

# EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

## Lab Report

*Complete this report YOURSELF except DATA taking parts! This report will not be submitted (except the very last page), but you should carefully complete it as preparation for the applied exam.*

### Suggested Pre-Lab Questions

#### Suggested Pre-Lab Questions

**Q1.** Show dimensional analysis of resistance  $R$  explicitly!

1

**Q2.** Below you are given a set of 4 data obtained in the Ohm's Law experiment. Calculate  $R_i$ ,  $R_{\text{average}}$  and  $\sigma_R$  and find  $R$  (Pay attention to significant figures and units!)

| V ( V )                                    | I ( A ) | R <sub>i</sub> (       ) | R <sub>i</sub> - R <sub>average</sub> (       ) | (R <sub>i</sub> - R <sub>average</sub> ) <sup>2</sup> (       ) |
|--------------------------------------------|---------|--------------------------|-------------------------------------------------|-----------------------------------------------------------------|
| 1.00                                       | 0.050   |                          |                                                 |                                                                 |
| 1.25                                       | 0.055   |                          |                                                 |                                                                 |
| 1.35                                       | 0.060   |                          |                                                 |                                                                 |
| 1.50                                       | 0.085   |                          |                                                 |                                                                 |
| R <sub>average</sub> =                     |         |                          | σ <sub>R</sub> =                                |                                                                 |
| R= R <sub>average</sub> ± σ <sub>R</sub> = |         |                          |                                                 |                                                                 |

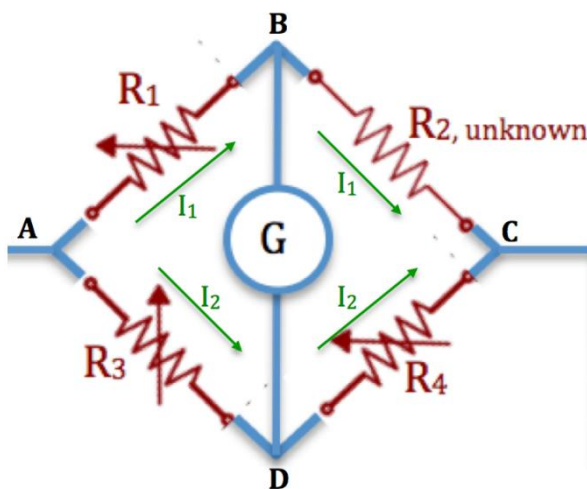
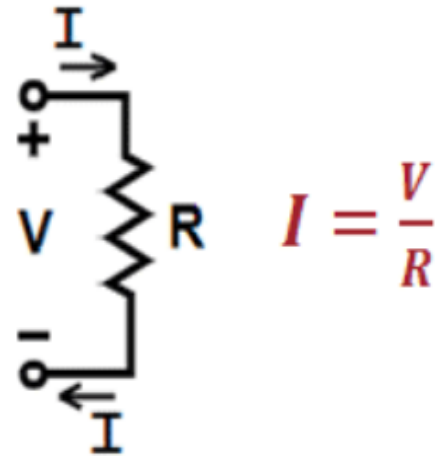
Comment on the result for  $R_4$ , regarding  $R_{\text{average}}$  and  $\sigma_R$ !

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

### EXPERIMENT :

**OBJECTIVE :** To determine the resistance of a conductor making use of Ohm's Law and Wheatstone bridge.

**THEORY :** Most conductors show ohmic character when current passes through them. There is a linear relationship between the potential difference across such a conductor and the current passing through it, where the proportionality constant  $R$  is the resistance. This is Ohm's Law.



$$V_{AB} = V_{AD}$$

$$V_{BC} = V_{DC}$$

In Wheatstone bridge there are two pairs of resistors connected in parallel. A galvanometer is connected between the points where individual resistors are connected together in each pair. To protect the galvanometer against excessive currents, a large resistance is connected in series with the galvanometer with the option to short it out using a switch. A low voltage power supply is connected across the points where each pair is connected in parallel to each other. In slide-wire Wheatstone Bridge case one pair of resistors is simply a wire, and the galvanometer is connected to a point on the wire with the help of a sliding connection. The resistance ratio on this part of the circuit is simply the

ratio of the lengths of the wire sections on each side of the sliding connection.

