Resistance measurement

1- Purpose of the experiment

Measure current, voltage and resistance using a multimeter. Calculate resistance using Ohm's law Assemble the assembly of simple and mixed electrical circuits. Determine the equivalent resistance of a mixed circuit. Check the law of nodes and the law of meshes Highlight the usefulness and use of the Wheatstone bridge, namely metals from the measurement of resistivity.

2- Concepts and preparation work

2-1- Some laws of electrical circuits

Consider a circuit consisting of a generator (E) connected to a resistance R (expressed in Ohms) using conductive wires (figure-1). Voltage is responsible for the movement of charges in an electrical circuit, current is the flow of these charges, and the resistance of an element of the circuit to oppose the flow of current.

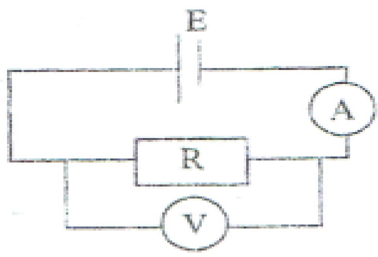

Figure-1

The voltage V (expressed in Volts) is measured using a voltmeter (V). It is a measurement carried out in parallel with an element of the circuit.

The current I (expressed in Amps) is measured using an ammeter (A). It is a measurement carried out in series with a circuit element. According to Ohm's law, measurements carried out with a resistance must satisfy the relationship: V=R.I

A group of resistors (R_1, R_2,……, R_n) in series has an equivalent resistance given by

$R_{eq}= R_1+R_2+……+R_n$, while $1/R_{eq}=1/ R_1+1/R_2+……+1/R_n$

when these resistors are connected in parallel.

- Calculate the equivalent resistance for R_1=100Ω, R_2 =150Ω, and R_3=200Ω.

2-1-a- R_1, R_2, R_3 are mounted in series R_{eq}=…… Ω.

2-1-b- R_1, R_2, R_3 are mounted in parallel R_{eq}=…… Ω.

2-1-c- R_1, R_2, R_3 are mounted in a mixed circuit according to figure-2 R_{eq}=…… Ω.

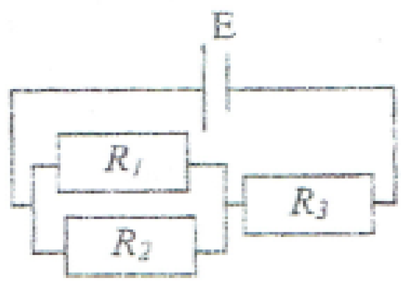

Figure-2

Note: The equivalent resistance is calculated from the equivalent circuit where each branch is replaced by a resistance by first simplifying the series resistance groupings.

2-1-d- R_1, R_2, R_3 are mounted in a mixed circuit according to figure-3 R_{eq}=…… Ω.

-The law of nodes applies to the connection points of circuit elements. The law of knots states that the sum of currents entering a node is equal to the sum of currents leaving nodes.

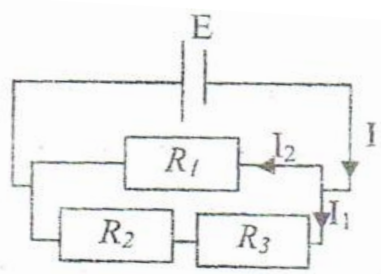

Figure-3

For the mixed circuit following figure-3 $I=I_1+I_2$

- The law of meshes applies to loops in the electrical circuit. The law of meshes states that the sum of the voltage rises while traveling through a loop is equal to the sum of the voltage drops (figure-4).

Mesh No. 1 traveled by the imaginary current I_1 :

$E= (I_1-I_2) R_1$

Mesh No. 2 traveled by the imaginary current I_2 :

$0= (I_2-I_1) R_1+(I_2) (R_1+ R_2)$

Where E is the voltage across the generator.

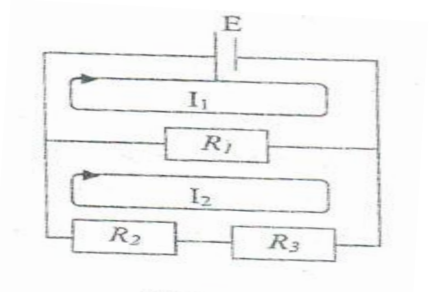

Figure-4

2-2 Wheatstone Bridge

The Wheatstone bridge is used to convert a variation in resistance into a variation in voltage, which makes it a sensor in environments where measurement is difficult.

