Baghdad University

Collage of Science for Women

Department of Physics

Electrical Laboratory

First Level

Bologna System

Electrical Lab Experiments

First Level

First Semester

ECTS -8

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Lecture 1
Equation of a straight line

Equation of a straight line

The equation of a straight line is one of the most important mathematical tools used to process practical data and extract basic information about the nature of a particular system. Each mathematical equation is characterized by containing two types of quantities. The first are constants such as numbers of various types or certain symbols in the equation that are identified from the beginning as constants, and the other quantities are variables, which are usually symbolized using letters, etc.

It can be known that the mathematical equation is a straight line equation (linear equation) if all the variables in the equation are raised to the power of one, regardless of the number of variables, and that the number of variables in the equation is related to the number of dimensions in which it is represented, for example.

2x - 3] or [y + 9 = 0] or [3z-2 = 7] Equation of a straight line in one dimension[

y - 3x + 1] or [z - 2x = 8] or [2y - z =0] straight line equation2D[

2x + y- z = 4] or [x = z+ 10y] 3D equation of a straight line 3D[

The following equations are non-linear because the variables in them are raised to powers other than one.

$\mathbf{x^3 + 7y = log\ z}$ is a three-variable equation, i.e. a three-dimensional nonlinear equation due to the presence of the cubic term in addition to the logarithmic term in the equation.

$\mathbf{siny + \sqrt{(x+6)} - e^{2x} = 0}$ (a two-dimensional equation that is nonlinear due to the presence of a function trigonometric and exponential functions in addition to the root function in it).

What concerns us in the topic of linear equations at this stage is the two-dimensional linear equation because it can be represented graphically on the surface of a notebook sheet, which is also a two-dimensional surface. The standard form of this equation is:

$$\mathbf{y = a.x + b}$$

Where (a, b) are constants (numbers) and they are what determine the nature of the equation of the straight line, and therefore it will be explain these constants in some detail

First: The constant: It is known as the x coefficient and represents the slope of the straight line equation. By slope, we mean the amount of deviation of the straight line equation from the horizon line. If the slope of the equation is positive, this means that the direction of the equation from left to right is upward, and vice versa if the slope of the equation is negative. However, if its slope is equal to zero, this means that the equation is horizontal, i.e. it is parallel to the x axis.

There are four ways to know the slope of the straight line equation, which are:

1. From the name (coefficient x) as we mentioned previously, the number multiplied directly by the variable x represents slope, but it should be noted here that the equation of a straight line must take the standard form before considering the coefficient x to represent the slope. For example, the slope of the equation of a straight line is

$$\mathbf{2y-3x+4 = 0}$$

It is (3/2) and not (-3) since the standard form of the above equation is y= (3/2) x-2

2. We derive the function If we take the above equation and derive it with respect to **x**,

dy/dx = 3/2

In general, the derivation of the standard form of the equation of a straight line is

dy/dx = a

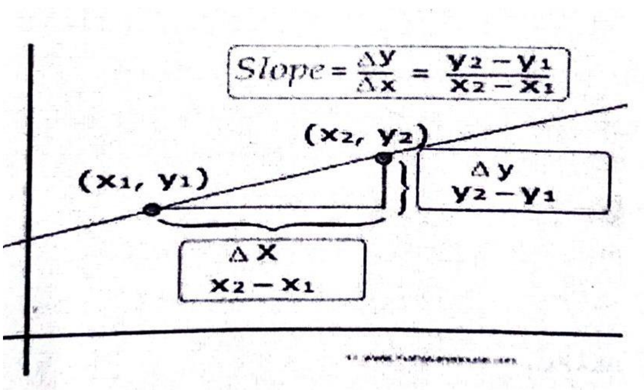
This represents proof that the derivative of the function represents the coefficient of the term **x** and represents the slope of the equation.

3. The graphical method This method is used a lot in practical aspects to calculate the slope and is based on the fact that the slope of the equation of a straight line, which is equivalent to its derivative, can be written in the form: dy Ay = lim dx slope = a = For linear equations, the value of the slope (the derivative of the function is constant even if the value of Ax differs from zero, so we can write:

$$\textbf{Slope} = \textbf{a} = \frac{dy}{dx} = \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x}$$

$$\textbf{Slope} = \textbf{a} = \frac{dy}{dx} = \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x} = \frac{\Delta y}{\Delta x} = \frac{y2 - y1}{x2 - x1}$$

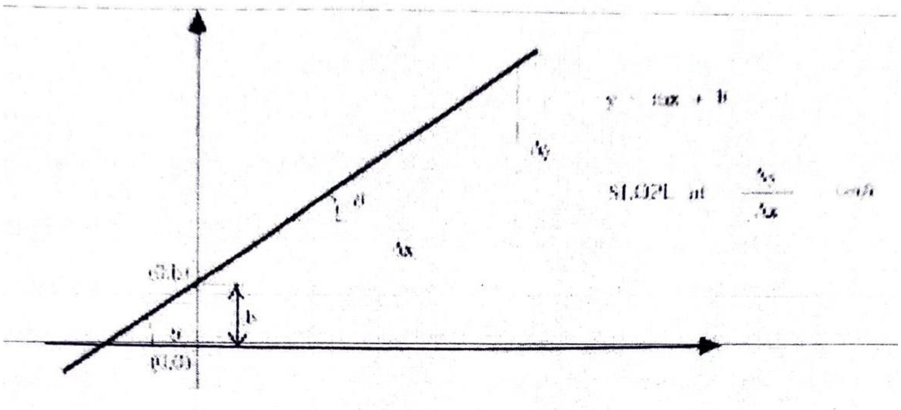
$$\textbf{Slope} = = \frac{\Delta y}{\Delta x} = \frac{y2 - y1}{x2 - x1}$$



To calculate the slope of any straight line, two points are taken not specifically within the straight line, and it is preferable that they are not experimental points. Since the direction of the line is always from left to right, the first point is on the left and the second point is on the right. Then the coordinates of the two points are extracted by knowing that the projection of the first point on the x-axis represents x_1 and that the projection of the first point on the y axis y $_1$ is. Similarly (x_2,y_2) is extracted, and finally the slope is calculated from the coordinate values using the law

$$\text{slope}= \frac{y2 - y1}{x2 - x1}$$

4. The angle shadow method: We mentioned previously that what is meant by slope is the amount of inclination of the straight line from the horizontal axis. Therefore, this slope is linked to an angle called the angle of inclination, as shown in the figure.



We also notice in the figure that both Δx and Δy and the equation of the straight line form a right-angled triangle to which the Pythagorean theory and the trigonometric relationships that follow apply. Therefore, the side Δy is (opposite) the angle of inclination $\theta$and Δx is adjacent to it (adjacent). According to what we have reached regarding the definition of inclination:

$$\textbf{Slope} = \frac{\Delta y}{\Delta x} = \frac{opposite}{adjacent} = \tan\theta$$

In practice, the slope can be calculated using a protractor by fixing the horizontal axis of the protractor with the horizon line on the drawing and then reading the angle of inclination of the straight line, and by taking the value of the shadow of this angle, the slope is calculated. The angle of inclination of the straight line can also be calculated if the slope is known by taking the inverse shadow of the slope to obtain the angle, for example, the angle of inclination of the equation in paragraph (1) is

$$\theta = \tan^{-1}(\text{slope}) = \tan^{-1}\left(\frac{3}{2}\right) = 56.31^\circ$$

Second: The constant b: It is known as the function intersection (intercept), which means that it is the point of intersection of the function with the y-axis. If the intercept is positive, the function intersects the y-axis above the origin and vice versa.

If it is negative, or if the intercept is equal to zero, then the equation of the straight line passes through the origin.

