21 March 2024

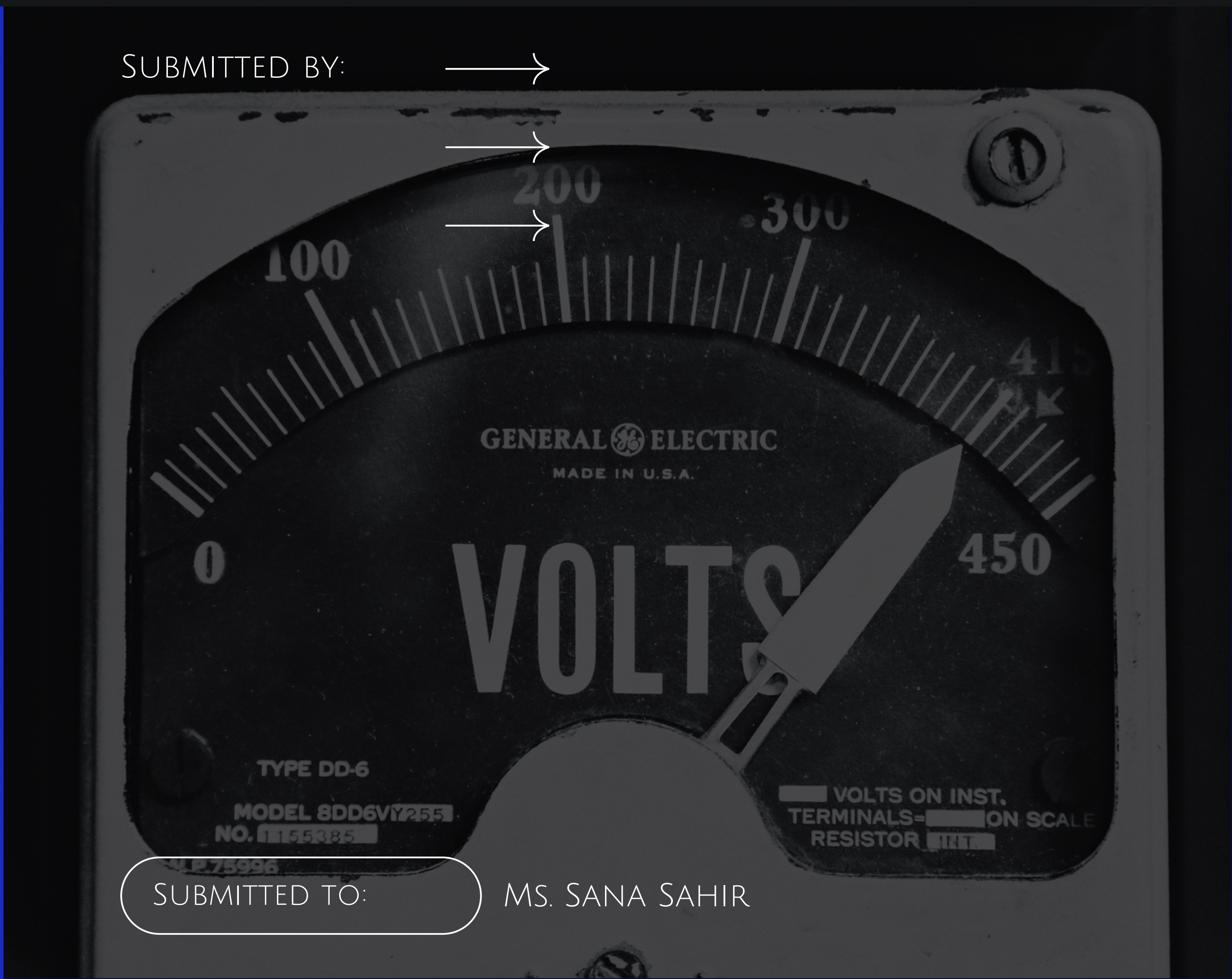
Winter 2024

experiment 2

Internal Resistance – Electrical Meters

University of Wollongong in Dubai

Submitted by: →
→
→



Submitted to: Ms. Sana Sahir

PHYS143
Physics for Engineers

Purpose

To measure the internal resistance of a meter.

Hypothesis Statement

When the decade box is connected in parallel, part of the current will flow through the ammeter and the rest will flow through the decade box, giving us a value of the internal resistance.

