Task

To connect resistances of various sizes in a circuit and examine the internal resistance of the source of voltage R_i, by measuring the current I and the terminal voltage of the source of voltage U_{Kl}.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Wire building block	39120.00	4
Lamp holder E10	17049.00	1
Resistor, 47 Ω	39104.62	1
Battery holder	39115.01	1
Connecting cable, 25 cm, red	07313.01	2
Connecting cable, 25 cm, blue	07313.04	2
Round cell, 1.5 V	07922.01	1
Filament lamp, 6V/0.5 A, E10, 1 pc.	35673.03	(1)
Multi-range meter	07028.01	2

Set-Up and Procedure

First experiment

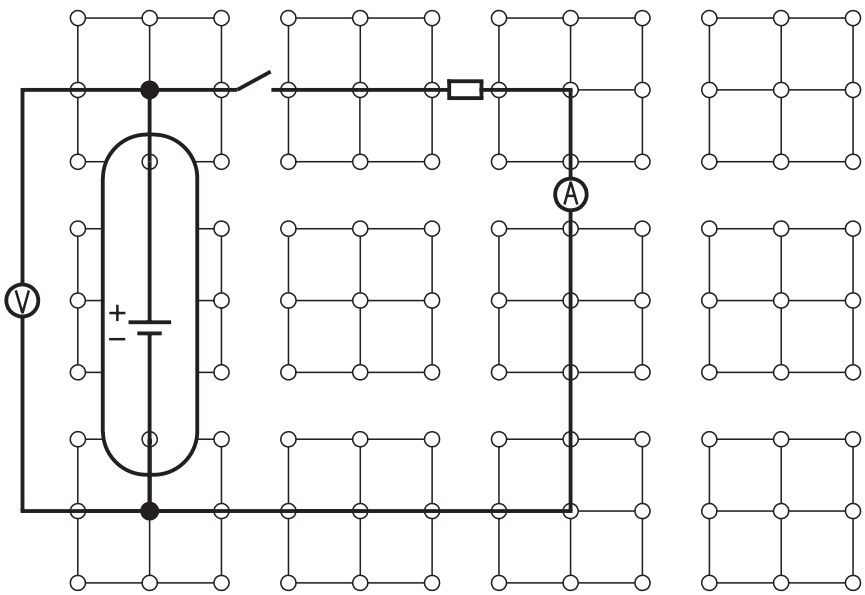
— Connect up the circuit as shown in Fig. 1, with the switch open.
— Select the 3 V- and 30 mA- measurement ranges.
— Measure the terminal voltage U_{Kl} for I = 0, i.e. without load; note the measured value in Table 1.
— Close the circuit, read off the terminal voltage U_{Kl} und current I (under load); note the measured values in Table 1.
— Open the circuit and replace the resistor with the filament lamp; change the ammeter to the 300 mA- measurement range.
— Close the circuit, again read off U_{Kl} und I and note the measured values.
— Open the switch and replace the filament lamp with a wire building block; change the ammeter to the 3 A-measurement range.
— Briefly (!) close the switch, read off the short circuit U_{Kl} and I and note them in Table 1.
— Note: The short circuit current must only be allowed to flow for a very short time, to avoid damaging the source of current.

Measurement Results

Table 1

Load I / A	Terminal voltage U_{Kl} / V
0	

Fig. 1



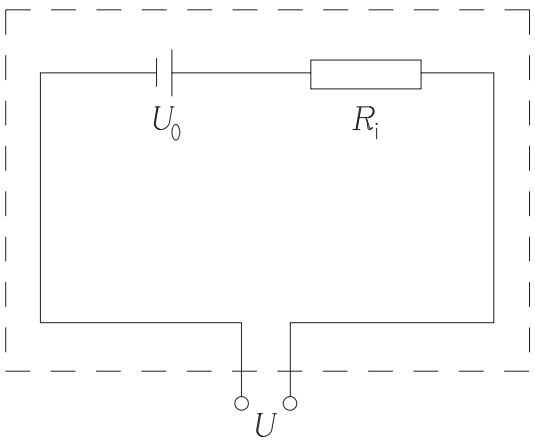
Evaluation

1. Formulate the relationship between the terminal voltage U_{Kl} and the load I in words.

2. Fig. 2 shows an alternative circuit diagram for the source of voltage with its internal resistance R_i. Under load, the voltage $R_i \cdot I$ drops across R_i. The voltage that the source of current supplies when not under load (i.e. with I = 0 A) is designated U_0. Formulate the relationship between U_0 and U_{Kl} in an equation. (Note: remember the law of connection in series $U_{tot} = U_1 + U_2$.)

3. Re-arrange the equation found in 2. for R_i and use the measured values for the short circuit in Table 1 to calculate the internal resistance R_i for the source of current used.

Fig. 2



(Do sources of current also have a resistance?)

A commercially available dry battery or single cell is extremely suitable for this experiment on the internal resistance of a source of current. It has an internal resistance which is high enough to be measured well, and it can easily be replaced should inattentiveness cause it to be destroyed by too long exposure to the overload.
The power supply is not suitable for this determination of internal resistance because it is voltage stabilized.

Notes on Set-Up and Procedure
Great attentiveness is necessary when reading off measured values during the short circuit, because when this is held for too long, the voltage to be measured drops significantly and the battery is destroyed. When at least two students work together, they should each simultaneously read one of the measured values for U_{Kl} and I, to minimize the duration of the short circuit. Otherwise the student should briefly make the short circuit twice, and in each case read one of the measured values.

Measurement Results
Table 1

Load I / A	Terminal voltage U_{Kl} / V
0	1.67
0.017	1.64
0.154	1.55
2.15	0.55

Evaluation
1. Terminal voltage drops under load, and the drop is greater the larger the load.
2. $U_0 = U_{Kl} + R_i \cdot I$ or
   $U_{Kl} = U_0 - R_i \cdot I$
3. $R_i = (U_0 - U_{Kl})/I$
   $R_i = (1.67\ V - 0.55\ V)/2.15\ A = 1.12\ V/2.15\ A$
   $R_i = 0.52\ \Omega$

Remarks
One group could possibly examine how a “used” battery behaves in the case of I = 0 or short-circuited, or even under a low load. The short circuit current and so the internal resistance are highly dependent on the charging condition of the battery. For this reason, the measurement results obtained by the separate groups will differ.
A battery (source of current) is of high quality when its short circuit current is particularly high, and thereby its internal resistance particularly low.
We recommend that possibly only one group examines the short circuit behaviour, and informs the rest of the students on their results. This would avoid other batteries from suffering a loss of quality.
We have deliberately not suggested changing to the 1 V measurement range when measuring U_{Kl} during the short circuit, as this measurement range is insufficient when the switch is opened!

(Do sources of current also have a resistance?)

Room for notes