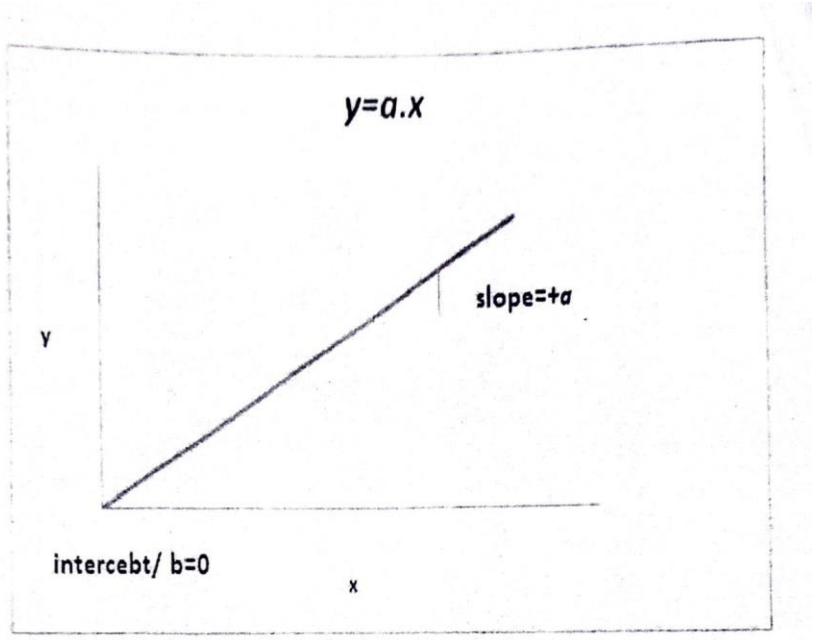
For example, the intersection value in the previous example is (-2).

Types of straight line equation

The first type: where the slope is positive and the intersection is at the origin, where the general formula is

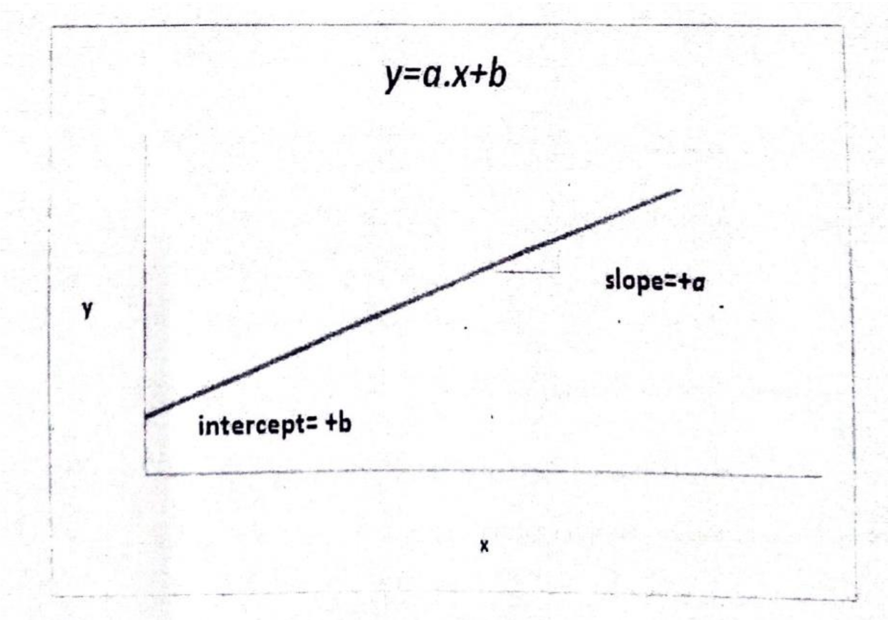
$$\mathbf{y = a.\ x}$$

The graph is



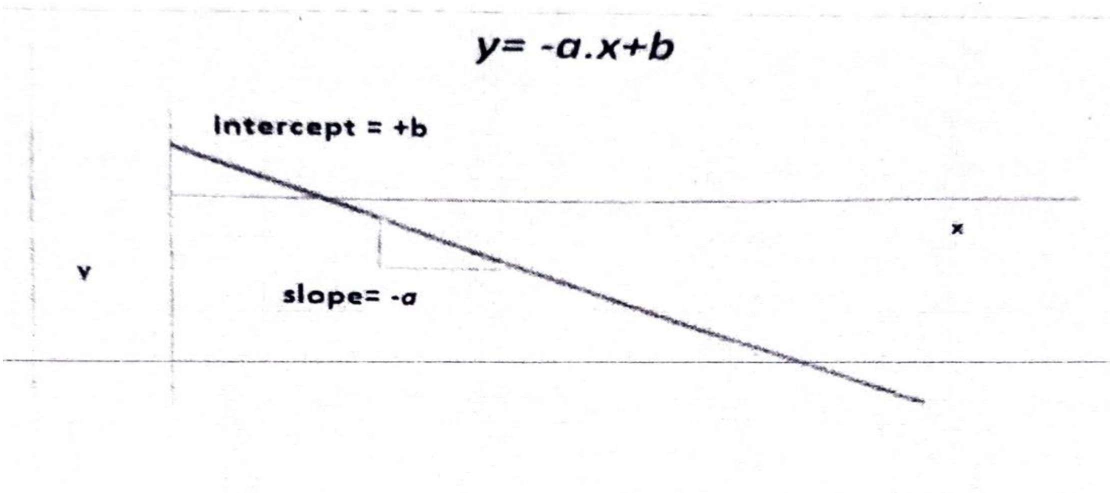
The second type: in which the slope is positive and the intercept is positive. Its general formula is + y = a. x and it represents

Graphically

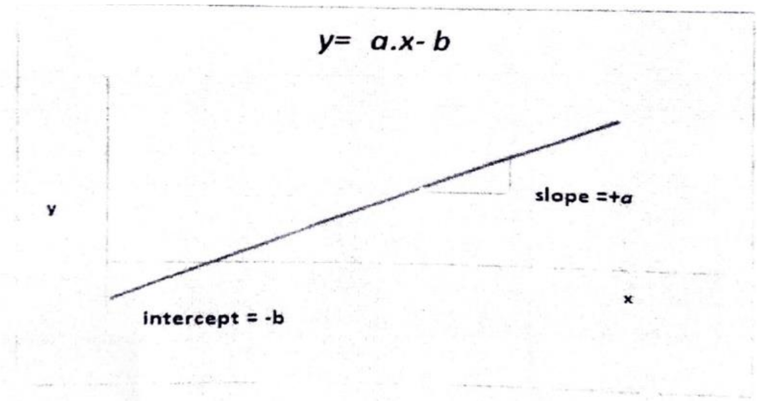


The third type: Have a negative slope and a positive intercept. Its general formula is

y = - a.x + b or y = b - a.x and its graph is



The fourth type: in which the slope is positive and the intercept is negative. Its general formula is y = a.x - b and its graphical representation is



H.W

Q/ Calculate the slope, intercept, angle of inclination, graph and type of equation

$$6y + \sqrt{2}x + 2 = 8$$

Q / Calculate the slope, intercept, angle of inclination, graph and type of equation

$$2y^2 - x = 1$$

Q/ Calculate the slope, intercept, angle of inclination, graph and type of equation

$$\frac{3}{4}x + \sqrt{7y} = 9$$

Q/ Prove that the slope of the equation

x = 7 is infinite

Lecture 2
Circuit component measurement and instrument readings

First Experience

Circuit component measurement and instrument readings

Multi meter

It is a device that includes three measuring devices at the same time, which are the ammeter, which is a current meter, the voltmeter, which is a voltage difference meter, and the ohmmeter, which is a measure of electrical resistance.

The multi meter is transferred from one device to another by means of the caliper, which is a rotating part located in the middle of the device that is rotated by hand and placed in front of the electrical quantity. The required quantity is measured, and the device turns into a scale for this quantity.

It is also used to test diodes, capacitors and transistors, as we will discuss later. The figure below represents the analog and digital multimeter. Now we come to the detailed explanation of each type of these devices:

First: Ammeter (current meter)

It is connected to the circuit in series (why?) where we choose the value of the current to be measured by placing the meter in front of the symbol that represents that value, for example if the meter is it refers to the symbol (A), which means that the ammeter measures current in amperes (amps), and if it was equivalent to (mA) meaning that the device measures the current in milliamperes (103) and it was the meter is marked with the symbol (A) (meaning that the device measures current in microamperes**.(10^{-6} amp (μA)**

Where the wire representing the positive is placed in the hole marked (A) or (mA) or (A) or a positive sign is drawn on it, while the negative sign is placed in the hole written on it (Com) is an abbreviation for the word Common in English, which means shared or drawn on it negative.

There are two types of devices: analog and digital.

We will give a detailed explanation of the measurement in each type.

