University of Baghdad
College of Science
Department of Physics
Asst. Prof. Sundus Mahmood Abbas
Asst. Prof. Dr. Ahmed Saleh Ahmed
Asst. Prof. Dr.Eman Mezher Nasir
Subject: Practical physics / Magnetism laboaatory
First class
Semester: 2nd course
Morning study

Lecture(1). graph line

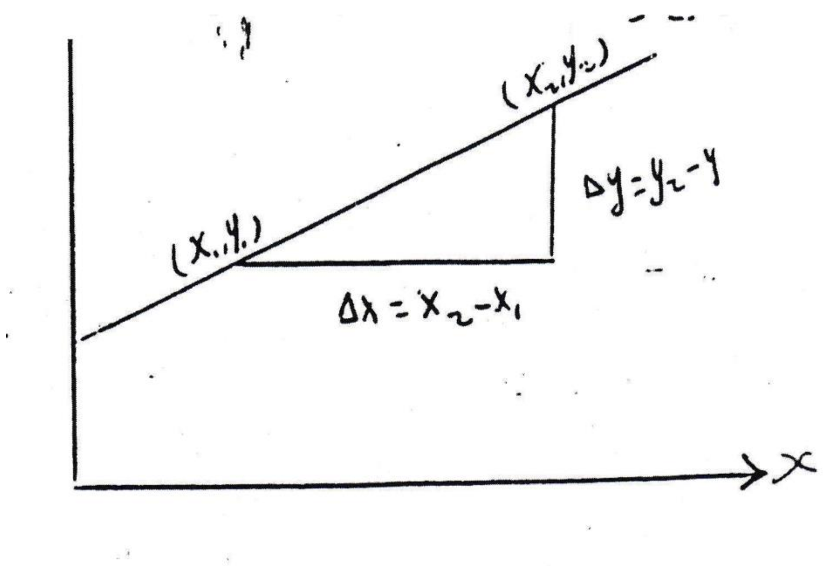
It is the curve that we get when drawing a variable Y, for example, as a function of another variable X, for example. In fact, drawing the graph of two variables represents a visual way to clarify and realize the relationship between them, and more and more, what we will encounter in our experiments are the cases in which the graph is straight and that the straight line equation is:

$$Y=ax+b$$

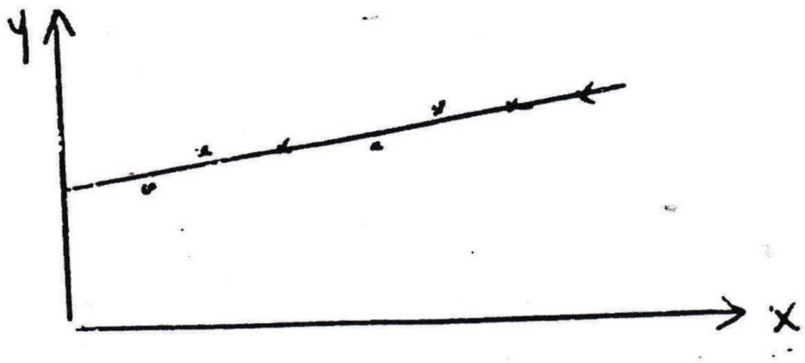
Where y is the function or variable dependent on the variable x, a: The slope of the straight line is equal to the change in y over the change in x, meaning that:

$$a = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

b represents the coordinates of the point of intersection of the line with the y axis, that is, it represents the value of y when the value of x becomes zero, as in the figure below:



When conducting an experiment and measuring ten values of x, for example, we will obtain, in return, ten values of y. Each pair of readings represents a point on the (x, y) level, as shown in the figure below:



Then we pass a graphic line between these points. And if the relationship is linear between x and y, then we pass a straight line between these points so that the sum of the squares of the deviations of these points from the straight line is the least possible. That is, the number of points below the line is equal to the number of points above the line, bearing in mind that the sum of the squares of the distances of the points below the line from the line is approximately equal to the sum of the squares of the distances of the points above the line from the line. Here are some notes for drawing such shapes, please commitment to them:

1- The y and x axes are 2 cm away from the edge of the paper.

2- Write on each axis the name of the variable, its symbol and its unit of measurement.

3- Write the number and title of each form directly below the form, as if we write:

Figure 1: Potential difference V as a function of current I.

4-Do not write anything on the data sheet other than what was mentioned above, with the exception of calculating the slope.

$$a = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

5- Remember that what the unit of length represents on the y-axis has nothing to do with what the unit of length represents on the x-axis, for example: 1 cm on the y-axis may represent 1 volt, while 1 cm on the x-axis may represent 0.001 ampere. In addition, it is possible to choose any suitable scale and obtain the same results.

Lecture7: Measuring devices

In this lecture, we will learn about some of the important measuring devices in the laboratory to conduct the experiment

1- Galvanometer (G):

A device highly sensitive to electric current consisting of a coil arranged on an iron core fixed to a shaft and placed between the poles of a permanent magnetic bar.

When an electric current passes through the coil, a torque is generated, which causes the axis to twist, and accordingly the pointer connected to the axis moves according to the type of curved measurement. When no electric current is passed, it is clear that the return torque is proportional to the angle of rotation.

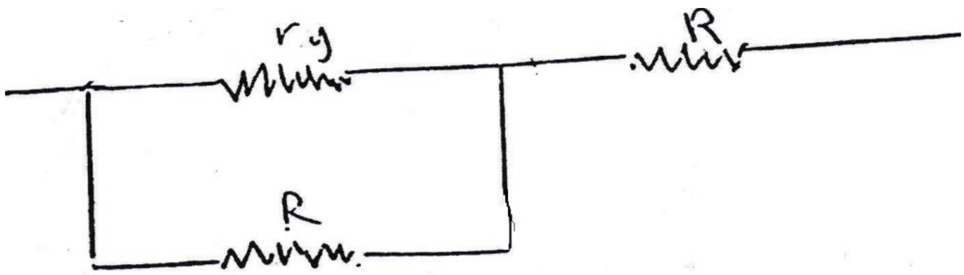
In fact, the angle of rotation or the magnitude of the deflection of the m}shar is directly proportional to the flowing current.

A galvanometer can be converted into an ammeter, a voltmeter, or an ohmmeter.

2- Ammeter (A):

A device used to measure ordinary electric currents. It is a galvanometer connected in parallel with a small resistance whose amount depends on the value of the current to be measured. If the ammeter is designed to measure fractions of ampere, then the resistance used is relatively large.

Since the ammeter is used to measure the current passing through a resistance, it must be connected in series with it, so that all current passes through it.



Lecture8: Measuring devices

In this lecture, we will learn about some of the important measuring devices in the laboratory to conduct the experiment.

