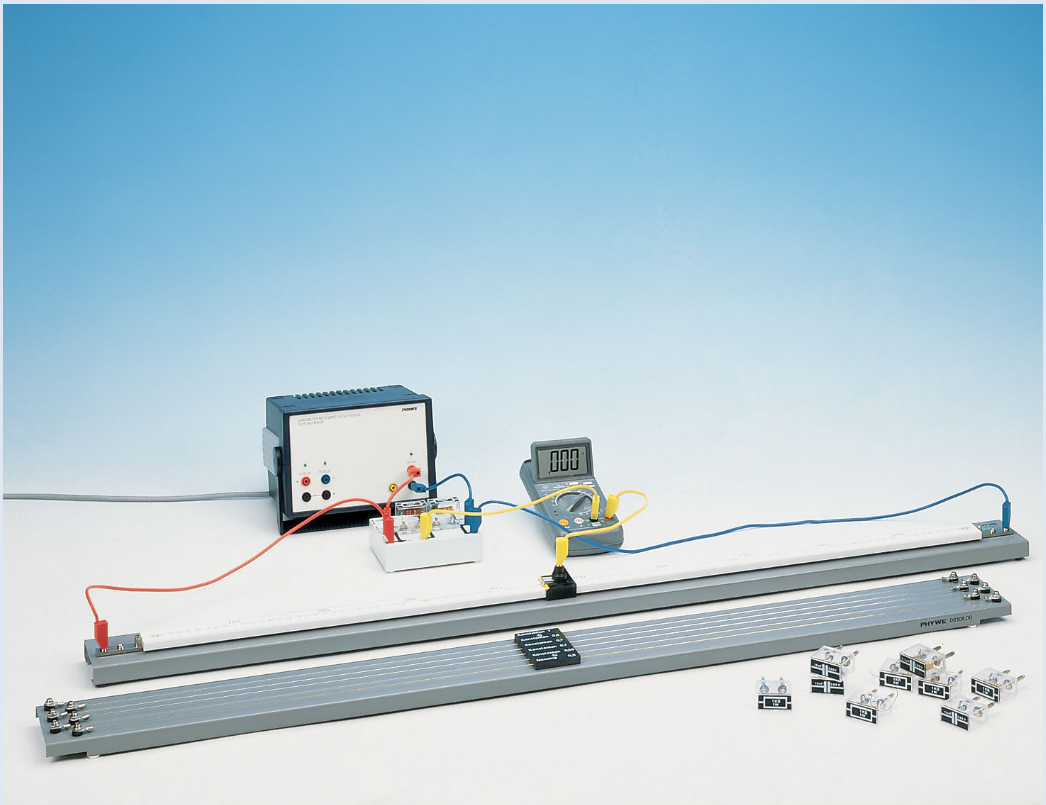
Wheatstone Bridge



What you can learn about ...

- → Kirchhoff's laws
- → Conductor
- → Circuit
- → Voltage Resistance
- → Para llel
- → connection Series
- → connection

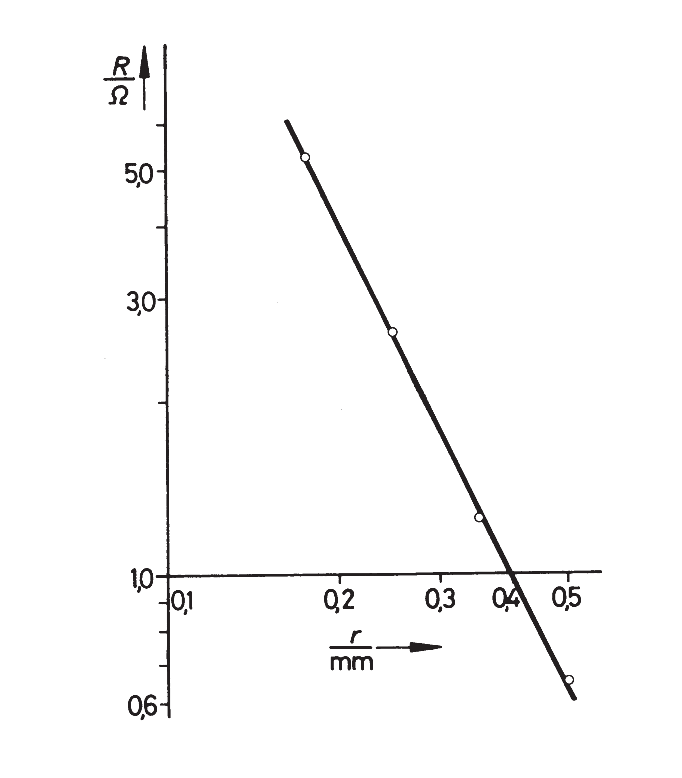
Principle:

The Wheatstone bridge circuit is used to determine unknown resist-ances. The total resistance of resis-tors connected in parallel and in series is measured.