1- The analog ammeter, which measures using the slope method (Analog)

We move the meter pointer towards (AC amp) to measure alternating current and (DC amp) to measure direct current. Sometimes the symbol (-) is written to indicate alternating current and the symbol (-) or (- - -) to indicate direct current. We choose the scale so that it is higher than the largest current in the circuit to protect the device from damage. If the circuit current is greater than the current measurement scale, this will lead to damage to the device.

Now we will talk about the measurement method in the analog device. For example, if the scale is from 1 to 50 and we have chosen the scale of 50, we read the numbers from 1 to 50 Depending on the number the indicator is on.

If the installment was on the number 50 and the scale was only from 5 to 250 and the indicator stopped at 100 or 150, how is it read?

In this case we apply the law:

$$\text{Read the indicator} \quad > \frac{\textit{selected Gradient}}{\text{Device Gradient}}$$

For example, when the index stands at 100 and the installment is at 50

$$\frac{50}{250} \times 100 = 20 \text{ amp}$$

When the indicator stops at 150 and the installment stops at 50

$$\frac{50}{250} \times 150 = 30 \text{ amp}$$

In the case of grading from 0 to 10 and divided into 50 and the index stops at 2

$$\textbf{Reading the} \times \textbf{indicator} \quad \frac{\textbf{Selected Graduation}}{\textbf{Device grading}}$$

$$\frac{50}{10} \times 2 = 10 \text{ amp}$$

Thus, if the chosen scale is different from the device scale, it is calculated from the law

2- Digital ammeter:

It is relatively easier as we choose from the installment the current value A in amperes, mA in milliamps and μA in micro amps. When the device is connected to a circuit, a number appears on the screen giving reading in the selected unit.

Second – Voltmeter:

It is a device connected to the electrical circuit in parallel (why) and is used to measure the electrical potential difference in the circuit or around the electrical load, where we can use it to measure the alternating electrical potential difference by placing the meter on the symbol ($\tilde{v}$) or ACV and the continuous one by placing the meter on ($\overline{v}$) or DCV, and it also measures the potential difference in the unit (Volt) and measures the potential difference in the unit of millivolts by placing the meter on the symbol (mv), and there is

Two types of it:

1. **Analog voltmeter**

It contains a slope that moves on a graduated plate. If the chosen graduation is from the installment is the same as the device's gradation. We read directly. If it is not the case, we apply the law:

$$\textbf{Reading the} \times \textbf{indicator} \quad \frac{\textbf{Selected Graduation}}{\textbf{Device grading}}$$

Same as explained with the ammeter.

:**2. Digital voltmeter**

It is a voltmeter that has a screen that shows the amount of voltage in the form of a number.

It measures AC and DC voltages in units of volts and millivolts as required. Choose it from the installment.

Third: Ohmmeter

It is a device that measures the electrical resistance resulting from the obstruction of electrical current by the particles of the material. The unit of measurement is the ohm, symbolized by (Ω) and the kilo ohm is (k Ω).

And the mega ohm (MΩ) and there are two types of this device:

A- Analog ohmmeter

It contains an indicator that moves on a scale opposite to the voltage and current scale, as you notice in multi meters. When both the voltage and current are zero, the resistance is infinite

(∞) and gradually decreases with the increase in current and voltage. Why?

When you put on (Ω), it means the number is multiplied by the symbol (×1), and we choose the scale. If we put the scale, the multiplication is by one. If it is on (×10), the number is by ten. If it is on ($\times_{1k}$), the number is by a thousand. If it is (×10k), the number is by ten thousand. The resistance scale is the highest scale in the device, and as we mentioned, it is opposite to the current and voltage scale.

B-Digital ohmmeter

It contains a screen. When the meter is placed on symbol (Ω) , it starts measuring the resistance.

Either in unit (Ω) or in unit (KΩ) or (MΩ) in the form of a number that appears on the screen.

The whistle symbol (″) if we put the scale on it and touch the ohmmeter wires, the ohmmeter starts. Continuous beeping is evidence that the device’s battery is in good condition. If not

This sound indicates a weak battery.

Resistance measurement by color method:

There are colors on the resistor that help to know the resistance value in case a device is not available Ohmmeter, where each color represents a number starting from the color closest to the resistor head.

Generally, the resistor contains four colors, where the first color represents a number taken from the table according to the color, for example, brown corresponds to one, red corresponds to two, and so on, as mentioned in the following table, No. (1). the second color also represents a number and is taken from the table.

The third color represents the number of zeros, while the fourth color represents the error percentage. If it is gold, it is 5%, and if it is silver, it is 10%. If there is no color, the error percentage is 20%. Figure No (1).

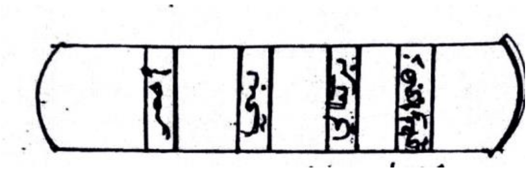


Figure No (1)

From Table No. 2

Red meets 2

Brown meets 1

Orange corresponds to 3 and since it is the third color, it represents the number of zeros, i.e. three zeros, so the value of the resistor is (Ω) 2100 and the fourth color is the error rate.

Golden error rate 5%

Silver error rate 10%

Without color, error rate 30%

Table No. (1)

Color	Number
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
Violet	7
grey	8
white	9

Expansion check:

1- Using analog ohmmeter

In this method, we place the divider on symbol ($\times^{1}$ K Ω) and connect the device to the capacitor. We notice that the tilt of the device moves from zero towards the right and then returns to its original position quickly. The reason for this tilt movement is the charging and discharging of the capacitor.

2- Using a digital ohmmeter

We put the installment on the capacitor symbol and connect the device to the capacitor. A number representing the capacitor capacity appears on the screen.

Diode check

To check the validity of the diode, analog and digital ohmmeters are used.

A- Using analog ohmmeter

This is done by converting the mu meter to an ohmmeter, where we choose the scale($\times^{1}$ K Ω) or ($\times^{10}$ K Ω)

We connect the ohmmeter wires so that the positive pole of the positive part of the diode P

And the negative N is forward bias as in Figure No. (2)

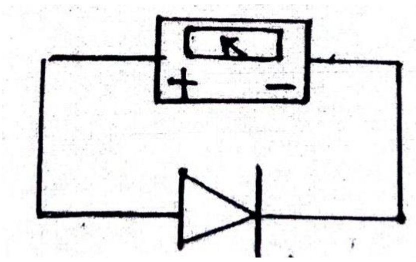


Figure (2)

We notice the movement of the slope and it indicates approximately a slight resistance of about (20Ω), which indicates the passage of current and when the connection is reversed, we notice that the slope does not move, i.e. the slope indicates high resistance. Within tens of thousands of ohms, no current passes through it, so you say that the diode is good, unlike that diode is bad.

2. Digital ohmmeter

We connect the positive terminal of the ohmmeter to terminal P and the negative terminal of the ohmmeter to terminal N. For the diode (forward bias, current must pass and the resistance must be small. Then we reverse the poles (reverse bias). We notice that the resistance value is large, and this indicates the quality of the diode. If the resistance is low in reverse bias, this means that the diode is damaged.

Device readings:

First - Voltmeter

1-Analog voltmeter:

We set the device’s voltage to AC and DC according to the source and choose from the voltage, for example:

The number 10 and we measure on a scale from 1 to 10

If we choose another scale and measure the quantum, we apply the previously mentioned law.

2- Digital voltmeter

We set the device's voltage to AC and DC according to the source by setting the voltage to ($\tilde{V}$) if it is alternating or ($\bar{V}$) if it is direct, and the voltage value will appear on screen

Second: Ammeter

1-Analog ammeter:

We put the divider, then connect the device in series to the circuit (why) and put the divider

On a certain scale, we read once on the same scale number and another time on another scale.

We apply the law

2-Digital ammeter:

We put the installment on the symbol of direct or alternating current ($\bar{A}$) and ($\tilde{A}$) and the connection as well respectively.

Third: Measuring resistance

1-Analog ohmmeter:

We place the multimeter scale on the ohmmeter side and choose the scale ($\times 1\Omega$) or ($\times 10\Omega$) and read on the upper scale which is opposite the direction of the voltage and current.

2-Digital ohmmeter:

We put the ohmmeter's probe on symbol (Ω), which is the resistance symbol, then connect the device to the resistance and the resistance value appears on the screen.