Assuming that the resistances in the wire part of the circuit are  $R_1$  and  $R_2$  and the other part are  $R_3$  and  $R_4$ , let us further assume that the current passing through the wire part is  $I_1$  and the other part is  $I_2$ . Then, adjusting the position of the sliding contact on the wire, the current through the galvanometer is brought to zero. This means that the potential differences across the resistances opposing each other in each pair will be equal:

$$I_1 R_1 = I_2 R_3$$

$$I_1 R_2 = I_2 R_4$$

Dividing the first expression by the second one, we get

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$$

since the resistance of a wire is proportional to its length, cross section and its material. Both parts being part of the same wire, the ratio of the resistances is equal to the ratio of their lengths. Using such a bridge and a known resistance, for a 100.0 cm wire in the bridge, we can determine the value of an unknown resistance as:

$$R_2 = \frac{(100.0 - L_1)}{L_1} R_1$$

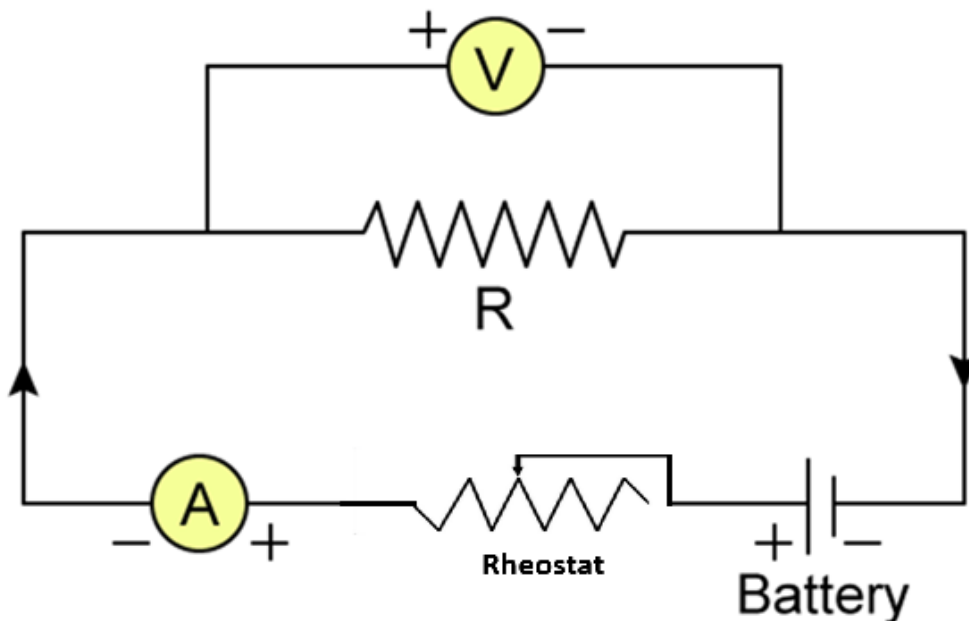
**APPARATUS :** Ammeter (DC), voltmeter (DC), rheostat (also used as a large resistor), DC power supply, resistance board, knife switch, slide-wire Wheatstone Bridge, galvanometer, resistance box, various types of cables.

