How high is the resistivity of some metals?

EEP 2.8

S

Task
To determine the resistivity of copper, iron and constantan.

Equipment

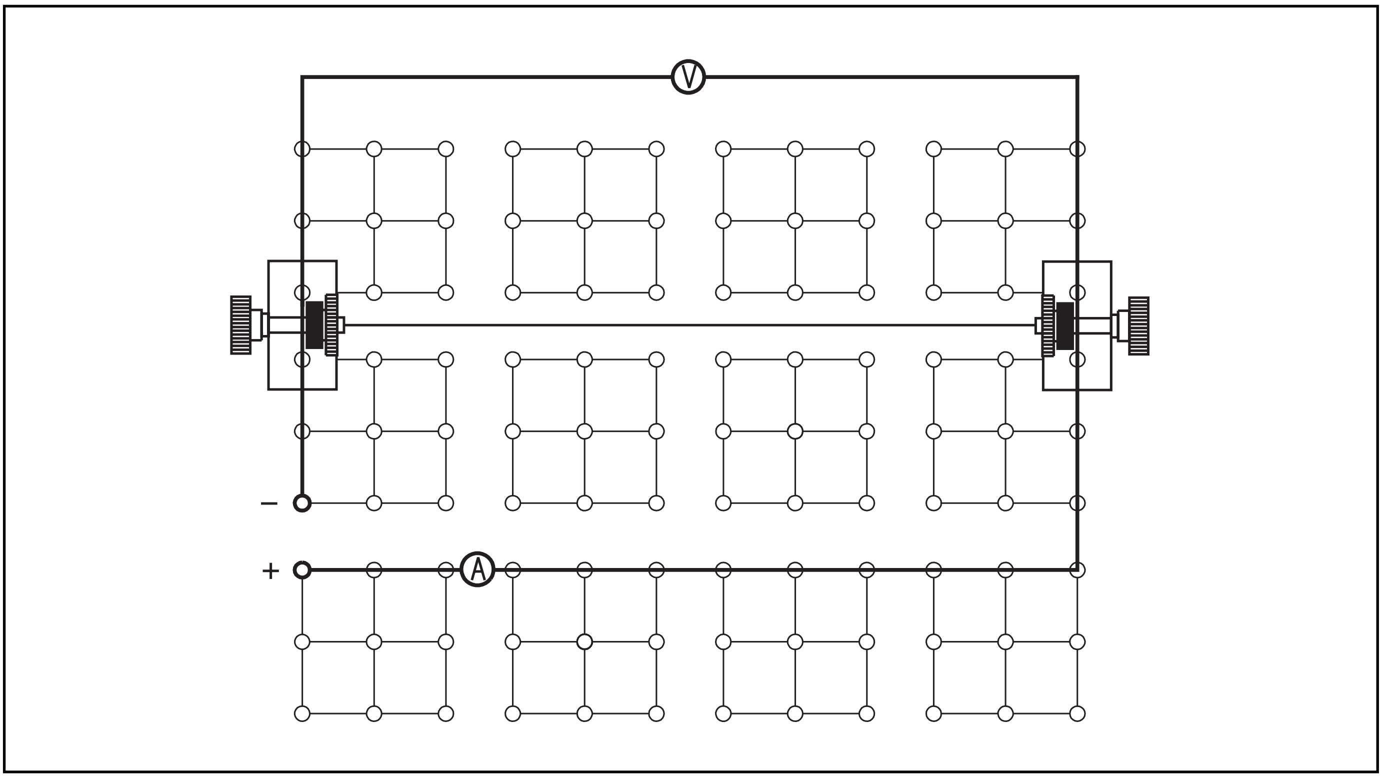
Plug-in board	06033.00	1
Wire building block	39120.00	3
Universal holder	39115.02	2
Connecting cable, 25 cm, red	07313.01	1
Connecting cable, 25 cm, blue	07313.04	1
Connecting cable, 50 cm, red	07314.01	2
Connecting cable, 50 cm, blue	07314.04	2
Copper wire, d = 0.2 mm, need approx. 30 cm	06106.00	(1)
Iron wire, d = 0.2 mm, need approx. 30 cm	06104.00	(1)
Constantan wire, d = 0.2 mm, need approx.. 30 cm	06100.00	(1)
Multi-range meter	07028.01	2
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1
Ruler		