3-By color method:

It was explained previously.

4-Fourth: Check the capacitor

Previously mentioned

5-Fifth: Diode check

Previously mentioned

Lecture 3
Find Low Resistance

Second Experience

Find Low Resistance

Objective:

Calculating low resistance

Instruments:

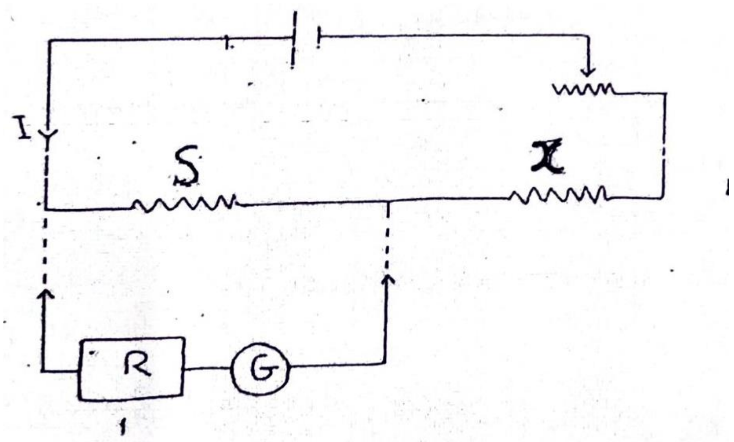
- power supply
- Variable resistance X
- Galvanometer
- High resistance
- Resistor box
- Unknown resistance

Theory

When current (I) passes through the electrical circuit, the galvanometer pointer deflects to read θ 1, θ2   Where:

θ_1 The amount of deflection in the galvanometer when current passes through the variable resistance (**x**).

θ_2 The amount of deflection in the galvanometer when current passes through the standard resistance (**S**).



The potential difference across the unknown resistance(**X**)

$$V_X = I * X \quad \text{-------------------- (1)}$$

The potential difference across resistance(**S**)

$$V_S = I * S \quad \text{------------------- (2)}$$

V_X is directly proportional to θ_1

V_S is directly proportional to $\boldsymbol{\theta_2}$

$$V_x \; \alpha \; \theta_1 \; \rightarrow I.X \; \alpha \; \theta_1 \; \dots\dots\dots..(3)$$

$$V_s \; \alpha \; \theta_2 \; \rightarrow I.S \; \alpha \; \theta_2 \; \dots\dots\dots..(4)$$

When:

$$I.X = k\,\theta_1$$

$$I.S = k\,\theta_2$$

k is the constant of proportionality and by dividing we find that

$$\frac{X}{S} = \frac{\theta_1}{\theta_2} \dots\dots\dots..(5)$$

$$X = S \times \frac{\theta_1}{\theta_2} \dots\dots\dots..(6)$$

How it works:

1. Before starting work, arrange the following table**:**

$S\ (\Omega)$	θ_1	θ_2	$X = S \times \frac{\theta_1}{\theta_2}\ (\Omega)$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2. Connect the electrical circuit as shown in the drawn Figure.
3. Set the resistance R to a certain value, and fix the voltage at (4volt) and the resistance at 50 (Ω).
4. Connect the Galvanometer circuit in parallel with the unknown resistance(X).
5. Record the value of θ_1 deviation in the galvanometer via (X).
6. Connect the Galvanometer circuit in parallel with the standard resistance(S).
7. Record the value of θ_2 deviation in the galvanometer via (S).
8. Repeat steps (4,5,6,7) by taking another value for (S).
9. Arrange the information as in the table, then extract the value of the unknown resistance from Equation (6).

Questions:-

1- If you know that the internal resistance of the galvanometer is (1), can we find the resistance (X) in this experiment?
2- If you know that the unknown resistance is large, is it possible to use this method to find its value? And why?

Lecture 4
Achieve Ohm's Law

Third Experience

Achieve Ohm's Law

Objective:

1. Verify Ohm's law practically by finding the linear relationship between the voltage difference and the current passing through a linear resistance.
2. Measure the resistance used in the experiment.

Instruments:

- A variable DC voltage source.
- A small resistance of about 100 ohms.
- A voltmeter. A voltmeter.
- Ammeter.
- Connecting wires.

Experimental Theory:

Ohm's law states that the potential difference between the two ends of a resistive metal conductor (V) is directly proportional to the intensity of the current passing through it (I) at constant temperature. This law is considered one of the very important laws in electricity, and its mathematical form is:

$$I = \frac{V}{R}$$

or

$$V = I R$$

or

$$R = \frac{V}{I}$$

Where R the constant of proportionality and its value is the value of the resistance of the metal wire used in the experiment, if (I) is marked in amperes and (V) in volts, then (R) is measured in ohms and this unit is symbolized by the symbol (Ω). Ohm's law only applies to linear resistors, and do not forget that electrical resistance is an electrical property of the material and represents the opposition it shows to the electric current when it passes through it and when a potential difference is applied to its ends. In general, conductors are considered linear resistors at constant temperature.

Method:

1. Connect the circuit as shown in Figure 1
2. Make sure the electrical circuit is connected correctly by observing the ammeter reading.
3. Record a set of readings for the current and voltage values by changing the variable resistance as in the table below:

V (volt)									
I (amp)									

4. Draw the relationship between the current (1) and the voltage (V) from the results you obtained as in Figure 2
5. Calculate the slope value from the relationship = slope AV
6. Calculate the resistance value from the relationship: R1/slope, which must equal the value of the fixed resistance used in the experiment**.**

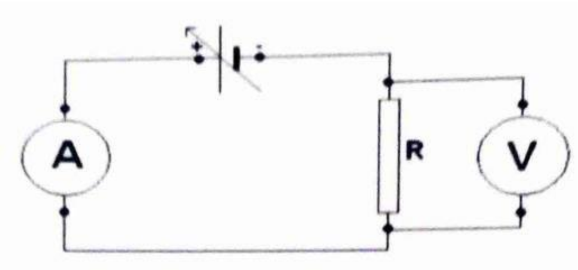


Figure 1

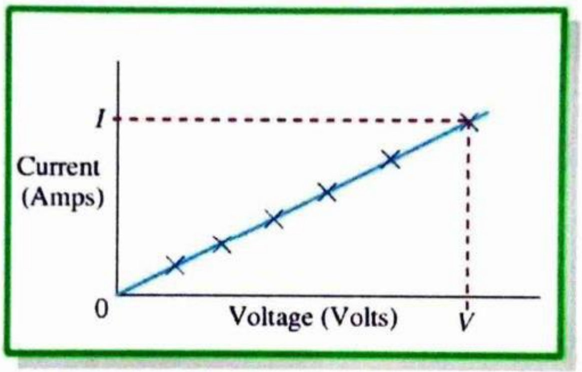


Figure 2

Notes:

1. It is preferable not to leave the circuit closed during the entire period of recording the readings in order to avoid sufficient heating in the resistance that affects the validity of the results of the experiment. 2. It is preferable to choose a voltmeter with a very high resistance in order to ensure that the current does not pass through it, and thus the current passing through the resistance is the same as the current measured in the ammeter.