### PROCEDURE :

#### Part 1: Ohm's Law:

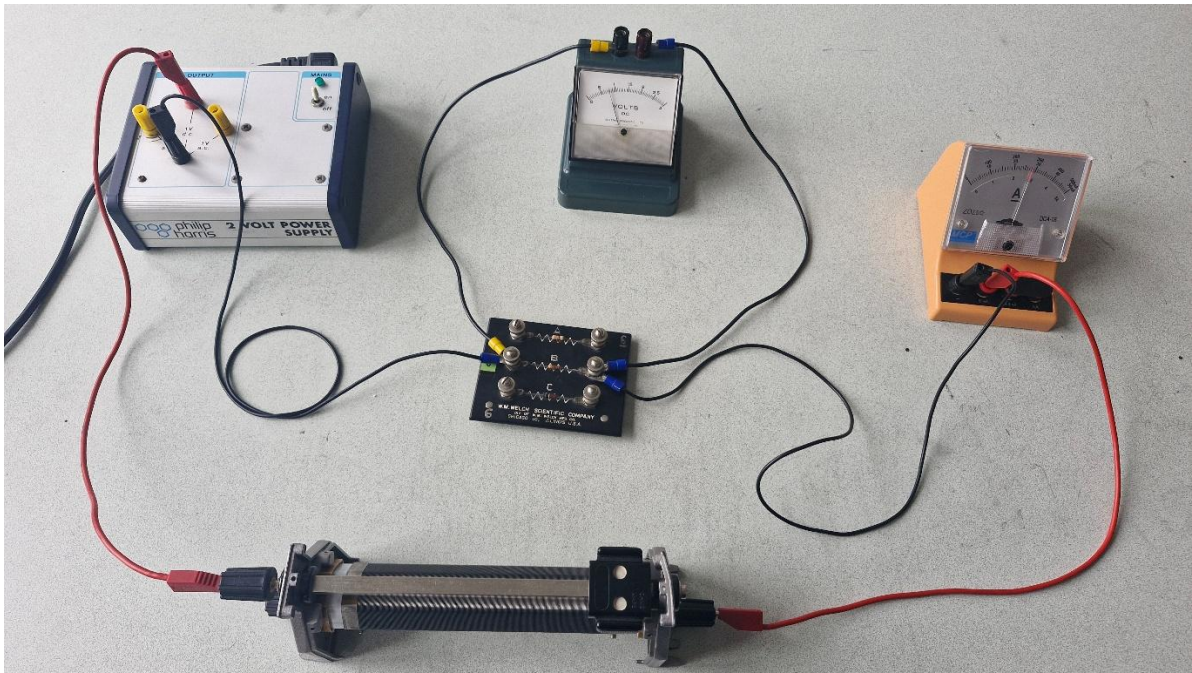
3

1. Construct the circuit with the DC-power supply.



## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

2. Choose one of the resistors and note the resistor number and resistor letter into the relevant box on the sheet. Example: 24C
3. Vary the applied voltage with the help of the rheostat and record 10 readings for the current and the corresponding voltage across the unknown resistance.
4. Calculate the corresponding resistance for each voltage-current pair and compute the average and the standard deviation of the resistance.



## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

### DATA – Ohm's Law

|                               |  |
|-------------------------------|--|
| Unknown Resistance<br>Number* |  |
|-------------------------------|--|

| # of<br>measurements,<br><i>N</i> | Voltage across the<br>Resistance<br><i>V</i> (      ) | # of<br>Significant<br>Figures : | Current in the<br>Circuit<br><i>I</i> (      ) | # of<br>Significant<br>Figures : |
|-----------------------------------|-------------------------------------------------------|----------------------------------|------------------------------------------------|----------------------------------|
| 1                                 |                                                       |                                  |                                                |                                  |
| 2                                 |                                                       |                                  |                                                |                                  |
| 3                                 |                                                       |                                  |                                                |                                  |
| 4                                 |                                                       |                                  |                                                |                                  |
| 5                                 |                                                       |                                  |                                                |                                  |
| 6                                 |                                                       |                                  |                                                |                                  |
| 7                                 |                                                       |                                  |                                                |                                  |
| 8                                 |                                                       |                                  |                                                |                                  |
| 9                                 |                                                       |                                  |                                                |                                  |
| 10                                |                                                       |                                  |                                                |                                  |

\* Write the unknown resistance number on resistance plate and the letter corresponding the resistance you measure. Example: 24C

