The resistance of wires – dependence on length and cross-section (Item No.: P1381100)

Curricular Relevance

Area of Expertise: Physics

Education Level: Age 14-16

Topic: Electricity

Subtopic: The electrical resistance

Experiment: The resistance of wires – dependence on length and cross-section

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

Additional Requirements:

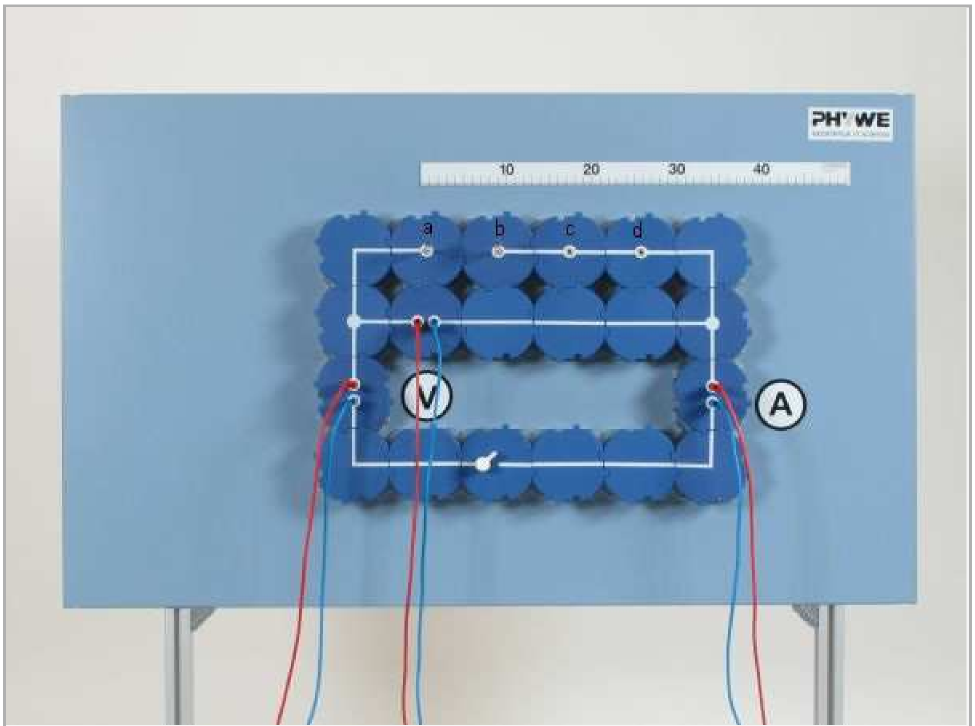
Experiment Variations:

Keywords:

Principle and equipment

Principle

The relationship between the value of the resistance of a wire and its length and cross-sectional area is to be examined in a demonstration.



Experimental set-up

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	Connect.straight w.socket,mod. DB	09401-11	2
12	Constantan wire, 6.9 Ohm/m, d = 0.3 mm, l = 100 m	06101-00	1
13	Constantan wire, 4 Ohm/m, d = 0.4 mm, l = 50 m	06102-00	1
14	Scale for demonstration board	02153-00	1
15	Connecting plug, 2 pcs.	07278-05	1
16	Constantan wire, 15.6 Ohm/m, d = 0.2 mm, l = 100 m	06100-00	1
17	Connecting cord, 32 A, 1000 mm, red	07363-01	3
18	Connecting cord, 32 A, 1000 mm, blue	07363-04	3
19	Alligator clips, bare, 10 pcs	07274-03	1

Set-up and procedure

1st. Experiment

- Connect up the circuit as shown in Fig. 1; clamp a part of the 0.2 mm diameter constantan wire between sockets a and b by means of the 2 crocodile clips on connecting plugs; select the 1 V- and 300 mA- measurement ranges; switch on the power supply and adjust it to 0 V.
- Close the switch, increase the power supply voltage until the current has reached 240 mA; measure the length of wire held and the voltage, enter the measured values in Table 1.