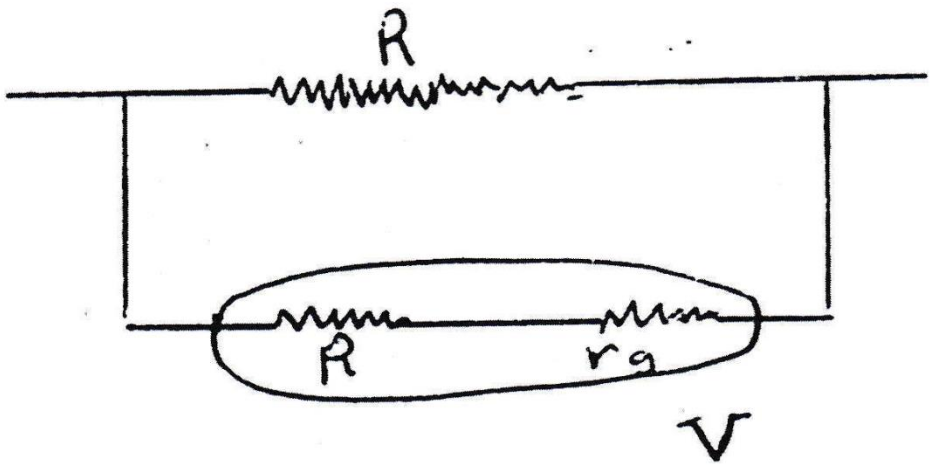
3- Voltmeter (V):

A device used to measure the potential difference between two points in an electric circuit, and for this reason it is connected in parallel with what is connected between those two points.

A voltmeter is a galvanometer with which a resistance is connected in series, the amount of which depends on the value of the potential difference to be measured.

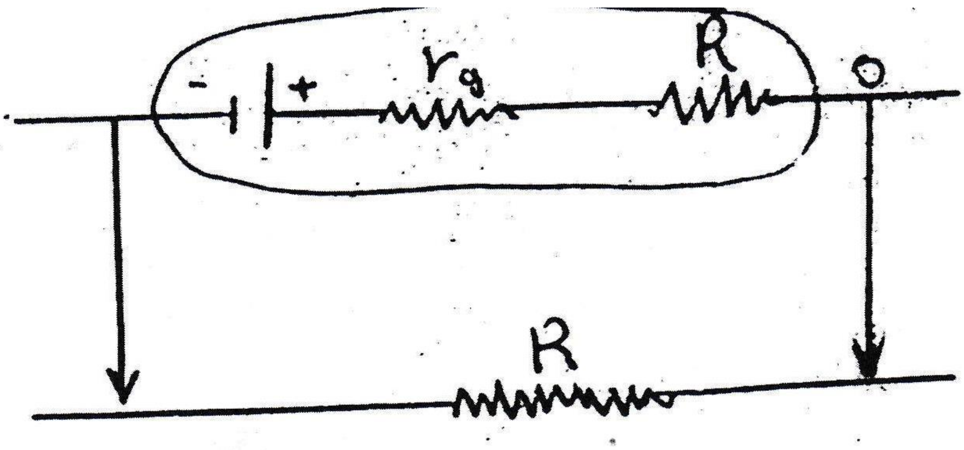
If the potential difference is large, the resistance is very large, and if the potential difference is relatively small, the resistance is relatively small

.



4- <u>Ohmmeter (O):</u>

A device used to measure resistors. It is a galvanometer with which a resistance and a battery are connected in a row so that if its ends are connected to each other, the pointer will deviate the greatest deviation, indicating that there is no external resistance.



Lecture9: Measuring devices

In this lecture, we will learn about some of the important measuring devices in the laboratory to conduct the experiment.

5- Ohmmeter (AVO)

A device that can be used as an A-meter, a V-voltmeter, or an O-meter.

The AVO meter contains various electrical equipment and many resistors of varying value, and its use and purpose is determined by the use selection switch.

If this key is placed in front of the cutter letter A, then its use is determined as an ammeter, and a small resistance will be connected in parallel with the galvanometer.

Likewise for the ohmmeter, And by the way, by placing the reuse switch in the appropriate position, the AVO can be used to measure the current or the continuous or alternating voltage difference.

And depending on the value of the resistance used, the range of the device for measurement is determined, and by range we mean the largest value that can be .measured

When placing the usage selection switch on the letter breaker A and opposite the range I, this means that the largest current that can be measured is one ampere, and if it is over a range of 10, then this means that the largest current that can be measured is ten amperes. The largest voltage that can be measured is 30 volts, and so on, and since the measuring plate on which the pointer moves is the same, then:

The correct reading of the device = (the reading of the indicator X the range) / (the largest reading on the measuring plate)

6- Resistors Box

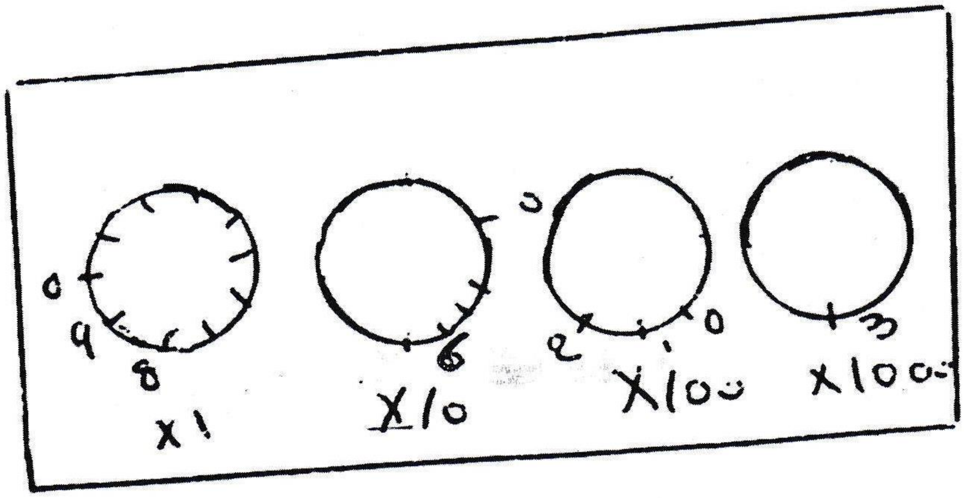
It is a group of resistors with double amounts that are all placed inside a box, and any of them can be connected to the other in a row to get a higher resistance according to what we want.

The resistors inside the box are usually classified into groups.

The first group are multiples of one, the second group are multiples of ten, the third group are multiples of hundreds, and there may be a fourth group for multiples of thousands.

There are several keys listed, each from 1-9, to choose the appropriate resistance, for example:

In the configuration shown in the drawing below, the resistance used is 3168 ohms.



