The dependence of the resistance of a wire on its material and the temperature (Item No.: P1381200)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Electricity
Subtopic: The electrical resistance
Experiment: The dependence of the resistance of a wire on its material and the temperature

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

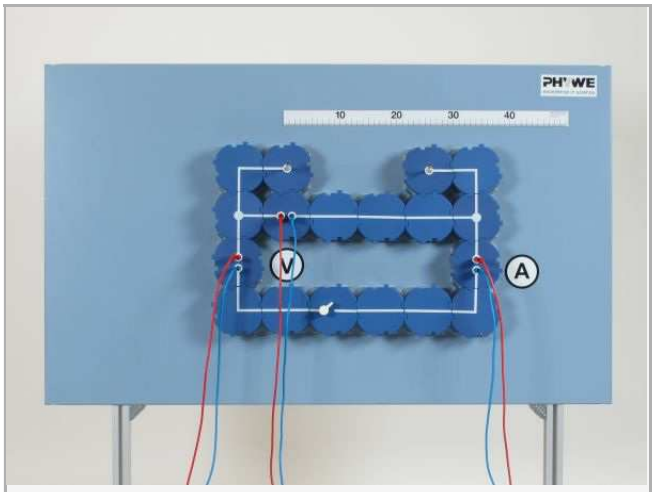
Experiment Variations:

Keywords:

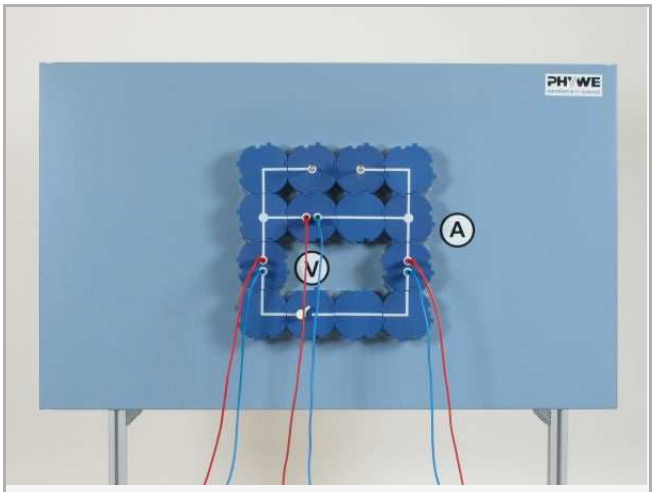
Principle and equipment

Principle

The influence that the material from which a wire is made and the temperature exert on the resistance of the wire is to be examined in a demonstration.



Experimental set-up Part 1



Experimental set-up Part 2

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	2
2	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
3	Demo Physics board with stand	02150-00	1
4	Switch on/off, module DB	09402-01	1
5	Connector interrupted, module DB	09401-04	3
6	Junction, module DB	09401-10	2
7	Electr.symbols f.demo-board,12pcs	02154-03	1
8	Connector, straight, module DB	09401-01	6
9	Connector, angled, module DB	09401-02	4
10	Connector, T-shaped, module DB	09401-03	2
11	Scale for demonstration board	02153-00	1
12	Connecting plug, 2 pcs.	07278-05	1
13	Constantan wire, 15.6 Ohm/m, d = 0.2 mm, l = 100 m	06100-00	1
14	Iron wire, d = 0.2 mm, l = 100 m	06104-00	1
15	Connecting cord, 32 A, 1000 mm, red	07363-01	3
16	Connecting cord, 32 A, 1000 mm, blue	07363-04	3
17	Copper wire, d = 0.2 mm, l = 100 m	06106-00	1
18	Alligator clips, bare, 10 pcs	07274-03	1

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Set-up and procedure

1st. Experiment

- Connect up the circuit as shown in Fig. 1; first clamp the copper wire between sockets a and b, using the crocodile clips on the connecting plugs; select the 1 Vand 300 mA- measurement ranges.
- Close the switch; switch on the power supply and, starting at 0 V, carefully increase the voltage until the current has reached 250 mA; measure the voltage and enter the measured value in Table 1.
- Set the power supply back to 0 V; replace the copper wire by the iron wire, and determine the voltage at 250 mA as above.
- Carry out the same procedure with the constantan wire.

