University Mohamed Khidir - Biskra

Module: PW Physics2 **Faculty of sciences and technology**
Level: 1st Year ST-LMD **Academic Year: 2023/2024**

Practical Work N°1: Electrical measurements

I- Objective of the experiment:

- How to use simple, non-digital electrical measuring devices.
- Set the measurement accuracy.
- Experimental verification of Ohm's law.

II- Theoretical principle:

We know that the reading on both the ammeter and voltmeter is related to both the caliber and ladder chosen.

The ladder (N) ⟷ Caliber

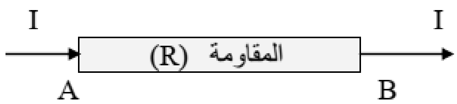
$$X_{mes} = \frac{caliber}{the\ ladder}\ reading$$

Reading ⟷ X_{mes}

N: The number of steps of the ladder

- <u>Ohm's law between two ends of a resistance:</u>

It is given by the potential difference between the two ends of a conductor AB by the following relationship V



$$V_{AB} = R \times I$$

Where: V_{AB} represents the voltage.

R: is the resistance of the ohmic conductor, and its unit is ohms (Ω).

I: the intensity of the electric current, and its unit is ampere (A).

- <u>Measurement errors</u>

1- Direct measurements:

When we use the voltmeter and ammeter, there is uncertainty in the measurement and this is due to several sources.

Error caused by the device ΔX_{cl}

It relates to the device only, according to its design, and this is known by knowing the device type:

<u>Device type for the voltmeter:</u>

- 1.5 voltmeters in alternating current AC.
- 1 voltmeter in DC (direct current).

<u>Device type for the ampermeter:</u>

2.5 In both cases AC and DC.

$$\Delta X_{cl} = device\ type \times (caliber / 100)$$

The error resulting from the method ΔX_l:

Regarding both scale and caliber. We consider that the error in reading is one-quarter of the scale.

The ladder (N) ⟷ Caliber

0.25 grade ⟷ X_l

$$\Delta X_l = 0.25 \times (caliber \,/\, The\ ladder)$$

The total error resulting from using the device is the sum of the previous two errors

$$\Delta X = \Delta X_{cl} + \Delta X_l$$

2. Indirect errors measurements: These errors generally result from the use of mathematical relations and relations. The generality in which we find uncertainty is as follows

Let us have a function f(x,y,z,….) multivariable, their differential is given by the following relationship:

$$df(x,y,z....) = \frac{\delta f(x,y,z....)}{\delta x}dx + \frac{\delta f(x,y,z....)}{\delta y}dy + \frac{\delta f(x,y,z....)}{\delta z}dz + ...$$

If the function f(x,y,z,….) A physical quantity, the uncertainty in which is given by the following relationship:

$$\Delta f(x,y,z....) = \left|\frac{\delta f(x,y,z....)}{\delta x}\right|\Delta x + \left|\frac{\delta f(x,y,z....)}{\delta y}\right|\Delta y + \left|\frac{\delta f(x,y,z....)}{\delta x}\right|\Delta z + ...$$

Some examples

Case of addition and subtraction

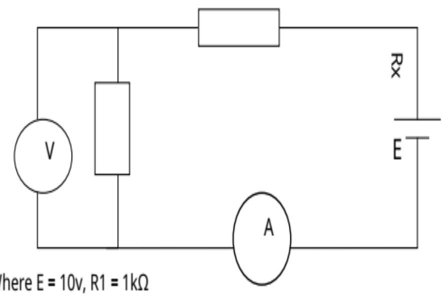
If $f(x,y) = x \pm y$ then $\Delta f(x,y) = \Delta x + \Delta y$

The case of multiplication or division

If $f(x,y) = x/y$ Or $f(x,y) = x.y$ Then $\frac{\Delta f(x,y)}{f(x,y)} = \frac{\Delta x}{x} + \frac{\Delta y}{y}$

Exercise:

Let us consider the electrical circuit shown in the following figure.



Where E = 10v, R1 = 1kΩ

Voltmeter type: ε_{cl}= 1%, Caliber=10v, the ladder = 100 scales

Ampermeter type: ε_{cl}=2.5%, Caliber=10mAm, the ladder = 100 scales

Measured Voltage: V_{mes} =3.8V

Measured intensity: I_{mes}= 6.4 mA

1- What is the reading on both devices?