Materials

- Power supply
- Resistor – 100 kΩ
- Resistance box
- Ammeter
- 4 banana cables

Procedure

1. Connect the circuit shown in Figure 1 while leaving the power supply turned off.
2. Ensure that the meter indicator mechanical zero is set properly so that the indicator reads precisely zero with no current passing through the meter.
3. Turn on the power supply and adjust the output voltage to produce exactly full-scale deflection on the meter being measured.
4. Connect the resistance decade box in parallel with the meter.
5. Set all decade boxes to the OFF position.
6. Add resistance on the decade box to produce exactly a half-scale deflection on the meter.
7. Record the sum of the resistances of all the switches that are turned ON in the resistance box.
8. Turn off the voltage source.

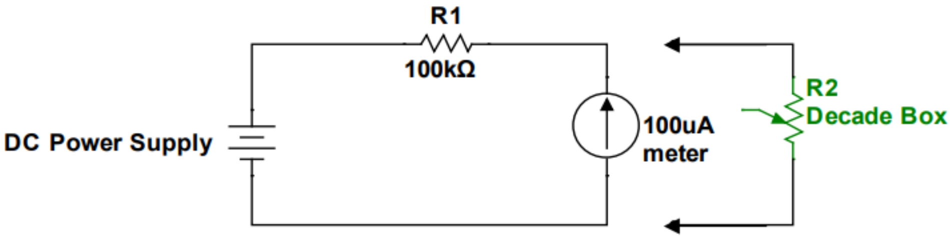


Figure 1: Circuit to be implemented

Data

R_1 = 100 kΩ
R_2 = 94 Ω

Observations

During this experiment we observed that when an ammeter is connected in series to a high resistance circuit, in our case a resistor of 100 kΩ reads out a full-scale reading of the current in the circuit. Subsequently once you add a decade box parallel to the ammeter into the circuit, this produces a half scale reading of the current present in the circuit. Since both the ammeter and the decade box are connected parallelly we know that the current splits equally and thus we observe that the resistance of the ammeter and the decade box is equal.

Conclusion

1. What was the purpose of this lab?

The objective of the lab was to investigate how a meter's internal resistance is measured.

2. How does the lab we perform relate to what we are studying in class?

The lab is connected to concepts about electric meters and limitations. Understanding how a meter's internal resistance affects accuracy is essential, especially when taking low current readings. The lab provides a concrete example of this concept.

3. Give a brief recap of the procedure used.

Connect the circuit in Figure 1 with the power supply off, ensure the meter indicator's mechanical zero is set properly, turn on the power supply and adjust the voltage for full-scale deflection, connect the resistance decade box in parallel with the meter, set all decade boxes to OFF, add resistance for half-scale deflection, record the sum of resistances of the ON switches, and turn off the voltage source.

4. What problems did you have during the lab? Did you have to modify your procedure?

There were a few instances throughout the internal resistance experiment where quick modifications were needed. First, there appeared to be a spike in resistance values in the decade box. We chose to measure again at the closest settings on the decade box that surrounded the optimal half-scale point to remedy this. With the information gathered, we could subsequently extrapolate the true half-scale resistance value.

5. Do your results make sense? If not, why? What are the sources of error?

Our internal resistance measurement was slightly higher than expected. The decade box may not have been precisely adjusted to produce an accurate half-scale deflection on the meter, which could be one explanation. A little fluctuation from the normal halfway point may result in an overestimation of the internal resistance.

Some of the sources of error could include loose wiring, human errors such as incorrect readings and equipment faults such as incorrect resistance from resistance box.

6. What did you learn from this lab?

By measuring a meter's internal resistance, we learned that common instruments like ammeters have distinct electrical properties that affect the outcomes. When measuring tiny currents, the resistance in the system can be particularly significant and could skew the results.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

A few adjustments could be made to improve the experiment. First, it would be useful to have an ammeter which has greater accuracy. This would allow for more reflection of changes in the circuit. Second, repeating the measurement several times can help reduce random mistakes. These errors could be caused by minute adjustments to the decade box, or even tiny variations in the power supply voltage.

§

Purpose

To find the value of an unknown resistor using the Wheatstone bridge method.