$R = 8x1 + 6x10 + 1x100 + 3x1000$

$= 8 + 60 + 100 + 3000$

$= 3168\ \Omega$

Lecture10: Measuring devices

In this lecture, we will learn about some of the important measuring devices in the laboratory to conduct the experiment.

7- Variable Resistance

Physically, it means the resistance shown by a conductor when an electric current passes through it.

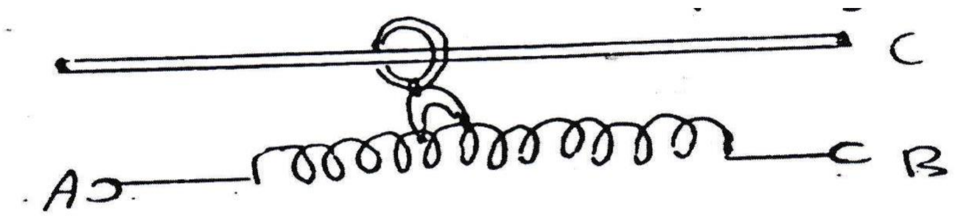
Static Resistance:

It is a constant resistance value due to the constant length of the wire.

Variable Resistance:

It is a wire coiled on an iron core and has two ends for connection A and B (black or white)

There is a piece of metal S that can slide on a metal rod, and its two ends are in permanent contact with the wire, and the rod ends at one end with a piece (usually colored).



Depending on how the variable resistor is connected, its use is determined:

1- If the two ends, A and B, are connected alone in the electrical circuit, then they will be used as a static resistance, in order to use the entire length of the wire.

2- If one of the two points A or B is connected with point C, then the part AS will be used, but if point B and point C are connected, then the part SBs will be used and the value of the resistance of the used part of the variable resistance. It depends on the location of S, and in such cases we have used the variable resistance to control the current.

3- The variable resistance is used as a voltage divider, that is, it is used to obtain a low voltage from a large voltage source, in the following way:

It connects the two ends of the voltage source to two points A and B, so we have applied all the potential difference to the entire length of the wire AB. Points C and A are connected to the other part of the electrical circuit. We have used the voltage part between S and A, and the sliding part S moves. We can control the voltage used.

Experiment (1)

Applying Ohm's Law in a Circuit Containing an Inductive Coil

Purpose of the Experiment:

1. To verify Ohm's law in an AC circuit containing an inductive coil.
2. To calculate the inductive reactance and the self-inductance of the coil.

Apparatus:

AC voltage source, Voltmeter, Ammeter for measuring AC values, Inductive coil.

Theory:

An inductive coil is one of the essential components in an AC circuit and can generally be considered pure due to the small resistance of its wires (r). When an alternating current with a fixed frequency passes through the inductive coil, it will exhibit impedance to this current equivalent to the impedance that a resistor offers in any electrical circuit. The impedance of the resistor is a constant value and equals the voltage applied across its terminals divided by the current passing through it as follows:

$V \propto I$

$V = Z\,I$ او

$$Z = \frac{V}{I} \qquad (1)$$

Where (Z) is the impedance, (V) is the voltage across the coil, and (I) is the current passing through the inductive coil, the relationship between the effective value of voltage (V_{rms}) and the effective value of current (I_{rms}) in the AC circuit is linear, thus requiring Ohm's law. The figure (1) shows the linear relationship between the voltage (V) and the current (I), with the slope equal to the impedance (Z_L).

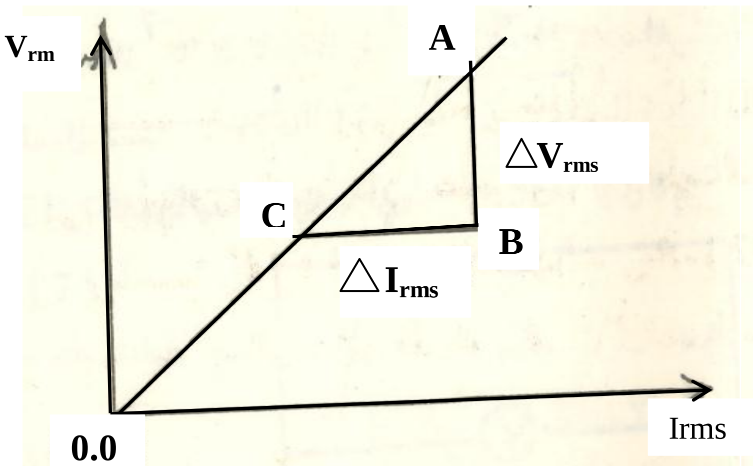


Figure (1)

The impedance of the coil is written as follows:

$$Z_L = \sqrt{{X_L}^2 + r^2} \qquad (2)$$

Where (X_L): is the inductive reactance of the coil.
(r): is the resistance of the inductive coil, which can be neglected due to its small value. The equation above can be simplified to:

$$Z_L = X_L = \frac{V}{I} \qquad (3)$$

The inductive reactance varies with frequency (f) and is represented by the following equation:

$$X_L = 2\pi f L \qquad (4)$$

Where a constant quantity L represents the self-inductance of the coil and its unit is Henry. By substituting equation (3) into (4), L can be written as follows:

$$L = \frac{1}{2\pi f} x \frac{V}{I} = \frac{1}{2\pi f} x \frac{AB}{BC} \qquad (5)$$

The value of (L) can also be calculated from the following theoretical relationship:

$$L = \frac{\mu_\circ \ A \ N^2}{l} \qquad (6)$$

Where A is the average cross-sectional area of the coil in square meters
N is the number of turns of the coil
l is the effective length of the coil in meters
μ_o is the permeability constant, given by

$$\mu_o = 4\pi \times 10^{-7} = 12.5 \times 10^{-7} \text{ Weber/amp. m}$$

Procedure:

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

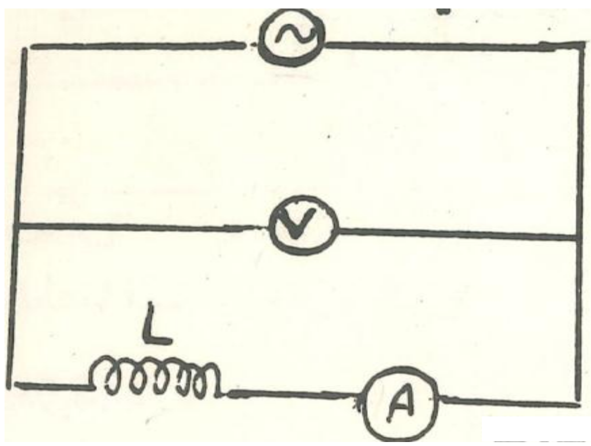


Figure (2)

2. Set the source frequency to 500 Hz.
3. Take several voltage readings (V) across the coil and record the corresponding current values. Organize the results as shown in the following table.
4. Repeat the previous step after setting the frequency to 100 Hz and record your results in the table as well.
5. Plot the relationship between V_{rms} and I_{rms}. Then calculate the inductive reactance X_L and the average self-inductance L.
6. Measure the inner and outer radii of the coil, then calculate the average radius and thus the average cross-sectional area of the coil.
7. Measure the effective length of the coil and record the value of N indicated on the coil.