2- Calculate both the absolute and relative uncertainty in electrical voltage and electrical intensity?
3- Calculate Rx ?
4- Calculate ΔR_x And $\Delta Rx/R_x$?

III.<u>Experiment:</u>

Let the experimental structures shown in Figures 1 and 2.

- Two resistors: one variable R_X of unknown value and the other constant R_1 = 1K Ω ±1Ω

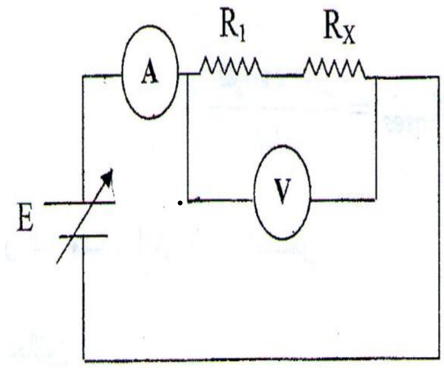


Figure.1

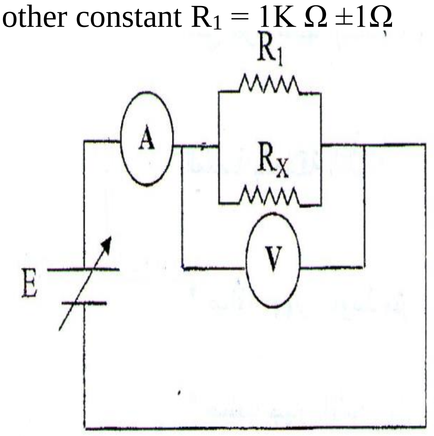


Figure.2.

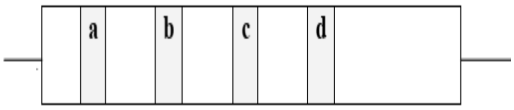
Questions:

Change the potential difference from 0 to 14_V, then write down the results in the table.

1. Give the method of filling the table?
2. Plot the graph $V_{mes}=f(I_{mes})$ with error barriers graphed?
3. Calculate the slope of the curve and deduce the value of R_X (exp) and compare it with the theoretical value of R_X(th)?
4. Calculate the relative uncertainty and absolute uncertainty of R_X?
5. Write the RX resistance in the form R_X =(…..±…..) ?
6. Answer the same questions when performing Experiment 2?
7. Compare R_X(th) and R_X(exp) in both cases (sequence and branching)? .
8. What is your general conclusion?

Δ Req	Δ Req / R_{eq}	R_{eq}	$\Delta V/V$	ΔV	V_{mes}	القراءة	السلم	العيار			$\Delta I/I$	ΔI	I_{mes}	القراءة	السلم	العيار		
									V_1								I_1	
									V_2								I_2	
									V_3	V							I_3	I
									V_4								I_4	
									V_5								I_5	

Appendix: How to read colored resistors



Let the colored resistor be as in the figure above. Its value can be read from the existing colors and for each color there is a number corresponding to it. Where

$$R = ab.10^{c} \pm d\%$$

You write the number ab. It is not a product, but rather a number. Its ones are the number b and its tens is the number a. d% represents accuracy in the design.
The number c is called the multiplier.
As for accuracy d%

Silver = 10%, Gold = 5%,

الرقم	اللون
2-	الفضي
1-	الذهبي
0	الأسود
1	البني
2	الأحمر
3	البرتقالي
4	الأصفر
5	الأخضر
6	الأزرق
7	البنفسجي
8	الرمادي
9	الأبيض

