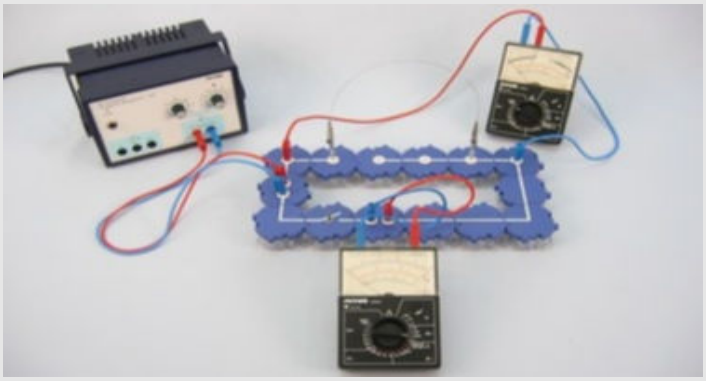
Set up the circuit as shown in the illustration on the left. Connect the power supply (left), a voltmeter (top) and an ammeter (bottom) to the circuit as in the illustration on the right. Clamp the copper wire using 2 alligator clips, right clip in position c.





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Procedure

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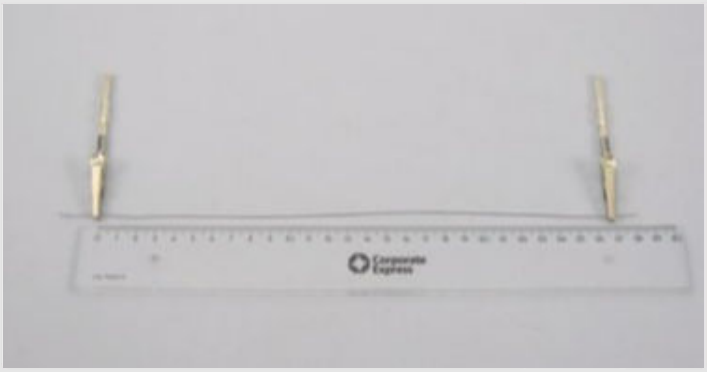
Set the power supply unit to $0\,V$ and switch it on. Carefully increase the voltage at the power supply unit until the ammeter reads $250\,mA$. Read the value of the voltage on the voltmeter and record it in the report. Then measure the length l of the clamped copper wire, as shown in the illustration, and also note this value.



- Now clamp first the iron wire and then the constantan wire between the alligator clips instead of the copper wire and proceed in the same way as before. Record both the voltage values and the lengths of the clamped wires in the report.
- Power supply unit on $0\,V$ and switch it off.

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Report

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Task 1

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Note down your measured values in the table. Calculate the resistance values of the wires from the pairs of values for the voltage U and the current strength I. The equation $R = \rho \cdot l \ / \ A$ applies to the resistance of a wire. The quantity ρ is called specific resistance. It is a material constant. Calculate the resistivity of the materials from which the examined wires $(d = 0,2\,mm)$ are made and enter the results of your calculations in the last column of the table.

Equipment	$I[A]$	$U[V]$	$l[m]$	$R[\Omega]$	$\rho[\Omega \cdot mm^2/m]$
Copper					
Iron					
Constantan					

Task 1

PHYWE

Note down your measured values in the table. Calculate the resistance values of the wires from the pairs of values for the voltage U and the current strength I. The equation $R = \rho \cdot l \ / \ A$ applies to the resistance of a wire. The quantity ρ is called specific resistance. It is a material constant. Calculate the resistivity of the materials from which the examined wires $(d = 0,2\,mm)$ are made and enter the results of your calculations in the last column of the table.

Equipment	$I[A]$	$U[V]$	$l[m]$	$R[\Omega]$	$\rho[\Omega \cdot mm^2/m]$
Copper					
Iron					
Constantan					

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Task 2

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What would be a possible definition of resistivity? Consider the unit of resistivity in the last column of the table. The specific resistance of a material indicates the resistance of a cable of this material at ...

- ... a length of $1m$ and a cross-section of $1mm^2$.
- ... of any length and a cross-section of $1mm^2$.
- ... of any length and cross-section.
- ... a length of $1m$ and any cross-section.

Task 3

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Although iron is cheaper than copper, copper is preferred as a conductive material in electrical engineering and electronics. Why?

- ☐ Copper looks nicer and feels better.
- ☐ Copper has a higher resistivity.
- ☐ Less copper is needed to achieve the same performance, so copper is cheaper to use overall.
- ☐ Iron is more susceptible to corrosion and is thus damaged more quickly.
- ☐ Copper has a lower resistivity.

Check

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Task 4

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The specific resistance is additionally temperature-dependent, but is usually given for 20°C. The table values for the specific resistances of the materials examined are for 20 °C:

ρ_{Copper} = 0,017 $\Omega \cdot mm^2/m$ ρ_{Iron} = 0,10 ... 0,13 $\Omega \cdot mm^2/m$

$\rho_{Constantan}$ = 0,50 $\Omega \cdot mm^2/m$

If the results of your measurements deviate relatively strongly from this: How can the deviations be explained?

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