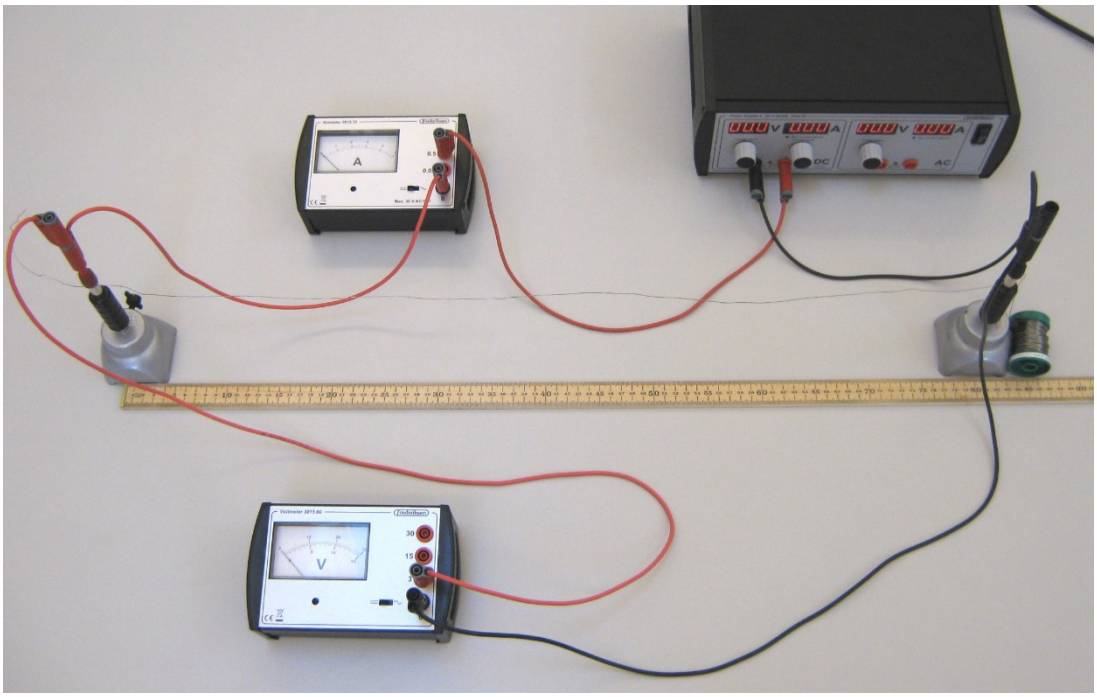
Ohm's law

Number	136050-EN	*Topic*	Electricity		
Version	2017-02-14 / HS	*Type*	Student exercise	*Suggested for* grade 7-10	*p.* 1/4



Objective
Examining the relationship between voltage and current for a metal wire.

Principle
A length of Kanthal wire is extended between two terminal posts in order to measure the current through the wire and the voltage across it.
For comparison, the same measurements are carried out for a small incandescent lamp.

The results are analysed graphically and compared with Ohm's law.

Equipment
(Detailed equipment list on last page)

Power supply
Volt- and ammeters

Kanthal wire 0.50 mm
Bulb, 6 V / 1 A

Socket for light bulb
Stand material
Lab leads
Ruler, 1 m

Using multimeters
Instead of Frederiksen's analog instruments, you can use digital multimeters. Hints for use:

As an ammeter
We will need a current of up to 0.5 A. The safest is to use the high current input of the meter. Look at the sockets: If there is a separate socket marked "10 A" – this is the one to use together with the "Com" socket.

As a voltmeter
If the multimeters hasn't auto-ranging, pick a range that is capable of measuring 3 V.
If the meter has both a "mV" and a "V" socket, use "V" together with the "Com" socket.

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Procedure

The wire can be re-used many times. Don't cut it, unless explicitly instructed to do so. Instead, just let the coil stand next to the experiment and re-wind the wire afterwards.

