Problem

Take a series of measurements for voltage and current in a circuit and determine the relationship between U and I with these measurements.

Equipment

Plug-in board	06033.00	1
Lamp holder E10	17049.00	1
Filament lamp, 4 V/0.04 A, E10, 1 pc.	06154.03	(1)
Resistor, 47 Ω	39104.62	1
Resistor, 100 Ω	39104.63	1
Wire building block	39120.00	1
Connecting cables, 25 cm, red	07360.01	1
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	2
Connecting cables, 50 cm, blue	07361.04	2
Multi-range meter	07028.01	2
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure

First Experiment

— Set up experiment as shown in Fig. 1, using the 47 Ω resistor initially (designated as R_1 in Table 1).

— Switch on power supply unit and, starting with 0 V, increase voltage in increments of 2 V. Measure the respective current and enter values in Table 1.

— Set voltage back to 0 V and replace the 47 Ω resistor R_1 with the 100 Ω resistor R_2.

— Again, increase voltage in increments of 2 V, measure respective current, and enter in Table 1.

— Switch power supply unit off.

Second Experiment

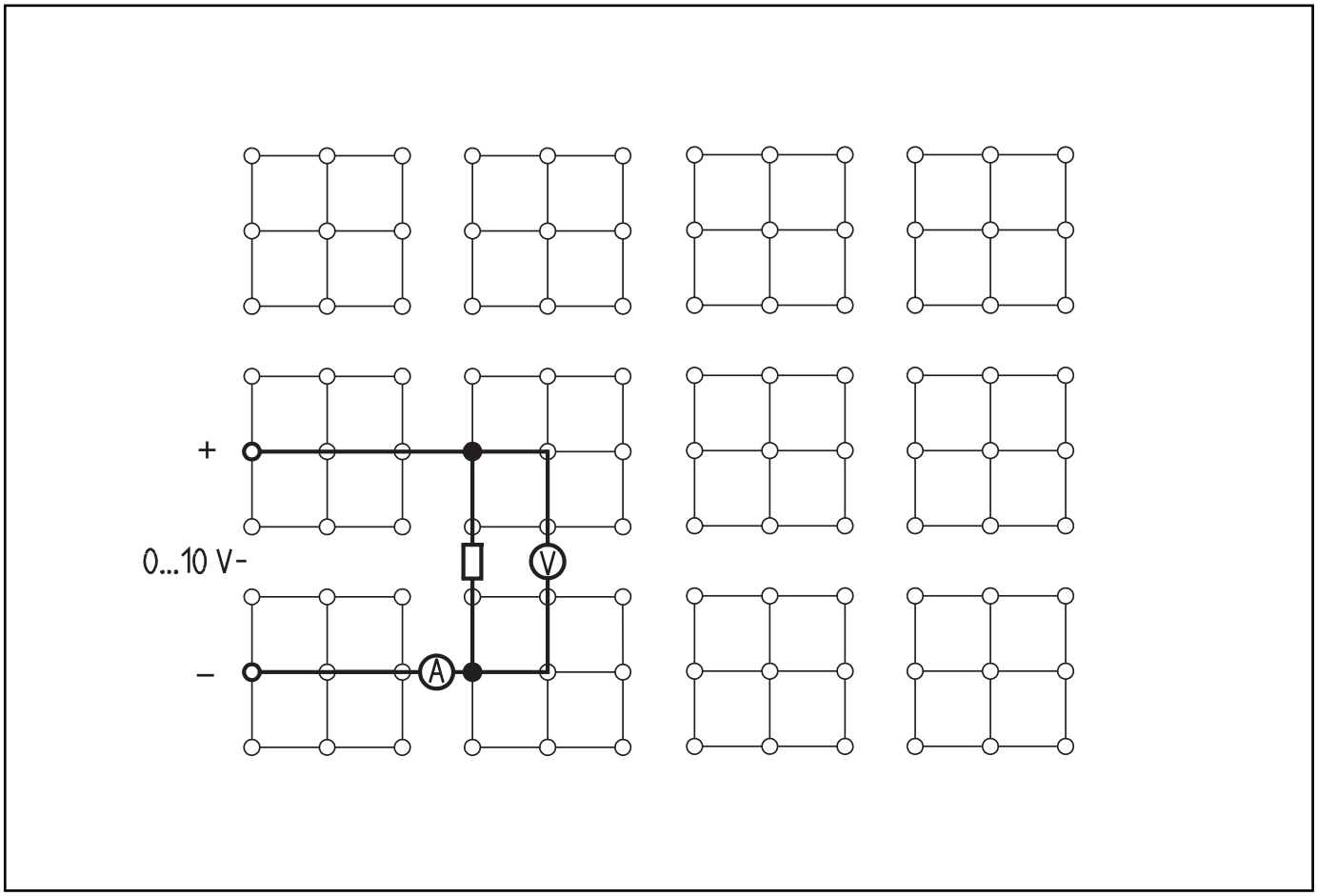
— Change experiment set-up. Connect a filament lamp to the circuit in place of the resistor.