What you need:

Resistance board, metal	06108.00	1
Simple slide wire measuring bridge	07182.00	1
Connection box	06030.23	1
Carbon resistor 10 Ω, 1W, G1	39104.01	1
Carbon resistor 100 Ω, 1W, G1	39104.63	1
Carbon resistor 150 Ω, 1W, G1	39104.10	1
Carbon resistor 330 Ω, 1W, G1	39104.13	1
Carbon resistor G1, 680 Ω, 1 W	39104.17	1
Carbon resistor 1 kΩ, 1W, G1	39104.19	1
Carbon resistor 4.7 kΩ, 1W, G1	39104.27	1
Carbon resistor 10 kΩ, 1W, G1	39104.30	1
Carbon resistor 15 kΩ, 1W, G1	39104.32	1
Carbon resistor G1, 82 kΩ, 1 W	39104.40	1
Carbon resistor 100 kΩ, 1W, G1	39104.41	1
Power supply 5 V-/1 A, +/- 15 V	13502.93	1
Digital multimeter 2010	07128.00	1
Connecting cable, 4 mm plug, 32 A, red, l = 50 cm	07361.01	2
Connecting cable, 4 mm plug, 32 A, yellow, l = 50 cm	07361.02	2
Connecting cable, 4 mm plug, 32 A, blue, l = 50 cm	07361.04	2
Resistor 1 Ω 2%, 2W, G1	06055.10	1
Resistor 2 Ω 2%, 2W, G1	06055.20	1
Resistor 5 Ω 2%, 2W, G1	06055.50	1

Complete Equipment Set, Manual on CD-ROM included
Wheatstone Bridge



Resistance of a conductor wire as a function of its radius r.

Tasks:

1. Determination of unknown resist-ances.Determine the total resistances
2. of resistors in series,
3. of resistors in parallel.
4. Determination of the resistance of a wire as a function of its cross-section.

Wheatstone Bridge

Related topics

Kirchhoff's laws, conductor, circuit, voltage, resistance, parallel connection, series connection.

Principle

The Wheatstone bridge circuit is used to determine unknown resistances. The total resistance of resistors connected in parallel and in series is measured.

Equipment

Resistance board, metal	06108.00	1
Slide wire meas. bridge, simple	07182.00	1
Connection box	06030.23	1
PEK carbon resistor 1 W 5% 10 Ohm	39104.01	1
PEK carbon resistor 1 W 5% 100 Ohm	39104.63	1
PEK carbon resistor 1 W 5% 150 Ohm	39104.10	1
PEK carbon resistor 1 W 5% 330 Ohm	39104.13	1
PEK carbon resistor 1 W 5% 680 Ohm	39104.17	1
PEK carbon resistor 1 W 5% 1 kOhm	39104.19	1
PEK carbon resistor 1 W 5% 4.7 kOhm	39104.27	1
PEK carbon resistor 1 W 5% 10 kOhm	39104.30	1
PEK carbon resistor 1 W 5% 15 kOhm	39104.32	1
PEK carbon resistor 1 W 5% 82 kOhm	39104.40	1
PEK carbon resistor 1 W 5% 100 kOhm	39104.41	1
Power supply, 5 V/1 A, +/-15 V	13502.93	1
Digital multimeter	07134.00	1
Connecting cord, l = 500 mm, red	07361.01	2
Connecting cord, l = 500 mm, yellow	07361.02	2
Connecting cord, l = 500 mm, blue	07361.04	2

Tasks

1. Determination of unknown resistances.

   Determination of the total resistance

2. of resistors in series,
3. of resistors in parallel.
4. Determination of the resistance of a wire as a function of its cross-section.