Fasten the wire thoroughly to the terminal posts with approximately 80 cm between the posts when the wire is tight.
Don't waste time on adjusting the length but measure the actual length accurately and write it down.

If the power supply has a current limiter, the measurements can be carried out with this turned fully up, with only the voltage adjusted. Turn the voltage down to 0 V while setting up.

When you connect the volt- and ammeters, proceed systematically:

1. First, establish a circuit for the **current** to follow
2. Next, connect the voltmeter between the points where the **voltage** is to be measured.

In this experiment, all measurements can be done with voltmeter range 3 V and ammeter range 0.5 A. Both voltage nor current must be kept below these limits.

The instruments are set to DC measurements.

Make a table for the result as shown below.

When ready, turn up the voltage slightly. Both instruments should respond now. Continue carefully until you reach either 3 V or 0.5 A.
Now you know the maximum values – write them down.

Now, you must plan and carry out a series of measurements – 7 to 10 all in all – with the voltage stepping up more or less evenly from 0 V to the maximum value.

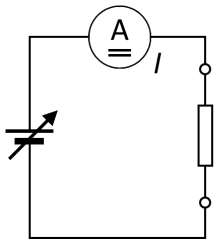
For each measurement, write down both voltage and current in the table.

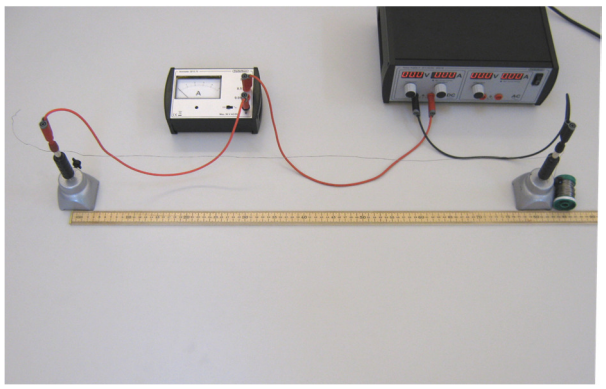
Now replace the wire and terminal posts with the 6 V / 1 A bulb in a socket. Repeat the entire measurement series. The lowest voltages are important here - try to hit about 0.1 V in one of the measurements.

Table for results

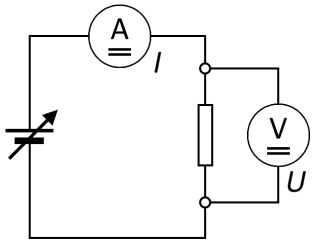
Make a table like the one below:

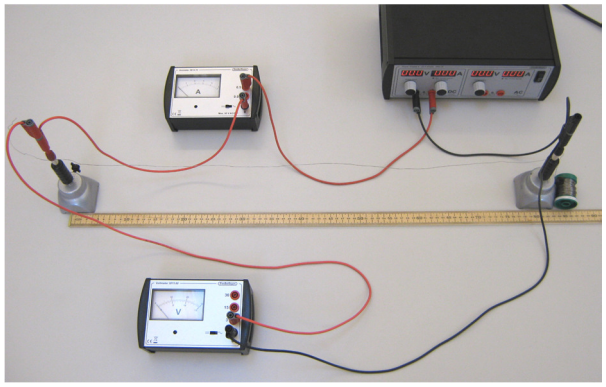
Measured		Calculated
U	*I*	*R*
V	A	Ω





1 First, establish a circuit for the current …





2 … then add the voltmeter.

Theory

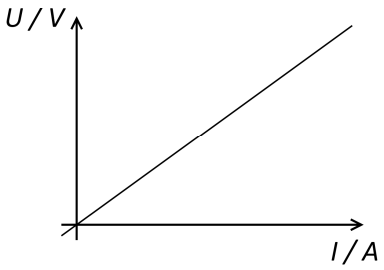
The voltage U across an electric component often varies in step with the current I through it. U is said to be proportional to I, and the relationship is expressed mathematically as:

$$U = R \cdot I$$

Here R is a constant, called the *components resistance*.
Thus, in this experiment we find the *resistance of this length of wire*. When you enter U in V and I in A, R will come out with the unit Ω (read: "ohm").