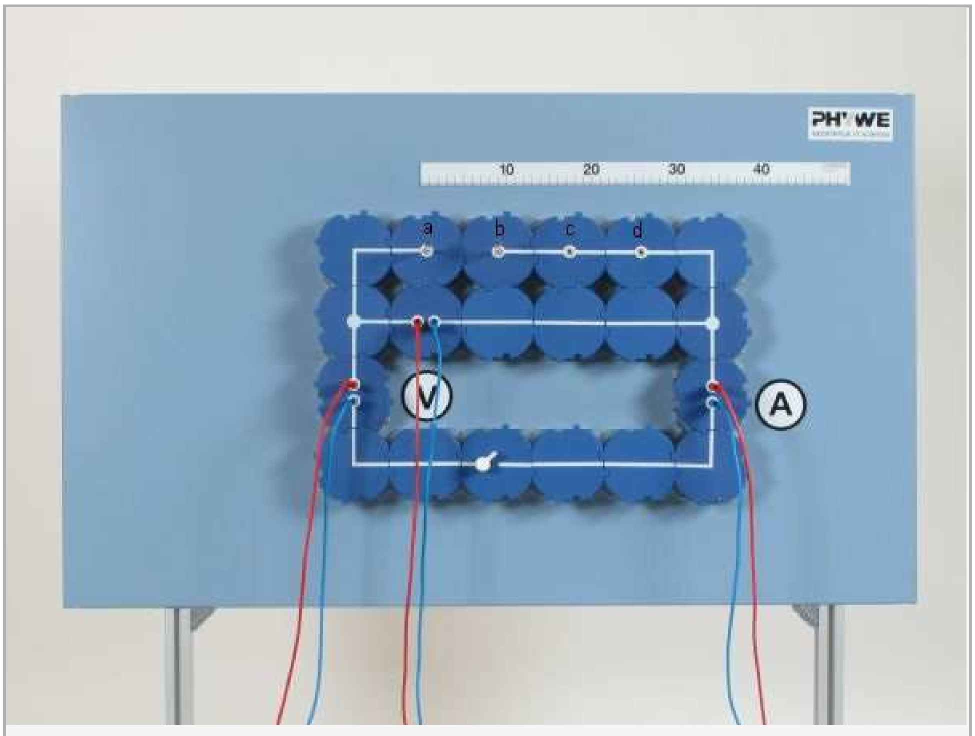


Fig. 1

- Open the switch; clamp a correspondingly longer piece of the wire between sockets a and c; remove the unnecessary module and repeat the measurements as above.
- Repeat the above procedure with the wire clamped between sockets a and d.

2nd. Experiment

- Leave the circuit connections as they were at the end of the first experiment; enter the value of the last voltage measured at $I = 0.24A$in the first line of Table 2.
- Replace the wire of $d = 0.2$mm with $d = 0.3$mm wire; measure the voltage at a current of $0.24\mathrm{A}$ and enter the measured value in Table 2.
- Replace the with $d = 0.4$mm wire and carry out the above procedure.

Observation and evaluation

Observation

Table 1 (d=0,2mm)

$\frac{I}{A}$	$\frac{l}{m}$	$\frac{U}{V}$	$\frac{R}{\Omega}$	$\frac{R*A}{\Omega*mm^2}$
0.24	0.08	0.32	1.33	16.6
0.24	0.16	0.64	2.67	16.6
0.24	0.24	0.95	3.96	16.5

Table 2 (l=0,24mm)

$\frac{d}{mm}$	$\frac{U}{V}$	$\frac{I}{A}$	$\frac{R}{\Omega}$	$\frac{A}{mm^2}$	$\frac{R*A}{\Omega*mm^2}$
0.2	0.95	0.24	3.96	0.031	0.12
0.3	0.42	0.24	1.75	0.071	0.12
0.4	0.24	0.24	1.00	0.126	0.13

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

Evaluation

After the values of the resistance have been calculated from U and I in Table 1, the graph of resistance against length of wire is plotted (Fig. 2). This leads to the assumption that there is a proportional relationship between R and l, and this is strengthened when the quotients R/l are calculated (last column, Table 1).

We therefore have $R \sim l$ oder $R/l = constant$ for a constantan wire whose cross-sectional area remains unchanged throughout the measurements.

After the values of the resistance have been calculated from U and I in Table 2, the graph of resistance R against the cross-sectional area of the wire is plotted (Fig. 3). This leads to the assumption that there is an inversely proportional relationship between R and A, and this is strengthened when the products $R \cdot A$are calculated (last column, Table 2).

We therefore have $R \sim 1/A$ or $R * A = constant$ for a constantan wire whose length remains unchanged throughout the measurements.

The complete results from the two experiments are:

$R \sim l$, for $A = constant$,

and

$R \sim 1/A$, for $l = aonstant$.

Or combining these, we obtain $R \sim l/A$.

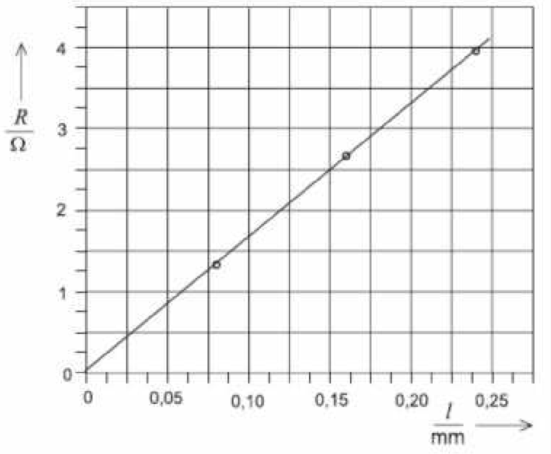


Fig. 2

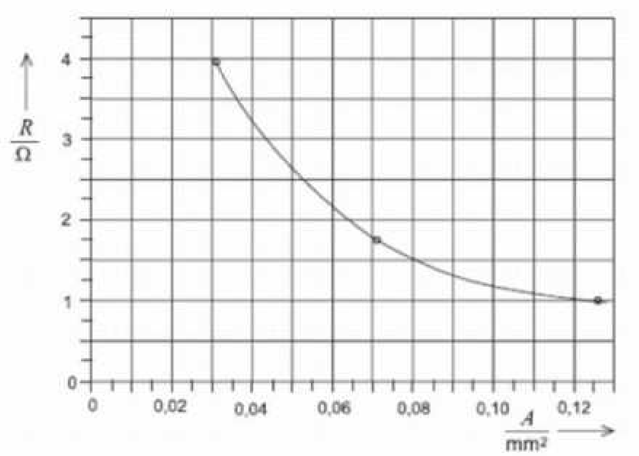


Fig. 3

Remarks

Take care to ensure that the fixed wire does not sag, but is also not too taut. The relationship $R \sim l/A$ is only valid for resistances which are temperature independent. Wires made of constantan alloy (DIN designation CuNi) have this property over a relative wide temperature range, and the constancy of its resistance was responsible for its name.
Ohm’s law is valid for constantan. Other metals do not have this property; the resistance of a wire made of a pure metal is therefore dependent on the material. The set of magnetically adhering electrical symbols for the demonstration board enables a circuit 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..