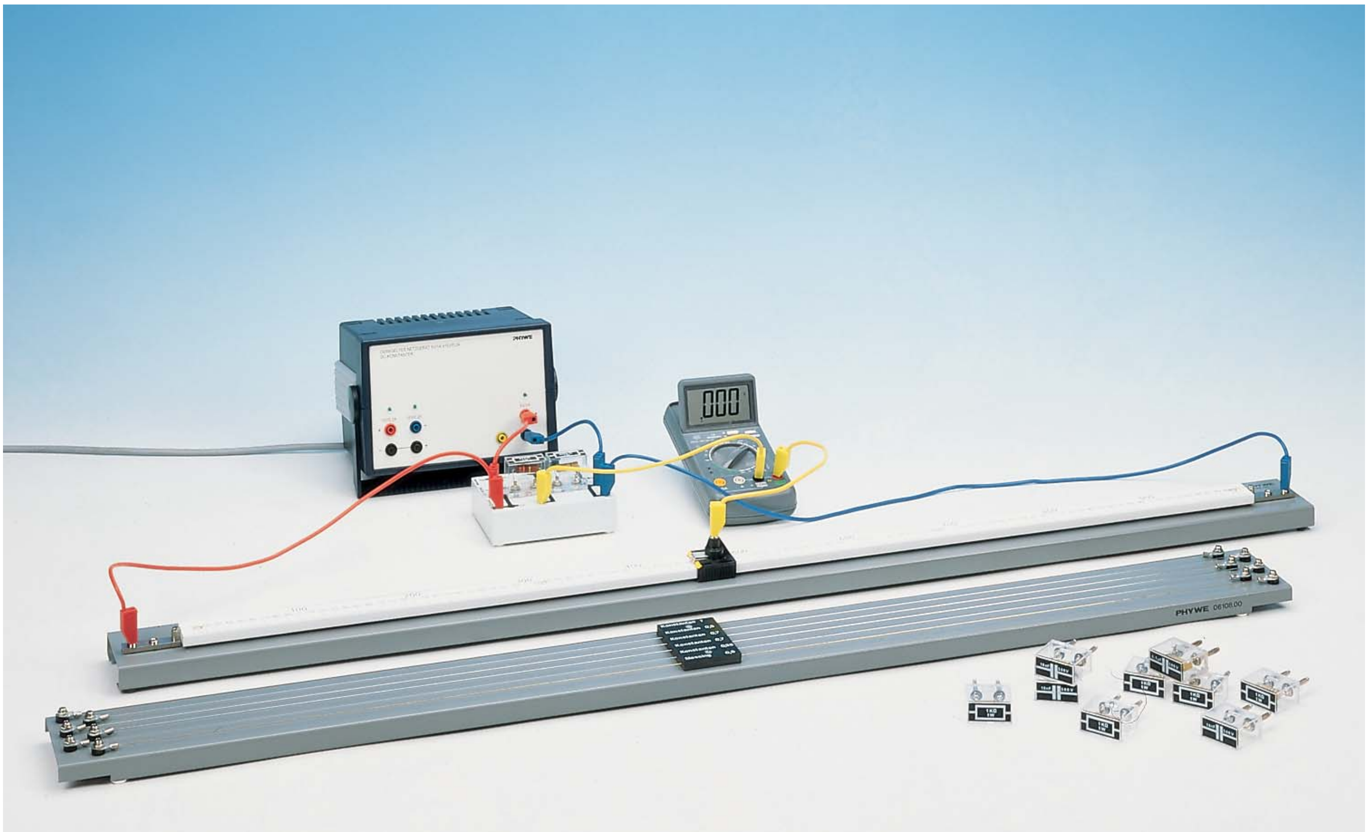
Set-up and procedure

The values of the resistors to be measured are made invisible and encoded as follows.

x 1	=	270	Ohm
x 3	=	15	KOhm
x 8	=	4.7	KOhm
x13	=	150	Ohm
x16	=	680	Ohm

The experimental set up is as shown in Fig. 1. The resistance to be investigated (single, parallel-connected, series-connected and wire resistances) are shown in Fig. 2 as R_x. Since the slide wire measuring bridge gives the best reading accuracy in its central part, it is useful to bring the measuring resistance R successively to the order of magnitude of R_x. The measuring instrument G (setting 100 μA $\triangleq$ 100 mV) should be balanced to zero by moving the slider.
The power unit is so designed that resistances from milliohms to Megohms can be investigated, but in the milliohm range the

Fig. 1: Experimental set up for determining an unknown resistance with the Wheatstone bridge.



resistances of the connecting leads must be taken into account. Through the pilot light, the power unit is short-circuit-proof.

Theory and evaluation

With branched circuits, in the steady-state condition, Kirchhoff's 1st law applies at every junction point:

$$\sum_{\nu} I_{\nu} = 0 \qquad (1)$$

where I_{ν} are the current values which lead to or from the junction point.

It is customary to take I_{ν} as negative if the corresponding current in the ν-th conductor is flowing away from the junction point.

For every closed loop C in a network of linear conductors, in the steady-state condition, Kirchhoff's 2nd law applies:

$$\sum_{\nu} (I_{\nu} R_{\nu} - U_{\nu}^{e}) = 0 \qquad (2)$$

where R_{ν} is the resistance in the ν-th conductor and U_{ν}^{e} the voltage.