Hz التردد	V_{rms}	I_{rms}
500	1 2 3 4 5 6	
1000	1 2 3 4 5 6	

Calculations:

1. Calculate the inductive reactance X_L from the graph, then calculate the average self-inductance L and compare it with the theoretical value indicated on the coil. Calculate the percentage error.
2. Calculate the value of L from equation (6) and then compare it with the theoretical value.
3. Discuss the reasons for the discrepancy in the value of L.

Questions:

1. Define Henry.
2. Why is a high frequency preferred when measuring the inductive reactance of a coil?
3. What is the nature of the relationship between inductive reactance X_L and frequency f?

Experiment (2)

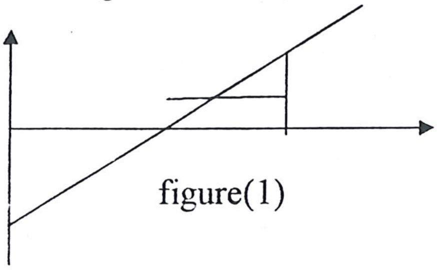
To Investigate Ohm Law's For A.C. Capacitive Circuit

The purpose of experiment:

1) To Investigate Ohm Law's For A.C. Capacitive Circuit.
2) Calculating the capacitate reactance (Xc).
3) Calculating the capacitance of capacitor.

Apparatus:

Low-voltage A.C. source, A.C. voltmeter, A.C. ammeter, Capacitor.



figure(1)

THEORY

Capacitor is one important element of electric circuit. By applying A.C. voltage with a specific frequency on the to ends of the capacitor then it will show resistance of current similar to any other resistance at any A.C. electric circuit .Then if the relation between the voltage active value (Vr.m.s)& the current active value (Ir.m.s.) is a direct relationship then it will be follow to Ohm's law.
A graph of (Ir.m.s) against (Vr.m.s) should give a **straight-line plot as indicated** .Thus V\I=const. (showing that Ohm's law applies also to this circuit. The ratio (V)\(*I*) gives, in this case, the capacitive reactance (Xc) of the circuit,
i.e.

$$Zc=\sqrt{Xc^2+r^2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$Zc=Xc=\frac{V(r.m.s)}{I(r.m.s.)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

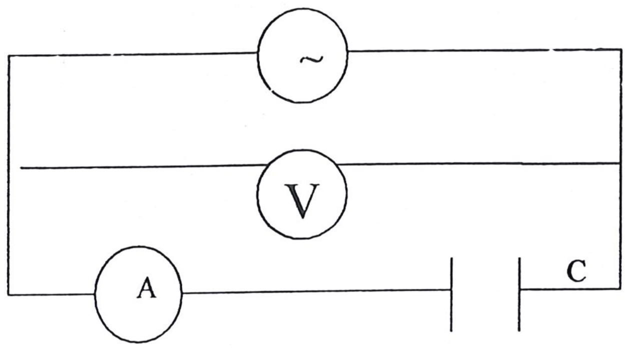
Where Zc: the total resistance
Xc: is the capacitive reactance.
r: is the resistance of the isolated material in the capacitor .
The value of (Xc) change with value of frequency of current that pass through in the capacitor according to the relation

$$X_C = \frac{1}{2\pi f c} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where f: frequency of supply, C: capacitance of capacitor in the circuit is measured by farad.

Practical:

A:1) Connect up the circuit as shown in figure (2).



2) give a constant frequency that value 100 HZ from A.C voltage source.
3) stating with the lowest of transformer secondary voltage across the circuit, read r.m.s. current I recorded by ammeter A. Repeat with successively higher voltages to the limit of the voltage range.
4) Record the current values against the appropriate voltage value (as shown in results table), these voltages having been checked at each stage by the a.c. voltmeter.

V r.m.s. (volt)	*I* r.m.s.(amp)
5	
10	
15	
20	
25	
30	

35	
40	
45	
50	

5) Draw the relation between Vr.m.s & I r.m.s... Record the theoretical value of capacitor.

B:

Repeat the steps (1-5) for electric circuit as shown in the figure (2) with addition another capacitor connect as series with first capacitor.

C:

Repeat the steps (1-5) for electric circuit as shown in the figure (2) with addition another capacitor connect as parallel with first capacitor.

A:

1) Calculate the capacitive reactance (Xc) for capacitor .from the slop of drawing between Vr.m.s. &*I* r.m.s...

2) Calculate the capacitive reactance (Xc) for capacitor too from Eq(3), comparing with the theoretical value & Calculate the percentage error .

B:

1) Calculate the theoretical capacitance of the two capacitors (at series connect) By

$$\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2}$$

calculate the theoretical Capacitive reactance (Xc) by use eq(3)

2) Calculate the capacitive reactance (Xc) for two capacitors .from the slop of drawing between Vr.m.s. &*I* r.m.s.. Comparing with the theoretical value & Calculate the percentage error..

3) Calculate the experimental capacitance of the two capacitors connecting in series. Comparing with the theoretical value & Calculate the percentage error.

C:

1) Calculate the capacitive reactance (Xc) for two capacitors connect as parallel .from the slop of drawing between Vr.m.s. &*I* r.m.s...

2) Calculate the capacitive reactance (Xc) for capacitor too from Eq(3), comparing with the theoretical value & Calculate the percentage error .

3) Calculate the experimental capacitance of the two capacitors connecting in parallel comparing with the theoretical value & calculate the percentage error.

Question:

1) What is the farad?
2) Why low frequency chosen for the A.C. at measuring a thermal capacity for the capacitor?
3) What the shape of drawing between capacitive reactance (Xc) & frequency (f)?

Experiment (3)

Tangent Galvanometer

APPARATUS

Tangent galvanometer, Ammeter, resistance plaug – key, power supply.

THEORY

It is a moving magnet type galvanometer. It consists of a circular frame on which three sets of coils of insulated fine copper 2, 50 and 500 turns are wound.
The frame is mounted vertically on abase carried on three leveling screws and can true around a vertical axis. At the center of the frame a compass needle like the one used in a deflection magnetometer.