Hypothesis Statement

We expect R_x (experimental value) to be similar to the theoretical value of the resistor.

Materials

- Power supply
- 2 resistors
- Slide wire
- Galvanometer
- Voltmeter, or Ammeter
- 6 banana cables

Procedure

1. Connect the circuit as shown in Figure 2 using a slide wire.
2. Using a known (R) and unknown resistor (R_x), balance the bridge by moving the slider. The current flow through the galvanometer must be zero.
3. Record the lengths l_1 and l_2.
4. Calculate and record the resistance of the unknown resistor, and the percentage error in values.

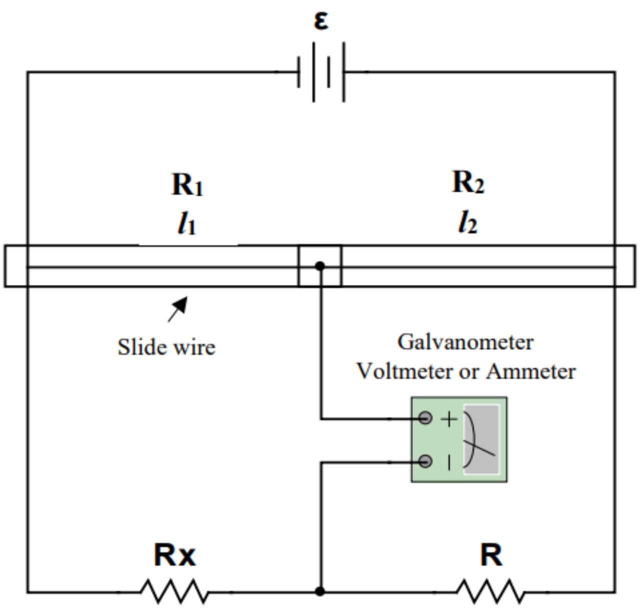


Figure 2: Set-up for DC Wheatstone bridge measurements.

Data

R (Ω)	l_1 (cm)	l_2 (cm)	R_x (kΩ)	$R_{x,\ theoretical}$ (Ω)	Percent Error (%)
120	45	55	100	98.18	1.85

$I_1 = I_2$ $I_3 = I_4$ $V_1 = V_3$ $V_2 = V_4$

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ $\frac{R_1}{R_2} = \frac{\rho\frac{l_1}{A}}{\rho\frac{l_2}{A}} = \frac{l_1}{l_2} = \frac{R_x}{R}$

$$\frac{l_1}{l_2} = \frac{R_x}{R} \Rightarrow \frac{45}{55} = \frac{R_x}{120} \Rightarrow R_x = \frac{45 \times 120}{55} = \mathbf{98.181818}\ \Omega$$

Observations

During the experiment we observed that as we slid across the Wheatstone bridge, we inched closer to a reading in the galvanometer that would suggest the voltage drop/current flow becomes zero. Once we reached the length of l_1 (45cm) and l_2 (55cm) it was observed that the galvanometer read a value of 0 μA. We then used the lengths across the Wheatstone bridge to find the resistance across each of them and then once we had 3 known values (l_1=45 cm, l_2=55 cm, R=120 Ω), we then used these values to deduce the theoretical value of the unknown resistor. Giving us a theoretical value (98.18 Ω) with a percentage error of 1.85% to the actual value of the unknown resistor.

Conclusion

1. What was the purpose of this lab?

This lab's purpose was to find the value of an unknown resistor using a Wheatstone bridge.

2. How does the lab we perform relate to what we are studying in class?

The experiment is closely related to concepts of resistance in a circuit, and series and parallel circuits. A Wheatstone bridge determines the resistance of an unidentified fourth resistor by measuring the voltage across the bridge, provided that the other three resistors' values are known. This lab directly corresponds as it is about measuring the unknown resistor using the bridge.

3. Give a brief recap of the procedure used.

The procedure involves connecting a slide wire Wheatstone bridge circuit with a known and unknown resistor, balancing the bridge by adjusting the slider until the galvanometer shows zero current flow, recording the slider lengths l_1 and l_2, then calculating the unknown resistance R_x and its percentage error.