This formula is known as *Ohm's law*.

A graph with I along the 1st axis and U along the 2nd axis results in a straight line through (0,0).



Even if this relationship between current and voltage often is valid, it is absolutely not universally true.

If U and I are known, R can be found:

$$R = \frac{U}{I}$$

If Ohm's law holds true for a given component, the value of R is a constant – and vice versa.

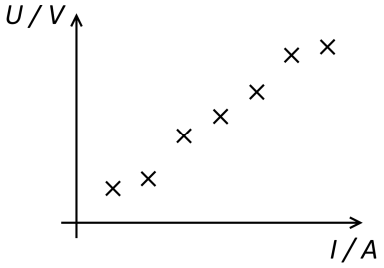
Even if Ohm's law does *not* apply, you can of course insert measured values of U and I to calculate R – but in that case it would not be correct to speak about a resistance.

Calculations

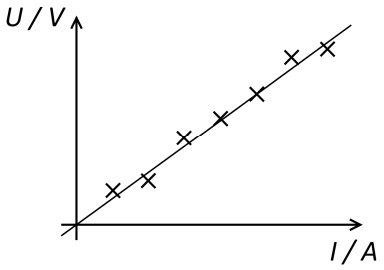
Draw a graph of the results for the Kanthal wire. It can be done in a spreadsheet or on paper:

The units on the axes should let 2 cm correspond to 0.1 A (1st axis) resp. 5 cm correspond to 1 V (2nd axis).

Plot the measurement points – mark them with small crosses – the points must ***not*** be connected by lines.



When all result have been plotted, try to draw a straight line through (0,0), lying as close as possible to all the measured points.
(A *transparent* ruler will be a great advantage.)



Calculate R for all measuring points in the table.

Similarly, plot the points for the light bulb in a spreadsheet or on paper. – Is it possible again to fit the points with a straight line through (0,0) ?

Discussion and evaluation

We must always take into account that measured values have uncertainties, meaning that small deviations from theory are acceptable!

We are interested to know if the metal wire obeys Ohm's law. That can be decided in two ways:

- Do the points roughly lie on a straight line?
- Has R approximately a constant value?

Do the two methods give the same answer?

Does the metal wire comply with Ohm's law? Does the light bulb? (Justify your answers.)

Teacher's notes

Concepts used

Voltage
Current
Resistance

Mathematical skills

Graph drawing
Evaluation of a simple formula

About the equipment

The instruments 381560 and 381570 are overload protected. They will also tolerate wrong polarity although only positive values can be read.

It will eventually be possible to read the current on a built-in ammeter in the power supply – if you want to avoid an external meter.
On the other hand, from a pedagogical perspective, it will be undesirable to use a built-in *voltmeter*. It will not in this context cause real problems for the measurement, but the students should get used to connect the voltmeter directly across the component in question.

Detailed equipment list

Specifically for this experiment

381570	Ammeter	
381560	Voltmeter	
115520	Kanthal wire 0.50 mm	
425040	Bulb 6 V / 1 A (box with 10)	
412000	Lamp socket E10, 2 connectors	

Standard lab equipment

361600	Power supply (Alternative power supply: 364000. The photo on p. 1 shows this model)	
435030	Terminal posts, insulated (pair)	
000410	Retort stand base, square	(2 pcs.)
105720	Safety cable, silicone, 50 cm, black	
105721	Safety cable, silicone, 50 cm, red	(2 pcs.)
105740	Safety cable, silicone, 100 cm, black	
105741	Safety cable, silicone, 100 cm, red	