The magnet of the magnetometer is directed in the direction of the horizontal component { H^0} to the intensity T errestrial field.

If a current {I} pass through a coil produced a magnetic field its intensity {E} vertical on coil plan. That's mean is vertical on {H^0}. Then the pointer is deflecting in the direction of the result of two fields.

If the deflection angle { ϴ } then:

$E = H^0 \tan \Theta$ ....(1)

But the intensity of the magnetic filed from in the coil:

$$E = \frac{Li}{10R^2} = \frac{2R\prod ni}{10R^2} = \frac{\prod ni}{5R}$$ Where L= 2 п Rn

$$\therefore \quad E = \frac{\prod ni}{5R}$$

L= The length of coil.
R= radius of coil.
I= current in the coil.
n= number of turns coil.

$$E = \frac{\prod ni}{5R} = H^0 \tan \Theta$$

$$\therefore \quad i = \frac{5RH^0}{\prod n} \tan \Theta$$

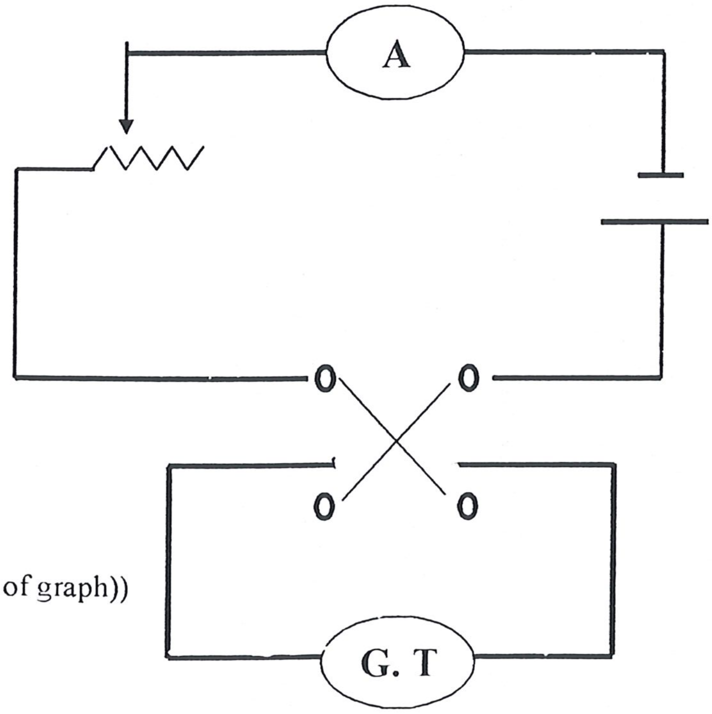
$$H^0 = \frac{\prod ni}{5R \tan \theta} = \frac{\prod n}{5R} * K$$

Where K is constant for the galvanometer called **reduction factor**.
Where **n, H^0 ,R** is consiant.
i= K tan ϴ.

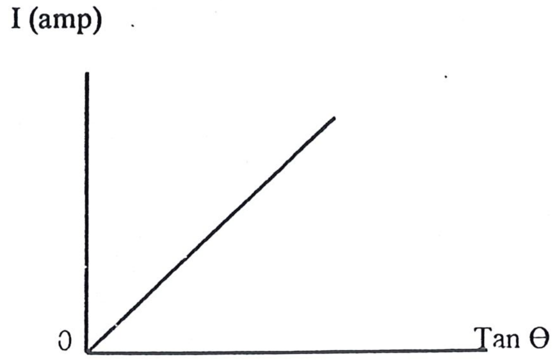
Practical:

1) Connect the circuit as in fig (1) where the coil is used with {50} turn.
2) We move the galvanometer unit it's pointer reads {0-0}. That's mean the magnetic of the galvanometer is parallel to coil.
3) Switch on the current and note the readings of bothe ends of pointer { Ө1, Ө2}
4) Reverse the dirction of current in the coil from the plug – Key and take readings of both ends of pointer { Ө 3, Ө 4} and the current value (i) must be constant.
5) Repeat the step (3), (4) for different value of (i) for adeflection of about (20-70) in the Ө and write in the table:

I	Ө1	Ө2	Ө3	Ө4	REVERSE CURRENT Ө AVE	TAN Ө



((The form of graph))



Slope = $\frac{dI}{dTan\theta}$ = K

Experiment (4)

Earth's Magnetic Field Horizontai Compound

The purpose of the experiment:

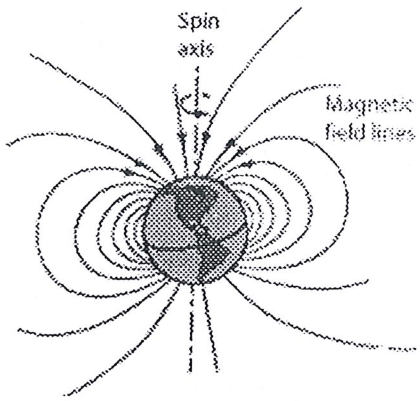
Calculated the Earth's Magnetic Field Horizontal Compound.

Apparatus:

Curved balance, magnetic axis, ruler and compass.

Theory:

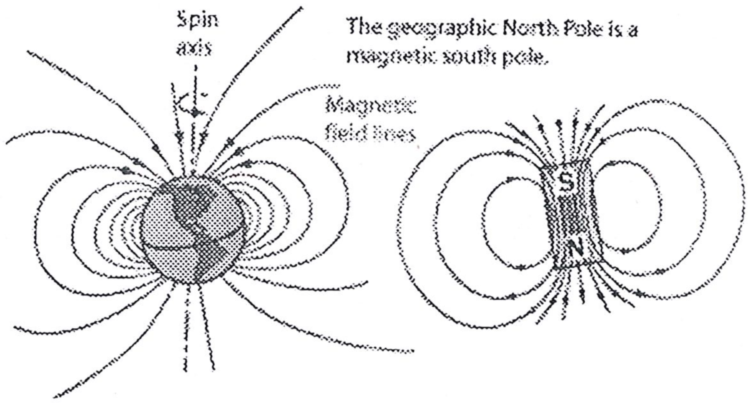
Earth has a magnetic field. If you pretended that Earth had a gigantic bar magnet inside of it (it doesn't really, of course), you would have a pretty good idea about the approximate shape of Earth's magnetic field. Earth's magnetic field is slightly tilted with respect to the planet's spin axis; there is currently a difference of about 11° between the two. Because of this difference, the Geographic North Pole and the North Magnetic Pole are not actually in the same place; likewise for the South Poles. This means that compasses do not always point directly towards True North.