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

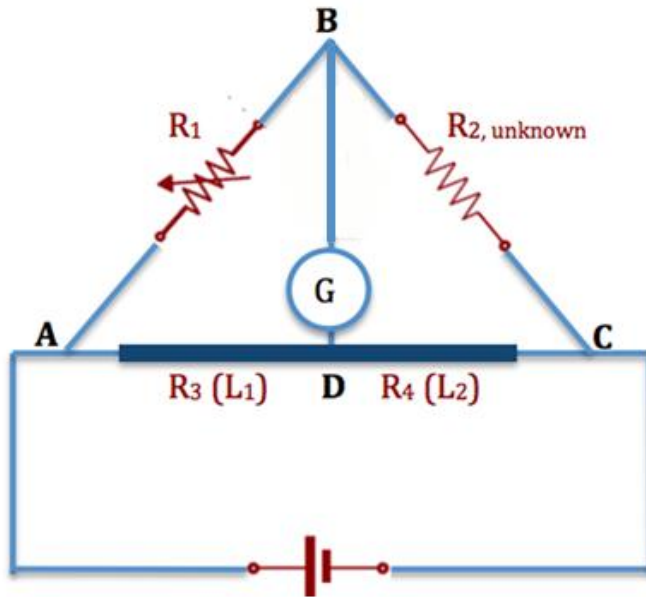
### CALCULATIONS – Ohm's Law

| # of measurements,<br>$N$ | $R_i$<br>(     ) | $R_{\text{average}} - R_i$<br>(     ) | $(R_{\text{average}} - R_i)^2$<br>(     ) |
|---------------------------|------------------|---------------------------------------|-------------------------------------------|
| 1                         |                  |                                       |                                           |
| 2                         |                  |                                       |                                           |
| 3                         |                  |                                       |                                           |
| 4                         |                  |                                       |                                           |
| 5                         |                  |                                       |                                           |
| 6                         |                  |                                       |                                           |
| 7                         |                  |                                       |                                           |
| 8                         |                  |                                       |                                           |
| 9                         |                  |                                       |                                           |
| 10                        |                  |                                       |                                           |
| $R_{\text{average}} =$    |                  | $\sigma_R =$                          |                                           |

6

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

### Part 2: Wheatstone Bridge:



1. Connect the circuit. Be careful, the  $G_1$  output of the galvanometer should be connected to the circuit and there should be a switch between  $G_0$  and  $G_1$ .

2. Set the resistance box to an appropriate value (generally something near the value you have found in the first part) and move the contact key on the slide wire until bridge is balanced.

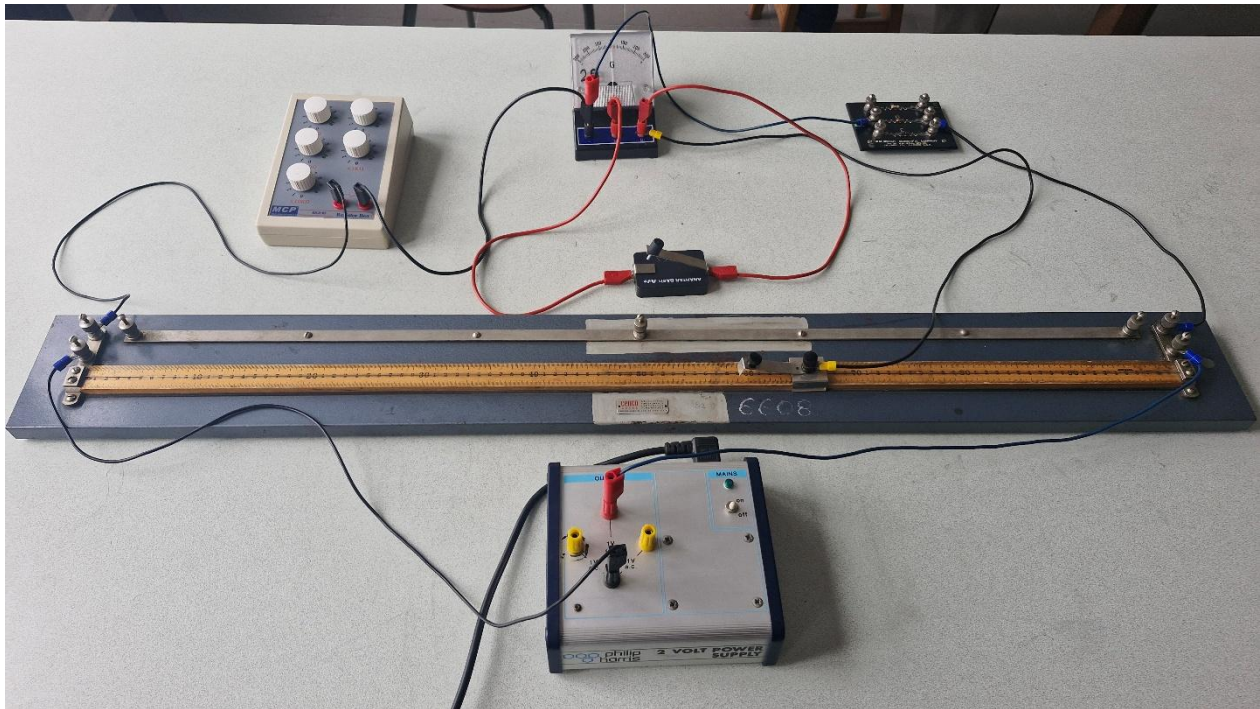
3. For the final precise adjustments close the switch and observe zero deflection on the galvanometer.