For the Wheatstone bridge circuit, one obtains

$$R_x = R \cdot \frac{R_1}{R_2} = R \cdot \frac{l_1}{l_2}$$

for an unknown resistance R_x with the designations of Fig. 2, in the balanced condition.

R_{X1}	268	Ω
R_{X3}	15.0	kΩ
R_{X8}	4.81	kΩ
R_{X13}	151	Ω
R_{X16}	682	Ω

Table 1: Resistances measured with the Wheatstone bridge.

From (1) and (2), there follows

$$R_{tot} = \sum_i R_i$$

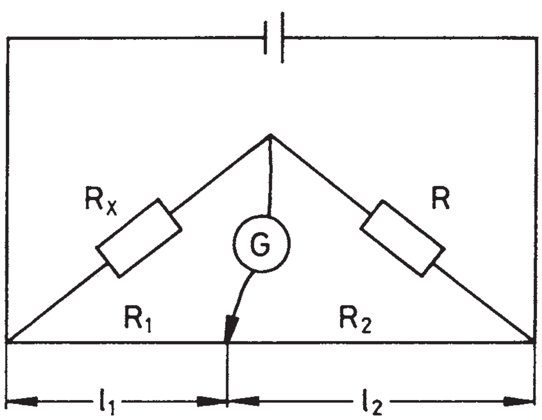


Fig. 2: Wheatstone bridge circuit.

for resistances R_i connected in series, and for resistances connected in parallel

$$\frac{1}{R_{tot}} = \sum_i \frac{1}{R_i}$$

1.	$R_{X1'}$	$R_{X13'}$	R_{X16}	85	Ω
2.	$R_{X1'}$	R_{X13}		96.6	Ω
3.	$R_{X1'}$	R_{X16}		192	Ω
4.	$R_{X1'}$	R_{X13}		420	Ω
5.	$R_{X1'}$	$R_{X13'}$	R_{X16}	1100	Ω
6.	$R_{X1'}$	$R_{X13'}$	R_{X16}	260	Ω

Table 2: Total resistance of resistors connected in parallel (lines 1, 2 and 3), in series (lines 4 and 5) and in series-parallel (line 6).

For a uniform conductor of length l and cross-sectional area A, the resistance is

$$R = \rho \cdot \frac{1}{A} \qquad (3)$$

where ρ is the resistivity of the material.

From the regression line to the measured values of Fig. 3 with the exponential statement

$$Y = A \cdot X^{B}$$

the exponent

$$B = -1.998 \pm 0.05 \qquad \text{(see (3))}$$

is obtained.

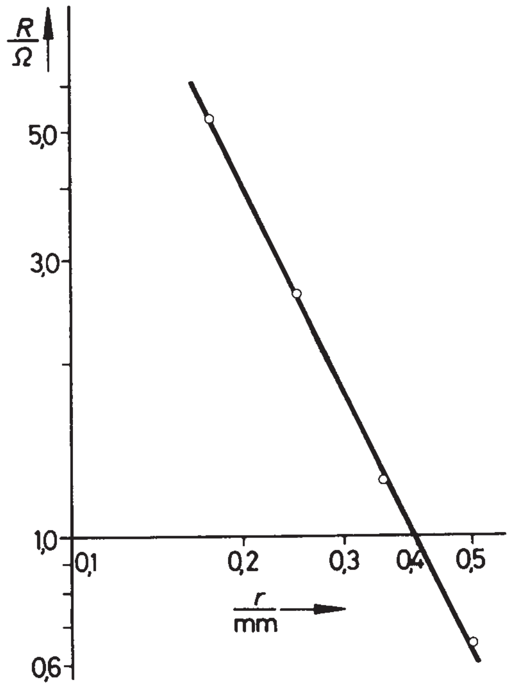


Fig. 3: Resistance of a conductor wire as a function of its radius r.

WHEATSTONE BRIDGE EXPERIMENT

1. Study with two resistor (R1 and R2). Their resistor values are known (Values are given on the top of the resistor).
2. Try to do the experiment with L1 20cm and 60cm (**Note**: Researcher assistant will help how you can give L1 and L2 values). Prove the wheatstone bridge.

L1 : R1 : L1 : R1 :

L2 : R2 : L2 : R2 :

3. In this case, you are going to know one resistor value and try to find the other one . Redo the

experiment with L1 30cm, 50cm ,70cm with three different resistor. (**Note**: Researcer assistant may help you)

L1 : R1 :

L2 : R2 :

L1 : R1 :

L2 : R2 :

L1 : R1 :

L2 : R2 :

Results and Discussions: Discuss the results.

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