Or the assembly of figure-5..

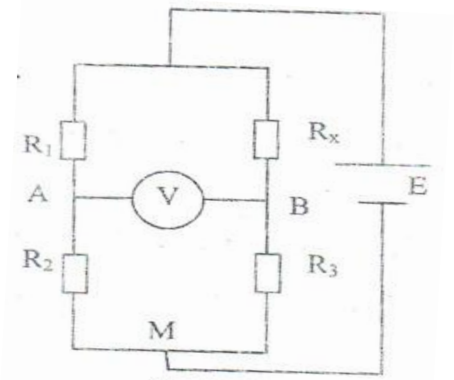

Figure-5

2-2-a- Give the meaning of U_{AM} ; U_{BM} ; U_{AB} in the figure-6.

2-2-b- Express $U_{AM} =f(R_1, R_2, E)$

U_{AM} =…………………………………………………

2-2-c- Express $U_{BM} =f(R_3, R_x, E)$

U_{AM} =…………………………………………………

2-2-d- Deduct $U_{AB} =f(R_1, R_2, R_3, R_x, E)$

U_{AB}=…………………………………………………

2-2-e- If U_{AB} =0, the bridge is said to be balanced.

Show that the expression for R_x takes a form independent of the supply voltage ………………………………………………………………………………………… …………………

3- Manipulations

3-1- Simple circuits

3-1-a- Series resistors

- Carry out the assembly where R_1, R_2, R_3 are mounted in series.
- Powering your circuit with voltage E=4,5 V and complete the table opposite.

	R_1	R_2	R_3
I (mA)			
V (Volts)			
Resistance (Ω)			

3-1-b- Parallel resistors

- Carry out the assembly where R_1, R_2, R_3 are mounted in parallel.

.- Powering your circuit with voltage E=4,5 V and complete the table opposite.

	R_1	R_2	R_3
I (mA)			
V (Volts)			
Resistance (Ω)			

3-2- Mixed tours

3-2-a-Carry out the assembly where R_1, R_2, R_3 are according to figure-2.

- Powering your circuit with voltage E=4,5 V and complete the table opposite.

	R_1	R_2	R_3
I (mA)			
V (Volts)			
Resistance (Ω)			

3-2-b- Carry out the assembly where R_1, R_2, R_3 are according to figure-3.

- Powering your circuit with voltage E=4,5 V and complete the table opposite.

	R_1	R_2	R_3
I (mA)			
V (Volts)			
Resistance (Ω)			

3-3- Measuring the resistivity of a material

Carry out the assembly of figure-5 where R_1= 1kΩ, R_2=100kΩ, and the resistant wire in place of R_x, - Powering your circuit with voltage E=4,5 V

Vary the resistance R_3 until the bridge is balanced (the galvanometer indicates zero voltage). For different values of section S of the resistant wire long l=1m.

a)- Complete the table opposite

b)- Deduce the type of the two metals; use the Table displaying resistivity values.

……………………………………………………..

……………………………………………………..

Wire diameter (mm)	*1*	*0,5*	*0,7*
R_3 (Ω)			
Resistance *R_x (Ω)*			
Resistivity *$\rho = R_x.S/l$ (Ω .cm)*			

جدول يمثل قيم المقاومة النوعية لبعض المعادن

Electrical resistivity for T=20°C

Material	Resistivity (Ω .cm)	Thermal coefficient (K^{-1})
silver	1.63	0.0041
Copper	1.69	0.00430
Gold	2.2	0.0040
Aluminum	2.67	0.0045
Tungsten	5.4	0.0048
Zinc	5.96	0.0042
Brass (copper + zinc alloy)	6.2-7.8	0.0016-0.0017
Iron	10.1	0.0065
Platinum	10.58	0.00392
Lead	20.6	0.0042
Constantan (Cu55/Ni45 alloy)	52	+/-0.0002
Carbon Germanium	1375 $46\ 10^{6}$	$-0.2\ 10^{-3}$ $-48\ 10^{-3}$
Silicium	$23\ 10^{6}$	$-75\ 10^{-3}$
Glass	$10^{10}\ 10^{14}$	
Hard rubber	10^{13}	
Suffer	10^{15}	
Fused Quartz	$76\ 10^{16}$	