4. Note the point where the slide wire touches the contact key.

5. Calculate the value of the unknown resistance in Table below.

7

6. Compare *resistance values found in the first and in the second parts*. (Refer to introduction part of the Lab Book for error calculation).



# EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

## DATA-Wheatstone Bridge

| Unknown resistance number                   | $R_1$                      | $L_1^{**}$ (      )        | $L_2$ (      )             |
|---------------------------------------------|----------------------------|----------------------------|----------------------------|
|                                             | # of Significant Figures = | # of Significant Figures = | # of Significant Figures = |
|                                             |                            |                            |                            |
| <b>Unknown resistance <math>R_2</math>=</b> |                            |                            |                            |

**\*\*  $L_1$  should be in the interval  $10.0 \text{ cm} < L_1 < 90.0 \text{ cm}$ . Otherwise, change  $R_1$  and retry!**

## RESULTS

**Ohm's Law:  $R_{\text{average}} \pm \sigma_R =$  .....**

8

**Wheatstone Bridge  $R_2 =$  .....**

## COMPARE Ohm's Law and Wheatstone Bridge Results ( $R_2$ and $R_{\text{average}}$ )

**% Error for  $R$  :**

.....

.....

.....

.....

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

### Suggested Post-Lab Question

**Q1.** Draw the circuit for measurement of Ohm's law in this experiment. Do not forget to add rheostat! What is the function of it in the experiment?

**Q2.** Explain what happens when the galvanometer and the power supply are exchanged in a balanced Wheatstone bridge. What happens to balance then? Give a mathematical proof of it. (Hint: Ignore the switch and rheostat on the bridge in the experiment. Draw the circuits before and after the exchange)

9

**Q3.** Determine the uncertainty  $\Delta R$  in the value of the unknown resistance if the uncertainty in determining the balance point on the slide-wire is  $\Delta L$ . Consult to the introduction part of your Lab Book or you may search for "Error propagation".

## EXP.1: Measurement of Resistance - Ohm's Law and the Wheatstone Bridge

**Q4.** Calculate the current in each resistance and the parts of the wire assuming that the power supply provides 1.0 V.

a- Can you calculate the current through the wire on the ruler? If not, what additional information would be required to calculate it?

10

b- Can you calculate the current (or did you actually measure it) on the bridge, when the bridge is balanced and unbalanced?

**Q5.** Which method is better when measuring the value of the unknown resistor. (Hint: Think about precision and significant figures!)

### Post-Lab Report

**Aim** of the experiment:

**Suggestions** for possible solutions to the problems experienced during the experiment:

**Conclusion:**

11 I have completed this experiment myself as specified in the lab sheet and as explained by the lab instructor.

**Name & Surname:**

**Student ID:**

**Lab Section:**

**Table #:**

**Date:**

Signature of the  
student

-----  
As the instructor of this Lab Section I confirm that the student has participated in and completed this experiment on time.

Stamp of the PHYS  
Labs and signature of  
the instructor

*This page serves as proof of the fact that the student participated in and completed the experiment, only if it is submitted in time and accepted by the Lab instructor. The student and the instructor shall sign it along with the stamp of the Physics Laboratories.*