Although scientists do not understand all of the details, they know that motions of molten metals in the Earth's core generate our planet's magnetic field. Movement of molten iron and nickel generates electrical and magnetic fields that produce Earth's magnetism. The flows of these molten metals in Earth's outer core are not perfectly steady over time, so Earth's magnetic field changes over time as well. The North and South Magnetic Poles wander over time; the North Magnetic Poie moved some 1,100 km (684 miles) during the 20th century. The strength of Earth's magnetic field varies as well; it has been decreasing slightly ever since around 1850. Over the course of Earth's history the magnetic field has actually reversed itself many times, with North becoming south and vice versa!

Earth's magnetic field extends thousands of kilometers (miles) outward into space. The field forms a gigantic magnetic "bubble" in space around Earth. This magnetic bubble is called the magnetosphere. Earth's magnetosphere shields our planet from most particle radiation that flows our way from the Sun and other radiation sources in space. The magnetosphere is not actually a sphere; it is shaped more like a teardrop, with a long "tail" extending away from the Sun.

Although Earth's magnetic field is roughly a dipole (like the field of a bar magnet) to a first approximation, it has a much more complex shape than a simple dipole field. The uneven flows and distributions of the molten metals that generate Earth's field cause the field to be quite "lumpy". The pressure of the solar wind, the stream of charged particles flowing outward from the Sun, also distorts the shape of the magnetic field surrounding Earth.



The names given to the Magnetic North and South Poles are potentially quite confusing. Recall that opposite poles of magnets attract, while like poles repel each other. If you take two bar magnets, and place their North Poles near each other, they will push themselves apart; likewise for two South Poles. If you place a North Pole near a South Pole, they will pull themselves together. The needle of a compass is a small bar magnet, with a North and a South Pole. The North Pole of the compass needle points North (roughly). But the North Pole of a magnet is attracted to a South Pole of another magnet. So Earth's North Magnetic Pole is actually a South Pole of a magnet!

Several other planets, and even a few moons, in our Solar System also have magnetic fields. Our Moon has a very weak magnetic field, as does the planet Mars. Mercury's field is a bit stronger. The giant planets Jupiter and Saturn have extremely powerful fields. Uranus and Neptune also have fairly strong fields. We don't know about Pluto yet, but it is unlikely to have a strong field if it has one at all. Venus does not have a magnetic field, probably because it rotates so slowly. Jupiter's moon Ganymede also has a magnetic field, and we have tentative hints that some other moons may have weak fields as well.

NOW, to calculate the magnetic fields using magnetic axis connect with balance we show the motion of axis is rotation moving, the oscillation's time is equal:

$$T = 2\pi\sqrt{\frac{I}{D}} \qquad \ldots\ldots\ldots\ldots (1)$$

Where

I= money of inertia for magnetic axis, D= curved constant, m = mass of magnetic axis, l =length of magnetic axis.

$$I = \frac{1}{12} m l^2 \qquad \ldots\ldots (2)$$

The money of inertia for magnetic axis depended on the displaced angle

$$T = D\theta \qquad \ldots\ldots\ldots (3)$$

This means

$$T = \mu B_e Sin\theta \qquad \ldots\ldots\ldots (4)$$

$$T = \mu B_e \theta$$

Where:

μ = moment magnetic, B_e= Earth's Magnetic Field Horizontal Compound.

From equations (3) & (4)

$$D = \mu B_e \qquad \ldots\ldots\ldots\ldots (5)$$

The magnetic field generating from magnetic axis, we can calculated by:

$$B = \frac{\mu_o}{2\pi}\frac{\mu}{\left(X^2 \frac{Tl^2}{4}\right)^{3/2}} \qquad \ldots\ldots\ldots (6)$$

From equations (5) & (6)

$$B = \frac{\mu_o}{2\pi}\frac{D}{B_e}\left(X^2 + \frac{l^2}{4}\right)^{-3/2} \qquad \ldots\ldots\ldots\ldots\ldots (7)$$

Since B and B_e vertical, so

$$B = B_e \tan\theta \qquad \ldots\ldots\ldots\ldots (8)$$

Where θ angle of compass, from equations (7) & (8)

$$\tan\theta = \frac{\mu_o}{2\pi}\frac{D}{B_e^{2}}\left(X^2 + \frac{l^2}{4}\right)^{-3/2}$$

$$\tan\theta = \left(2*10^{-7}\right)\frac{D}{B_e^{2}}\left(X^2 + \frac{l^2}{4}\right)^{-3/2} \quad \ldots\ldots\ldots\ldots (9)$$

Practical:

1) Moving the magnetic axis by small angle and calculate the oscillation's time.
2) Calculate the money of inertia (I), using equation (2).
3) Using equation (1) to calculate the curved constant (D).
4) Put the compass on different distance (X), and read the compass value.
5) Do the table includes $\tan\theta$ & $\left(X^2 + \frac{l^2}{4}\right)^{-3/2}$,drew the relation between this values.
6) Using the slop to calculate the Earth's Magnetic Field Horizontal Compound from equation (9).

Questions:

- If change the mass or the length of the magnetic axis, is this effected on the oscillation's time (T)? Explain this with equation?
- What the useful to calculate the Earth's Magnetic Field Horizontal Compound?
- Is the Earth's Magnetic Field value change with the different places in the earth?
- Can you calculate the B_e from drew the relation between $\tan\theta$ and X?

Experiment (4)

Generating of a Uniform Magnetic Field via Helmholtz Coil

APPARATUS: Helmholtz coil, ammeter, compass, power supply, rheostat (variac), metric ruler.

THEORY

When a current I passes through an N- turn Helmholtz coil of radius R, a magnetic field flux density B will be generated at the midpoint of the distance separating the two coils, and this magnetic field may be given by the following formula:

$$B = \frac{\mu_O I R^2 N}{(R^2 + X^2)^{3/2}} \text{------}(1)$$

Where B represents the magnetic field flux density at the midpoint of the distance separating the two coils and is measured in TESLA=Weber/m^2, $\mu_O = 4\pi \times 10^{-7}\, m \cdot kg \cdot C^{-1}$ is the magnetic permeability of the vacuum, and X is the distance between the midpoint and each coil.

As it has earlier been indicated, the magnitude of B can be measured using the compass. Thus:

$$B = B_e \tan\theta \text{------}(2)$$

Here, θ is the compass's angle of rotation and $B_e = 0.5 \times 10^{-4}\, Tesla$

By direct substitution of equation 1 in equation 2 one can get:

$$\tan\theta = \frac{\mu_O I R^2 N}{B_e (R^2 + X^2)^{3/2}} \text{------}(3)$$

It has been found that a comparatively uniform magnetic field is generated at the midpoint of the distance separating Helmholtz coils whenever the distance separating the two coils is equal to R.