Questions:

1. List the most important sources of error in the experiment?
2. Discuss why the internal resistance of the ammeter must be very small and the internal resistance of the voltmeter very large?
3. Which is better to achieve Ohm's law, a small resistance or a large resistance? And why?
4. Is the voltage applied to a circuit affected by the amount of resistance in it

Lecture 5
Finding the internal resistance of a voltmeter using the graph method

Fourth Experience

Finding the internal resistance of a voltmeter using the graph method

Objective

Finding the internal resistance of a voltmeter using a graph

Instruments:

- Lead cell or battery, voltmeter reading (3-0.1V), resistor box value
- It ranges from (0.1-1000 Ω)

Theory:

A voltmeter is a moving coil galvanometer. To convert a galvanometer into a voltmeter, a resistor called a shunt is connected in series with the galvanometer. It is then used to measure the potential difference between two points. The shunt idea enables us to change the scale of the voltmeter. And make it within limits greater than it is

In Figure (1), (E) represents the electromotive force and (R) represents the resistance used from the resistor box. If we assume that (R_V) is the internal resistance of the voltmeter and (V) is the voltmeter reading, which represents the potential difference between its two ends, and that (I) is the intensity of the current passing through the circuit, which is

$$I=E/R_V+R \text{ ……………… (1)}$$

Neglecting the internal resistance of the lead battery, the value of E is

$$E=IR+IRv$$

Voltage through voltmeter

$$V=I\ Rv$$

$$V = (E/R_V+R)Rv$$

$$(R_V+R)V = ER_V$$

$$R_V+R=(ER_V).1/V$$

$$R=(ER_V).1/V - R_V$$

Since both E and R_V are constant, the relationship between the relationshipRand1/V is linear in Figure (1), so the straight line intersects the y-axis in a Campania shift and is negative, and this amount is R_V. The slope of the straight line represents (ER_V), and since (R_V) was found from the intersection, the value of (E) can be calculated from **the slope.**

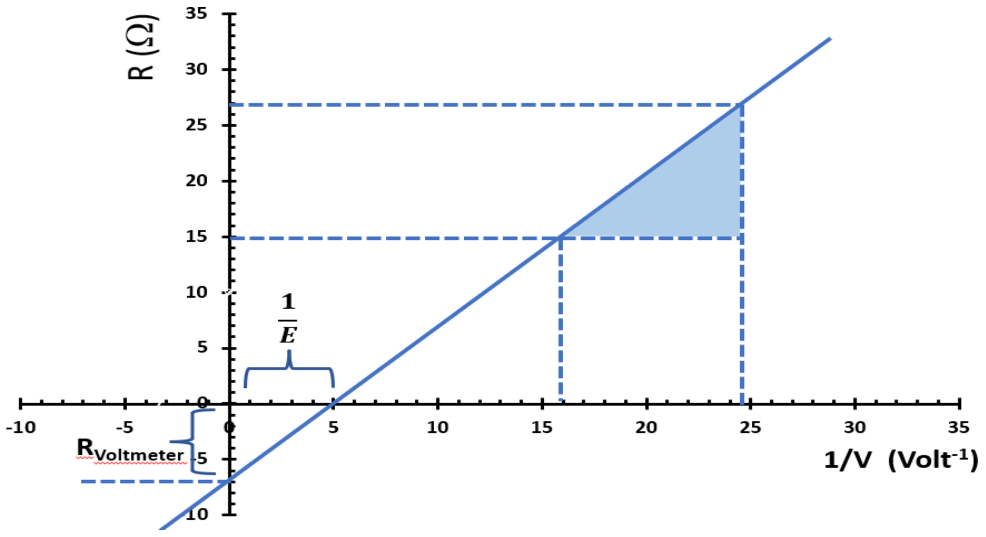


Figure 1

Methods:

1- Connect the electrical circuit as shown in Figure 2.

2- Make sure that the circuit is connected correctly by one of the laboratory officials.

3- Take a large resistance (R) and note if the voltmeter reads any reading. Say the value of the resistance (R) until the voltmeter reads its highest value and record the value(R) and voltmeter reading (V).

4- Repeat step (3) several times, take different values of (R) and record the corresponding (V) and arrange the results in a table as shown below.

5-After making sure that all readings are taken, cut off the power, disconnect the circuit and arrange the devices in their original place

R(Ω)	**V (V)**	**1/V(Volt)** $^{-1}$

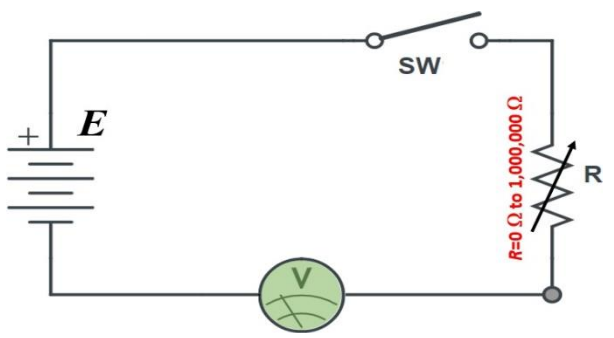


Figure 2

Results and calculations:

1-Draw a graph between the values of R (Ω) on the y-axis and the values of 1/V ($volt^{-1}$) on the x-axis from the measured values found in the previous table.

2-Calculate the value of (R_V) from the point of intersection of the line with the (R) axis.

3-Calculate the value of (E) from the slope of the straight line.

4-Calculate the percentage error.

Questions:

1-Is the resistance of the voltmeter small or large and why**?**

2-What are the possible errors in this experiment? And how can they be reduced.

Lecture 6
Ohm's law in a circuit containing an inductive coil

Five Experience

Ohm's law in a circuit containing an inductive coil

Objective

Study and investigation of Ohm's law in an alternating circuit containing an inductive coil

Instruments:

- Low voltage AC source
- Inductive coil
- Voltmeter A.C
- Connecting wires

Theory:

The inductor is one of the important elements in an alternating circuit (AC circuit). This inductor is not generally pure due to the resistance of its wires. When a current of constant frequency passes through the inductor, it will show an impedance to this current similar to that shown by the resistance in an electrical circuit. The resistance of the resistance is a fixed quantity equal to the result of dividing the voltage (V) applied between its two ends by the current (I) passing through it.

According to Ohm's law.

$$V \alpha I$$

$$V = Z\, I \;.......(1)$$

Where Z is the impedance. In a circuit containing a coil, the voltage across it leads the current passing through it by an angle of (90°)

The relationship between the effective value of the root mean square (rms) of the current (Irms) passing through the current coil in an alternating circuit and the effective value of the voltage (Vrms) on its two ends is a linear relationship, so it will be subject to Ohm's law. The curve drawn between the voltage Vrms on the y-axis and Irms on the x-axis will be a straight line passing through the origin with the same slope as the impedance slope(Z_L) of the coil Figure (1). This impedance consists of the inductive reactancec(X_L) and its resistance (r) where

$$z = \sqrt{X_L^2 + r^2} \dots\dots\dots\dots (2)$$

The inductive circuit changes with frequency (and current passing through the inductive coil as follows:

$$X_L = 2\Pi l f \;......(3)$$

Where L fixed quantity for the coil is called the coil inductance or inductance coefficient and is estimated in Henrys, where the value of (L) depends on the number of coil turns, its diameter, length, and the nature of the coil core Therefore, the approximate value of L can be calculated from the following equation:

$$L = \frac{\mu_\circ N^2 A}{\lambda} \text{ ....(4)}$$

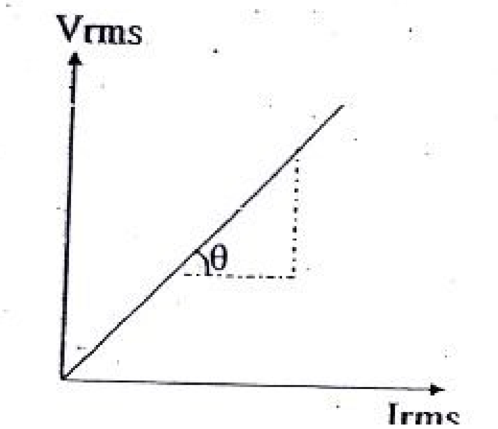


Figure 1

Where:

A: Average value of the cross-sectional area of the inductive coil in square meters.

N: Number of turns in the coil.

λ: Length of the coil in meters.

$\mu_\circ$:Permeability in vacuum.

Methods:

1. Connect the electrical circuit as shown in Figure (2)

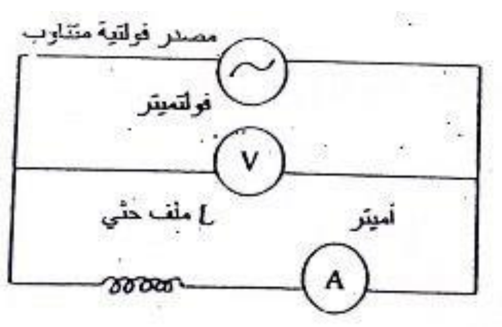


Figure 2

2. After ensuring that the circuit is connected correctly by one of the laboratory officials, take a high and stable frequency from the voltage source (350)Hz

3. Take several readings for (V) and record the values of the current passing through the circuit and arrange the readings as in the table shown.