4. What problems did you have during the lab? Did you have to modify your procedure?

Fortunately, there were no problems during the lab as the experimental results matched the theoretical results. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

The results do make sense, and the theoretical value closely matches the actual value, with a low percentage of error. Some sources of error could be human error in recording length and improper calibration of the multimeter.

6. What did you learn from this lab?

This lab has taught how a Wheatstone bridge works and how an unknown resistance can be found when other resistances are given.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this experiment again in the future, we would take multiple readings to ensure that the value of the unknown resistor is close to the original value.

§

Purpose

To calculate the resistivity of the wires in the resistance bridge.

Hypothesis Statement

A wire with a smaller resistance and/or a wire with a smaller area would result in a lower resistivity since resistivity is directly proportional to area and resistance, and inversely proportional to length.

Materials

- Multimeter
- Probe wires
- Resistance bridge

Procedure

1. Connect the multimeter to the resistance bridge as shown in Figure 3.
2. Measure the resistance of the wire.
3. Calculate the resistivity of the wire using the formula $\rho = \frac{RA}{l}$

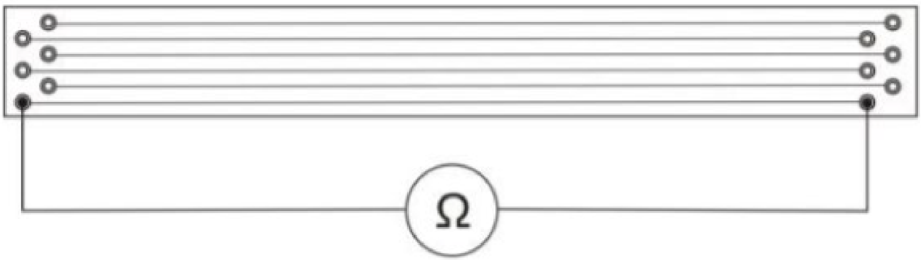


Figure 3: Circuit to be implemented

Data

Material	Diameter (mm)	R (Ω)	A (mm^2)	l (mm)	ρ (Ω mm)
Constantan	1	0.7	0.7854	1000	5.4978×10^{-4}
Constantan	0.7	1.3	0.3848	1000	5.0030×10^{-4}
Constantan	0.5	2.5	0.1963	1000	4.9087×10^{-4}
Constantan	0.35	5.2	0.0962	1000	5.0030×10^{-4}
Brass	0.5	0.4	0.1963	1000	7.8540×10^{-5}

Observations

In this experiment we tested 5 wires of different diameters of equal lengths (1000 mm), four of them being made of similar material (Constantan) and one being made of brass. We observed that the wires made of constantan had similar values to each other for the calculated resistivity of the wire ($\rho = 5.0030 \times 10^{-4}$ Ω mm) except for the first wire, which may have been due to a calculation error. The resistivity of a wire is directly proportional to the cross-sectional area and the resistance of the wire and is inversely proportional to the length of the wire but also remains constant for a material since resistivity is the ability of a material to resist the flow of current. The more the resistance of current through a material, the more resistivity of the material.

Conclusion

1. What was the purpose of this lab?

The purpose of this lab was to calculate the resistivity of the wires in the resistance bridge.

2. How does the lab we perform relate to what we are studying in class?

The lab experimentally proves concepts such as Resistivity of a wire and Ohm's Law. The experiment is a direct link to these concepts.

3. Give a brief recap of the procedure used.

Connect a multimeter to a resistance bridge, measure the resistance of the wire, and subsequently calculate the wire's resistivity using the formula $\rho = \frac{RA}{l}$.

4. What problems did you have during the lab? Did you have to modify your procedure?

Fortunately, there were no problems during the lab as the experimental results matched the theoretical results. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

Yes, the results make sense. Resistivity of a wire is a characteristic property of a material and should the similar for all samples of a particular material. As observed from the data, the resistivity of constantan is very similar for all the samples of constantan.

6. What did you learn from this lab?

The lab has taught us that resistivity of a wire is a property of a material itself, and that resistivity depends on the resistance of the wire, the cross-sectional area of the wire, and the length of the wire. The resistivity of the wire is directly proportional to the resistance and the cross-sectional area, and is inversely proportional to the length of the wire.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this lab in the future, we would improve the procedure by finding out different factors which affect the flow of resistivity would improve the table of data acquired by utilizing less time needed to conclude the experiment.

§