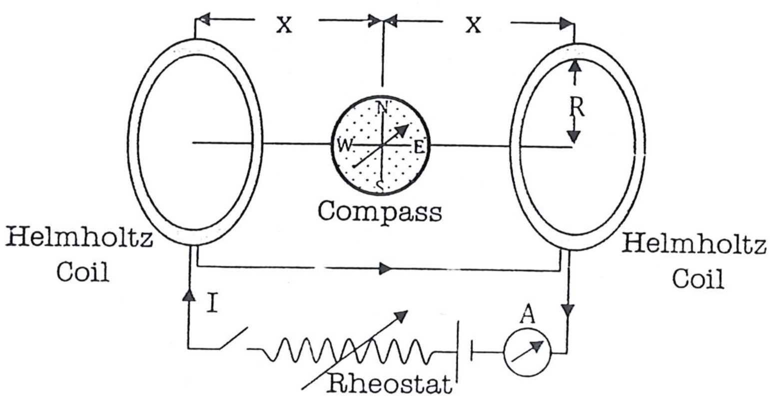


Figure 1: Electrical circuit of Helmholtz coil

PROCEDURE:

1. The electrical circuit shown in figure 1 is connected. No attempt to switch ON the power supply should be made till a supervisor first check the proper electrical connections.
2. The distance X in the figure 1 is made 2 cm, and then the rheostat is carefully adjusted until the angle, that the compass pointer indicates, is 60 - 70°. The reading of the ammeter is recorded in a suitable table. *The value of current passing through the Helmholtz coils must be maintained constant throughout the experiment.*
3. The two coils are moved towards the compass which has to be kept at its position (at the midpoint of the distance between the two coils). At each value of X, the corresponding deflection θ of the compass pointer is recorded in the table.
4. Equation 2 is then used to estimate the magnitude of B for each value of X.
   HINT: $B_e = 0.5 \times 10^{-4}$ Tesla
5. A graph of B as a function of X is plotted, from which the magnitude of B is deduced at X=R/2.
6. Using the value of B calculated from step 5, the number of turns of each coil may be evaluated using equation 1.

Discussion :

1. What is meant by "Uniformity of magnetic field"?
2. How can the magnetic field strength be increased at the midpoint of the distance between the Helmholtz two coils?
3. In results analysis, has a uniform magnetic field been obtained? Discuss in brief.
4. If a magnetic bar has been suspended between the Helmholtz coils, and the circuit of the coils is switched ON, will the position of the magnetic bar be changed? Discuss briefly.

Experiment (7)

Resonance in AC Circuits

Purpose of the Experiment:

To calculate the resonant frequency of inductive and capacitive reactance when they are connected:
a. In series, b. In parallel

Apparatus:

AC signal generator, ammeter AC, capacitor, inductor, switch

Theory:

In AC circuits that contain resistance, inductance, and capacitance, the phase difference between the current and the voltage across the resistor is zero. The phase difference between the voltage and the current across the inductor is such that the voltage leads the current by 90 degrees, while the voltage across the capacitor lags behind the current by 90 degrees. This phase change can be represented using vectors as shown in Figure (1). The impedance (Z) that the circuits present to the current is given by:

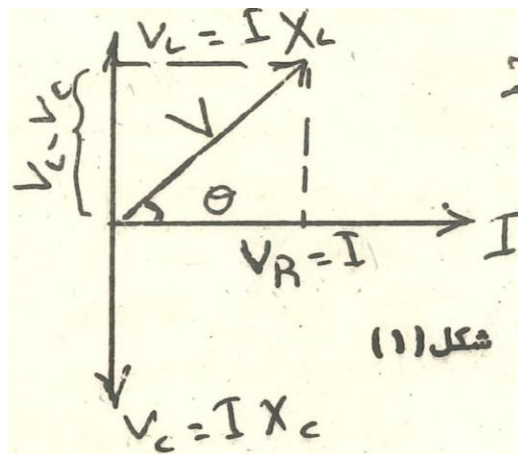
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad (1)$$

Where (R) is the resistance, (X_L) is the inductive reactance given by

$$X_L = 2\pi f L \qquad (2)$$

and (X_C) is the capacitive reactance given by

$$X_C = \frac{1}{2\pi f C} \qquad (3)$$



شكل (١)

The resonant frequency: is the frequency at which the inductive reactance equals the capacitive reactance, making the circuit behaves as resistive circuit. From Figure (2) is

$V_L = V_C$
$V_L = V_C = 0$

It is shown that the total voltage (V) aligns with the current (I), meaning there is no phase difference, and the circuit acts as a pure resistive circuit. At resonance, the inductive reactance equals the capacitive reactance, i.e.

$X_L = X_C$

$2\pi f L = \frac{1}{2\pi f C}$

$f_r = \frac{1}{2\pi \sqrt{LC}}$

Where f_r is the resonant frequency.

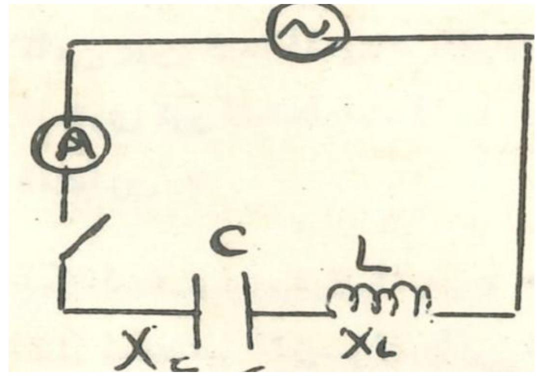


Figure (2)

Procedure:

1. Connect the circuit as shown in Figure (2).
2. Before turning on the AC signal generator set the output voltage to 5 volts and keeps it constant throughout the experiment.
3. Calculate the theoretical resonant frequency using the values of (C) and (L) recorded on the capacitor and inductor respectively.
4. Take five frequency readings from the signal generator below the resonant frequency and five readings above it. Record the current for each case and tabulate your results as shown below.
5. Plot the relationship between current (I) and frequency (f), then determine the practical resonant frequency as the lowest point on the curve, as shown in Figure (3).
6. Compare the theoretically calculated resonant frequency with the practical value and calculate the percentage error. Repeat steps (1- 6) after connecting the inductor and capacitor in parallel.

Questions:

1. Why should the voltage remain constant throughout the experiment?
2. Does the resonance frequency graph differ when C and (L) are connected in parallel?