Vrms (volt)	Irms (amp)

4. Draw a graph between the values of (Vms (volt) on the y-axis and (Ims (amp) on the x-axis
5. Calculate the total impedance of the circuit from the slope of the graph
6. Find the value of the inductive response (X) from equation (2) which is the practical value and calculate the theoretical value from equation (3)

Questions:

1. What is the henry?
2. Discuss the reasons for the difference in the value of (X) calculated from equation (3) from the practical value.
3. Why is a high frequency chosen for the alternating current when measuring the impedance of a coil? Mention the equations if any?
4. What is the shape of the curve drawn between the impedance of coil 2 and the frequency?

Lecture 7
The law of connecting resistors in a series

Six Experience

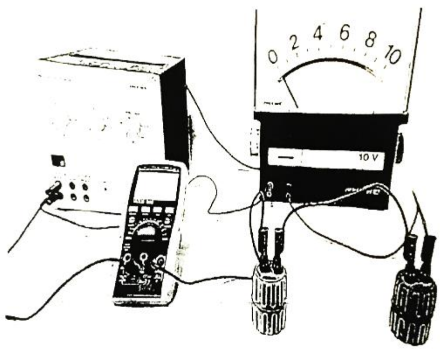
The law of connecting resistors in a series

Objective:

1. Connect the resistors in series and find the equivalent resistance.

Instrument:

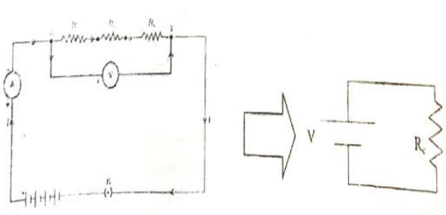
DC voltage source (battery), 2 resistors, voltmeter, ammeter, connecting wires, as shown in the following figure:

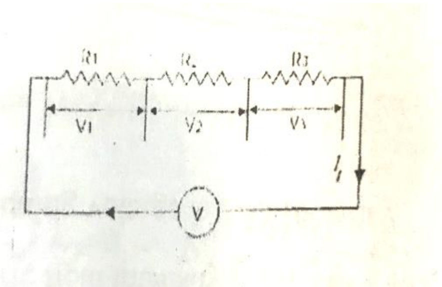


Connecting resistors in series:

In the case of series connection, as in the figure, the current passes through the resistors one after the other, and therefore the current passing through them is the same as the current coming out of the source (battery) and passing through the two terminals (X-Y):

$$I_T = I_1 = I_2 = I_3 \ldots\ldots\ldots\ldots\ldots.. (1)$$





(Rs) is the equivalent resistance (the first figure on the right) and according to Ohm's law, the value of Rs is:

$$Rs = R_1 + R_2 + R_3 \ldots\ldots\ldots\ldots\ldots. \quad (2)$$

Note: In an electric circuit, the components of the circuit share the current passing and flowing from the electric source so that the same current passes through them, thus reducing the electric voltage applied to each component in the circuit. If it happens that the circuit stops

If one component of the circuit stops working, the current flow to the other components will stop as well.

Methods:

First: Connect the resistors in series

The resistors are connected in series in the electrical circuit and connected in parallel with the voltmeter. Therefore, the potential difference between the two ends of any of them will be less than the potential difference of the battery, but the current supplied by the battery to the circuit is the same as the current passing through each resistor. Together, the resistors form a specific value for the total resistance as in the equation (1).

1. Replace the voltage and record the corresponding current values, then arrange your readings in the following table:

NO.	1	2	3	4	5
Voltmeter Reading V (V)	0.5	1.0	1.5	2.0	2.5
Ammeter Reading I (mA)					

2. Draw a graph between the current I on the x-axis and the voltage V on the y-axis, then Extract the slope? What does it represent?

3- Compare the calculated (practically) equivalent resistance value with the theoretical value.

Questions and comments:

1-Why is the ammeter is connected in series while the voltmeter is connected in parallel? What are the risks if the opposite happens?

2- Choose two values for I in the case of a series connection (the readings are recorded in the table), then deduce the values of each ofV_1 On R_1,V_2 On R_2(Using Ohm's law), then add $V_1+V_2$for each value of I. Compare the result with the voltage across the two terminals of the source in each case, i.e. with the V corresponding to each I in the table. What do you notice? Is what was observed expected?

3. Choose two values for V in the parallel connection case recorded in the table, then deduce the values of each of I_1 in $R_{1,}$ I_2 in R_2 and then add $I_1 + I_2$ for each value of V.

Compare the result with the value of I coming out of the source in each case (i.e. with I in the table). Record your observations. Do your observations agree with what was expected?

Video presentation:

https://www.youtube.com/watch?v=8RJ6Kdk8KDo&t=390s

Lecture 8
The law of connecting resistors in a parallel

Seven Experience

The law of connecting resistors in a parallel

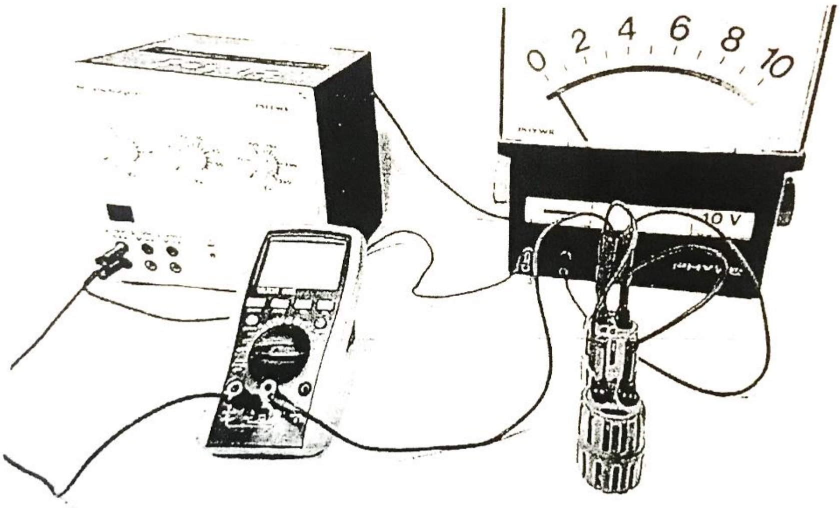
Objective:

Connect the resistors in parallel and find the equivalent resistance.

Instruments:

DC power source (battery), 2 resistors, voltmeter, capacitance meter

DC current (ammeter), connecting wires, as shown in the following figure

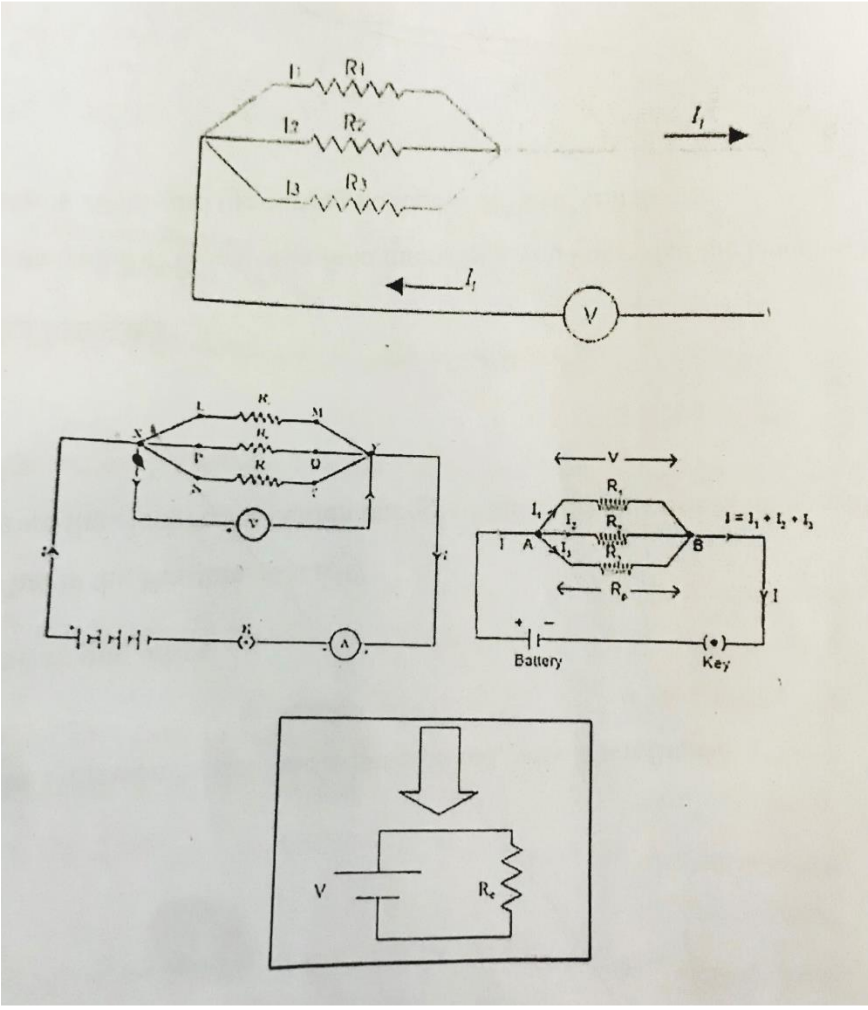


Second:

Connecting resistors in parallel:

When connecting two or more resistors in parallel, as in the following figure, the voltage difference on each of them is the same as the voltage difference (V) of the source, and the total current (I_T) coming out of the source is distributed among the connected resistors R_1, R_2, R_3, as shown

$$I_T = I_{1+} I_{2+} I_3 \ldots\ldots\ldots\ldots\ldots.. (1)$$



If the equivalent resistance of two resistors R_1, R_2, R_3 is (R_P), then according to Ohm's law, it will be

$$\frac{V}{RP} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3} \quad \rightarrow \frac{1}{RP} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \ldots (2)$$

Methods:

Second: Connecting resistors in parallel

1- Connect the electrical circuit as shown in the following figure:

NO.	1	2	3	4	5
Voltmeter Reading V (V)	0.5	1.0	1.5	2.0	2.5
Ammeter Reading I (mA)					

2- Repeat steps 1 to 3 for the series connection. Then plot the voltage versus current graph

Find the equivalent resistance Rp.

3- Compare the calculated equivalent resistance value practically and theoretically, then interpret the results.

Questions and comments:

1. Why is the ammeter connected in series while the voltmeter is connected in parallel? What are the risks that, what happens if the opposite happens?

2. Choose two values for I that are not in the case of consecutive connection of the readings recorded in the table, then deduce the values of each of them V_1On R_1,V_2On R_2.

(Using Ohm's law), then add V_1+V_2 for each value of I. Compare the result with the potential difference across the two terminals of the source in each case,(i.e. with V corresponding to each I in the table). What do you notice? Is what was observed expected?

3- Choose two values for V in the parallel connection case recorded in the table, then deduce the values of each ofI_1in $R_{1,}I_2$ in R_2 and then add $I_1+ I_2$ for each value of V.

Compare the result with the value I coming out of the source in each case (i.e. with I in the table). Record your observations. Do your observations agree with what was expected?

Video presentation

hups://www.youtube.com/watch?v=8RJ6Kdk8KDo&t=390s+

Lecture 9
Measuring the Inductance of a coil and determining its Resistance Using a Voltmeter

Eigth Experience

Measuring the Inductance of a coil and determining its Resistance Using a Voltmeter

Instrument:

coil (24 mH) , known resistance value(4,6,8 Ω), (A.C)electric power source (50 Hz) , (A.C) voltmeter.

Theory:

In the figure (1) , since the resistance (R) is purely resistive , the voltage difference across it (V1) is in phase with the current flowing through it (I) . However , in the case of the coil , assuming its resistance is Zero , the phase difference between (V1) and (V2) is (90_{o}) .

Since the inductance of the coil is not purely inductive (meaning there is some resistance) , it is practically impossible to create a coil with only inductance , as the coil always possesses a certain amount of resistance . Notice in the diagram that the phase difference is not equal to 90 degrees .

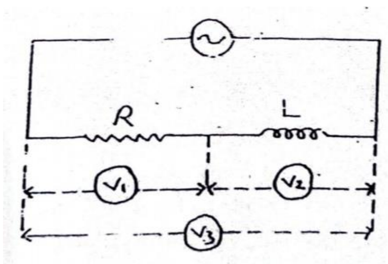


Figure (1)

Vectors (v1 , v2 , v3) can represent it along with its direction, and we can use the resulting drawing to determine the inductance and resistance of the coil as follows :

A - Draw a line parallel to (I) and take the phase AB represented as the magnitude (v1) .

B – Focus on a point (A) and draw an arc with an opening equal to (v3) .

C - Focus on a point (B) and draw an arc with an opening equal to (v2) .

D – The two arcs will intersect at a point (C). Complete the parallelogram by analyzing the vector (v2) .

It is possible to determine both (vL) and (vr) .

you can determine both the projection (v2) on the y- axis representing (vL) and the projection (v2) on the x- axis representing (vr) .

if the electrical current (I) flowing in the circuit is as shown :

$$I=\frac{V_1}{R}=\frac{V_L}{X_L}-\frac{V_r}{r}$$

$$V1 = RI = AB \quad \ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

then (vr) represents the voltage across the coil resulting from its resistance (r) .

$$vr = rI = BD \ldots\ldots\ldots.(2)$$

From equations (1) and (2) , it follows that

$$r = \frac{BD}{AB} \cdot R\ (\Omega) \quad \ldots\ldots\ldots\ldots.. (3)$$

As for (vL) represents the voltage across the voltage across the coil due to its reactance (XL).

$$VL = XL\ I = 2\ \pi\ f\ L\ .\ I = CD$$

$$L = \frac{CD}{AB} \cdot \frac{R}{2\ \pi\ f} (\ Henry\ ) \ldots\ldots\ldots.(4)$$

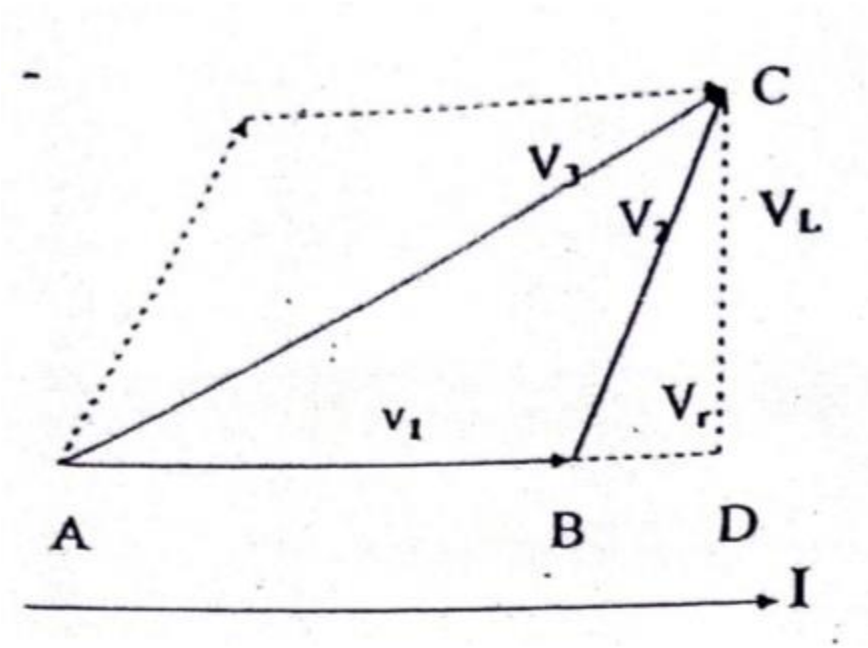


Figure (2)

Procedure:

1- connect the electrical circuit shown in figure (1) , where R represents the pure resistance. Since the coil has both resistance and inductance , we can think of it as composed of a pure resistance (r) and a pure inductance (L) ; refer to figure(2).

2- Measure the voltage across the resistor (R) by connecting the voltmeter between points (1) and (2) , let it be (v1) .

3- Measure the voltage across the coil (L) by connecting the voltmeter between points (2) and (3) , let it be (v2) .

4- Measure the voltage across the entire circuit by connecting the voltmeter between points (2) and (3) , let it be (v3) .

5- Change the source voltage and repeat the steps (2),(3),(4).

6- Repeat step (5) several times and record your measurements in a table, noting the frequency of the applied voltage.

7- Draw the voltage phasor diagram and use it along with the relationship (3) and (4) to calculate the inductance (L) and resistance (r) of the coil .