Set-Up and Procedure
— Connect up the circuit as shown in Fig. 1; first fix the copper wire between the universal holders.
— Measure the length of the inserted piece of wire and note the measured value in Table 1.
— Select the 1 V- and 300 mA- measurement ranges.
— Set the power supply to 0 V, then switch it on.
— Carefully increase the power supply voltage until the ammeter shows 250 mA.
— Read the voltage from the voltmeter and note it in Table 1.
— Set the power supply back to 0 V.
— Remove the copper wire from the universal holders and replace it first with the iron wire, then with the constantan wire. As previously, measure the voltage at 250 mA in each case and note the values in Table 1.
— If appropriate, measure the lengths of the inserted pieces of wire and also note these second and third values for l in Table 1.
— Set the power supply to 0 V and switch it off.

Observations and Measurement Results
Table 1

Wire tested	$\frac{I}{A}$	$\frac{U}{V}$	$\frac{l}{m}$	$\frac{R}{\Omega}$	$\frac{R \cdot A / l}{\Omega \cdot mm^2/m}$
Copper	0.25				
Iron	0.25				
Constantan	0.25				

Fig. 1



Evaluation

1. Calculate the values of the resistances of the wires tested from the pairs of values for voltage U and current I and enter them in Table 1.
2. The following equation is true for the resistance of a wire:
   $R = \rho \cdot l / A$.
   The quantity ρ represents the resisivity (also called the specific resistance). It is a constant for a given material. The value of ρ given in Tables is usually for a temperature of 20°C. Calculate the resistivities of the materials (substances) of which the tested wires are made and enter the results of your calculations in the last column of Table 1.
3. Consider the unit for resistivity (shown at the head of the last column in Table 1) and formulate a definition for resistivity.

   The resistivity of a material is

   ....

   ....

   ....

   ....

   ....

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

   ....

   ....

   ....

   ....

   ....

   ....

5. The values given in Tables for the resistivities of the materials tested at 20°C are:
   $\rho_{Copper} = 0.017\ \Omega \cdot mm^2/m$,
   $\rho_{Iron} = 0.10 \ldots 0.13\ \Omega \cdot mm^2/m$,
   $\rho_{Constantan} = 0.50\ \Omega \cdot mm^2/m$.
   Should the results from your measurements be considerably different from these values, how can you explain the difference?

   ....

   ....

   ....

   ....

   ....

   ....

(How high is the resistivity of some metals?)

From the experimentally determined relationships R ~ l when ρ and A are constant, and R ~ 1/A when ρ and l are constant, and through R ~ l /A, resistivity was introduced as a material "constant" and the equation R = ρ · l /A was developed.
The students should use this equation to experimentally determine the quantity ρ for common conductor materials.

Notes on Set-Up and Procedure
When the students have already experimentally determined that R ~ l and/or R ~ 1/A, they will experience no difficulty in connecting up the circuit.
In contrast to the determination of ρ for constantan, it is necessary to work particularly carefully in determining for iron, and even more so for copper. For example, the relative error for voltage is high when making measurements on the copper wire, and with the iron wire, an onset of rust could prevent contact from being optimal.

Measurement Results
Table 1

Wire tested	I / A	U / V	l / m	R / Ω	R ·A / l / Ω· mm^2/ m
Copper	0.25	0.030	0.202	0.12	0.018
Iron	0.25	0.265	0.202	1.06	0.16
Constantan	0.25	0.818	0,202	3.27	0.50

Evaluation
1. Refer to the next to last column in Table 1.
2. Refer to the last column in Table 1.
3. The resistivity of a material is the size of the electrical resistance of a wire made from that material which has a length of 1 m and a cross-sectional area of 1 mm^2.
4. Copper is preferred because of its lower resistivity, i.e. because of its higher conductivity.
5. Greater deviations from the ρ for copper could be caused by the small swing of the voltmeter pointer, which could result in a relatively large display error. Greater deviations from the ρ of copper and iron could occur because their temperature was above 20°C, but this is of no consequence with constantan.

Remark
A current of 250 mA is recommended so that the wires do not heat up too much, and so that the measuring ranges for U and I do not have to be changed.

The resistivity of wires

(How high is the resistivity of some metals?)

Room for notes