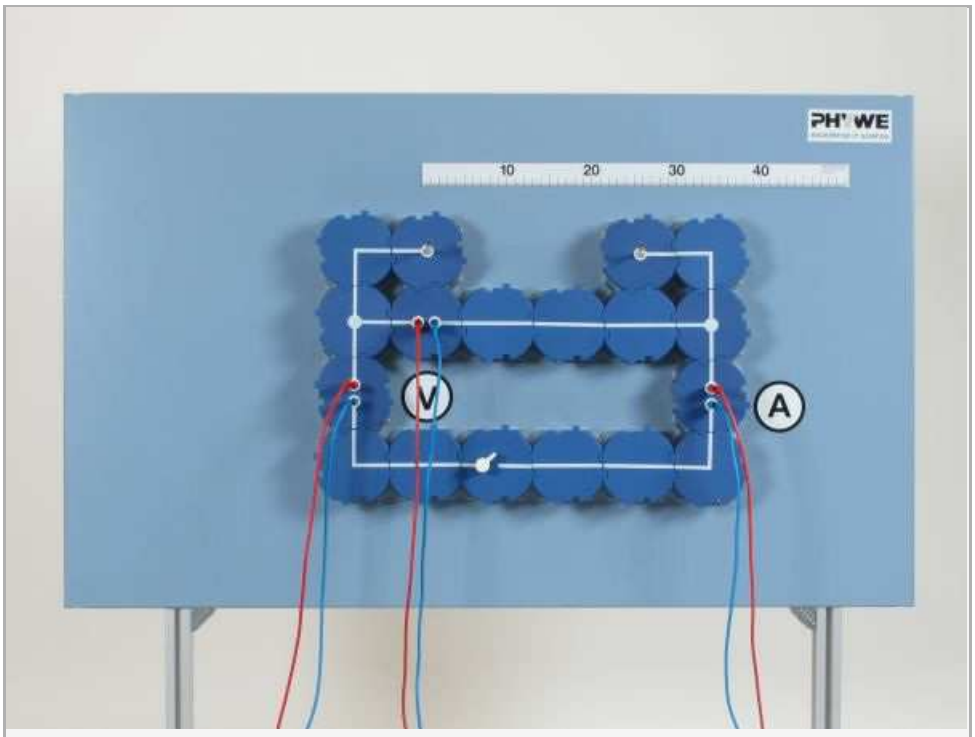


Fig. 1

2nd. Experiment

- Change the circuit used in the first experiment by removing 4 of the straight connector modules (see Fig. 2).
- Use a pencil or similar to coil the copper wire, then fix it at position a with the crocodile clips, so that the axis of the coil is vertical and some centimeters from the module; select the 3 V- and 1 A- measurement ranges.
- Increase the voltage from 0 V upwards until the current has reached a value of 0.6 A.
- Heat the coil with a flame as uniformly as possible and observe the deflection of the ammeter (1).
- Carry out the same procedure with the iron and constantan wires, and note your observations (2), (3).

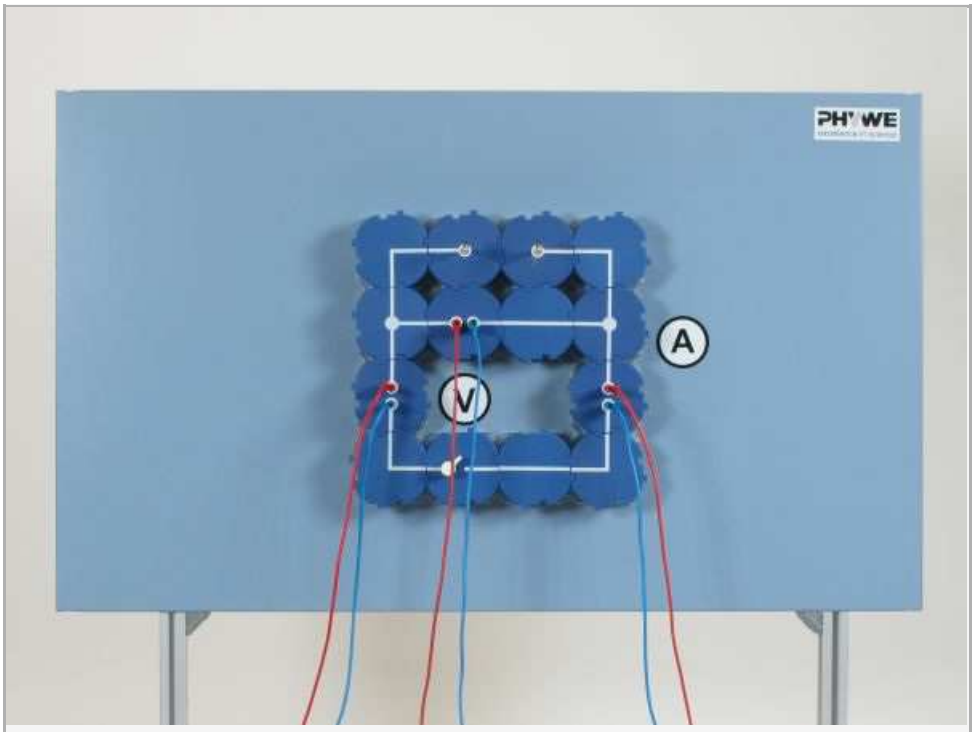


Fig. 2

Observation and evaluation

Observation

1. There is an appreciable decrease in the current when the copper coil is heated.
2. The iron coil behaves similarly to the copper coil.
3. On heating the constantan coil, the current only decreases when the coil is very strongly heated, and then only a little.

Table 1

Material	$\frac{I}{A}$	$\frac{U}{V}$	$\frac{R}{\Omega}$
Copper	0.25	0.042	0.168
Iron	0.25	0.25	1.00
Constantan	0.25	0.98	3.92

Evaluation

The values of the resistance of wires of the same length and cross-sectional area are dependent on the material from which they are made (see the last column, Table 1). The copper wire has the smallest resistance; the resistance of the iron wire is far higher than that of the copper wire, but far lower than that of the constantan wire.

The resistance of a copper and iron wires is highly dependent on the temperature, and is higher the higher the temperature. Constantan wires have an almost constant resistance over a large temperature range. The resistance of wires is given by the equation

$$R = \rho \cdot l / A$$

where ρ is the resistivity (specific resistance). It is a characteristic of a material and its value is, in general, independent of temperature. Its unit is $\Omega \cdot \mathrm{mm}^2 \cdot \mathrm{m}^{-1}$.

Remarks

Ohm's law, $I \sim U$ or $U = R \cdot I$, is only valid under the condition that $R = \mathrm{const.}$, in other words, not for wires made of a pure metal. It is of no account here whether the increase in temperature is caused by external heat, or by internal heat resulting from a large current. The flame should not be too large when heating the coils, and also not be held too near to them, so that the wires do not melt.

The set of magnetically adhering electrical symbols for the demonstration board enables circuits to be demonstratively labelled. The set consists of V and A indicators as well as blanks on which whatever is appropriate can be written, e.g. the connections for current and voltage measurements. The blanks can also be used to label the applied voltage or to describe resistances, positions, switch settings etc..

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com