Lecture 10
The investigation of a charged capacitor discharge and the calculation of its time constant

Nine Experience

The investigation of a charged capacitor discharge and the calculation of its time constant

Objective:

1. To understand the method of charging and discharging capacitors.
2. To calculate the time constant for the capacitor discharge process.
3. To calculate the value of the voltmeter resistance.

Instruments:

1- DC power supply.

2- A capacitor with a value of (500 – 1000) micro farads.

3- Voltmeter.

4- Connection wires.

5- Stop watch.

Theory:

The capacitance is given by the following equation:

$$C = \frac{Q}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Since the capacitance (C) measured in farads, the charge (Q) measured in coulombs, the voltage (v) measured in volts.

From the above equation, we can see that the voltage is directly proportional to the charge.

$$v = \left(\frac{1}{C}\right)Q \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Since $\frac{1}{C}$ the constant of proportionality .

Is the time the time constant for exponential growth or decay? (τ)

In seconds for the capacitor to charge or discharge to a certain percentage of the final voltage.

The time constant can be calculated using the following equation:

$$\tau = R\,C \ldots\ldots\ldots\ldots. (3)$$

Since (τ) is in second, the resistance (R) in ohms ,

. And the capacitance is in farads (not micro farads)

The exponential relationship for the decay and discharge of a capacitor is:

$$V = V_o \, e^{-t/_{R\,c}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

R : the resistance through which the capacitors charge dissipates .

C : the capacitance of the capacitor .

V_o : the initial voltage of the capacitor after the charging process is complete .

V : the instantaneous voltage at a time of .When the capacitor begins to discharge at time .

$$t = R\,c \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

by substituting equation (5) into equation (4) , we get :

$$V = V_o / e \ \ldots\ldots\ldots\ldots\ldots.(6)$$

If we plot a graph between the values of (v) and (t) , we obtain a curve as shown in figure (2) , from which we can determine the time constant (τ) and calculate the resistance (R) of the voltmeter .

Methods :

1- connect the experimental circuit as shown in figure (1) .

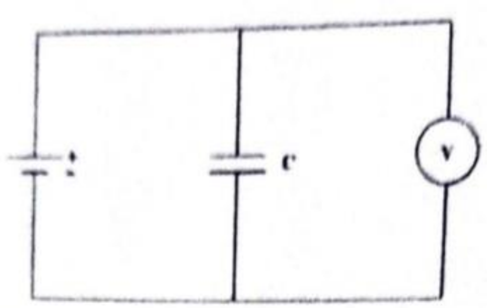


Figure (1) : the electrical circuit for the experiment.

3- Charge the capacitor until it reaches V_o, which represents the highest value on the voltmeter, and record the value of V_o.
4- Disconnect one of the wires from the source so that the capacitor discharges, and record the time required for the voltmeter reading to reach (1- V_o) volts using the stop watch.

4- Repeat steps (2) and (3) for different voltages, recording the corresponding times.

5- Record the information as shown in the following table:

V (volt)	V_o	V_o-1	V_o-2	V_o-3	V_o-4	V_o-5	V_o-6
t (sec)							

6- plot a graph of v (volt) on the vertical axis and t (sec) on the horizontal axis , as shown in figure (2) .

7- Calculate the value of (V_o / e) , where V_o is the maximum voltage and e is a function .

e= exp (1) = 2.718

8- Place the value of (V_o / e) on the vertical axis and determine the corresponding time constant (τ) , as shown in figure (2) .

9- Calculate the time constant (τ) .

10- Calculate the resistance (R) of the voltmeter using the relationship R= τ/c .

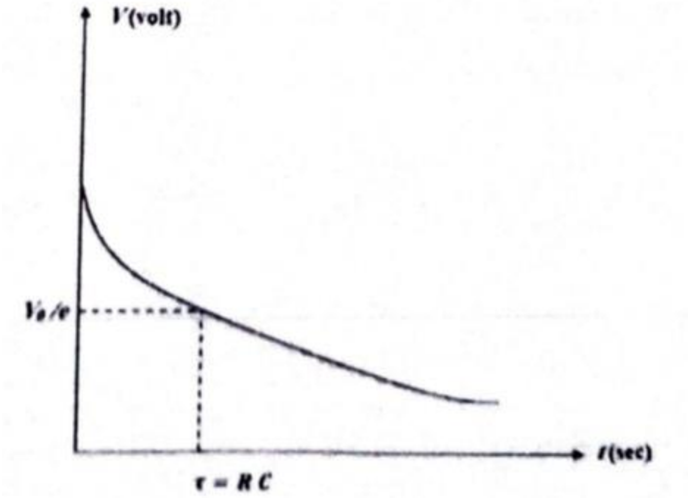


Figure (2) the graph used to calculate the time constant and the resistance of the voltmeter.

Questions:

1- Define a capacitor?

2- What factors affect the discharge time?

3- Does the discharge time depend on the resistance of the voltmeter?

4- Why is the resistance of the voltmeter large?

5- What is the reason for always connecting the voltmeter in parallel in experiments?

Lecture 11

Converting an Ammeter into a Resistance Measuring Device (Ohmmeter)

Ten Experience

Converting an Ammeter into a Resistance Measuring Device (Ohmmeter)

Instruments:

1. Millimeter
2. Lead – acid battery
3. Resistance box (10 - 2500 Ω) R
4. A fixed resistance (50 Ω)

Theory:

The value of the current flowing through the following electrical circuit is given by the following equation:

$$I = \frac{E}{R+R_o} \dots\dots..(1)$$

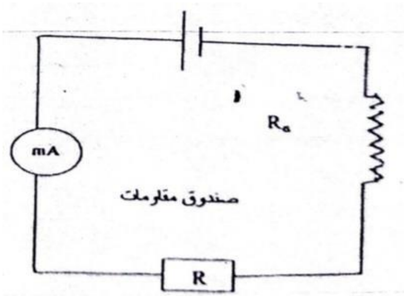


Figure (1)

Where:

I: the electric current flowing through the circuit.

E: the electromotive force of the battery. Where:
I: the electric current flowing through the circuit.
E: the electromotive force of the battery.
R: resistance box.
R_o: fixed resistance.

The electric current intensity depends only on the value of R

Because (E) is constant and (R_o) also remains constant throughout the experiment.

Thus , the ammeter records the greatest deflection when (R=0)

The ammeter records zero when ($R \rightarrow \infty$)

the ammeter records a mid- scale reading when ($R=R_o$)

Based on this principle , the given ammeter can be calibrated in terms of resistance values (R) , provided that both the electromotive force (E) of the battery and the resistance R_o Remain constant.

Therefore , this device (the milliammeter with resistance R_o)Can be used , after calibration , to measure an unknown resistance.

Method:

1. Before starting the experiment , arrange four tables as follows:
2. Connect the electrical circuit as shown in figure 1
3. Observe the first table.

Set the value of (R = 10 Ω) and record the deflection of the milliammeter. Change the resistance in steps of (10 Ω) each time and record the corresponding deflection until (R) reaches approximately (150 Ω)

4. Observe the second table.

Continue increasing the resistance (R) in steps of (20 Ω) each time until it reaches approximately (600 Ω) and record the corresponding deflection of the ammeter each time.

5. observe the third table.

Continue increasing the resistance (R) in steps of (50 Ω) each time until it reaches approximately (1500 Ω) and record the corresponding deflection of the ammeter each time.

6. observe the fourth table .

Continue increasing the resistance (R) in steps of (100 Ω) each time until it reaches approximately (2500 Ω) and record the corresponding deflection of the ammeter each time.

7. use the device (milliammeter and known resistance R_o) to determine the values of four unknown resistances by recording the value of i for each resistance and using the known R_o.

Note:

You can take any resistance value from the resistor box and consider it unknown. Then , measure the value of i , given that (R_o) is known and (E) of the battery is known.

Apply the following equation:

$$I= E/(R+R_o)$$

8. Repeat the previous procedure four times, changing the value of (R) from the resistor box each time and considering it unknown.
9. Compare the (R) values obtained from the equation with the (R) values taken from the resistor box.
10. Plot a graph for each of the four tables. Make the best use of the graph paper , and using the devices scale , determine the values of the unknown resistances.

Questions:

1. Prove that ($R= R_o$) when the devices pointer indicates the midpoint of its scale.
2. Can the scale obtained for the device in the above experiment be used to measure resistance using the same ammeter and R_o , but with a different battery that also has a constant voltage but differs from the one used for the above scale ?