— Connect direct voltage and increase in increments of 2 V starting at 0 V, measure respective current, and enter in Table 2.

— Observe the brightness of the filament lamp during this experiment and note.

— Switch power supply unit off.

Fig. 1



Observations and Measurement Results

Table 1

$\frac{U}{V}$	$\frac{I}{A}$		$\frac{U/I}{V/A}$	
	(R_1)	(R_2)	(R_1)	(R_2)
0	0	0	–	–
2				
4				
6				
8				
10				

Table 2

$\frac{U}{V}$	$\frac{I}{A}$	$\frac{U/I}{V/A}$
0		
2		
4		
6		
8		
10		

Brightness of filament lamp during experiment:

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Evaluation

1. Graph the measurement values from Table 1 for the components R_1 and R_2 in Fig. 2.
2. What would you guess is probably the relationship between current I and voltage U for each component? Check your hypothesis by calculating the quotients of U / I from the pairs of measurements and entering the values in column 3 of Table 1.
   What is apparent from the results?

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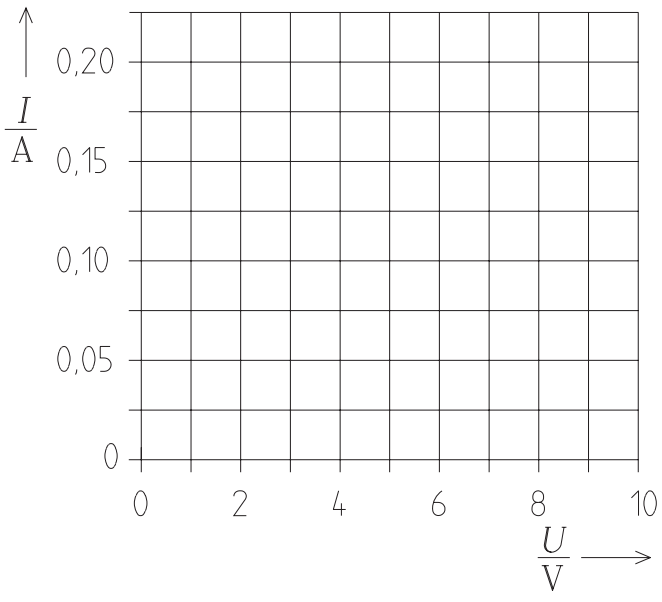
This relationship between current and voltage is referred to as Ohm's Law.

Fig. 2



3. The quotient of U / I for R_1 is about half that for R_2. In other words, R_1 obstructs the electrical current about half as much as R_2. Therefore, it makes sense to define the quotient U / I = constant as electrical resistance R: U / I = R. The unit for resistance is 1 V/A = 1 Ω. Calculate the average values of U / I for R_1 and R_2 and compare these with the values printed on the components used in the experiment.
   Why do these values deviate from one another?

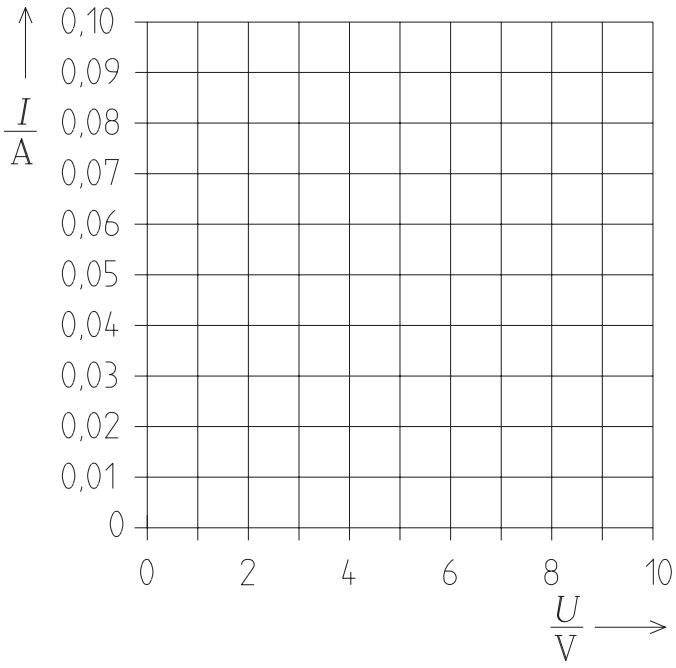


Fig. 3

4. Draw the graph resulting from the U and I measurements for the filament lamp (Table 2) in Fig. 3.

5. Calculate the quotients U / I for Table 2 and enter them in column 3.

6. With the results from questions 4 and 5 in mind, answer the following question:
   Does Ohm's Law also apply to the filament lamp?
   Why or why not?

7. While the defining equation R = U / I is always true, as long as I ≠ 0, Ohm's Law only applies under one certain condition. Which one?
   (Note: The brightness of the filament lamp is an indication of the temperature of its metallic filament.)

(What is the relationship between voltage and current?)