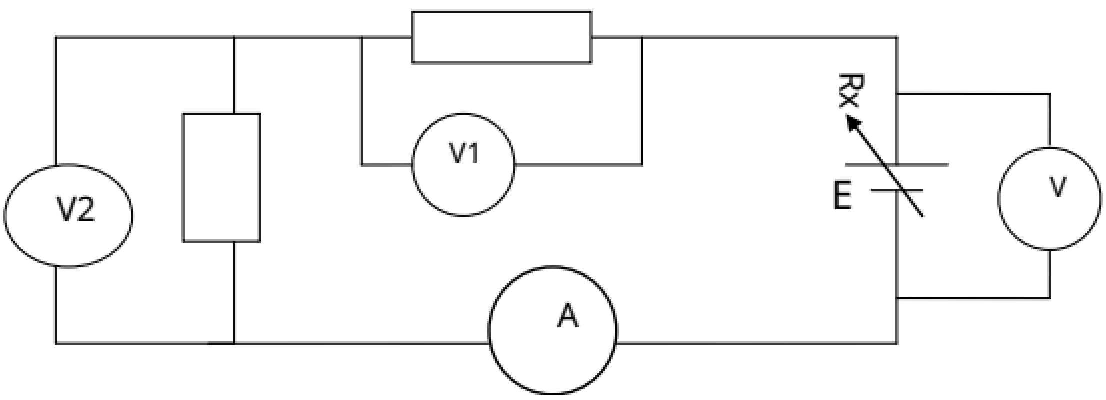
Note: If the number of colors on the resistor is 6, the reading is as follows
- The first three colors: record numbers (ones, tens, hundreds)
- Fourth color: multiplier (power of ten)
- Fifth color: precision in design
- Sixth color: temperature coefficient

III Used equipment

- Ampermeter: with different calibers and scales (ladder), connected in series with the electrical element to be measured.
- Voltmeter: connected in parallel with the electrical element to be measured, the potential difference between its two ends
- Electric current generator: the cycle of generating alternating electric current between the two poles  and continuous between the two poles (+, 0, -).
- Fixed and variable resistors, connecting wires.

IV Experiment

I- Achieve the electrical circuit shown in the following figure R1=0.1KΩ



Change the generator voltage E from 0 to 25V and fill out the following table

E (V)	Ampere meter				Voltmeter1				Voltmeter 2			
	Caliber	Ladder	A tΩ reading	(mA)I	Caliber	The ladder	reading	V1(V)	Caliber	Ladder	A tΩ reading	2(V)V
0												
5												
10												
15												
20												
25									R2			

1- Notice the sum of the two voltages recorded on the two voltmeters?

2- Draw the graph $V_1=f_1(I)$? Compare the value of the slope of the line with the value of R_1, What do you conclude?

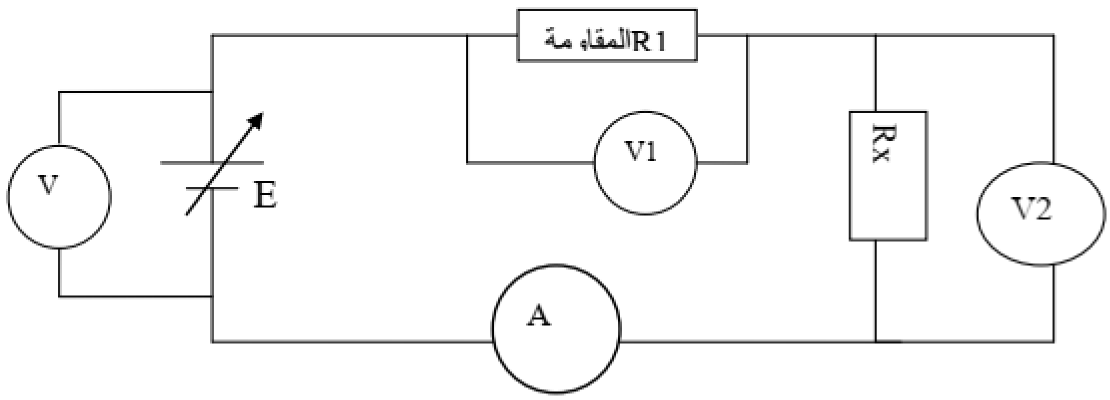
3- Draw the graph $V_2=f_2(I)$? Calculate from the statement R_x?

4- Calculate ΔR_x And $\Delta Rx/R_x$

5- Repeat the experiment using alternating current

6- What is your conclusion from this experience?

II- Achieve the electrical circuit shown in the following figure $R_2=1K\Omega$



Questions:

1- Fill out the following table:

R1(KΩ)	V1(v)						V2(v)					
	Caliber	Alice did not	reading	V1	Δv	Δv/v	Caliber A	to place	reading	V2	Δv	Δv/v
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

2- Notice the sum of the two voltages recorded on the two voltmeters?

3- Draw the following two graphic curves $V_1=f_1(R_1)$ and $V_2=f(R_1)$ on the same millimeter paper?

4- Interpret the curve (is it consistent with theory)?

5- What is your general conclusion?