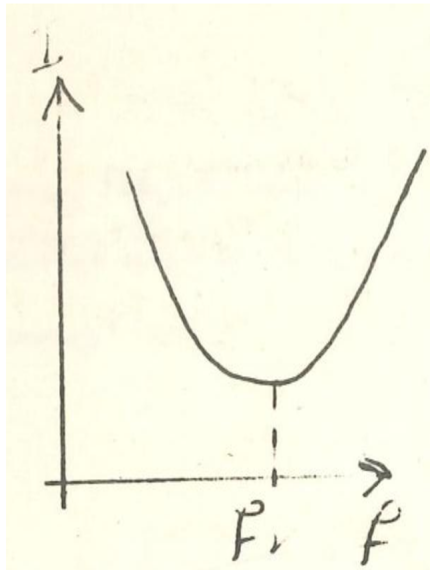


Figure (3)

الربط على التوالي		الربط على التوازي	
f (Hz)	I (Amp.)	f (Hz)	I (Amp.)

Experiment (8)

Calculating the Inductance and Resistance Values of a Coil

Apparatus:

Coil, Resistor, AC voltage generator, Voltmeter and ammeter, Caliper

Theory:

The coil exhibits inductive reactance (X_L) to the alternating current passing through it, and this reactance depends on the frequency (f) and inductance (L).

$X_L = 2\pi f L$ (1)

The total impedance of the coil (ZL) is the vector sum of the inductive reactance and the resistance r:

$$Z_L = \sqrt{r^2 + {X_L}^2}$$

Ohm's law can be applied to the coil as shown in the following equations (3) (4):

$Z^2 = r^2 + 4\pi f^2 L^2$ (2)

$V_L = I Z_L$ (3)

$V_L = I X_L$ (4)

The alternating voltage represents a vector whose length is proportional to the voltage value, and its direction is determined by the voltage phase.

Procedure:

Part One:

1- Connect the following circuit (see Figure 1).
2- Take different values of frequency (f) and record the readings of the ammeter and voltmeter for each frequency value.

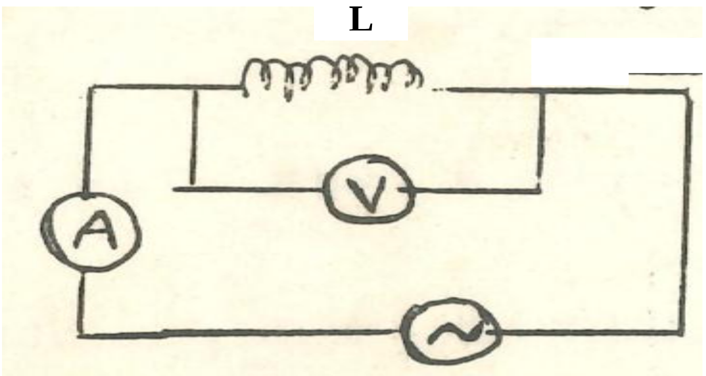


Figure (1)

3- Use equation (3) to calculate the total impedance (Z_L).
4- Create a table of the squared values of the total impedance $(Z_L)^2$ and the squared values of the frequency (f^2), then plot the relationship between them.
5- Refer to equation (2) and calculate the values of inductance (L) and resistance (r) from the plotted graph in step (4).

Part Two:

1- Connect the following circuit see Figure (2).
2- Record the voltmeter reading (V_R).

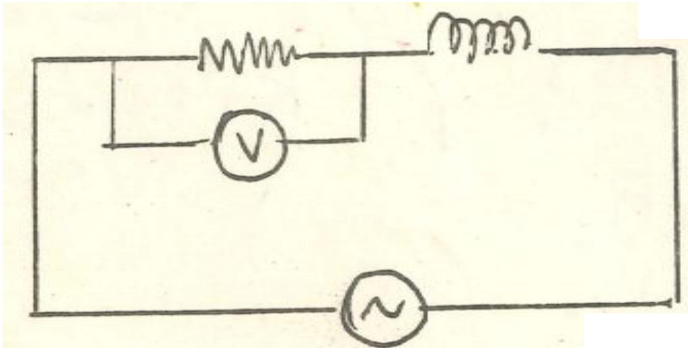
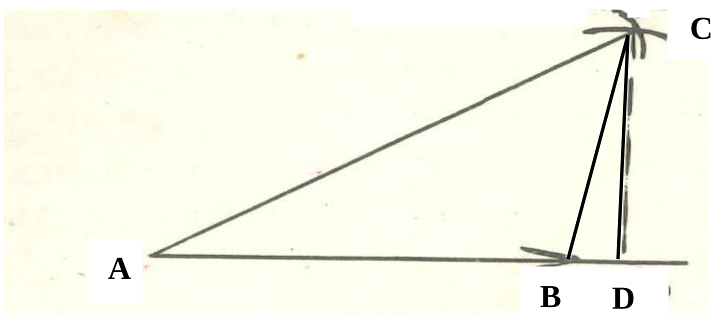


Figure (2)

3- Choose an appropriate scale to represent V_R with a vector (e.g., 1 cm for each volt).
4. Draw the vector ($\overrightarrow{AB}$) on the x-axis to represent the resistor voltage V_R.
5. Connect the voltmeter across the coil and record its reading as V_L.

6. Connect the voltmeter across the AC voltage source and record its reading as V.
7. Use the same scale to calculate the lengths of the voltage vectors: total voltage V and coil voltage V_L.
8. Open the calipers to the length of the vector representing the total voltage V, place it at point A, and draw a small arc.
9. Open the calipers to the length of the vector representing the coil voltage V_L place it at point B and draw another small arc.
10. The arcs intersect at point C.
11. Draw a perpendicular from point C to the x-axis, cutting it at point D (see Figure 3).
12. Measure the distances AB, BD, and CD, then apply equations (5) and (6) to calculate the inductance and resistance values in sequence.



الشكل (3)

Scale: Voltage /cm

Scale =K

$V_R = K\,(AB)$

$K\,(AB) = I\,R$

$I = \frac{K(\boldsymbol{AB})}{\boldsymbol{R}}$

$K\,(CD) = I\,X_L$

$K\,(CD) = \frac{K(AB)}{R}\,X_L$

$$X_L = \frac{(CD)}{AB}\,R \qquad (5)$$

$L = \frac{(CD)}{AB}\ R\ \frac{1}{2\pi f}$

K (BD) =I r

$K\,(BD) = \frac{K\,(AB)}{R}\ r$

$r = R\ \frac{BD}{AB}$ (6)

Questions:

1. Why do we plot the relationship between (Z^2) and (f^2) to calculate L and r instead of plotting the relationship between Z and f to obtain the same information?
2. If a resistor R is connected in series in the first circuit, will it affect the relationship between f and Z (discuss)?
3. Why is the voltage phase of the coil (V_L) less than 60 degrees?
4. Is it permissible to algebraically sum the values of V_L and V_R to find the total voltage?
5. In this experiment, two methods were used to calculate the inductance and resistance values. Which method is more accurate (discuss)?