The students should first recognize Ohm's Law I ~ U on the basis of the measurements they've taken. Then, they should determine the condition R = constant for the validity of this law.
To avoid confusion between the words "resistor" (the electrical component) and "resistance" (the physical term), the components are referred to as R_1 and R_2, marked 47 Ω and 100 Ω.

Notes on Set-Up and Procedure
The resistance values and the voltage settings are such that the measurement ranges of 10 V- and/or 300 mA- are sufficient for these measurements.
Before students switch on the power supply unit, instruct them how to connect the meters correctly and what measurement ranges they need to set.

Observations and Measurement Results
Table 1

$\frac{U}{V}$	$\frac{I}{A}$		$\frac{U/I}{V/A}$	
	(R_1)	(R_2)	(R_1)	(R_2)
0	0	0	–	–
2	0.042	0.019	48	105
4	0.086	0.039	48	103
6	0.130	0.059	46	102
8	0.173	0.080	46	100
10	0.216	0.100	46	100

Table 2

$\frac{U}{V}$	$\frac{I}{A}$	$\frac{U/I}{V/A}$
0	0	–
2	0.037	54
4	0.053	75
6	0.069	87
8	0.082	98
10	0.093	108

Brightness of filament lamp during experiment: The filament lamp shines very weakly at 2 V and more brightly with increasing voltage and/or current.

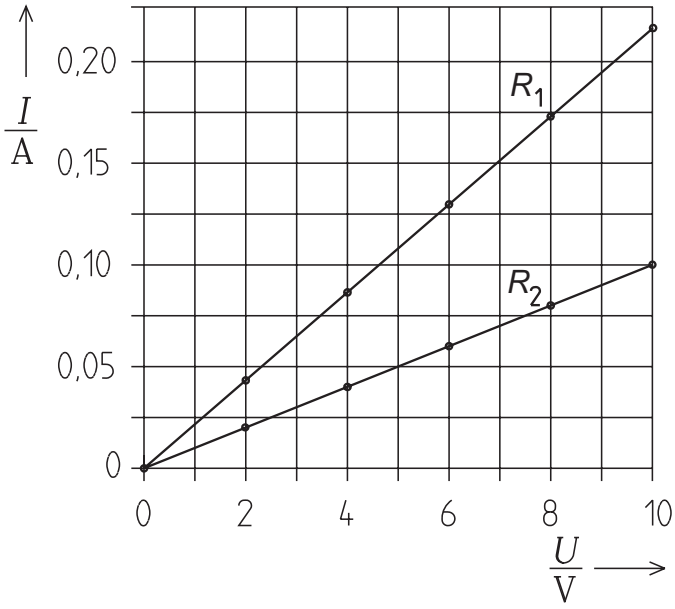
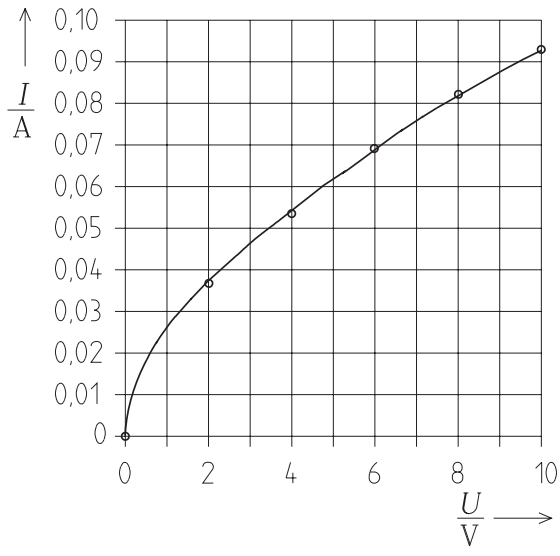


Fig. 2

Evaluation
1. See Fig. 2.
2. Probable relationship: The current changes in the same proportion as voltage. I and U are proportional to one another, I ~ U.
   Check: See Table 1, column 3.
   Conclusion: U / I = constant for each component.

Fig 3



(What is the relationship between voltage and current?)

3. Average for R_1: U / I = 46.8 V/A = 46,8 Ω
   Average for R_2: U / I = 102 V/A = 102 Ω
   These values are approximately the same as the values printed on the components. The deviations result from measurement errors during the measurement of current and voltage and from the tolerance of the resistance values.
4. See Fig. 3.
5. See Table 2, column 3.
6. Ohm's Law does not apply to the filament lamp. Explanation: The graph in Fig. 3 is not a line, and the quotient U / I is not constant.
7. The condition for Ohm's Law to apply is: ϑ = constant.

Notes

The relationship I ~ 1/R when U = constant can be proven by comparing the values for I and R in Table 1 line for line. Fig. 2 shows that the slope of the graph gets steeper as resistance is decreased.

For pure metals, the condition for the validity of Ohm's Law, that R = constant, is the same as the condition ϑ = constant. Certain alloys, such as constantan, have a constant resistance in a relatively large temperature range.